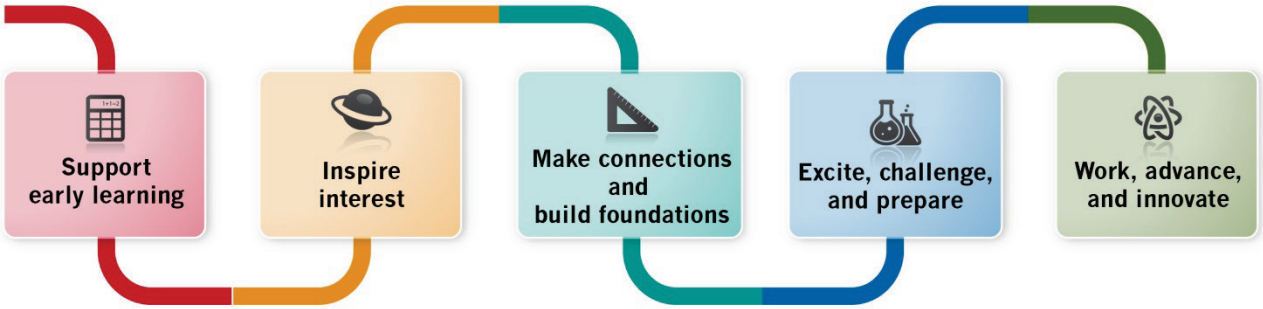
STEM IN MINNESOTA (Science, Technology, Engineering, Math)



Education and Workforce Disparities

Race/ethnicity: A cradle to career perspective

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JANUARY 2014

Minnesota is becoming increasingly diverse. Yet, when we look at skills needed to meet current and future workforce requirements – including problem-solving skills, technological literacy, scientific reasoning, and mathematical skills – we see alarming racial gaps that begin very early and persist to work careers.

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 blacks, American Indians and Hispanics. Addressing these gaps is an issue of economics as well as equity.

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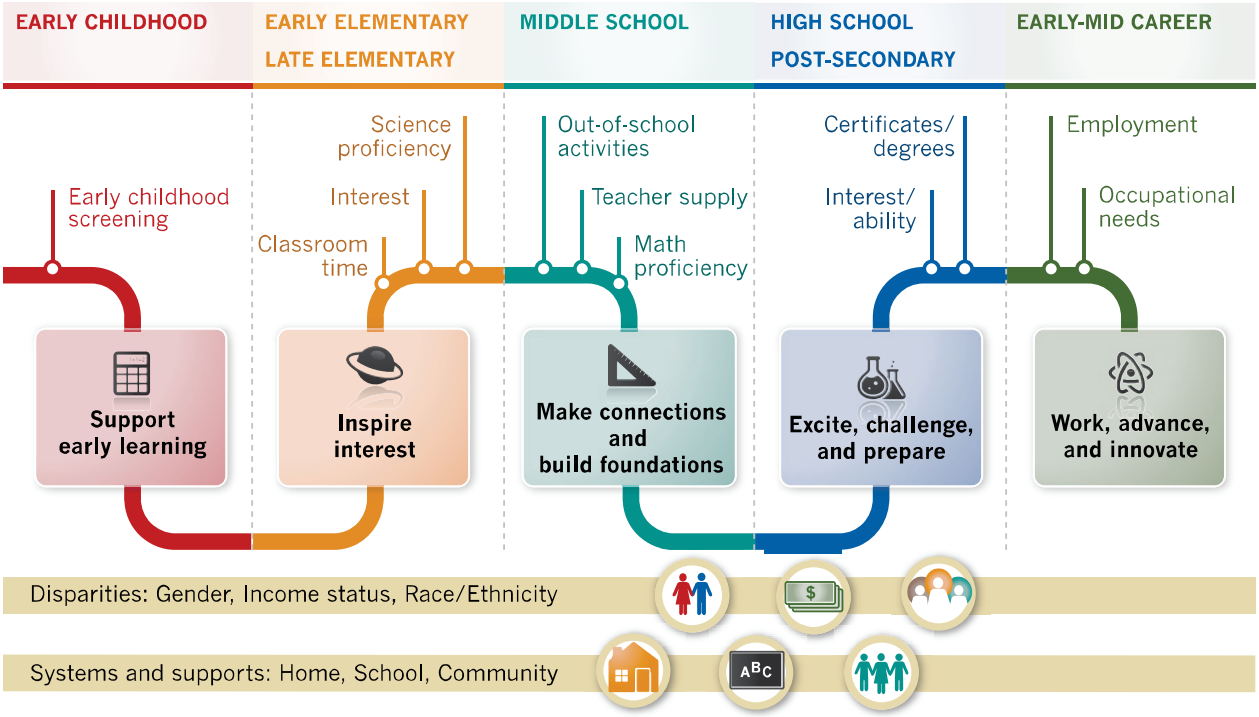
This paper was developed to augment STEM information on the Minnesota Compass website, which provides a common foundation of knowledge and resources that can be used to collectively address concerns and most effectively target resources. The website is organized around a cradle-to-career framework.



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 six sections with each section identifying racial 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
- STEM postsecondary degree completion
- STEM occupations

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

Key findings for Minnesota students

Currently, the race/ethnicity of Minnesota's K-12 public school student population is 2 percent American Indian, 7 percent Asian, 7 percent Hispanic, 11 percent black, and 73 percent white. The fastest growing groups are non-white.

Proficiency

- Gaps in math and science skills by race/ ethnicity begin early and persist throughout elementary and high school years. Gaps are especially large between white students and American Indian, black and Hispanic students.
- When differences in family income and language are taken into account, substantial gaps in science and math skills still exist between white students and American Indian, black, and Hispanic students, but not between white and Asian students.
- High school graduates of color are less prepared to succeed in college-level courses in math and science than white students, based on ACT results.
- Among those who complete a postsecondary degree, the proportion in each racial/ethnic group who complete it in a STEM field is quite similar, between 15 and 21 percent. It's highest among Asians and lowest among American Indians.

Interest

- Racial gaps for student interest levels in STEM and science are much narrower and look much different than for student achievement levels. For example, in fourth grade, Asian students are the most likely to be interested in studying science with little difference among the other racial/ethnic groups; in eighth grade, black students are the most likely to participate in science activities outside of school, and among those prepared for college-level math and science courses, black students are also most likely to indicate that they will pursue a STEM major in college.

Workforce participation

- American Indians, blacks, and Hispanics are likely to be underrepresented in the Minnesota STEM workforce relative to their numbers in the working-age population, as they are nationally (but data specific to Minnesota were unavailable).
- The percentage of workers in each racial/ ethnic group that are employed in STEM occupations varies. Asians have the highest percentage and American Indians have the lowest percentage.

Some potential contributing factors:

- Students of color tend to receive somewhat fewer hours of science instruction in fourth grade than white students.
- American Indian, black, and Hispanic students are more likely to attend high schools that do not offer advanced courses in math and science compared to white and Asian students.
- Eighth-grade black students tend to have less prepared and experienced math teachers, and math and science teachers with fewer resources available for instruction, compared to white and Hispanic students.

Suggested actions

- Increase access and participation of children of color in high-quality preschool programs with a strong math component.

- Provide timely extra support (such as one-on-one tutoring) to students falling behind in math in the early elementary grades. Continue to monitor progress and intervene quickly when needed in later grades.
- Integrate the teaching of science with other STEM subjects to enhance students' science learning.
- Foster greater engagement of parents in working with their children to improve their math skills.
- Use student assessments such as EXPLORE (eighth grade) and PLAN (tenth grade) to monitor students' progress towards college readiness, develop their course plans, and determine what supports or interventions may be needed to keep them on track.
- To help more students be prepared for advanced high school courses in math and science, eliminate course options in grades 6-10 that have reduced expectations.
- Hold schools accountable for students' performance in science as is done with math and reading.
- Implement incentives or other mechanisms to get more top-performing math and science teachers into the classrooms of the students who need their help the most.
- Eliminate inequities by race/ethnicity in the resources available for math and science instruction.
- Connect instruction in meaningful ways to students' lives and provide frequent opportunities for students to engage in scientific inquiry and the processes of developing scientific knowledge.
- Improve K-12 teaching of science through improvements in teacher preparation programs and teacher professional development opportunities.
- Boost time spent on science in elementary school (Minnesota lags behind the nation) and eliminate inequities in time spent by race/ethnicity.
- Increase the number of high schools that offer Advanced Placement (AP) courses in math and science and the proportions of American Indian, black, and Hispanic students who enroll and succeed in AP courses in math and science.
- Increase the proportions of underrepresented students who qualify for and take advantage of dual enrollment opportunities such as Post-Secondary Enrollment Options (PSEO).
- Increase student awareness of STEM jobs and careers
- Make greater efforts to retain underrepresented students pursuing STEM majors in college by providing bridge programs from high school to college, offering earlier opportunities to take research courses or participate in faculty research programs, facilitating student relationships with faculty in their major, and encouraging participation in student study groups.
- Foster partnerships between businesses and undergraduate STEM programs to increase student retention by providing them with exposure to STEM jobs and careers.
- Ensure access of all children and their families to informal science education programs to stimulate interest in science and provide "hands on" learning opportunities.

Math proficiency

Key findings

Gaps in math skills by race/ethnicity begin before kindergarten

Gaps in math skills 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 Mathematical Thinking items from the Work Sampling System. Results from this assessment indicated that 50 percent of white children were proficient in Mathematical Thinking, followed by 37 percent of Asian children, 30 percent of black children, 24 percent of American Indian children, and 20 percent of Hispanic children. Hence, substantial gaps in math learning by race/ethnicity were already present when children entered 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%). Analyses were not conducted of the relationship of race/ethnicity to proficiency in Mathematical Thinking (Minnesota Department of Education, 2013a).

Gaps in math learning by race/ethnicity persist and sometimes grow, in the early elementary grades and middle school years

A nationally representative study by the National Center for Education Statistics found that in the spring of first grade white students were more likely than black and Hispanic students to solve addition, subtraction, multiplication, and division problems (Museus, Palmer, Davis, & Maramba, 2011).

By third grade in Minnesota, there are large gaps between white students and American Indian, black, and Hispanic students in math proficiency. In 2013, American Indian, black, and Hispanic third graders had proficiency rates that were 28-34 percentage points below white third graders on Minnesota Comprehensive Assessments, Series III (MCA-III) math tests. The MCA-III helps districts measure student progress toward Minnesota's Academic Standards.

A key indicator of student math skills in Minnesota is eighth-grade math proficiency based on the MCA-III. Statewide results from spring 2013 show large differences in math proficiency by race/ethnicity. Sixty-six percent of white eighth graders were proficient compared to 29 percent of American Indian and black eighth graders and 34 percent of Hispanic eighth graders. Sixty percent of Asian eighth graders were proficient. The gap in proficiency rates between white eighth graders and American Indian and black eighth graders was 37 percentage points, and between white and Hispanic eighth graders, 32 percentage points (Minnesota Department of Education, 2013b).

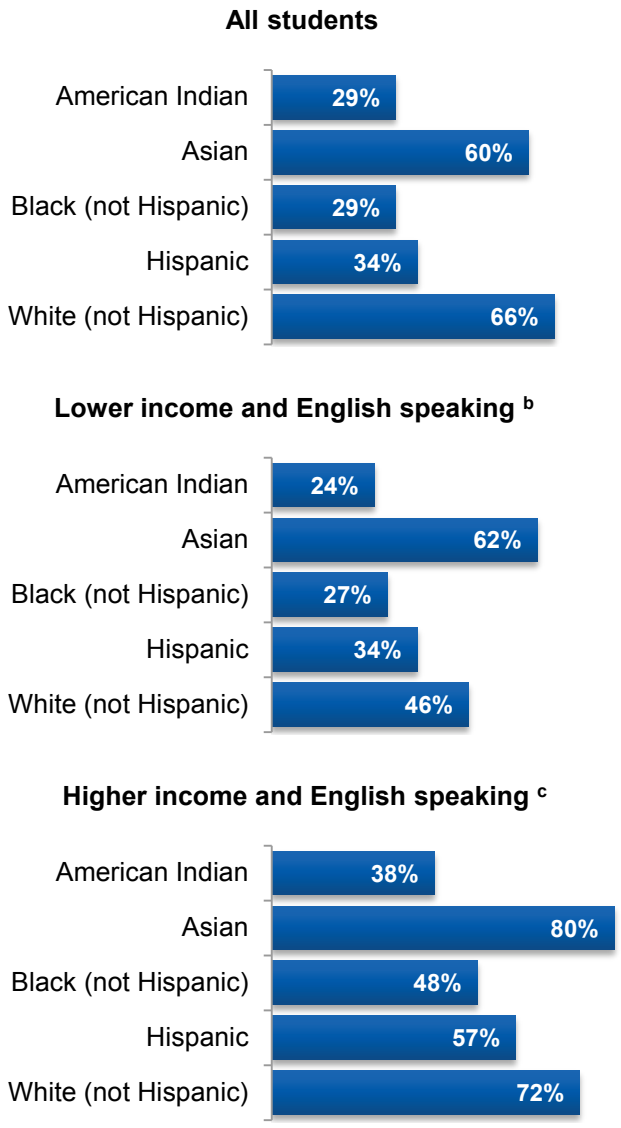
Even after taking family income and language differences into account, substantial racial/ethnic gaps in eighth-grade math skills still exist

Compared to white students, students of color are more likely to be from lower-income families and to be English learners, both associated with lower proficiency in math. Overall, students eligible for free or reduced-price lunch (family income at or below 185% of the federal poverty level) have much lower proficiency rates in math than higher-income students. Overall in Minnesota, the proficiency rates in eighth-grade math for these lower and higher-income groups in 2013 are 38 percent and 70 percent, respectively. English learners have a very low proficiency rate in eighth grade math (21%).

If these two factors are taken into account by examining eighth-grade math proficiency rates among only lower-income, English-speaking students, we obtain the following results by race/ethnicity: Asian students have the highest proficiency rate at 62 percent, followed by white students at 46 percent, Hispanic students at 34 percent, black students at 27 percent, and American Indian students at 24 percent. Hence, when income and language are taken into account, proficiency gaps still exist between white students and American Indian, black, and Hispanic students but they are smaller (12 to 22 percentage points). Asian students' proficiency is considerably higher than all the other racial/ethnic groups, including white students (Figure 1).

A similar pattern of results in eighth-grade math is found for higher-income, English-speaking students by race/ethnicity, although proficiency rates are higher in all racial/ethnic groups. More specifically, there are smaller gaps between white students and black, Hispanic and American Indian students, with Asian students having the highest proficiency rate (Minnesota Department of Education, 2013b).

1. Eighth-grade math proficiency: Minnesota students, 2013, percent proficient [a]



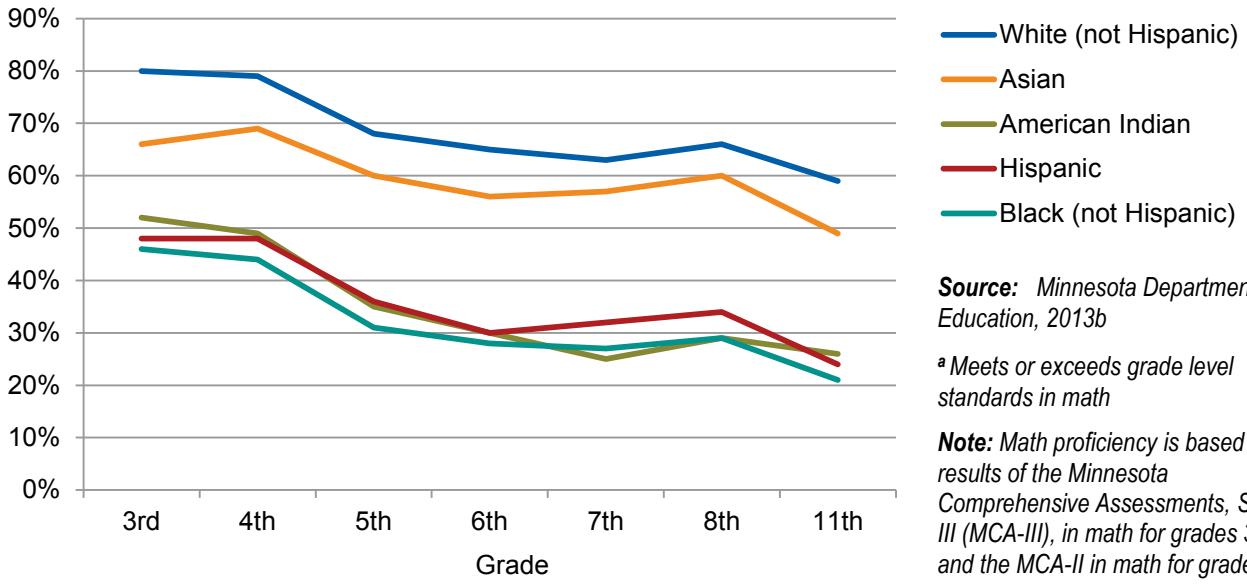
Source: *Minnesota Department of Education, 2013b*

[a] *Meets or exceeds eighth-grade standards in math based on the MCA-III math test.*

[b] *Family income at or below 185% of the federal poverty line (i.e., eligible for free or reduced lunch) and not receiving English learner services.*

[c] *Family income above 185% of the federal poverty line (i.e., ineligible for free or reduced lunch) and not receiving English learner services.*

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



Source: *Minnesota Department of Education, 2013b*

[a] Meets or exceeds grade level standards in math

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.*

Eleventh grade math scores show overall achievement is lower, and gaps remain

In eleventh grade, the proficiency rates in MCA-II math for American Indian, black, and Hispanic students were 33-38 percentage points below that for white students. Overall, across all the racial/ethnic groups, math proficiency rates declined from third to eleventh grade. The largest single year decline was from fourth grade to fifth grade for all groups except Asian students (Figure 2). The decline for all students combined was from 71 percent proficiency in fourth grade to 60 percent in fifth grade (Minnesota Department of Education, 2013b).

National Assessment of Educational Progress (NAEP) results for Minnesota students show racial gaps similar to those found in state MCA assessments

NAEP tests, often called the "Nation's Report Card," report at the state level for grades 4 and 8 based on a representative sample. NAEP math results for Minnesota students in 2013 show achievement gaps between white students and black and Hispanic students that are similar in size to those found with the MCA-III math test.

The NAEP math proficiency rate for fourth graders was 67 percent for white students compared with 32 percent for black students and 34 percent for Hispanic students. Asian students had a proficiency rate of 52 percent.

One encouraging finding in the NAEP results is that the gap between white and black students in fourth grade has decreased over the past 11 years. Overall, Minnesota ranked first among the states in fourth grade math results in 2013 with the black-white gap being similar to the national average.

Eighth-grade math results in 2013 for Minnesota from the NAEP show similar overall gaps by race/ethnicity to the MCA-III scores. The NAEP proficiency rate for white students was 54 percent compared to 15 percent for black students and 20 percent for Hispanic students, a 39 and 34 percentage point gap, respectively, compared

to white students. Asian students had a proficiency rate of 43 percent for a gap of 11 percentage points with white students. While overall Minnesota eighth graders perform better on NAEP math on average than their peers nationwide, the white-black achievement gap in Minnesota is wider than in most states and hasn't changed significantly in 13 years (U.S. Department of Education, Institute of Educational Sciences, National Center for Education Statistics [U.S. DOE], 2013).

Potential contributing factors to racial gaps

Eighth-grade black students tend to have less-prepared and less-experienced math teachers with fewer resources available for instruction

Teachers' content knowledge and teaching experience in a subject area can affect student performance. At least part of the explanation for the gaps in math proficiency may relate to differences by students' race/ethnicity in their teachers' level of preparation and experience to teach math. There is a tendency in Minnesota for black students to have teachers that are less prepared and experienced to teach math than for white and Hispanic students. NAEP data from 2011 for Minnesota show that 35 percent of eighth-grade math teachers for black students have an undergraduate major in math compared to 44 percent for white students and 46 percent for Hispanic students. Turning to experience, 61 percent of Minnesota eighth-grade math teachers for black students had five or more years of experience teaching math compared to 82 percent for white students and 80 percent for Hispanic students.

Eighth-grade math teachers were asked in 2011 how many of the resources needed for instruction were provided by their school system (none, some, most, or all). Black students were more likely to have math teachers with fewer resources for instruction. Sixty-seven percent of black students had teachers who reported being provided with most or all of the instructional resources they needed compared to 79 percent for white students and 84 percent for Hispanic students (Change the Equation, n.d.).

Actions to reduce gaps

Increase access and participation of children of color in high-quality preschool programs

To reduce these gaps, 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 low-income families and children of color, 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 (What Works Clearinghouse, 2007).

Provide timely interventions early to avoid later math difficulties

Once students are in school, it is important for teachers to monitor students' performance closely and intervene early with extra help when students start falling behind. Kindergarten or early first grade is not too early to intervene with children having 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's critical for students to have successes and gain confidence in their ability to learn math early on, 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 and Bayerl, 2008).

Implement strategies to get more qualified, top-performing teachers in low-performing classrooms with sufficient instructional resources

Inequities in math teachers' preparation and experience and in the instructional resources available to them, by race/ethnicity in Minnesota, suggest that some of the students who need highly- qualified, well-resourced math teachers the most are less likely to have them. These inequities, particularly for black students, need to be eliminated if the achievement gap is to be closed. 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.

Encourage mentoring and develop a more diverse teacher pool

More mentoring by outstanding math teachers of teachers working in classrooms with at-risk/ struggling students could be helpful. Also, greater racial/ethnic diversity among math teachers could be helpful in reducing achievement gaps. In this regard, it is important for teacher preparation programs to emphasize recruiting, supporting, and preparing aspiring teachers of color for K-12 teaching in order that teacher demographics more closely match student demographics (MN P-20 Education Partnership, 2011).

Foster greater engagement of parents to support their children's learning

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

Science proficiency

Key findings

Large gaps in science proficiency by race/ ethnicity occur in fifth grade

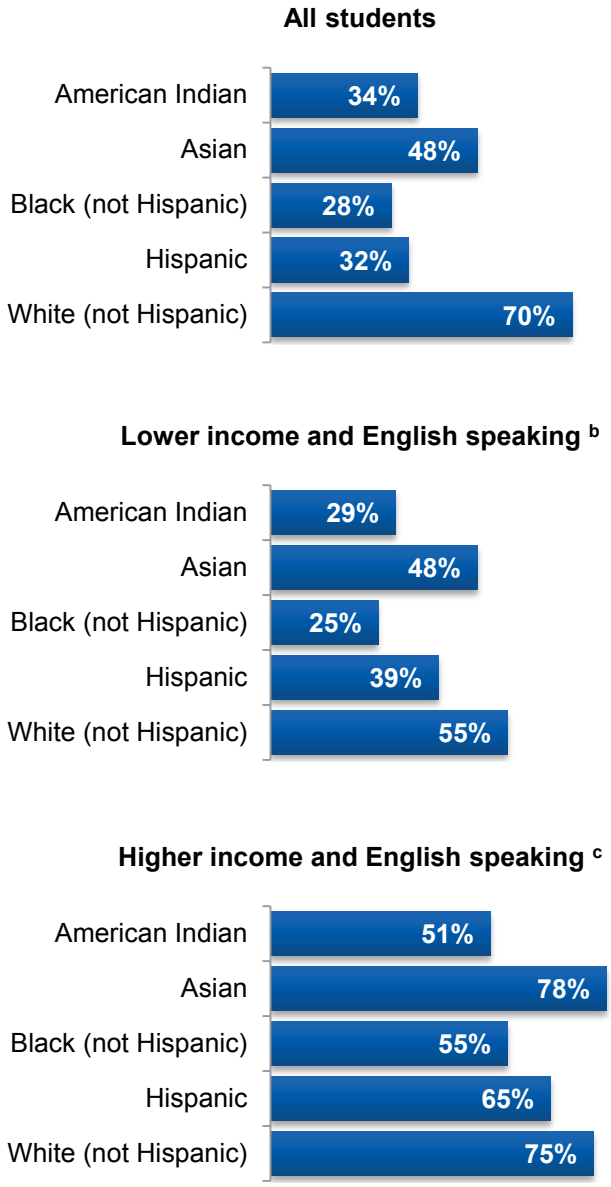
A key indicator of student science skills in Minnesota is fifth-grade science proficiency based on the Minnesota Comprehensive Assessments, Series III (MCA-III). Statewide results from spring 2013 show large differences in science proficiency by race/ethnicity. Seventy percent of white fifth graders were proficient in science, followed by 48 percent of Asian fifth graders, 34 percent of American Indian fifth graders, 32 percent of Hispanic fifth graders, and 28 percent of black fifth graders (Minnesota Department of Education, 2013b). The gap in proficiency rates between white fifth graders and American Indian, Hispanic, and black fifth graders was 36-42 percentage points, and between white and Asian fifth graders, 22 percentage points (Minnesota Department of Education, 2013b).

When differences in family income and language are taken into account, substantial racial/ethnic gaps in fifth-grade science proficiency still exist

As with math, family income and language are strongly related to proficiency in science, and also related to race/ethnicity. The fifth-grade science proficiency rate in 2013 of students from lower-income families (eligible for free or reduced-price lunch) was 35 percent compared to 74 percent for higher-income students (ineligible for free or reduced-price lunch). English learners have a very low proficiency rate in fifth-grade science (16%). If we take students' family income and language into account, gaps between white students and American Indian, black, and Hispanic students are narrower, and proficiency rates for Asian and white students are quite similar.

Repeating the analysis we did for eighth-grade math for fifth-grade science, we find the following proficiency rates for lower-income, English-speaking students: 55 percent for white students, 48 percent for Asian students, 39 percent for Hispanic students, 29 percent for American Indian students, and 25 percent for black students (Figure 3). Hence, the gaps between white students and students in other racial/ethnic groups are smaller, especially for Hispanic and Asian students. A somewhat similar pattern of results in fifth-grade science is found for higher-income, English-speaking students by race/ ethnicity, although proficiency rates are higher in all race/ethnicity groups. More specifically, there are smaller gaps between white students and black and American Indian students, a much smaller gap between white and Hispanic students, and Asian students have a slightly higher proficiency rate than white students (Minnesota Department of Education, 2013b).

3. Fifth-grade science proficiency: Minnesota students, 2013, percent proficient [a]



Source: *Minnesota Department of Education, 2013*

[a] *Meets or exceeds fifth-grade standards in science based on the MCA-III science test.*

[b] *Family income at or below 185% of the federal poverty line (ie., eligible for free or reduced lunch) and not receiving English learner services.*

[c] *Family income above 185% of the federal poverty line (ie., ineligible for free or reduced lunch) and not receiving English learner services.*

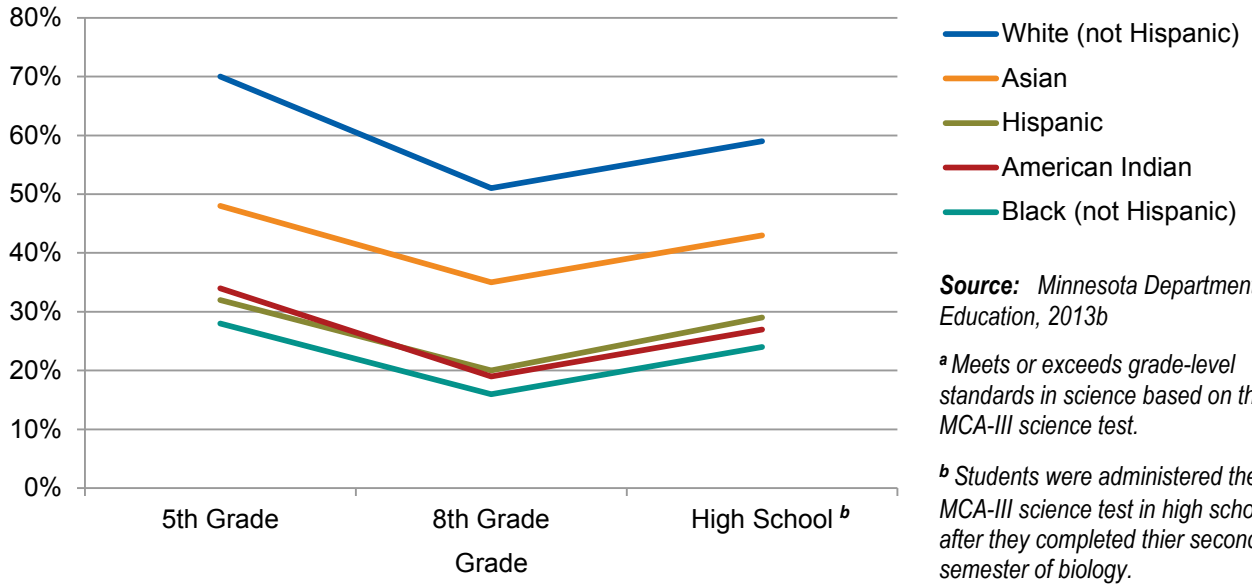
Large gaps in science proficiency by race/ ethnicity also occur in middle school and high school

Large gaps between white students and students of color 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 (Figure 4). 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. Gaps continued to be large between white students and American Indian, black, and Hispanic students in eighth grade (31-35 percentage points across the three groups) and high school (30-35 percentage points across the three groups). The gap between white and Asian students (in favor of white students) was 16 percentage points in both eighth grade and high school (Minnesota Department of Education, 2013b).

Nationally, Minnesota scores high in overall science proficiency, but when looking at racial gaps, moves down to middle of the pack

Although Minnesota students performed better than students nationally on average, NAEP science results for Minnesota fourth graders also showed large gaps in proficiency between white students and students of color. In the most recent year NAEP fourth-grade science data are available (2009), white students had a proficiency rate of 51 percent, followed by 31 percent for Asian students, 16 percent for Hispanic students, and 12 percent for both American Indian and black students. Hence, proficiency gaps in NAEP fourth-grade science were similar to those seen above for MCA-III fifth-grade science for Minnesota students – compared to white students, the gaps were 35-39 percentage points for American Indian, black, and Hispanic students, and 20 percentage points for Asian students. The gaps for black and Hispanic students compared to white students in Minnesota were near the national average (U.S. DOE, 2013).

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



Source: *Minnesota Department of Education, 2013b*

[a] Meets or exceeds grade-level standards in science based on the MCA-III science test.

[b] Students were administered the MCA-III science test in high school after they completed thier second semester of biology.

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.*

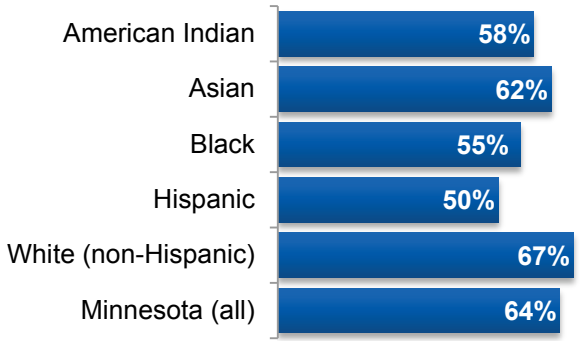
The gaps in NAEP science proficiency seen among Minnesota fourth graders also occurred in eighth grade. The NAEP eighth-grade results for 2011 showed that 49 percent of white students were proficient in science followed by 29 percent of Asian students, 18 percent of Hispanic students, 14 percent of American Indian students, and 10 percent of black students. Compared to white students, proficiency gaps were 31-39 percentage points for American Indian, black, and Hispanic students, and 20 percentage points for Asian students. Again, Minnesota eighth graders performed better on average than eighth graders nationally while the gaps for black and Hispanic students compared to white students were near the national average (U.S. DOE, 2013).

Potential contributing factors to racial gaps

Students of color tend to receive somewhat fewer hours of science instruction in fourth grade than white students

At least part of the explanation for these gaps in science proficiency may relate to inequities in the amount of time spent on science in the classroom for different racial/ethnic groups, and differences by students' race/ethnicity in their teachers' level of preparation and experience to teach science. 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). Results indicated differences in the percentages of students who received two or more hours of science instruction per week by race/ethnicity (Figure 5). White students were most likely to receive two or more hours of science instruction (67%), followed by Asian students (63%), American Indian students (58%), black students (55%), and Hispanic students (50%) (U.S. DOE, 2013). Minnesota lagged behind the nation in time spent on science in grades 1-4 for the most recent data available (2008) (Change the Equation, n.d.).

5. 4th graders with 2 or more hours per week spent on science by racial and ethnic group, Minnesota, 2009



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

Eighth-grade black students tend to have science teachers with fewer instructional resources who are slightly less prepared and experienced compared to white and Hispanic students

Black eighth graders in Minnesota in 2011 were less likely to have science teachers that were provided with most or all the instructional resources they needed. Forty-nine percent of black students had science teachers who reported having most or all of these resources compared to 66-67 percent for white and Hispanic students (Change the Equation, n.d.).

As mentioned earlier, teachers' content knowledge and teaching experience in a subject area can affect student performance. There is a slight tendency in Minnesota for black students to have teachers that are less prepared and experienced to teach science than white and Hispanic students. NAEP data from 2011 for Minnesota show that 69 percent of Minnesota eighth-grade science teachers for black students have an undergraduate major in science compared to 79 percent for white students and 76 percent for Hispanic students. Regarding

experience, 74 percent of Minnesota eighth-grade science teachers for black students had five or more years of experience teaching science compared to 80 percent for white students and 77 percent for Hispanic students (Change the Equation, n.d.).

Actions to reduce gaps

Increase school accountability for science performance

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 stronger efforts to improve students' performance in the subject.

Provide more professional development opportunities for teachers

Improving the teaching of science is likely an important component in increasing the interest and performance of all students in science. 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).

Integrate science instruction with other STEM subjects

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).

Boost time spent on science, and eliminate inequities

Efforts should be made to eliminate racial/ethnic inequities among students in class time spent on science, instructional resources available to teach sciences, and science teachers' preparation and experience to teach science (Change the Equation, n.d.).

Ensure access of all children and their families to informal science 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).

Increase diversity of teachers

As discussed earlier related to achievement gaps in math, it would likely be helpful to have greater racial/ethnic diversity among science teachers so that teacher diversity in this regard more closely matches student diversity. Greater emphasis by teacher preparation programs on recruiting, supporting, and preparing aspiring K-12 science teachers of color could help accomplish this (MN P-20 Education Partnership, 2011).

College readiness in STEM

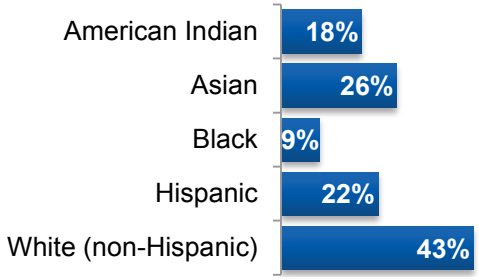
Key findings

High school graduates of color are less prepared to succeed in college-level courses in math and science than white students, based on ACT results

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. Again, results indicate substantial gaps by race/ethnicity – 43 percent of white students were "able" followed by 26 percent of Asian students, 22 percent of Hispanic students, 18 percent of American Indian students, and 9 percent of black students (Figure 6) (ACT, Inc.).

6. Percent of 2012 Minnesota high school graduates who are able in STEM



Source: *ACT, Inc.*, 2013

Note: *"Able" students are those meeting both science and math benchmarks on the ACT assessment.*

Potential contributing factors to racial gaps

American Indian, black, and Hispanic students are more likely to attend high schools that do not offer advanced courses in math and science compared to white and Asian students

At least part of the reason for the gaps in meeting ACT math and science exam benchmarks may be due to differences in the opportunity to take advanced courses in math and science in Minnesota high schools by students' race/ethnicity. For example, 24 percent of black students and 20 percent of American Indian students were in schools that did not offer advanced mathematics courses (trigonometry, elementary analysis, analytic geometry, statistics, and pre-calculus)

compared to 14-15 percent of Asian and Hispanic students, and 11 percent of white students. Similarly, 43 percent of American Indian students were in schools that did not offer calculus compared to 29-34 percent of students in other racial/ethnic groups. Turning to science, American Indian (22%), black (21%), and Hispanic (18%) students were more likely to attend high schools that did not offer chemistry compared to white (12%) and Asian (14%) students. Similarly, American Indian (28%), black (24%), and Hispanic (21%) students were more likely to attend high schools that did not offer physics compared to white (17%) and Asian (15%) students (Change the Equation, n.d.).

Actions to reduce gaps

Provide more Minnesota high school students with the opportunity to take rigorous, advanced courses in math and science and succeed in them

Greater access to these courses could be accomplished by more high schools offering Advanced Placement (AP) courses in math and science. AP courses are offered in about 270 Minnesota high schools with AP offerings being the most limited in rural school districts. The participation of students of color in AP courses has increased recently. However, American Indian, black, and Hispanic students continue to be greatly underrepresented in these courses compared to white and Asian students (Minnesota Office of Higher Education, 2013). Increasing participation by students of color in dual enrollment programs such as Minnesota's Post-Secondary Enrollment Options (PSEO) is another potential way of increasing opportunities for rigorous course-taking while in high school (Mueller & Gozali-Lee, 2013).

Students, of course, need to be prepared to succeed in AP or other advanced high school courses when offered the opportunity to take them. As we have seen from earlier achievement data, American Indian, black, and Hispanic 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 such as inequities in educational opportunities, disparities in the quality of education, and differences in beliefs or expectations regarding their academic abilities in their earlier school years.

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 6-10 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.

STEM interest

Key findings

The pattern we see in math and science proficiency of large gaps between whites and other racial/ethnic groups (or whites/Asians and other race/ethnic groups) is generally not seen in the data available on interest in science or STEM. In fact, whites often have about the same or lower interest than other racial/ethnic groups.

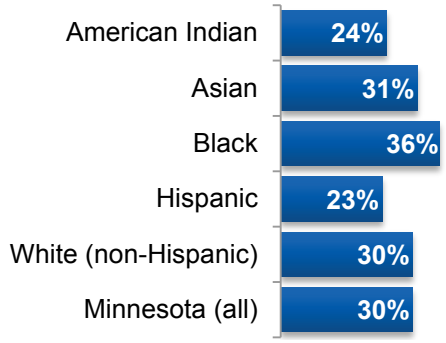
Asian fourth graders were the most likely to be interested in studying science with little difference among fourth graders in other racial/ethnic groups

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 race/ethnicity indicated that Asian fourth graders were more likely to have high interest in science (68%) than other racial/ethnic groups. The proportions of other groups indicating a high interest in science were 59 percent for Hispanic students, 56 percent for white students, 55 percent for black students, and 52 percent for American Indian students (U.S. DOE, 2013).

Black eighth graders were the most likely to participate in science activities outside of school while American Indian and Hispanic eighth graders were the least likely to do so

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," 30 percent of Minnesota eighth graders said they did non-school science activities. Figure 7 indicates that black students were most likely to say they participated in non-school science activities (36%), followed by Asian students (31%), white students (30%), American Indian students (24%), and Hispanic students (23%) (U.S. DOE, 2013).

7. Percent of 8th graders doing science activities not for school by racial and ethnic group, Minnesota, 2011



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

Note: *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."*

Among high school graduates taking the ACT, American Indian and black students expressed more interest in majoring in STEM fields

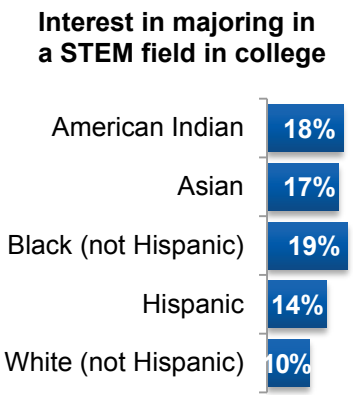
High school graduates in 2012 who took the ACT exams while in high school were asked their choice of a major in college. Those students who indicated that they were "very sure" of their choice of a STEM college major were classified

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. American Indian high school graduates were most likely to be interested in STEM (16%), followed by black graduates (14%), Asian and Hispanic graduates (12% each), and white graduates (9%) (ACT, Inc.). Although more high school graduates of color taking the ACT exams indicate an interest in pursuing a STEM major, it is important to remember that lower proportions of students of color graduate from high school than white students. Minnesota four-year (on-time) high school graduation rates in 2012 were highest for white students (84%), followed by Asian students (74%), Hispanic students (53%), black students (51%), and American Indian students (46%) (Minnesota Department of Education, 2013b). In addition lower proportions of American Indian, black, and Hispanic Minnesota high school graduates are likely to have taken the ACT exams than white and Asian students. This is because the ACT is taken mostly by college-bound students and the rates of college enrollment are lower for American Indian, black, and Hispanic Minnesota high school graduates (Minnesota Office of Higher Education, 2013).

Among high school graduates taking the ACT who were prepared for college-level STEM courses, students of color expressed more interest in majoring in STEM fields than white students

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). Students of color who were able in STEM were more likely to be interested in STEM compared to white students (Figure 8). Ten percent of able white students were interested in majoring in a STEM field in college compared to 19 percent of able black students, 18 percent of able American Indian students, 17 percent of able Asian students, and 14 percent of able Hispanic students (ACT, Inc., 2013). Less than 5 percent of high school graduates in any of the racial/ethnic groups were both able and interested in STEM based on the ACT results (4.5% of Asians, 4.4% of whites, 3.3% of American Indians, 3.1% of Hispanics, and 1.6% of blacks). 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.

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



Source: *ACT, Inc., 2013*

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

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

Actions to increase interest in STEM

Improve STEM teaching

As discussed earlier, improving how science and other STEM subjects are taught is potentially important to increasing interest in these areas. 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 in STEM

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 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 jobs and 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).

STEM postsecondary degree completion

Key findings

American Indian, black, and Hispanic students are less likely to complete a postsecondary credential than whites or Asians

As discussed earlier, American Indian, black, and Hispanic students in Minnesota are less likely to graduate from high school than white and Asian students and, if they do, they are less likely to enroll in college than white and Asian students. Once in college or postsecondary institutions, a similar pattern is seen for completion of postsecondary degrees or certificates. For example, the six-year graduation rates at Minnesota four-year institutions (2002-2011) by race/ethnicity are as follows: 64 percent for white students, followed by 60 percent for Asian students, 51 percent by Hispanic students, 40 percent for black students, and 36 percent for American Indian students (U.S. DOE, 2013).

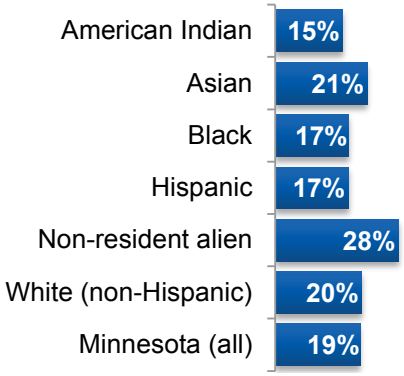
National studies have found differences by race/ethnicity in college completion rates among students pursuing postsecondary degrees in STEM. For instance, a national longitudinal study found that white and Asian/Pacific Islander students were more likely to complete a bachelor's degree in STEM than black and Hispanic students (Chen & Weko, 2009). This is likely related to greater attrition from STEM majors in college among minority students (excluding Asians). National research indicates that black, Latino, and American Indian first-year college students who show an interest in STEM fields are much less likely to earn STEM degrees than students from other racial/ethnic groups (President's Council of Advisors on Science and Technology, 2010).

Among those completing postsecondary degrees or certificates, the proportions receiving them in STEM are fairly similar across racial/ethnic groups

For degrees awarded from Minnesota postsecondary institutions from July 1, 2011 to June 30, 2012, 21 percent of degrees/certificates awarded to Asian students were in STEM, followed by whites at 20 percent, blacks and Hispanics at 17 percent, and American Indians at 15 percent. Among non-resident alien students, 28 percent of degrees/certificates awarded were in STEM (Figure 9). The percentages for black, Hispanic, and American Indian students might be lower than for students in the other racial/ethnic groups due at least in part to greater attrition from STEM majors.

Among those receiving degrees/certificates in STEM, students of color were more likely to receive them in the following fields than white students: computer fields; math; STEM management, sales, and related; and social sciences. White students were more likely to receive STEM degrees/certificates in health fields; life and physical sciences; STEM postsecondary education; and production and trade. Students of color and white students were about equally likely to receive them in engineering (U.S. Department of Education, n.d.).

9. Proportion of postsecondary degrees and certificates awarded in STEM by racial and ethnic group, Minnesota, 2012



Source: *U.S. Department of Education, n.d*

Blacks and Hispanics (and probably American Indians, too) are underrepresented in the number of postsecondary degrees/certificates they earn relative to their numbers in the college-age population

As a result of the patterns noted above, there are discrepancies in Minnesota between the percentage of STEM postsecondary degrees and certificates awarded to racial/ethnic groups and the percentage they represent of the college-age population. While blacks represented 5.6 percent of the college-age population in 2009, they received only 3.4 percent of STEM degrees/ certificates awarded. Similarly, Hispanics represented 4.8 percent of the college-age population but received only 1.6 percent of STEM degrees/certificates awarded (Change the Equation, n.d.). A similar discrepancy likely exists for American Indian students but no data were available for this group.

Actions to reduce gaps

Make greater efforts to retain underrepresented students pursuing STEM majors in college

Student retention or persistence in undergraduate STEM majors is associated primarily with three aspects of their experience: intellectual engagement and achievement, motivation, and identification with a STEM field (President's Council of Advisors in Science and Technology, 2012).

- **Intellectual engagement and achievement.** Students who play an active role in pursuing scientific knowledge, both in the classroom and the lab, learn more and develop more confidence in their abilities, increasing their likelihood of persistence. Strategies to engage students in the classroom could include such activities as problem-based learning, case studies, problem sets in groups, concept mapping, computer simulations and games, and an analytical challenge before a lecture. STEM college students are often quite far along in their programs before they have the opportunity to experience the excitement of scientific research. Such research experiences in the first two years of college improve students' attitudes toward STEM fields and increase retention of STEM majors. Two strategies to enable students to have these experiences earlier are replacing traditional labs with more widespread integration of discovery-based research courses into introductory STEM curricula and increased opportunities for STEM students to participate in faculty research programs in the first two years of college.
- **Motivation.** While partially intrinsic, motivation can also be greatly affected by the college environment. Students having the opportunity to develop relationships with faculty members, or faculty members serving as role models or mentors to students, can be important to student motivation and persistence. Peer support and participation in student groups can also be important to motivation. The degree of financial support and family support can affect motivation too.
- **Identification with a STEM field.** Students who develop meaningful relationships with faculty and peers, participate in study groups, and are involved in a research laboratory are more likely to have stronger identification with their STEM field and have higher retention or persistence in that field.

The practices just described are important for retention of all students pursuing undergraduate majors in STEM fields, but may be especially important for students in underrepresented groups such as American Indian, black, and Hispanic students. Two reports focusing on college students of color pursuing STEM majors emphasize many of the practices just described as well as some others. These include: forming meaningful relationships with faculty, mentoring, effective academic advising, tutoring, opportunities to engage in hands-on research, participation in student study groups, peer support, and financial support (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2011; Association of Public and Land-Grant Universities, 2012).

For students who are underprepared academically for college and pursuing STEM majors which often includes students of color, bridge programs from high school to college can be helpful in retention. Best practices for these programs include:

- Enrichment activities and cohort events that help students become part of a community and build a student support network

- Academic classes during the summer before college entry to improve college readiness
- Mentoring, academic advising, and tutoring in college including help finding a research laboratory

Foster partnerships between businesses and undergraduate STEM programs to increase student retention by providing them with internships, mentoring, or "hands on" training in STEM jobs

Partnerships between businesses and undergraduate STEM education programs can help increase student retention in STEM majors, especially if they have a focus on students of color and other underrepresented groups. Such partnerships can provide mentoring and hands-on training for STEM college students through cooperative education, learn and earn, and internship programs which are proven ways by which businesses can both recruit future workers and help students complete their college studies. These programs can also help develop students who more quickly integrate into the workplace and have higher job satisfaction (President's Council of Advisors on Science and Technology, 2012; Committee on STEM Education, National Science and Technology Council, 2013; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2011; Association of Public and Land-Grant Universities, 2012).

STEM workforce participation

Key findings

American Indians, blacks, and Hispanics are underrepresented in the STEM workforce relative to their numbers in the working-age population nationally, and very likely in Minnesota too

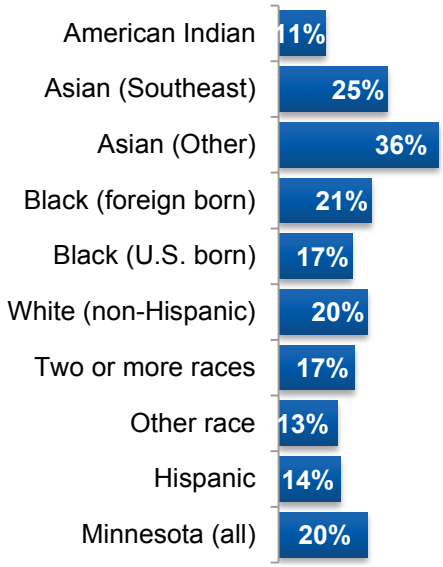
Nationally, American Indians, blacks, and Hispanics are underrepresented in the science and engineering workforce in relation to their proportion of the population as a whole. In contrast, Asians are more highly represented in science and engineering occupations than in the population overall (National Science Board, 2012). Unemployment rates are higher for minority scientists and engineers than for white scientists and engineers (National Science Foundation, Division of Science Resources Statistics, 2011). Based on the American Community Survey, in 2011 blacks represented 11 percent of the workforce but only 6 percent of STEM workers. Hispanics represented 15 percent of the overall workforce and 7 percent of the STEM workforce that year (Landivar, 2013). While these are national data, it seems likely that underrepresentation of American Indian, black, and Hispanic workers in STEM fields occurs in Minnesota as well based on the STEM data by race/ethnicity provided in this paper.

The percentage of workers within each racial/ethnic group that are employed in STEM occupations is highest for Asians and lowest for American Indians

Overall in Minnesota, the percentage of workers employed in STEM occupations in 2011 is the same (20%) for white workers and workers of color, although there are differences among the

groups included in the workers of color category. Specifically, Asians (other than Southeast Asians) have the largest proportion of workers employed in STEM fields at 36 percent, followed by Southeast Asians at 25 percent, then foreign-born blacks at 21 percent, whites at 20 percent, U.S.-born blacks at 17 percent, Hispanics at 14 percent, and American Indians at 11 percent (Figure 10). Workers of color in Minnesota were more likely to be employed in the following STEM occupational categories than whites: computer and math; STEM production and trade. White workers were more likely to be employed in the following STEM occupational categories than workers of color: health fields; architecture and engineering. Workers of color and white workers were about equally likely to be employed in the following STEM occupational categories: life, physical, and STEM social sciences; STEM management, sales, and related (Ruggles, Alexander, Genadek, et al., 2010).

10. Proportion of workers employed in STEM occupations by racial and ethnic group, Minnesota, 2011



Source: *Ruggles, Alexander, Genadek, et al., 2010)*

Actions to reduce workforce gaps

Encourage partnerships between businesses and educational institutions to increase exposure of underrepresented students to STEM occupations and career possibilities

Nearly all the action steps mentioned above to increase academic achievement and interest in STEM by students of color could be helpful in increasing their STEM workforce participation. Encouraging partnerships between businesses and undergraduate STEM education programs (as described above) emphasizing students of color could be particularly important in boosting STEM workforce participation of minorities. Such partnerships at the high school level might also be helpful in increasing interest in STEM jobs and careers. For example, the Step-Up summer internship program operated by AchieveMpls could potentially be helpful in generating interest in STEM careers.

Encourage employers to follow best practices in hiring and retaining STEM workers

More employers following best practices in the recruiting, hiring, retaining, and advancement of STEM workers would likely increase the numbers of minority workers in the STEM workforce. Examples of such practices include: recruiting widely, removing any race identifiers in screening resumes, ensuring pay equity, transparency in criteria and opportunities for advancement, professional development opportunities, training of all employees to prevent discrimination and resources for employees who experience it, and professional coaching or mentoring programs. See "Best Practices" in the "Work, Advance, and Innovate" part of the STEM section of Minnesota Compass for further details.

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