STEM Achievement Gap Strategic Planning Workgroup Final Report

December 2011

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2011 MN STEM Achievement Gap Strategic Plan

Executive Summary:

In June 2010, the Minnesota P-20 Education Partnership formed the STEM (science, technology, engineering, and mathematics) Achievement Gap Strategic Planning Workgroup. The seventeen-member workgroup included representatives from K-12 district and school leadership, higher education, business community and other educators. The members of the workgroup are listed in the appendix.

Vision and Charge:
The specific charge to the group was:
Develop a statewide plan to close achievement gaps among elementary student groups (K-8) in the STEM (science, technology, engineering, mathematics) disciplines. The plan should address the following—

- Analyze the achievement patterns of Minnesota's students by gender, ethnic and socio-economic student subpopulations;
- Analyze the patterns of curriculum, instruction, teacher preparation, professional development, assessment, and learning environments in Minnesota that close or widen the achievement gap across gender, ethnic, and socio-economic subpopulations;
- Propose goals and benchmarks for tracking the progress of student subpopulations;
- Propose a STEM data dashboard with key STEM measures for tracking progress of student subpopulations on the goals and benchmarks; and
- Suggest a coherent statewide strategy for closing the gaps in achievement among student subpopulations. Strategies for closing the gaps may include the areas of culture, curriculum and instruction, teacher preparation and professional development, assessment, learning environments, and/or others as appropriate.

The workgroup began its work in July 2010 and completed the report in December 2011. The group analyzed achievement gap data, reviewed reports/research, visited schools, heard from panel presentations and developed the following recommendations. The recommendations are more fully described and justified in the committee report sections of the document.

Recommendations:

1. The P-20 Education Partnership should organize an achievement gap strategic planning process in which the major stakeholders are involved in goal setting and the other activities of strategic planning.

2. Minnesota needs to have/develop web-based common assessments for:

- All STEM disciplines (Science, Technology, Engineering, and Mathematics)
- All grade levels 2-8; Common assessments at K and 1 may be delivered one-on-one by teachers and scores entered into the database.

3. Minnesota needs to collect and disseminate STEM common assessment achievement data in a state web-based database/data warehouse. Customizable reports and analysis features should be available:

- to all schools with achievement details and demographic data available at the individual student, class, teacher, school, district and state levels
- to the public with summary achievement and demographic data available at the school, district and state levels

4. In some cases, potential solutions to reducing the STEM achievement gap are inexpensive or have no cost associated with them; those solutions should be implemented statewide. However, in cases where the solution costs are high and budgets are strained, it may make good economic sense to concentrate funding in the districts with the greatest risk factors.

5. Research should be done in Minnesota K-12 education to clearly identify the most significant contributing factors to the STEM achievement gap, and the relative magnitude of each of their contributions to the gap.

6. Incorporate cultural competency and effort-based intelligence into professional development for teachers, administrators and pre-service teachers

7. In order to address the needs of the future workforce, greater emphasis needs to be placed on successfully equipping ALL students with knowledge and skills in the STEM fields.

8. All schools should be encouraged to partner with local businesses, organizations, and higher education institutions to support STEM programs, provide role models/mentors, and increase student engagement toward career goals. This process could be greatly enhanced through state-wide/regional coordination.

9. Models of exemplary school leadership relative to reducing the achievement gap should be identified and included as a basis for professional development of school leaders (principals, curriculum coordinators, board members, etc.).

10. Adopt state standards for technology education so that Minnesota standards exist in all STEM content areas.

11. Identify, disseminate and replicate best practices in curriculum, instruction and assessment related to reducing the STEM achievement gap.

12. Teacher preparation programs should recruit, support and retain persons of color and diverse backgrounds, including STEM professionals, for K-8 teaching, with a goal of matching staff demographics to student demographics.

13. Improve teacher preparation through more content and pedagogy in STEM subjects, integrated STEM.

14. Teacher professional development should be focused on deeper STEM content as well as pedagogy specific to addressing the achievement gap.

Introduction

In June 2010, the Minnesota P-20 Education Partnership formed the STEM (science, technology, engineering, and mathematics) Achievement Gap Strategic Planning Workgroup. The seventeen-member workgroup included representatives from K-12 district and school leadership, higher education, business community and other educators. The members of the workgroup are listed in the appendix.

Vision and Charge:
The specific charge to the group was:
Develop a statewide plan to close achievement gaps among elementary student groups in the STEM (science, technology, engineering, mathematics) disciplines. The plan should address the following—

- Analyze the achievement patterns of Minnesota's students by gender, ethnic and socio-economic student subpopulations;
- Analyze the patterns of curriculum, instruction, teacher preparation, professional development, assessment, and learning environments in Minnesota that close or widen the achievement gap across gender, ethnic, and socio-economic subpopulations;
- Propose goals and benchmarks for tracking the progress of student subpopulations;
- Propose a STEM data dashboard with key STEM measures for tracking progress of student subpopulations on the goals and benchmarks; and
- Suggest a coherent statewide strategy for closing the gaps in achievement among student subpopulations. Strategies for closing the gaps may include the areas of culture, curriculum and instruction, teacher preparation and professional development, assessment, learning environments, and/or others as appropriate.

The workgroup received clarification that the workgroup should focus on the grade range K-8.

The Workgroup's Approach:

The workgroup conducted thirteen meetings from July 2010 through November 2011. Full workgroup meetings focused on reviewing data, visits to schools, a panel presentation and a survey of school leaders, a presentation by state experts, and a review of STEM achievement gap research,

Three meetings were devoted to the review of data related to student achievement in each of the STEM areas. For mathematics and science the data came from international (PISA and TIMSS), national (NAEP), Minnesota (MCA) assessments. For technology and engineering, the sources of data included course enrollment data, Project Lead the Way implementation and technology education requirements. The workgroup also reviewed data on Minnesota demographics and the STEM employment outlook.

The workgroup visited Farnsworth Aerospace Magnet School in St. Paul and Salk Middle School in Elk River to gain insight into strategies used by schools to address the

STEM achievement gap. One meeting was devoted a panel of district, school and community leaders. The workgroup also conducted a survey of school leaders.

The workgroup reviewed research reports related to the STEM Achievement Gap. These reports (see appendix for a list) were accessible to the workgroup through a web repository. The Science Museum Science House staff also presented research related to the cultural issues involved in the achievement gap.

The workgroup broke into four subcommittees, which conducted further research and wrote findings and recommendations for the final report. The subcommittees are:

- Cultural Aspects
- Leadership and Beliefs
- Curriculum, Instruction, Assessment and Support
- Teacher Skills

Defining STEM:

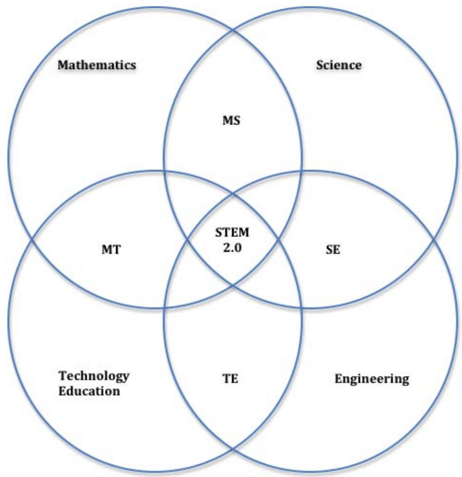
Essential to the workgroup accomplishing its charge was a common understanding of STEM. The group was influenced by the following definitions**:**

The National Governors Association considers STEM literacy to be "an individual's ability to apply his or her understanding of how the world works within and across four interrelated domains:

- *Scientific literacy* is the ability to use scientific knowledge... and processes to understand the natural world and to participate in decisions that affect it...
- *Technological literacy* in the modern world means the ability to use, manage, understand, and assess technology...Technology is the innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.
- *Engineering literacy* is the understanding of how technologies are developed via the engineering design process... Engineering design is the systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.
- *Mathematical literacy* means the ability of students to analyze, reason, and communicate ideas effectively as the pose, formulate, solve and interpret solutions to mathematical problems in a variety of situations (National Governors Association, 2010)

The Minnesota Department of Education (MDE) uses the following definition of STEM: "Integrated STEM Education is standards-based, best-practice instruction from the fields of science, technology, engineering, and mathematics to explore relevant questions and problems based in the natural and designed world. It provides intentionally-designed, linked-learning experiences for students to apply and develop understandings of Science, Technology, Engineering, and Mathematics concepts and processes."

The workgroup is defining STEM 1.0 as existing when students experience all four topics (Science, Technology, Engineering and Mathematics). However the true ultimate goal of STEM education would be STEM 2.0, when students experience the four areas in an integrated fashion – the same way these topics are integrated in the real world. The workgroup was able to visit schools using the STEM 2.0 model.



Additional confusion exists in defining the Technology portion of STEM. Some literature and many educators as well as educational leaders use a very narrow definition of technology (small "t") – meaning computers and computer related experiences/devices. The workgroup uses a broader definition of technology (big "T") – meaning human innovation: Technology is the modification of the natural environment in order to satisfy perceived human needs and wants (ITEA, 2000).

Approaching the Achievement Gap:
The workgroup struggled with the difficulty of separating strategies to address the K-8 STEM achievement gap from the broader aspects of achievement gaps in all areas. In addition many strategies that are helpful for students that are underachieving are also helpful for all students. Hence this report will include strategies that help all students as well as strategies that affect under-performing students.

In many senses this report is not a strategic plan. It does not lay out a well-defined road map and timeline for actions that will lead to closing the achievement gap. It presents the observations, analysis of data, and recommendations of a workgroup of Minnesotans from a variety of perspectives that spent more than a year of information gathering and discussion. This report could be considered research that could be used in a strategic planning process.

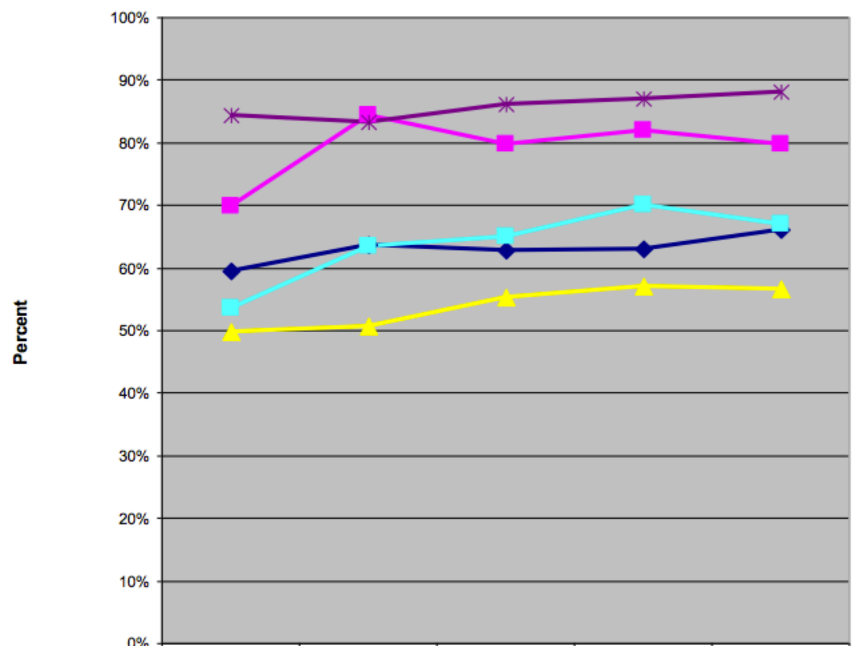
Recommendation:
1. The P-20 Education Partnership should organize an achievement gap strategic planning process in which the major stakeholders are involved in goal setting and the other activities of strategic planning.

STEM Achievement Gap Data General Findings:

1. Evidence of a STEM achievement gap exists in Mathematics and Science. In those two subjects the gap between the highest and lowest performing groups of students (especially in terms of ethnicity and poverty) is among the greatest in the United States. Examples of data showing this gap include the following charts from the MN Comprehensive Assessments for Mathematics (samples from grades 3 and 8 are shown) and science (samples from grades 5 and 8 are shown):

Percentage of Students Proficient by Year - Ethnicity

Grade 3 Mathematics MCA-II

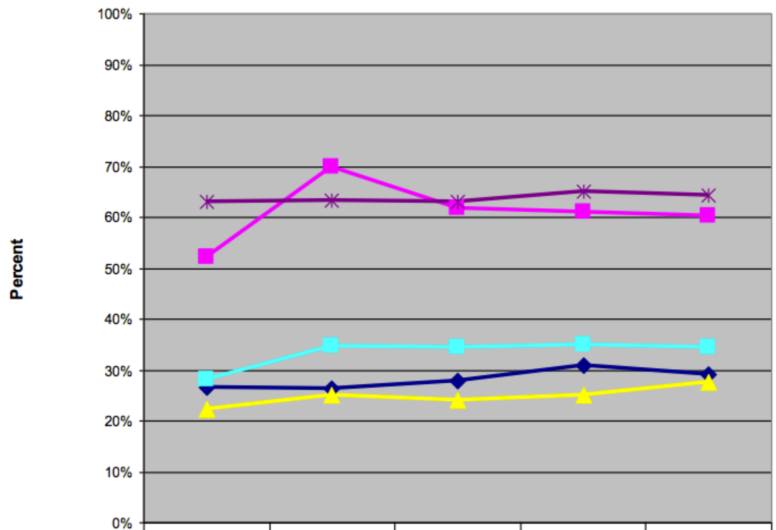


	2006	2007	2008	2009	2010
American Indian	60%	64%	63%	63%	66%
Asian/Pacific Islander	70%	84%	80%	82%	80%
Black	50%	51%	55%	57%	57%
Hispanic	53%	63%	65%	70%	67%
White	84%	83%	86%	87%	88%

Year

Percentage of Students Proficient by Year - Ethnicity

Grade 8 Mathematics MCA-II

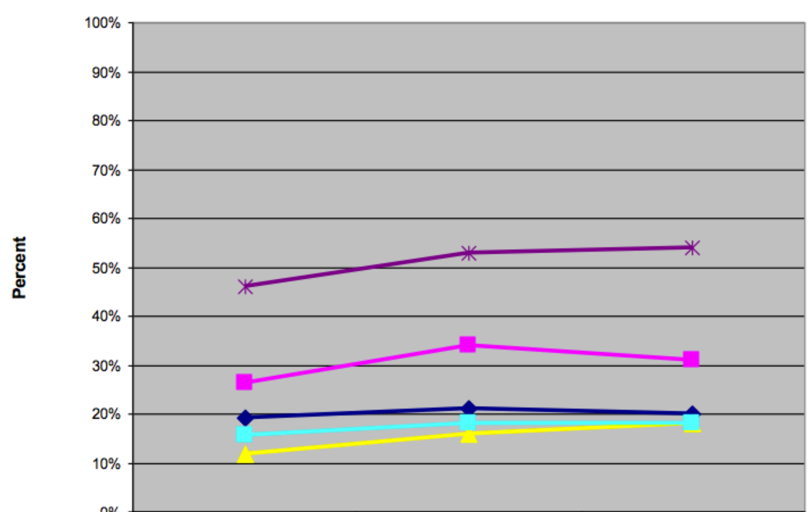


	2006	2007	2008	2009	2010
American Indian	27%	26%	28%	31%	29%
Asian/Pacific Islander	52%	70%	62%	61%	60%
Black	22%	25%	24%	25%	28%
Hispanic	28%	35%	34%	35%	35%
White	63%	63%	63%	65%	64%

Year

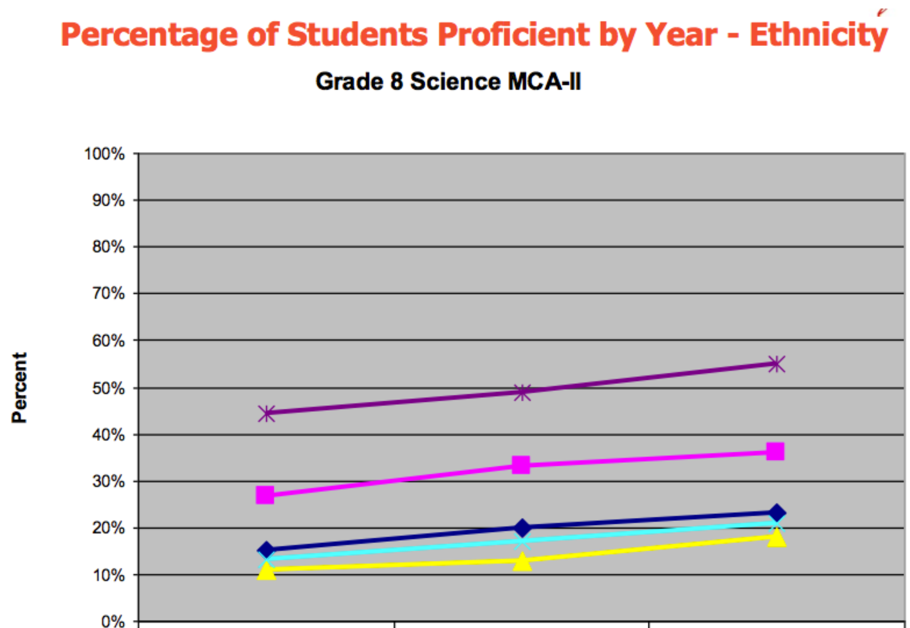
Percent of Students Proficient by Year - Ethnicity

Grade 5 Science MCA-II



	2008	2009	2010
American Indian	19%	21%	20%
Asian/Pacific Islander	26%	34%	31%
Black	12%	16%	18%
Hispanic	16%	18%	18%
White	46%	53%	54%

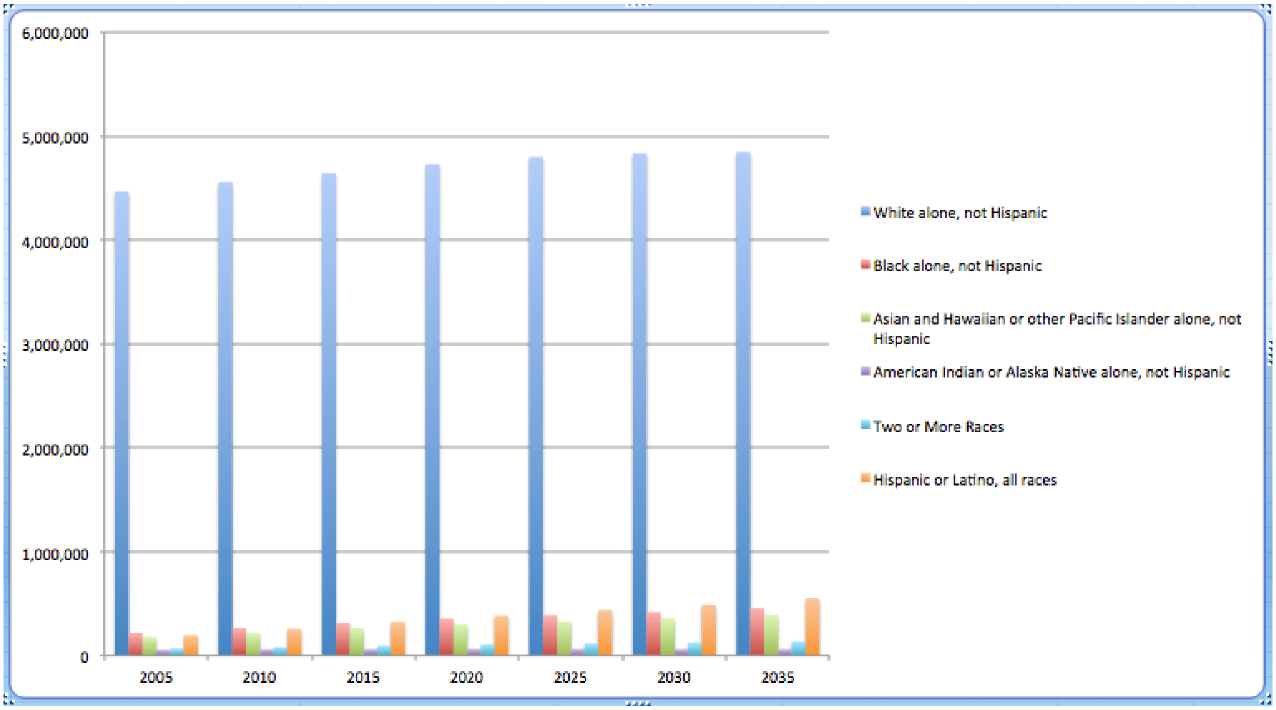
Year



	2008	2009	2010
American Indian	15%	20%	23%
Asian/Pacific Islander	27%	33%	36%
Black	11%	13%	18%
Hispanic	13%	17%	21%
White	44%	49%	55%

Year

2. The students in the lowest performing STEM achievement groups (schools with greater than 75% of students in poverty, for example) tend to be concentrated in only about a dozen of the state's more than 360 districts. The following chart shows the projected ethnic population growth in Minnesota through the year 2035. (Data from MN State Demographic Center, 2009: MN Population Rates by Race and Ethnicity)



3. Evidence of the STEM achievement gap for mathematics and science in grades K-2 is very slim, since the first statewide assessments do not begin until grade 3 in mathematics and 5 in science.

4. Evidence of a STEM achievement gap in the topics of Technology and Engineering is only anecdotal, since no common assessments exist in MN for these two topics in grades K-8. The first assessment of Engineering will occur as part of the 2014 MCA III exams, but there is no schedule for any type of Technology assessments in MN. Even in the case of the MCA III exams in Science/Engineering, those topics are only required to be tested twice (grades 5 and 8) in the grade range of this report.

5. Some MN schools in grades K-8 can be described as “beating the odds” by having reduced the achievement gap (raising the achievement of the lowest performing students) in spite of having very high percentages of diversity and poverty. The strategies used in these schools may serve as examples of “best practices” in reducing the gap and may offer replicable strategies.

6. Minnesota does not have standards in all areas of STEM. The area of Technology does not have state standards and the area of Engineering has only had standards since the 2009 revision of the Science standards. Standards define what students should know and be able to do, which can then be measured by standards-based assessment.

Goals, Benchmarks and Methods for Tracking Progress of Students in STEM:
Tracking the progress on achievement related to the STEM content areas is an essential state function. Currently the only common measures of achievement (and the related achievement gap) are the Minnesota Comprehensive Assessments (MCAs). The MCAs however, are limited in what they can measure in grades K-8:

- The MCAs exist at grades 3 through 8 for math. There is no common measure of mathematics achievement in grades K-2.
- MCAs exist at grades 5 and 8 for science. There is no common measure of science achievement in grades K-4, 6 or 7.
- Although the MN Science standards have included engineering concepts since 2009, the MCA tests will not reflect the engineering standards until the MCA III Science tests begin in the spring of 2012. No common achievement data related to engineering concepts currently exists, and after the spring of 2012 we will still not be gathering engineering achievement data at grades K-4, 6 or 7.
- No common assessments related to technology content exist in MN for grades K-8, and there are currently no plans to implement a technology assessment.
- STEM is ideally viewed as an integration of the four fields of Science, Technology, Engineering and Mathematics, yet there are no common assessments of integrated STEM in grades K-8 in Minnesota.
- As part of the public school system, charter schools must participate in MCA testing. However, home-schooled students or students in private schools in MN are under no obligation to participate in MCA testing and therefore no common data exists for those entities.

In a time of seeming proliferation of high stakes testing, the reality is that MN does not have adequate common statewide measures of STEM achievement at all grades and in all of the STEM fields, and therefore documentation of the actual STEM achievement gap is difficult to obtain. Additionally, the extent to which MN school systems can attempt to follow best practices (by using data to make decisions related to STEM achievement) is significantly hindered by the lack of common data. This is an area that MN could exercise leadership within at the state level.

Recommendations:
2. Minnesota needs to have/develop web-based common assessments for:

- All STEM disciplines (Science, Technology, Engineering, and Mathematics)
- All grade levels 2-8; Common assessments at K and 1 may be delivered one-on-one by teachers and scores entered into a database

Since MCAs (which include mathematics, science and soon, engineering) satisfy part of this requirement, priority should be given to developing technology common assessments first (as well as addressing the need for state Technology standards), and then the remaining STEM common assessments at the missing grade levels next. It is not the intent of this recommendation that the state develop targets and Adequate Yearly Progress measures for these common assessments. Rather, the intent is to have the state take leadership in developing common assessments that districts can use in a way that provides a statewide perspective for local decision-making.

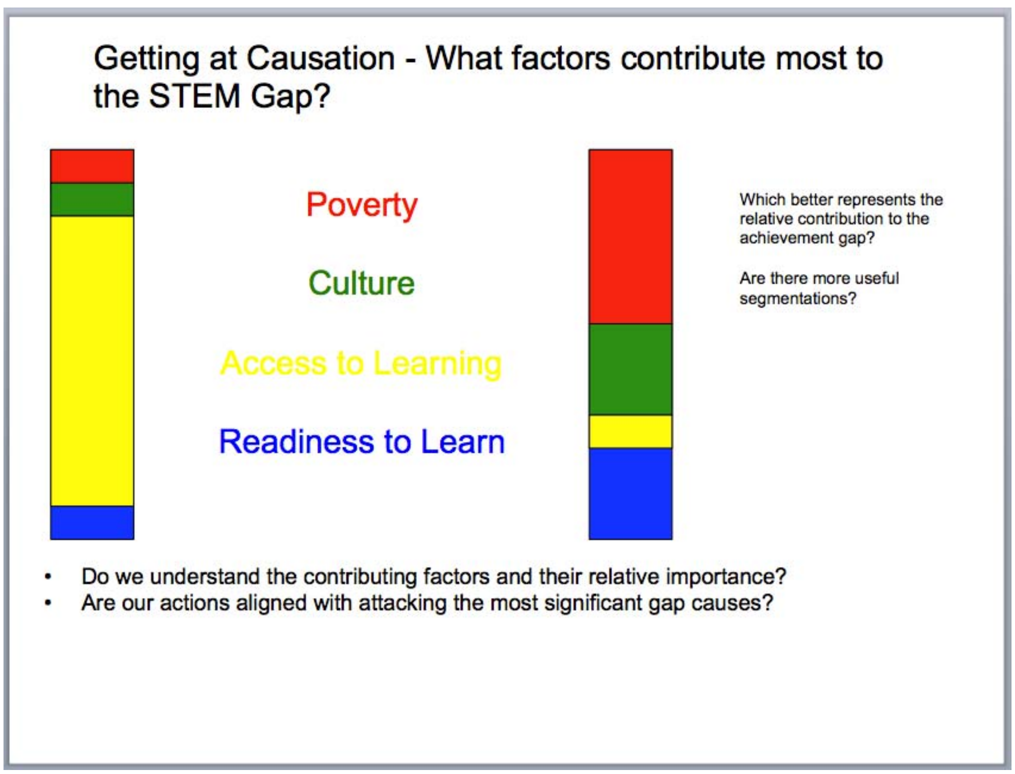
3. Minnesota needs to collect and disseminate STEM common assessment achievement data in a state web-based database/data warehouse. Customizable reports and analysis features should be available:

- to all schools with achievement details and demographic data available at the individual student, class, teacher, school, district and state levels
- to the public with summary achievement and demographic data available at the school, district and state levels

With the increasing number of mobile students in MN, the historical records of individual student achievement need to be able to move from school to school or district to district within this database/data warehouse.

4. In some cases, potential solutions to reducing the STEM achievement gap are inexpensive or have no cost associated with them; those solutions should be implemented statewide. However, in cases where the solution costs are high and budgets are strained, it may make good economic sense to concentrate funding in the districts with the greatest risk factors.

Factors Contributing to the STEM Achievement Gap:
Further work needs to be done, specific to Minnesota's student population regarding the factors contributing to the STEM achievement gap. The following graphic, similar to one originally proposed by one of the committee members effectively communicates this issue:



Recommendation:

5. Research should be done in Minnesota K-12 education to clearly identify the most significant contributing factors to the STEM achievement gap, and the relative magnitude of each of their contributions to the gap.

Reports of Subcommittees

I. Cultural Aspects of the STEM Achievement Gap

Beliefs about Learning and Achievement:
Carol Dweck (2000) identifies two contrasting views toward learning that are often held by students and adults.

- *Fixed Intelligence:* This view holds that people innately believe that their intelligence is a personal characteristic that cannot be changed. As a result people do not want to engage in tasks that make them look dumb. A consequence of this view is often “learned helplessness. They blame their level of intelligence and other factors outside themselves for their failures. They consider their successes as a result of “luck”.
- *Variable Intelligence:* People with this view believe that intelligence can be changes through experience. It can be increased by effort. Tackling a difficult task is seen as a challenge that will increase their intelligence. This attitude is often called resilience. Whatever the result of an effort, they do not consider themselves to be failing. They can get smarter through “effort-based learning.”

A teacher can reinforce a fixed intelligence view by misplaced praise. By praising the person rather than the accomplishment, the student may assume it was result of innate ability. Praising the effort put into the accomplishment can help students move toward the malleable intelligence point of view. (Dweck, 2000)

Dick Corbett et al. describe three attitudes that educators often have about the success of their students.

- All children can succeed . . . if they are willing to try.
- All children can succeed . . . but some don’t because of their families.
- All children can succeed . . . and it is educators’ responsibility to see that they do.

Educators may have the view that they are limited in the amount their students can accomplish due to factors they cannot control, such as student apathy, economic status of the family, lack of parent involvement, and language ability. While these factors may have a significant impact on the students, it is important to foster a school culture where educators take the attitude that “it’s my job to see that all students succeed.” (Corbett, 2002)

The Role of Cultural Competency in Addressing the Achievement Gap:
Many cultures contribute to the richness of our world community. Just as every culture has time-honored traditions that make its heritage unique, each of us has individual qualities that make us special. In knowledge there is understanding; in understanding there is respect and where there is respect, growth is possible.

Educators who are culturally competent will be able to engage students in STEM through culture. Teachers who are prepared in cultural competence often have additional resources to motivate and encourage students to achieve their academic potential in STEM by utilizing cultural connections. While African Americans are one of the fastest growing populations in Minnesota, teachers often lack the tools to effectively engage these students to increase their academic achievement in STEM. According to recent statistics the current graduation rate of African American students in Minneapolis Public Schools is 35%.

Cultural competency is an important part of a well-rounded education and teachers should encourage students to celebrate and embrace diversity, regardless of race, ethnicity, gender, etc. By providing cultural awareness strategies, events, activities, lesson plans, and projects that serve to motivate and encourage students to study STEM and excel academically (for example: George Washington Carver and the peanut, Charles Drew and blood plasma, Garrett Morgan and the traffic light, Benjamin Banneker's layout of Washington, D.C. Lewis Latimore, Edison scientist, etc., etc.,). It cannot be stressed enough how important cultural competency is for students in a global world. A strong commitment to diversity and inclusion will make Minnesota schools stronger and better able to serve diverse populations of students as well as reach out to the various communities.

Educators who are culturally competent and prepared will learn how to engage multicultural students in STEM and become more culturally literate. They will also learn how diverse students can achieve their academic potential in STEM by reaching them through their culture.

This is an example of how to get students who are culturally diverse, motivated and close the STEM Achievement Gap with projects like this in a school. (Thomas Edison is a very diverse high school.)

> **Thomas Edison High School "Goes Solar"**
> CBS EcoMedia Inc. ("EcoMedia") and Boston Scientific unveiled recently a solar project on the gymnasium rooftop at Thomas Edison H.S. The solar photovoltaic system is designed as an educational tool for students, teachers, and administrators and is the first environment project to be funded as a result of Boston Scientific's participation in EcoMedia's EcoAd program. The rooftop solar system is designed to give students hands on learning tool to understand the science of solar energy as part of the broader earth and climate science curricula.

Research on Culture and Gender in STEM:
While progress has been made in K–12 mathematics and science education over the last decade, critical disparities continue both nationally and regionally—especially when gender is considered along with race/ethnicity and class (Corbett, *et al.,* 2008). Based on the 2005 8th Grade NAEP Science Assessment, boys perform slightly better than girls in science (an average difference of 4.88 points across the five states). But the

glaring gaps in achievement are based on students' race/ethnicity, and class. In Minnesota, the gap between whites and blacks in science is 45.35 points (the largest in the nation); between whites and Hispanics, 32.35; and between those not eligible and eligible for reduced and/or free lunch, 22.73 (NCES, 2005).

The *diversity index* reflects the likelihood that any two randomly selected students will be of a different race/ethnicity. Between 1987 and 2006, the diversity index increased in cities like Osseo, MN by 47% St. Paul's student population, for example, is 74% students of color with no single group comprising more than 25%. With Native students, a burgeoning population of Latino, African American, Hmong, and East African students in both rural and urban areas, and a mainly white, retiring, female K–12 teaching workforce, Minnesota is a place where the complex identities of students and teachers are in extreme transition.

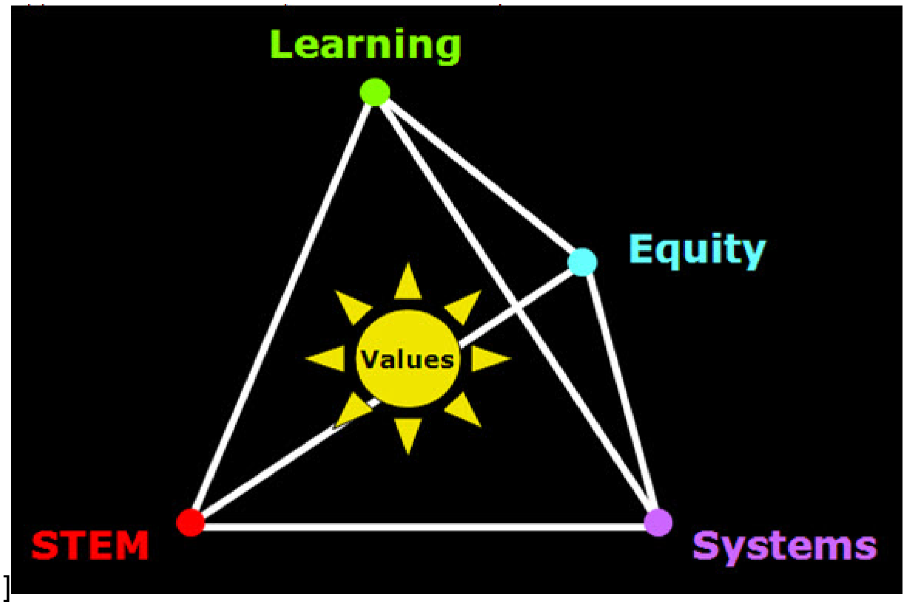
Reconstructing the Nature and Culture of the STEM Disciplines:
Nature and culture refer to the discipline-specific ways of knowing, that include values, beliefs, and structures inherent to STEM knowledge and its development. The research literature suggests that traditional societal and classroom portrayals of the Nature of Science (NOS) may be alienating for many members of underrepresented groups (Capobianco, 2007; Richmond *et al.,* 1998).

Research also shows that students and teachers do not develop a more modern understanding of NOS unless it is explicitly taught in ways that both encourage learners to identify with *and* actively critique the STEM disciplines (Lederman, 1999, 2007). In particular, a focus on science as tentative, subjective, creative, and socially and culturally embedded stands in stark contrast to a positivist approach to science as certain, objective, strictly rational, and universal. Incorporation of cultural perspectives on the nature of science, for example that western science brings with it traditional western notions of masculinity that may alienate girls (Haraway, 1988 and Brickhouse, 2001), further broadens this critique. In addition, comparisons among the natures of science, math, and technology/engineering allow for a deeper understanding of the similarities and differences between the disciplines and ways in which they support one another in STEM learning.

An Example of Approaches to Culture in STEM Professional Development

The Science Museum Professional Development programs in STEM have focused on four guiding principles.

1. Integrated STEM: teaching the skills and concepts of STEM through an authentic, problem-based approach
2. Effort-Based Learning: Intelligence is not a fixed trait and can be increased through effort.
3. Equity: Address access issues including curriculum and culturally responsive pedagogy
4. Systems: including standards, curriculum, vertical alignment and beliefs and culture of the school.



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Nexus is designed for district-based teams with leadership responsibilities for K–12 STEM education. Active since 2006, the program addresses situated leadership and consists of a 7-day institute spread out over the academic year. With a current average of 65-85 participants per year, Nexus represents 20-25 districts from across the State. The impact of Nexus can be generalized into four major themes: (1) Leaders increased their understanding and capacity to integrate STEM, effort-based learning, and instructional strategies. (2) They emerged with increased focus on access and equity, gaining in-depth understanding about culturally relevant curriculum, culturally relevant teaching, and race and racism. (3) Leaders' attitudes about facilitating adult learning and their capacity to assist teachers in issues pertinent to closing the racial achievement gap became significantly more positive. (4) Nexus is viewed by participants as a much needed and valued program, providing the foundation for a community of statewide STEM leaders.

Recommendation:
6. Incorporate cultural competency and effort-based intelligence into professional development for teachers, administrators and pre-service teachers

II. The Impact of Leadership and Beliefs on the Achievement Gap

Data and Research:
By integrating STEM into our K-8 students' learning experience, students will better grasp and retain foundation skills in literacy and arithmetic (3R's), build those competencies that are increasingly needed for success in the future, and be better prepared for high school and then college, career and citizenship (CCC). An integrated STEM approach is more likely to align stakeholders toward a shared vision that is tied to a manageable change process if the approach targets and can be shown to:

1. increase the effectiveness and efficiency of learning and retaining 3R foundation skills;
2. improve student attitudes toward relevance, motivation and awareness of career possibilities;
3. enable the mastering of CCC type competencies and build student's self-confidence in their own ability to do and understand "STEM".

Underpinning this conclusion are key themes, which are covered in more depth within this report. Among the themes covered are:

- The critical need to forge a shared vision for the role of STEM.
- A shared vision requires clarity on the problem we are trying to solve.
- It may be difficult to gain the support and alignment on a shared vision that does not tackle all the "Achievement Gaps"
- What gets measured reflects what is valued and steers what is done. Today a focus on the 3R's, Reading, wRiting, and aRithmetic, tends to crowd out other subjects, particularly when K-5 teachers are pressed for time and resources.
- Perceptions and anxiety exists that more STEM means less of something else they value.
- The exploding number of distractions and stimuli has significant implications on students learning.
- Competing views believe that the skills that most matter for the future are competencies such as the 3C's, or critical & creative thinking, communication, and collaboration together with expanding students' skills in areas such as curiosity and initiative as well as learning to ask the right questions through what Mission Hills School calls "Habits of Mind". Weighing evidence, seeing connections, identifying cause and effect, and awareness of varying viewpoints, are a few examples of the types of habits that are core to this school's measures of student success (Wagner 2010).
- The most important outcomes of K-8 STEM education tend to be most often expressed in terms of *skills, competencies and attitudes* which are not only key to success for higher-level STEM subjects, but are increasingly important for CCC, regardless of the field of study. Few place learning a survey of "science and engineering" *fact content* as a priority outcome for K-8 STEM.
- Gender and race representation in many professions, including many STEM related fields, remains quite biased and has systemic implications.

- The widening economic and social realities between our richest and poorest are often discussed issues, which give birth to many education and career implications.
- Examples on the use of technology suggest there is opportunity to move from funding technology as a tool for enhanced teaching in better-funded schools to the use of technology as a means for achieving better results within constrained budgets. The rub is that to do this, requires letting go of old models rather than just layering on new ones.
- Research indicates that teacher quality matters and that great teachers are the most certain factor in closing any gap. “Over the past 50 years researchers have looked at a number of factors that affect student achievement, including curriculum, race, poverty, and school organization. None of these has had as big an impact on student learning as a good teacher. This finding holds true regardless of the achievement level of the students in the teacher’s class.”(Write et al., 1997, p 63 referring to Marzano, Robert A.2003).
- Similarly, leadership matters, whether at the classroom, school, district, community, state, or national level. Leaders that acted as champions, breaking the rules in positive ways to do what was needed to create the right environment, the right motivation, the right relevancy appeared to make the most difference.
- The overall process for attracting, preparing, licensing and hiring K-6 elementary education teachers appears to result in a teacher population that, compared to college bound students in most other fields, took less rigorous STEM related courses in college. If the outcome is that as a group, elementary school teachers are not confident and comfortable in their own ability to “do” and “understand” science, mathematics and engineering, it is logical that students’ often cited “no one ever really uses this stuff”, may be reinforced when they hear explicitly from a teacher something along the lines of “I’m not really a math type of person”, or even the more subtle signals that the teacher really does not want to go to all the work of setting up experiments. This too could have systemic feedback implications.
- Rather than making STEM education a stand alone mission, there seems to be more common ground for building support in putting forward STEM as a part of an approach aimed at improving foundation skills, mastering competencies needed for the future and overcoming the barriers that keep students from being ready, comfortable and confident in tackling more challenging issues in fields such as STEM.
- Classic models on change management suggest that one big difference between aspiration and a shared vision is achieving and maintaining alignment among key stakeholder groups and sponsorship from their leaders, coupled with a manageable change process.
- Alignment of stakeholders around a shared vision is becoming perhaps more difficult in today’s circumstances. Yet casting the net wider, to really engage those stakeholder groups who have in the past been on the margin, may be a key to implementable change toward a shared vision.

Research on the Importance of STEM:

At a time when unemployment is high in many parts of the United States, employers bemoan the fact that many technical job openings go unfilled. While this crisis may take years to resolve, it has serious ramifications at a time when federal and state governments are trying to jump-start the national and local economies. The CEO of Caterpillar, the heavy equipment manufacturer, recently appeared before a business roundtable on manufacturing, saying, “We cannot find qualified hourly production people, and for that matter, many technical, engineering service technicians, and even welders, and it is hurting our manufacturing base in the United States” (Chicago Tribune, 2011). A 2006 study conducted by ACT showed that high school students need to be educated to comparable levels of readiness in mathematics, regardless of whether future plans included college or entering the workforce (ACT, 2006). A recent study from the Georgetown University Center on Education and the Workforce (Carnevale, etal., 2010) projects that by 2018, 70% of jobs in Minnesota will require post-secondary education. Growth is occurring in professional and managerial jobs that add 80 percent of product value through design, marketing, finance, and management positions, many of which require STEM skills.

Many students continue to struggle with mathematics and science. Historically, no more than 43% of students taking the ACT in the last half decade have scored above the college readiness benchmark in mathematics, and less than 30% of students have scored above the benchmark in science. These statistics become even bleaker when evaluated by race and ethnicity (ACT, 2010).

The Minnesota Department of Employment and Economic Development reports that 93% of STEM occupations require some type of post-secondary certificate or degree and at least 11% of total new job growth over the next decade will be in STEM occupations (Vilsack, 2011). Employment in the healthcare sector is projected to grow by 26%, and by 21% in the professional, scientific, and technical sector over the next decade.

These trends are of great concern to employers who already see a growing mismatch between skills of potential workers and the skills that employers seek to hire. The shortfall in Minnesota is expected to be especially noticeable in the healthcare professions. Minnesota’s population is aging and combined with retirements, and with an inadequate number of individuals trained as doctors and nurses over the last several decades, the Minnesota State Demographer’s Office is projecting a significant shortfall in healthcare professionals over the next decade (Minnesota State Demographic Center, 2010).

Clearly, there is a need to prepare all students better in the STEM fields and to close the STEM achievement gap. This would go a long way to addressing the needs for preparing potential employees for careers in STEM occupations. But there may also be deficiencies and short circuits in our system for transitioning from school to the workplace. Some countries that are routinely leading the world in the performance of their students on international assessments in mathematics and science have also built systems that are designed to translate academic skills into workplace skills. Finland and

Singapore have developed multiple pathways for students that are successful in delivering occupational skills by the secondary level. Japan has designated high schools that supply high quality candidates to prestigious employers. These employers then assume responsibility for on-the-job training (Tucker, 2011). As has been observed elsewhere, closing of the STEM achievement gap will not be easy and the solutions will necessarily be complex. It is clear that it is vital for the economy and well being of our country, and it will require all of us working together toward improving the whole system.

Policies, Practices and School Climate that Promote Mastery of Fundamental High Academic Skills to Support STEM Learning:

- STEM Graduation requirements: If Minnesota's businesses and industries are dependent on graduates possessing STEM skills and knowledge, then MN should explore graduation policies and requirements addressing all four STEM content areas
- STEM OTL (opportunities to learn; course offerings): Currently there are no requirements that districts offer technology and engineering courses
- STEM remediation: Remediation opportunities need to be provided more uniformly for students under-performing in STEM content areas. Many districts are doing this in the area of mathematics to ensure their "Adequate Yearly Progress" status. But, because of limited resources, these efforts are often focused on "bubble students" (those students closest to, but just below, the level required to be considered proficient). Students at the lowest performance levels often are not provided remediation opportunities, and rarely are students required to participate in remediation of science, technology or engineering content.
- Staff Development focused on STEM: School staff development funding in recent years has been heavily focused on the high-stakes testing topics of mathematics and reading. Teachers of technology, science and engineering are experience significant reductions in the availability of staff development funds and are routinely denied funding to attend staff development opportunities. In addition, many of the smaller districts in Minnesota do not have the staff, expertise or local resources necessary to provide quality staff development experiences in these topics. It is essential that these districts provide opportunities for teachers to attend the state conferences and other professional development events offered by groups such as MCTM, MnSTA, MTEEA, and the MN Science and Math Teacher Academies.
- PLCs: Professional Learning Communities (PLCs) are a well-established model for providing opportunities for professional discussion at the local level. But seldom do the current middle school models allow teachers to meet across the STEM disciplines. To achieve the vision of integrated STEM, schools should consider regular integrated PLC meetings of STEM teachers.
- STEM leadership: One of the striking characteristics of the successful STEM schools the workgroup observed, was the impact of strong STEM administrative leadership. This leadership took place in a variety of ways:
    - Vision: The strong and clear STEM vision of the leader
    - Tenacity: the ability of the leader to push toward goals, often in very creative ways in spite of obstacles encountered

- Communicator: The ability to effectively communicate to the variety of stakeholders in the school system
- Connecter: The ability to connect/partner with local businesses and other external entities to overcome funding and other challenges
- Motivator: The ability to motivate staff, students and parents to achieve goals
- Team Builder: The ability to assemble a strong team with all of the essential roles to carry out the work

It is difficult to say how scalable these characteristics are, but it was clear in the workgroup observations that these were critical attributes in the schools that were successfully addressing the achievement gap. Perhaps these are the kinds of leaders that should be targeted to lead schools with significant STEM gap issues.

Mechanisms for STEM Advocacy, Networking, and Dissemination:
Following is a list of mechanisms observed in schools that had successfully addressed STEM achievement gap issues, or suggestions that surfaced from the workgroup panel discussion or survey:

- Connections/partnerships were established with local STEM-based businesses; school leader membership with Chambers of Commerce; Advisory Committees
- Tours of local STEM businesses; STEM guest speakers in classrooms
- Participation in local and state STEM functions/organizations: SciMathMN, MN STEM Network, Bakken Museum, Science Museum of MN, U of MN STEM Center;
- Providing staff development on STEM resources such as the MN STEM Teacher Center (www.scimathmn.org/stemtc), Regional mathematics& Science Teacher Academies,
- Providing funding/opportunities for staff to attend state conferences offered by STEM professional organizations; MCTM, MnSTA, MTEEA
- Providing STEM coaches as part of the support system for teachers
- STEM teacher certification from institutions such as College of St. Catherine
- STEM Parent nights at schools
- STEM career days at schools
- Student participation in STEM competitions or co-curricular programs such as FIRST Robotics, Lego Robotics, Supermileage, Science and STEM Fairs

Research on Partnerships and Their Role in Closing the Gap:
Virtually any current success story of closing the achievement gap includes partnerships with community organizations, businesses, foundations, faith communities, or other educational entities. Many social factors have been documented to contribute to the achievement gap and it is clear that these factors cannot be mitigated without the involvement of the broader community beyond the formal school system (Mueller, 2006).

Blanks, etal. (2010) identified seven key lessons concerning effective collaboration among partnering organizations. First, because time and resources are limited, collaborations should be focused on efforts that are a true priority, which could not be accomplished as efficiently or effectively without the partnership. Second, partnerships represent an opportunity for innovative thinking about organizational structures and how to achieve goals and desired outcomes. Third, partnerships should examine how the collaboration can maximize cost effectiveness and efficiency. Fourth, collaborations can improve the probability of success by starting small with goals that are realistic and achievable. It is much easier to build on early success than on failures. Fifth, partnerships should include an honest assessment of strengths and weaknesses. Individual strengths should be leveraged for the good of the partnership. Sixth, effective partnerships require hard work including effective communication, detailed planning, and an agreed upon approach to shared decision-making. Lastly, partnerships should define metrics that allow partners to assess the value of the partnership so outcomes and value produced can be weighed against resources used.

Similarly, Kania and Kramer (2011) have identified five conditions that exist when collaborations are most successful. These conditions are: a common agenda, shared measurement systems, mutually reinforcing activities, continuous communication, and backbone support organizations. Kania and Kramer coin the term "collective impact" to describe the condition where a group of participants representing multiple sectors commit to a common agenda for solving a specific social problem. These collective impact initiatives differ from garden variety collaboration because they involve a centralized infrastructure, a dedicated staff, and a structured process leading to a common agenda, metrics, ongoing communication, and mutual reinforcement among all parties (Kania and Kramer, 2011).

A common agenda is arrived at by developing a common understanding of the problem and developing a joint approach to solving the problem through agreed upon actions. In order to arrive at collective impact, differences in problem and solution definition must largely be identified, discussed and resolved. Funding can play a key role in aligning multiple organizations to support a common goal.

A common agenda is useless without a means to measure and report success. Consistently collecting indicators across all participating organizations ensures alignment of efforts and accountability.

Collective impact is achieved by playing to the strengths of each participant in a coordinated manner. Each participant's efforts must fit into and support an overarching plan. Each participant is free to organize its own efforts toward achieving the common goal.

Communication is a critical component with frequent and continuous meetings and exchange of information. In addition to communication about progress of the work, considerable time must be spent developing a common vocabulary and shared measurement systems. Kania and Kramer (2011) have found that most successful collaborations have used external facilitators and structured agendas to support successful communication.

The final key component is the establishment of a separate organization and staff to serve as the backbone for the initiative. Coordination is time consuming and the participating organizations do not have the time to create and maintain a supporting infrastructure. Ideally, the backbone organization focuses people's attention, creates a sense of urgency and frames issues as both opportunities and difficulties to be considered while bringing the necessary skills and force to bear in negotiating conflict among stakeholders.

Certainly, a significant aspect of the STEM achievement gap is the multitude of social factors that adversely impact student achievement. Few would disagree that the breadth and magnitude of these challenges require many and diverse organizations working collaboratively to solve these problems.

Yet, specifically with respect to the STEM achievement gap, there are concerns about America's commitment to STEM education. Hess, etal. (2011) argue that the business community has a significant role to play in improving STEM education in the United States. But these improvements won't come through the traditional business-school partnerships that simply promote best practices, provide resources, and moral support. The task of greatly improving STEM education in the United States will not be easy but Hess etal. (2011) identify strategies that business can promote.

Specifically, the business community should support initiatives like the Common Core State Standards but recognize that clearer standards are necessary but not sufficient. Business should work proactively with the K-12 system and the post-secondary system to shape program offerings for alignment with labor needs. There are also opportunities to support ventures that personalize instruction for individual student needs. STEM professionals instructing students on a part-time basis can enhance teaching of STEM subjects.

In addition, businesses can model the benefits of specialization and productivity enhancements with respect to teaching. As an example, the best teachers should be encouraged and rewarded for taking on more students successfully. A gifted elementary mathematics teacher should be employed to teach mathematics to all students at a grade level rather than the more common classroom teacher role. Business leaders can leverage the use of technology in bringing high quality STEM instruction to rural or urban schools. In a related vein, businesses can encourage providers of top-notch mathematics and science instruction that can serve districts that are trying to fill holes or weaknesses in STEM education.

Hess etal. (2011) believe that business can support these initiatives by championing accountability and system redesign, providing expertise in areas of performance evaluation, human resources, information technology, and data systems, and by partnering with innovators to model unconventional approaches to STEM education.

The following is an example of a STEM Partnership Including businesses, organizations and higher education:

3M and St. Paul Public School's STEM Partnership

3M and the St. Paul Public Schools have a long history of partnering on STEM issues and programs. With 3M's support, SPPS created a scaffolded science and engineering system. This curriculum begins in elementary school with the state science standards and the district's science curriculum designed to meet these standards. The curriculum is supplemented through a series of 3M funded field experiences at each grade level. St. Paul has worked with a number of local informal science education programs to create pre and post visit lessons with the onsite experience that aligns to and supplements the work being done in the science classroom.

To help move toward a true STEM program, 3M funded the inclusion of the Engineering is Elementary curriculum in each of the grades 1-6. The kits for each grade level were specifically selected to match the standards and topics addressed at that grade. This allows students to apply the concepts learned in science to solve an engineering problem, which reinforces their science understanding at the same time they are practicing the engineering design cycle. Grade level specific classroom libraries were then created to integrate science and engineering into the students' literacy block. Teachers were trained on both the engineering and literacy strategies to be used with the specific classroom libraries. 3M has helped the district continue it's engineering integration into 7th and 8th grade by providing start up funding for the Gateway to Technology curriculum and Project Lead the Way in grades 9-12. Additional partners in these efforts include the University of Minnesota, Hamline University, and the Science Museum of Minnesota. Several volunteers from 3M are involved by tutoring students, coaching robotics teams and mentoring interns at 3M.

Assuring that District Leadership Have STEM Skills/Understanding, and Make it a Priority for <u>All</u> Students:

According to Wahlstrom etal. (2010), a study devoted to understanding the traits of effective principals found that high student achievement is linked to "collective leadership" of educators, parents, and others that influence school decisions. The study found that collective leadership has a stronger influence on student learning than any individual source of leadership. Teachers from high-performing schools attribute greater influence to teacher teams, parents, and students. This collective leadership tends to occur because effective principals encourage others to participate in leadership. However, without adequate supports for collective leadership, principals will tend to focus on the daily responsibilities of running the school rather than create a more democratic and inclusive culture.

When teachers perceive greater involvement by parents and where shared leadership is practiced, student achievement is higher. Hence, Wahlstrom etal (2010) assert that teachers and principals can directly increase student learning by creating a culture of shared leadership and responsibility within the wider community.

In addition to creating a culture of leadership, teachers and principals each can contribute to the classroom experience. Relationships among teachers in a building are important in establishing a strong foundation for improving instruction. Supportive professional communities encourage teachers to be leaders in buildings assuming roles such as mentor, coach, specialist, facilitator, etc. Wahlstrom etal (2010) found that leadership practices targeted at teachers' instruction have significant although indirect effects on student achievement. Where teachers and principals share leadership, working relationships are stronger and student achievement is higher. Effective schools have principals who collaborate with teacher leaders and other outside experts to address improvement initiatives. Effective principals in these schools perform important boundary spanning roles related to these initiatives.

School districts also play a role in equipping principals and teachers for effective leadership that benefits students. Key district behaviors include: provision of human and financial resources; encouraging and supporting relationships with parents and the community; allowing schools flexibility in pursuit of goals; supporting data driven decisions; allowing schools to staff according to their needs; and, providing clear direction through achievement standards and district wide curricula. Leaders in high performing districts communicated expectations for principal leadership and provide learning experiences that support these expectations. These districts also actively monitor principal performance and provide necessary interventions. In summary, Wahlstrom etal. (2010) find that effective leadership integrates clear expectations and accountability with efficacy and support through the engagement of stakeholders.

Another emerging point of view on leadership is captured in a study by Nathan and Plotz. Nathan and Plotz (2008) conducted a study that included interviews with leaders from business. Their research began from the premise that leadership in any type of organization can make a significant difference in what the organization accomplishes. Furthermore, effective leadership in schools is critical for student achievement. In addition, there is evidence that the educational establishment might learn some lessons about leadership from business.
From their research, Nathan and Plotz (2008) arrived at several key conclusions including:

- Every school employee should have a clear understanding of the school's priorities and how their work can help accomplish the goals
- Principals, superintendents, and directors should view succession planning and leadership development as a core responsibility
- Listening and learning from the customer is vital
- Regular assessments should be performed to evaluate the organization and whether it is improving
- Employees should be encouraged to take risks

- Mistakes are a part of the learning process for organizations making progress
- Leaders must have integrity
- Educational leaders should have mentors from both the world of education and business
- Aspiring leaders should be given projects that will help them develop key skills
- Benchmarking should be encouraged to learn about best practices and effective use of technology
- Potential administrators should be trained in cohorts that are given extensive opportunity to interact with outstanding administrators
- Technical skills needed by leaders can be taught and are necessary but not sufficient for great leadership.
- The most effective leaders encourage and inspire people.

While these approaches and perspectives on effective leadership are not specific to STEM, they do represent elements of leadership that would benefit a school or district that was attempting to make STEM education a priority for all students. That is, the steps to effective leadership are likely the same, irrespective of whether the need for improvement is in reading or the STEM disciplines.

Examples of Valuable Partnerships:
One of the best examples of successful partnerships is the Strive Together partnership in the Cincinnati, Ohio area. With growing concern about the region's ability to remain competitive, a partnership was formed that included early childhood educators, school superintendents, college presidents, business leaders, corporate and private foundation directors, and a range of executives from non-profit and advocacy groups. More than 300 leaders came together with the recognition that fixing a single point on the education continuum would make little difference unless all parts of the continuum were improved simultaneously. No single organization could accomplish this task alone. The mission of Strive Together became to coordinate improvements at every stage of a young person's life, cradle to grave (Kania and Kramer, 2010).

Strive Together has reported gains in 34 of 53 success indicators over the last three years. By analyzing data, they have been able to identify patterns that allow improvement of the overall system. For example, Strive found that college enrollment rates could be boosted by making sure that students receive one-on-one college counseling and assistance preparing financial aid forms. The partnership has also allowed for information to be used to address individual student needs. Each school has a data analysis room where teachers meet on a regular basis to review data on academic performance, behavior, attendance, and special services each student is receiving. Through the network of partners, teachers can easily connect students and families with external resources like mentoring and tutoring. The data systems also provide the information necessary to understand what is working and then share that information with the entire system (Bornstein, 2011)

Another example of collaboration intended to address many of the social factors that contribute to the achievement gap comes from the Northwest Minnesota Council of Collaboratives (NMCC). The NMCC was formed to improve services and reduce costs in meeting the health and well-being needs of youth and families in six northwestern Minnesota counties. The NMCC consists of 54 partners representing families, school districts, public health, social services, law enforcement, and non-profits. The collaborative efforts of NMCC have led to the strengthening of programs designed to serve youth and families while making better use of community resources. Access to services is now coordinated through a single system which allows teachers to more efficiently connect a struggling student with a partner who can provide the needed care. The NMCC is also better able to respond to family and student needs in a way that is culturally responsive in a region where demographics are changing. The NMCC also takes advantage of technology to provide a coordinated clearinghouse of information.

Like Strive Together, the NMCC requires extensive communication between partners. Monthly governance meetings are held and reviews of goals, objectives, and outcomes are conducted. Clear protocols have been established for the pursuit and preparation of grant proposals. A lead agency is identified and a governance group provides input and oversight of the proposal process. Regular evaluation of needs and partner capabilities and capacity occurs continuously in pursuit of maximized use of resources and delivery of services (Blanks, etal. 2010).

Hess etal. (2011) illustrate one example of how businesses can be proactively involved with schools through the relationship between Merck and the New Jersey Public Schools. Merck launched the Merck Institute for Science Education nearly 20 years ago with the goal of reshaping science education in the state of New Jersey. Merck has worked directly with districts and community leaders in developing science standards that meet the needs of a 21st century workforce. In addition, Merck created several professional development programs designed to mentor teachers in application of real-world, standards-based curriculum.

State and Federal Standards Related to STEM:

Minnesota last revised state standards for mathematics in 2007. The next revision of Minnesota’s mathematics standards is scheduled for 2015-2016. Currently, Algebra I is required in 8th grade and three credits in mathematics are required in grades 9 through 12, encompassing algebra, geometry, and data analysis and probability. Algebra II is required, beginning with the class of 2015.

The Common Core Standards in Mathematics were developed by the National Governors Association Center for Best Practices and have been widely adopted across the United States. Minnesota, however, has elected not to adopt the Common Core State Standards in Mathematics at this time.

Minnesota’s science standards were revised in 2009 and will next be updated in 2017-2018. The current standards are being implemented for the first time during the 2011-2012 school year with assessment beginning in the spring of 2012. Current graduation requirements include three credits of science in grades 9 through 12, including one credit in biology, and one credit in either chemistry or physics, beginning with the class of 2015. Minnesota recently agreed to participate in leading the development of Next Generation Science Standards, along with 26 other states. The first step in this process was the release by the National Research Council of a framework of core ideas and practices in sciences and engineering. The second step underway is the development of science standards based on this framework.

Recommendations:

7. In order to address the needs of the future workforce, greater emphasis needs to be placed on successfully equipping ALL students with knowledge and skills in the STEM fields.

8. All schools should be encouraged to partner with local businesses, organizations, and higher education institutions to support STEM programs, provide role models/mentors, and increase student engagement toward career goals. This process could be greatly enhanced through state-wide/regional coordination.

9. Models of exemplary school leadership relative to reducing the achievement gap should be identified and included as a basis for professional development of school leaders (principals, curriculum coordinators, board members, etc.).

III. Curriculum, Instruction, Assessment and Support to address the STEM Achievement Gap

Curriculum and Instructional Practices to Address the Achievement Gap:
The following are examples of curricular/instructional approaches that have shown promise in addressing/reducing STEM achievement gaps:

1. The curriculum needs to be Rigorous, Relevant and built on Relationships (Bill Daggett, Ray McNulty: http://www.leadered.com/rrr.html). The curriculum should not be remedial.
2. Instruction should utilize inquiry and engineering design to engage students build their investigation skills, strengthen their reasoning and help them learn and apply concepts. Inquiry and design activities have students ask their own questions or address a problem and then carry out investigations and/or testing a design.
3. Relevance is gained by building on the prior experiences of students, including making connections to socio-cultural experiences of students. The inclusion of current, local and global issues promotes the applicability of STEM instruction (Upadhyay, 2006).
4. Build pathways K-8 where specific foundation skills based on standards and best practices are in place at each grade level. Teachers need to understand the skills students have coming into their classrooms and where they need to have their students by the end of the school year. Learning Targets are identified for each grade level. All students need access to the curriculum. The intended curriculum must reflect the standards and specific curriculum benchmarks. There must be sufficient time in the school day so that the standards are achievable (U.S. Department of Education, 2003).
5. Develop science investigations built on low-cost no-cost materials, so that schools can utilize diverse resources without needing extra support for schools that have less funding. This will promote inquiry STEM activities and also make it possible for activities that can be brought home (Brown, 2006).
6. Build wonderment and creativity in students. Wonderment is any idea that students would like to think about, know about or investigate. Creativity promotes the many ways students can envision how they could engage in an issue (Ben-Tov, 1995).
7. Develop strategies and teaching skills to differentiate instruction to meet the needs of individual students and subgroups in the classroom. Make certain that intervention programs are effective help students with deficiencies while challenging them with stimulating learning of new ideas and skills.

Instructional Methods that Provide STEM in Context K-8 (Experiential) and Strengthen Learning in Context (e.g. Mathematics and Literacy):

1. Provide authentic problems that connect to real world experiences and promote the use and learning of skills from several disciplines including STEM and

literacy. (Cervetti, Gina N., P. David Pearson, Jacqueline Barber, Calabrese Barton & Tan, 2010).

2. Develop pipelines to community resources - parents, museums, and local industry. (See the Leadership section of this report.)
3. Use reading and writing to deepen student understanding of STEM and use STEM experience to motivate engagement in reading and writing. Do not rely on reading and writing to replace inquiry and design activities that promote the development of STEM concepts.
4. Engage students in hands-on STEM inquiry and design. Build common classroom experiences that all students share.
5. Utilize the students' first language (home language) as resource to transition into science content language. Often students can discuss observations, claims and reasoning in their first language and then translate that into scientific vocabulary.

Opportunities to Structure the Learning Experience Within and Beyond the School Walls to Increase STEM Opportunities for Underachieving Students:

1. Family STEM nights. These school events may include a series of activities that make use of common materials, to build parent knowledge and promote parent/student/school interactions.
2. Student led stories that are situated in students' own community or context as a part of taking science outside school: Students engage in STEM content enacted in their communities or environment. These stories provide a real-life connections to what students are learning in STEM topics or unit
3. After-school or out -of-school time for science: These can use the resources of community education and community organizations.
4. The use of science notebooks can establish habits for learning science and make connections between STEM and literacy
5. Build inquiry STEM into summer school programs and encourage involvement in summer camps, museums, parks and informal play.
6. Inspire all students to see themselves as "people of science" by strengthening their disposition toward science (called "science assets") as well as related teacher professional development. An example is the Bakken Museum's classroom residencies.

   The theory behind The Bakken's classroom residencies is that in order to motivate and improve mastery of the *what* (science content knowledge) and the *how* (processes and skills associated with inquiry and engineering design) of science; students must embrace the *why* (personal relevance). Bakken classroom residencies include instructional strategies that engage all students in strengthening their Science Assets, especially reluctant science learners and those from groups traditionally underrepresented and under-served in science – students of color, students of poverty, and girls. Related teacher professional development addresses science content, instructional practice and Science Assets.

Science Assets are research-based strengths or dispositions that are believed to be indicators of student engagement and achievement in science now, and of STEM workforce participation and civic engagement in the future. Science Assets describe a young person's science self-concept that allows them to imagine how and why knowledge of science will inspire their creativity and curiosity, allow them to make a difference in the world, and offer exciting career opportunities in the future.

Science Assets include key dispositions such as: an understanding and appreciation for the role of creativity and innovation in the scientific enterprise; sense of value and relevance of science to their daily lives, at home, in school and in future work; confidence in their own abilities to engage in the scientific world; and sense of belonging to a larger community of People of Science. The learning activities that make up the classroom residencies are designed to build Science Assets and lead students to perceive themselves as "People of Science." People of Science possess the positive science self-concept described above, paired with relevant science knowledge and skills necessary for civic engagement and 21st century workforce participation.

Methods to Translate STEM Standards into Instruction that Address the Achievement Gap:

1. Adopt state standards for technology education (the T in STEM). *Standards for Technological Literacy* as well as *National Education Technology Standards* can serve as models.
2. Emphasize the overarching concepts that connect the standards together and pay close attention to their development across grade levels. Help students make connections.
3. Provide differentiated instruction to students. This requires an assessment/data system that identifies students in need of different instruction/content, as well as the professional development to provide staff with differentiation strategies.
4. Interventions are needed when students are unable to meet STEM goals. Again the identification of students needing intervention must be based on data, and teachers will need professional development on effective interventions. The interventions will likely need to be fundamentally different than the original (unsuccessful) instructional approach. The Key Concepts math intervention classes at Coon Rapids Middle School are an example of a successful, fundamentally different approach.
5. A number of STEM occupations or STEM fields are gender-skewed, so strategies that encourage non-traditional gender participation should be explored and implemented.
6. Ensure that STEM examples, activities and assessments accurately reflect or are relevant to the life-experiences of "gap students".
7. Continuously practice/re-practice STEM skills to build confidence
8. Focus on inquiry teaching and learning as best practices.

9. Utilize the English Language Proficiency and Minnesota Content Standards alignment study to correlate the development of language skills to the learning of concepts.
10. Train teachers on using the Frameworks for Mathematics and Science Standards (www.scimathmn.org/stemtc). Suggestions are provided in each Framework for working with students that struggle.
11. Encourage teachers to participate in professional development offered through the MN Mathematics and Science Teacher Academies (MSTA - 9 state regions: http://www.scimathmn.org/stemtc/mathematics-and-science-teacher-academy)
12. Utilize the experience of the U of MN STEM Center based on their work in Native American communities
13. The Bakken Museum Teacher in Residence Program – a collaborative one-year professional leave position supported by Minneapolis Public Schools and the Bakken Museum. The Teacher in Residence participates in and helps lead Bakken educational programs and professional development. The participating teacher will increase their expertise in and knowledge of science content, best practices and innovative strategies for teaching science, program evaluation and staff development.

Assessment Practices to Allow Mastery of STEM Concepts and Skills

1. Focus instruction and target student needs through formative assessment. (Harlan, Wayne 2000) (Keeley, Page 2008)
2. FOSS ASK assessments
3. Project-Based assignments/Learning

Recommendations:

10. Adopt state standards for technology education so that Minnesota standards exist in all STEM content areas.

11. Identify, disseminate and replicate best practices in curriculum, instruction and assessment related to reducing the STEM achievement gap.

STEM curriculum and instruction must:

- focus on fewer in-depth concepts and skills so that students and teachers can spend more time and resources learning STEM content
- connect students' lived experiences, including family, community, and after school experiences
- allow all students in the elementary grades, including Pre-K, to build a strong foundation for future learning and civic participation
- open possibilities for engaging in scientific practices that bring all content areas together

IV. Impact of Teacher Skills on the STEM Achievement Gap

Data/research on Achievement Gap Related to Teacher Skills:
Educational research points to the teacher as a crucial link in the development of academic success for all students. Teacher preparation programs and professional development experiences should focus on increasing teacher effectiveness resulting in increased student performance and a decrease in disparities amongst student groups. As STEM occupations hold some of the greatest promise for future employment, current and future K-8 teachers should be well versed in STEM content and best practices, helping to prepare the workforce of the future, as well as increasing overall public STEM literacy. (Note: High School STEM teachers have a major in the content area they teach.)

The values and belief systems of pre-service and in-service teachers might be obstacles to the teaching and learning process of STEM. Many elementary teachers are “generalists” and are primarily concerned with nurturing a child’s development of language and mathematical skills along with a general development of students’ academic competency. Most elementary teachers do not have a STEM mindset (for a number of reasons) and are therefore unprepared to create the inquisitive atmosphere necessary for the development of STEM learning. Students may also catch these attitudes.

Minnesota K-8 Preparation Programs:
All teacher preparation programs in Minnesota are governed by state statute, implemented by the MN Board of Teaching (BOT). It is important to note that preparation programs are evaluated on meeting teacher preparation standards, which are covered in numerous courses. The BOT does not specify the courses that are required for programs, only that courses in the program meet the required standards. All programs attempt to graduate effective teachers to meet the demands of contemporary diverse classrooms.

From a survey of MN teacher preparation institutions, it is clear that there is a wide variety in the number of science and mathematics courses and credits required of elementary education majors. The number of credits varies from 6-12 credits in science content and 6-8 credits in mathematics content. All elementary education majors are required to complete a number of credits (4-6) in science and mathematics methods courses.

For majors completing the middle school endorsement in science or mathematics, additional specific content courses (totaling 20-28 credits) and a methods course (2-4 credits) is required.
In addition to these content and methods courses, all education majors complete courses and/or coursework about the diverse student population in the contemporary elementary classroom. All education majors complete a student teaching experience that has to be at least 10 weeks in length.

STEM Initiatives in Teacher Preparation:
A number of interesting initiatives have recently been established within K-8 preparation programs that focus on STEM preparation. St. Catherine University has a developed a unique STEM Certificate required of all elementary education majors. The certificate is comprised of 3 courses, one of which is an engineering course. Two additional mathematics courses are required for elementary education majors. In addition, majors have a semester long residency in elementary schools where they teach science, mathematics and social studies in an integrated block before their student teaching experience.

Metropolitan State University through its Urban Teacher Program has worked to diversify the teaching workforce and has focused on science and mathematics preparation. All elementary education majors take courses such as Mathematics for Elementary Teachers and Mathematics Methods K-8. Mathematics Methods K-8 is a combined class of both elementary and secondary education majors by design so that both groups learn together. Courses focus on efficacy and attitude issues with elementary education majors, as well as a deep understanding of mathematics for teaching (even with the mathematics education majors!)

The Bush Foundation has joined with 14 higher education institutions in Minnesota, North and South Dakota to reform teacher preparation. The goal of this effort is to “increase by 50 percent the number of students in Minnesota, North Dakota and South Dakota, from pre-kindergarten through college, who are on track to earn a degree after high school, and eliminate disparities among diverse student groups” (http://www.bushfoundation.org/education/overview).

Strategies to Assure STEM Teacher Quality - Including Teacher Preparation, Professional Development and Teacher Assessment

Strengthening Elementary/K-8 Teacher STEM Content Knowledge and Confidence:

Elementary teachers often express discomfort teaching science and mathematics. With the introduction of engineering into the K-8 curriculum, teachers are showing high levels of anxiety about their ability to meet these standards effectively. Schibeci and Hickey (2000) reported that with elementary teachers more than learning content knowledge is required to change practice. They believed that such a change is dependent on “a scientific dimension—to promote change in teachers’ concepts and support development of more sophisticated ideas, theories and principles; a professional dimension—based on content to be taught in elementary classes, thus a having high relevance and purpose to teachers; and a personal dimension—related to everyday life and providing a motivation for teachers to learn and understand” (Loughran, 2002, p. 1048). Given the introduction of engineering standards in the New Generation Science Standards, it is clearly important that content in this area needs to be incorporated into K-8 teacher preparation programs. Building confidence in teachers in STEM teaching is also an outcome of this and should be a focus in teacher preparation programs.

From fall 2012, all education majors in preparation programs will be required to complete the Teacher Performance Assessment. While there is a science assessment for high school science and mathematics majors, K-8 education majors will be assessed in mathematics but not in science.

Alternative Licensure and Teach For America:
Teachers who receive licenses through the Alternative Licensure system or Teach For America should also have content knowledge and experience in teaching STEM.

STEM Professional Development Opportunities:
All IHEs, non-profit STEM organizations (The Works, Bakken Museum, etc.) currently offer professional development opportunities for teachers in some areas or disciplines of STEM. Some experiences are more focused in working with specific audiences, such as the University of Minnesota STEM Center's work in Native American Communities, or with district wide STEM initiatives, such as the STEM Graduate Certificate offered through the National Center for STEM Elementary Education, St. Catherine University. The Works offers professional development experiences and conferences focused on engineering.

However, research points to the following characteristics as important in creating effective professional development experiences for teachers. One of the most important of these is that teacher professional development needs to be focused on content and pedagogy. It also needs to be at least 50 hours over a 6-12 month period. Use of a cohort model as a professional learning community is also important. Finally, creating a systemic approach to the professional development of all staff and administrators in the school, with this development as a central and strategic focus of district efforts.

Existing STEM PD available Through Regional Mathematics/Science Teacher Academies (MSTP):
The mathematics and Science Teacher Academy includes nine regional Teacher Centers and a virtual resource Teacher Center found online at http://www.scimathmn.org/STEMTC. The regional teacher centers provide high-quality professional development to teachers so they can effectively deliver the Minnesota K-12 Academic Standards in mathematics and science. The centers are funded through the federal Mathematics and Science Partnership (MSP) Title IIB dollars and are partnerships among a regional service cooperative, an institute of higher education, and a high needs local school district. The goal is to improve academic achievements of elementary and secondary students in mathematics and science by increasing instructional quality. Each region provides a mathematics module and a science module that includes 30 or more hours of professional development through workshop and professional learning community each year.

One of the key initiatives to improving student proficiency in STEM areas of study is the federal Mathematics and Science Partnerships (MSP) program authorized under Title II, Part B of the Elementary and Secondary Education Act (ESEA), as amended by the No Child Left Behind (NCLB) Act of 2001, CFDA 84.366B. Currently this is funded federally at 175 million dollars and it is formula funded to states in relation to the student poverty rate. Minnesota was awarded 1,829,425 dollars in the 2011 funding year. The goal of the federal MSP program is to improve academic achievements of elementary and secondary students in mathematics and science by increasing instructional quality. Since 2001, the Minnesota Department of Education has awarded grants for partnerships of institutes of higher education (IHE), high needs local educational agencies (LEA), and other partners. This program has created model professional development programs such as TRIBES that has focused on promoting culturally relevant instruction for Minnesota Native American students as well as MnSTEP, which has created professional development programs that have created certifications in high-need STEM areas.

For the past three years, Minnesota has funded the Minnesota Mathematics and Science Teacher Academy (MSTA) through MSP funding. The MSTA has provided statewide professional development through nine regional Teacher Centers. Each of the regions work with an institute of higher education (IHE) and a high needs local education agency (LEA) to develop modules in both mathematics and science that is targeted to the needs of the region. For the 2011-12 school year, mathematics is providing modules focusing on understanding of rational numbers in grades 3-8 and science is providing modules focusing on life science in grades 7-12 integrating the nature of science and engineering. Schools with 75% participation of teachers at the designated grade level and content area then commit to participate in the 30 plus hours of professional development in workshop and professional learning community settings. For the 2011-12 school year 25% of the 1.8 million dollar funding was targeted for the regions to develop and deliver professional development that is specific to reducing the STEM achievement gap, specifically in mathematics. Currently work is being done in the planning stages with the LEA and IHE partners and the delivery will start in January of 2012.

Encouraging Teachers to Participate in Professional Development:
Financial and/or credit incentives are the helpful in encouraging teachers to be involved in professional development experiences. Higher level of assistance should be awarded to elementary teachers who participate in STEM professional development experiences.

Teacher Assessment:
Teachers play one of the most important roles in student learning. The assessment of new and current teachers and their impact on student learning should be an ongoing process that assists the teacher in her/his own professional development and in understanding and improving student academic growth.

- Teacher Performance Assessment will become a requirement of all teacher candidates as part of their student teaching in fall 2012.
- Existing models of assessment with associated instruments are available for teacher evaluation.
- One example is the Teacher Evaluation System (http://educationnext.org/evaluating-teacher-effectiveness/) used in Cincinnati.

STEM Teaching Best Practices that Reduce the Achievement Gap:
While the strategies or best practices listed below are generally used in association with a specific area, many are utilized across the different areas of STEM.

Pedagogy for Learning in Science (Appleton, 2007)**:**

- Inquiry
- Conceptual Change (misconceptions)
  - Making students aware of their initial ideas (Ready Set Science)
  - Cognitive conflict (disequilibrium)
  - Small group interaction-Sharing ideas
  - Models and Analogies
  - Scaffolding
  - Applying new understandings in different contexts (Ready Set Science)
  - Providing time for students to discuss the nature of learning and the nature of science (Ready Set Science)
- Writing: Science Notebooks
- Small Group work
- Simulations (computer-based, games, etc.)
- Problem Solving and discrepant events
- Learning Cycle (5Es: engagement, exploration, explanation, elaboration, and evaluation.
- Student Questions and Identifying Students' Initial Ideas
- Making Thinking Visible: Talk and Argument (Ready Set Science)
- Making Thinking Visible: Modeling and Representation (Ready Set Science)
- Graphic Organizers
- Differentiation for diverse learners

Engineering for Elementary Educators:

- Engineering Design Process and Problem Solving
- Direct instruction (structured overview, lecture, explicit teaching, drill and practice, demonstration, guided practice)
- Interactive instruction (brainstorming, peer/partner learning, discussion, laboratory groups, cooperative learning, problem solving, conferencing),
- Indirect instruction (reflective discussion, concept mapping and attainment, inquiry)
- Independent study (learning centers)
- Experiential learning (field trips, conducting experiments - as appropriate and extended into the engineering design process as contrasted with a pure science model of experimentation, story telling, model building - as appropriate and applied to engineering and more of "prototypes" and technology)
- Instructional skills (explaining, demonstrating, questioning - technique and levels)

Mathematics:
- Number Talks (for mental computation) (Parrish, 2010)
- Socratic Method (questioning)
- Writing: mathematics journals
- Open-ended Problems
- Recreational Mathematics
- Making Connections to Everyday Life
- Think Alouds
- Mathematical Debate/Argumentation
- Multiple Representations
- Problem Solving Process (i.e. Understanding the Problem, Devising a Plan, Carrying out the Plan, Looking Back) (Polya, 1973)
- Multi-cultural Instructional Approaches
- Role models, readings, etc.
- Comparing “western” science to approaches by other cultures
- Use in assignments, projects, and assessments
- Detecting bias in texts and other instructional materials

Other Instructional Approaches:
- Integrative Nature of STEM (STEM 2.0 or iSTEM)
- Connections with Literacy (Use of Anticipation Guides; Reading Like a Scientist, Engineer or Mathematician; Use of non-fiction; etc.)
- Use of technology (computer software, probes, Smart boards, etc.)

Scalable Strategies to Improve K-8 Teaching Skills in STEM
1. Teacher preparation programs should recruit, support and retain persons of color and diverse backgrounds in K-8 teaching (e.g. Metropolitan State University, Concordia University, TC2).
2. In addition, recruitment of STEM professionals who would be interested in teaching should be considered. They could be licensed through IHE preparation programs, Alternative Licensure or Teach For America. They could be recent STEM graduates or mid-career STEM personnel who seek a new opportunity and want to share their love of STEM.
3. As Darling-Hammond (2010) recommends “more coursework in content areas and in how to teach the content” (p. 206) is required in programs. Therefore, 3-4 science courses, which should include engineering and technology content, and 2-3 Mathematics courses should be in place to strengthen content knowledge. These content courses should be rigorous in nature and challenging. To aid in the development of these courses, the MN Board of Teaching Preparation Standards should be more descriptive and specific in content. In addition, the MN Licensure Teaching Examinations would be more clearly aligned with the specific content.
4. Methods or pedagogy courses should be connected to residencies or Professional Development School experiences. Connecting methods courses to residencies or Professional Development School Models creates a focus on helping candidates learn specific practices and tools that they will apply in

student teaching (Darling-Hammond, 2010). These courses should also contain coursework or experiences related to STEM 2.0 or iSTEM (integrative STEM). Additional topics covered in these courses should include effective management of the learning environment and differentiating STEM for the diverse populations of students in contemporary classrooms.

5. In addition, “carefully selected and supervised student teaching experiences, well matched to the contexts in which candidates will later teach” (Darling-Hammond, 2010, p. 206) should be the norm in teacher preparation programs. During this experience, there should be opportunities to study and evaluate district curriculum. While Darling-Hammond recommends a capstone project—typically a portfolio of work done in classrooms with students—which examines the quality of their practice, all education majors will be required to complete the Teacher Performance Assessment.
6. Darling-Hammond (2010) recommends that programs should create a “tightly coherent set of learning experiences, grounded in a strong, research-based vision of good teaching, represented both in coursework and clinical placement where candidates can see good teaching modeled and enacted” (p. 213). To do this, programs need to develop formal Professional Development School relationships based on some form of a Teacher Residency Model. Once a teacher graduates from the preparation program, school districts should have Teacher Mentoring and Induction Systems in place to support and retain teachers.

Teacher Professional Development Opportunities

1. Professional development experiences should be based on research that shows effective experiences should be at least 50 hours over a 6-12 month period.
2. Teachers should be encouraged to enroll in professional development opportunities especially if it is district-approved. Teachers should receive either graduate credits, or stipends for enrolling in these experiences.
3. When new teachers enter schools, induction support should be available to them.

Teacher Assessment

1. Science assessment should be considered as part of the Teacher Performance Assessment in elementary teacher preparation programs
2. Teachers should be assessed for Professional and Student Growth using validated instruments
3. Assessment should be connected with existing evaluation in school systems (Focused observations, etc.)
4. Teachers should receive professional development in how to use data to make decisions in the classroom to improve student learning in STEM (differentiation, etc.)
5. School districts should be encouraged to implement this evaluation/assessment.

Recommendations:

12. Teacher preparation programs should recruit, support and retain persons of color and diverse backgrounds, including STEM professionals, for K-8 teaching, with a goal of matching staff demographics to student demographics.

13. Improve teacher preparation through more content and pedagogy in STEM subjects, integrated STEM.

14. Teacher professional development should be focused on deeper STEM content as well as pedagogy specific to addressing the achievement gap.

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Appendix

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MN STEM Achievement Gap Strategic Planning Workgroup Meeting Dates

2010 Meeting Dates:
Sept 9 - 1:00
Oct 14 - 10:00
Nov 11 - 1:00
Dec 9 - 10:00

2011 Meeting Dates:
Jan 20 - 1:00
Mar 17 - 10:00
April 20 - 1:00
May 12 - 1:00
June 30 – 10:00
July 14 - 10:00
Sept 15 - 1:00
Oct 12 – 8:00 (workgroup work day)
Nov 10 - 10:00

Meeting Summaries

July 22, 2010 Organization of the workgroup, review of the charge, and input for the meeting schedule

September 9, 2010 Presentations and discussion of achievement gap data in science and mathematics, including:

- International assessments (PISA and TIMSS),
- National assessments (NAEP)
- Minnesota data (MCA)
- Analysis of data from Minneapolis and Anoka-Hennepin school districts.

October 14, 2010 Presentations and discussion of achievement gap data in technology and engineering, including:

- Limitations of data analysis
- STEM enrollment data
- Technology education requirements
- Project Lead the Way implementation

November 11, 2010 Tour of Farnsworth Aerospace Magnet School (K-8) St. Paul and panel on approaches toward the STEM achievement gap by urban districts

- Farnsworth core priorities: solid teaching, experts brought into the school, real-world and field experiences,
- Other significant practices: parent involvement, quality equipment, Engaging Classroom Assessments, projects
- Washington MS: Collaboration including Professional Learning Communities, interventions by small groups, extended day programs, Project Lead the Way
- St. Paul District – science specialists in each school, Science curriculum integrated with literacy, Engineering is Elementary and Project Lead the Way

December 9, 2010 Tour of Salk Middle School, Elk River and panel on approaches toward the STEM achievement gap by rural districts.

- Salk STEM Magnet program: desegregation effort to attract students from Osseo includes marketing, strong parent involvement, STEM theme for each quarter, STEM emphasis in instruction, Professional development in cultural competence
- Elk River data: stronger achievement for students in magnet program resulted in an inverse gap
- Red Lake and Onamia districts: kids not used to rigor and resist, motivate students through project-based learning, large professional development efforts
- Anoka-Hennepin: important to understand the meaning of growth, be accountable for the learning of every student

January 20, 2010 STEM Employment Outlook - Rachel Vilsack, Minn. Dept. of Employment and Economic Development (DEED), Brainstorming on subcommittee structures

- Minn. STEM employment: Computer Sci. 120,000, Life & Natural Sci. 74000, Engineering 66,600, mathematics 8,000, This represents 10% of Minn. jobs. Only some of health care jobs are included
- 2009-2019 projections by DEED
    - Growth in jobs 8.7%

- Will need 639,000 new workers for replacements of retirees, etc.
- Healthcare and social assistance will increase the most
- Manufacturing and information services will lose the most
- STEM Job Growth: Computer Sci. 13%, Math 10%, Natural/Life Sci. 55, Engineering 5%
- 33% of Minn. jobs will require postsecondary education, biggest share in advanced degrees.

February 17, 2010 Research on the STEM Achievement Gap – Liesl Chatman and staff of Science House

- Importance of bringing a cultural lens into STEM instruction and curriculum.
  - To what extent is the achievement gap culturally based?
  - What successful, replicable cultural bridges and "best practices" have been developed?
- Research of Dweck and others: Intelligence is viewed either through a "fixed intelligence" approach where someone is either smart or not; or through a "variable intelligence" approach where hard work makes one smarter. It appears that the "variable intelligence" approach is more successful when working with students. The belief system of both teachers and students in this area needs to be addressed.
- Both institutional cultures and specific ethnic cultures need to be considered.
- Perhaps an inventory of each school or classroom is needed to identify most likely factors for their particular gap. See notes for possible causal factors

March 17, 2011 Organization of subcommittees and refinement of their charges. Beginning of subcommittee work

April 20, 2011 Subcommittee work and report preview

May 12, 2011Subcommittee work

June 30, 2011 Panel discussion: "Beating the Odds" approaches

- Kent Pekel, University of Minnesota Executive Director of College Readiness
- Neal Thao, Metropolitan State University
- Peter Olson-Skog, Carver Elementary School, Maplewood, Principal
- Brent Gish, Red Lake Schools, Superintendent
- Allen Ralston, Clearbrook-Gonvik Schools, Superintendent

Some significant comments from the panel discussion:

- What works in one setting will not necessarily work in another setting. It is important to figure out what caused things to work. Stay the course long enough to show proof of concept. Initiatives need to be sustainable, not grant driven
- It is important to honor the culture so that students stay engaged.
- Look for cultural bias in the measurement materials (standards and tests). Culturally responsive content and pedagogy are important.
- The school, not the classroom, needs to be the unit of change. Define the change for all staff and stakeholders.
- Positive Behavior Intervention System is an initiative that scales-up well. Response to Intervention and Cognitively Guided Instruction are recommended programs

- Frequent family contact is important
- Belief that all students can learn is critical and realizing that all students can't be treated equally
- Engineering can be a theme to unify the school. Business partnership can support the program.

September 15, 2011 Report organization, Development of a survey of school districts, Subcommittee Work

October 4, 2011 Survey was sent out

October 13, 2011 Subcommittee work.

November 10, 2011 Report compilation and approval

A Compilation of US and Minnesota STEM Achievement Gap Research and Data

The following Google Collection houses the research, articles and data gathered by the Workgroup in their work on the STEM achievement gap. This collection has now been opened for public access at the address below:

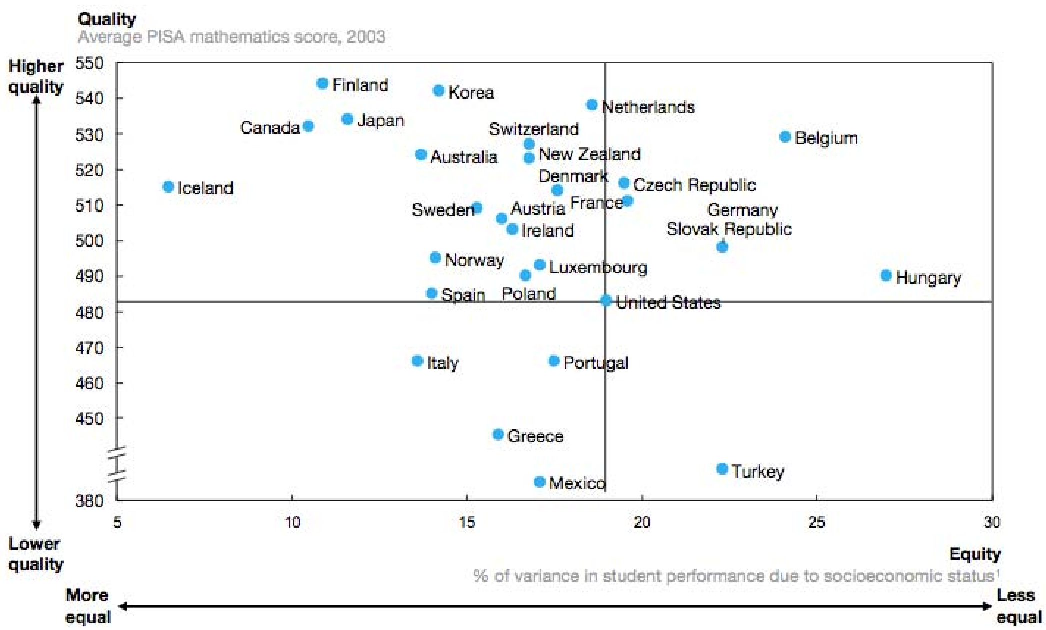
http://bit.ly/t2gyXZ

Additional Data Considered by the Workgroups:

The following five data displays come from the April 2009 McKinsey and Company report titled *The Economic Impact of the Achievement Gap in America's Schools*.

Exhibit 2

17 countries have higher average test scores and lower income-based inequality than the United States

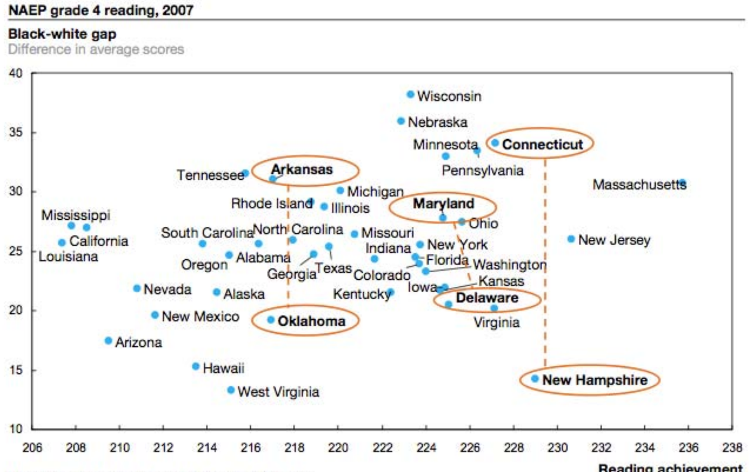


1 Socioeconomic status as measured by PISA's index of economic, social, and cultural status.

SOURCE: Learning for Tomorrow's World – First Results from PISA 2003; McKinsey analysis

Exhibit 4

Neighboring states with similar overall scores can have large achievement gap differences



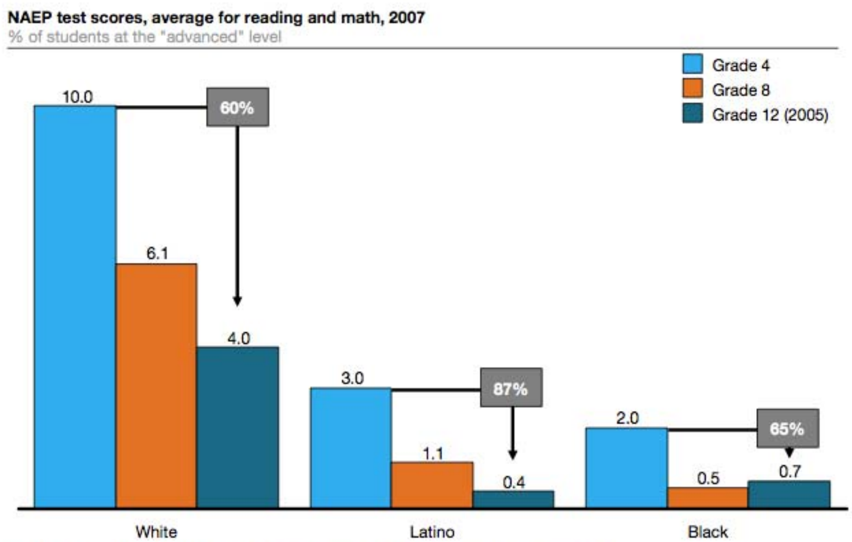
1 Only states with statistically significant black populations included.
SOURCE: USDOE, NCES, National Assessment of Educational Progress (NAEP) Summary Data Tables

9. Insufficient data exists today to document gaps related to other underserved communities, such as Native Americans.

10. While this research focuses on the achievement gap measured starting in fourth grade there is extensive evidence of the importance of early childhood education in building the necessary cognitive abilities before kindergarten and how many young children are entering kindergarten unprepared.

Exhibit 5

Few black and Latino students score at the "advanced" level, and the percentage declines over time

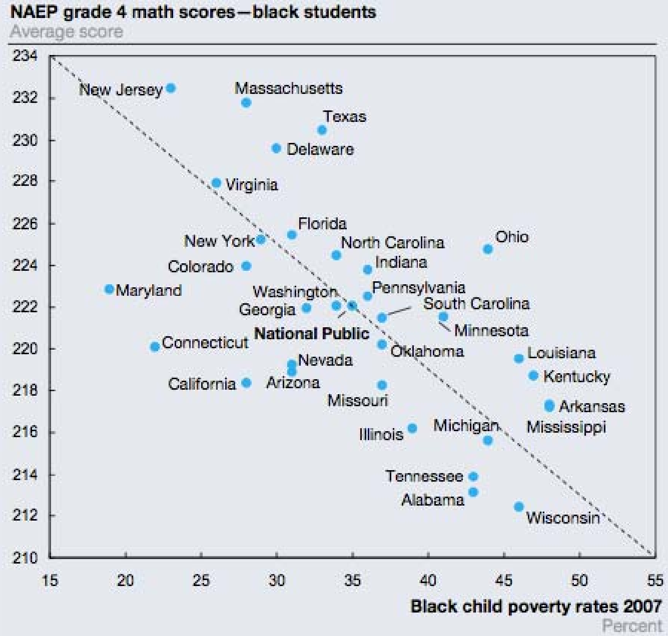


Note: In some cases the number of black and Latino students at the "advanced" level was statistically insignificant.
SOURCE: USDOE, NCES, National Assessment of Educational Progress (NAEP) Summary Data Tables

11. US Census Bureau, "*An Older and More Diverse Nation by Midcentury*," press release (August 14, 2008)

Exhibit B

Test scores for black students strongly correlate to black poverty rates

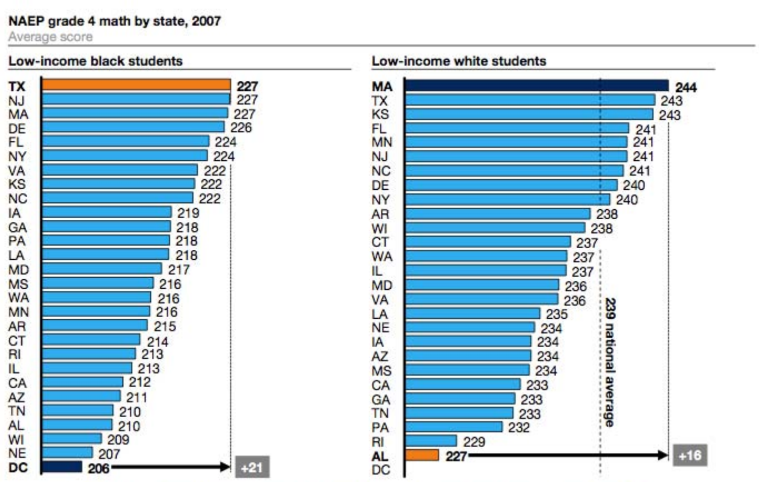


Note: Some states discluded because not enough black students in population (e.g., Idaho).

SOURCE: USDOE, NCES, NAEP Summary Data Tables; Annie Casey Foundation 2008; McKinsey analysis on subset of states

Exhibit 8

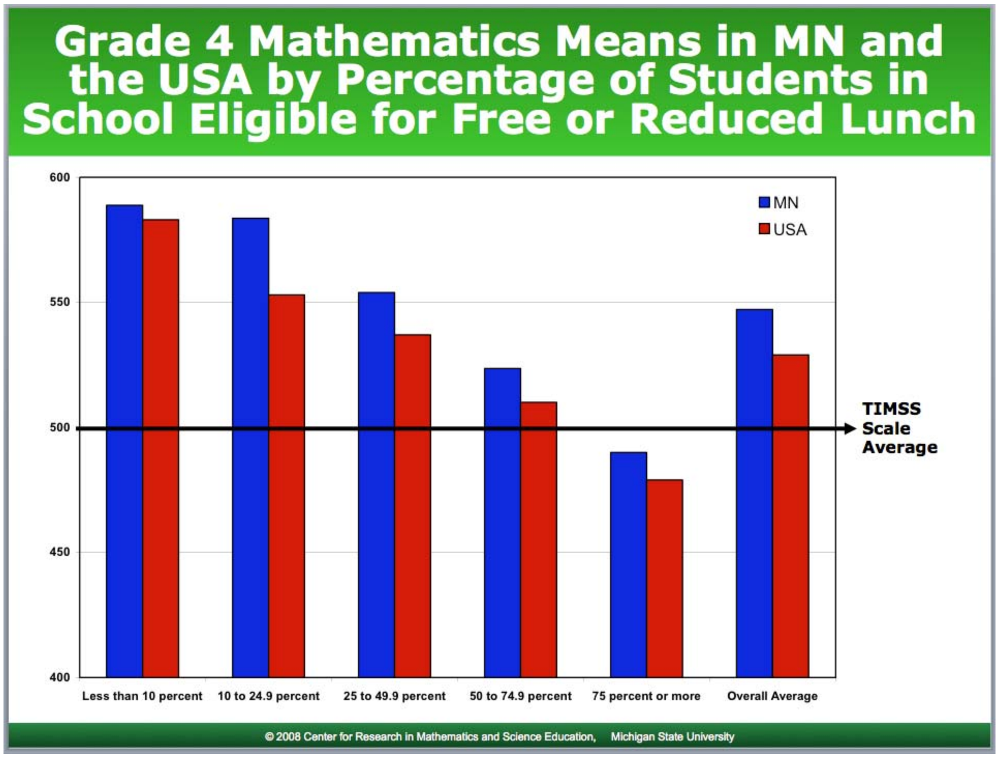
Differences in achievement between states can be as high as two years of learning even after controlling for race and income

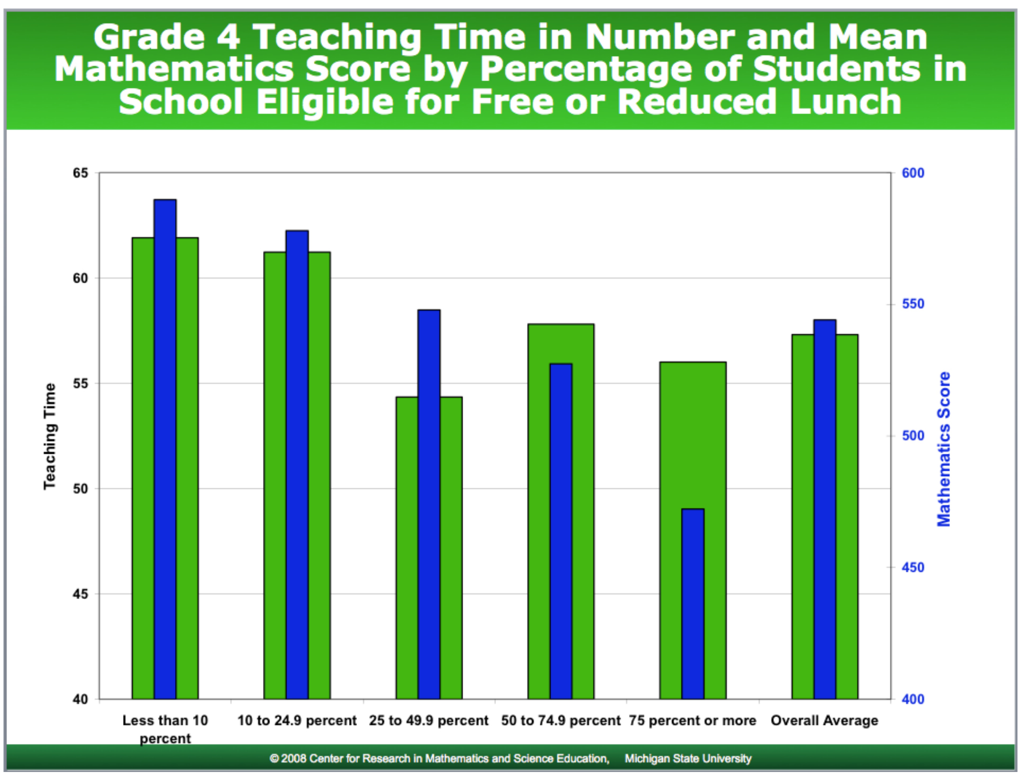


Note: Low income is defined as eligible for federally subsidized lunch; DC does not have a statistically significant population of low-income white students. Full analysis may be found in companion report.

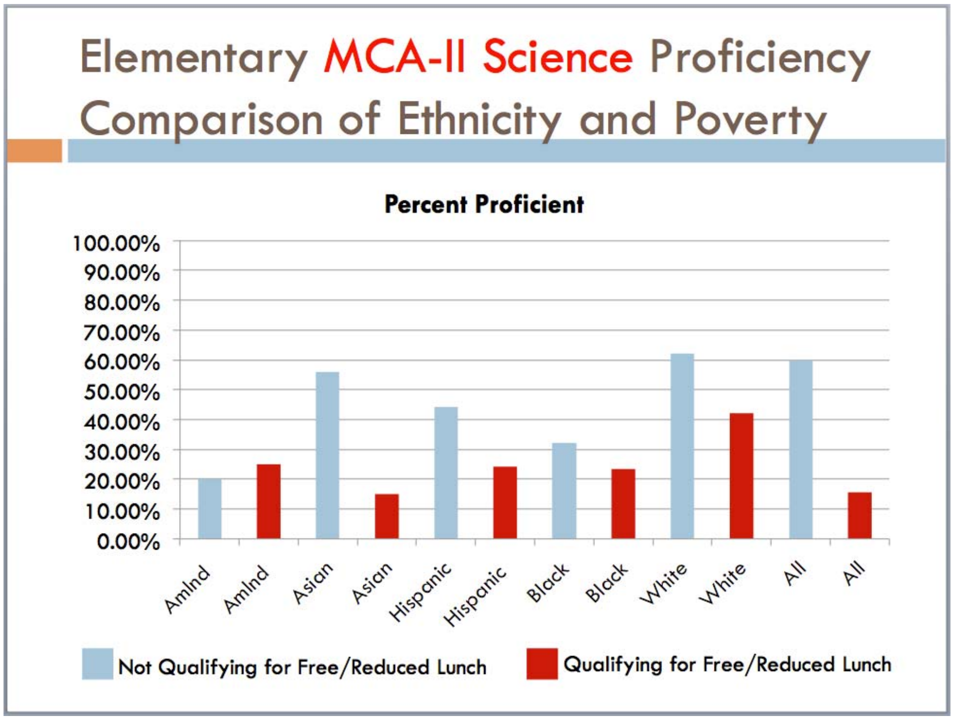
SOURCE: USDOE, NCES, National Assessment of Educational Progress (NAEP) Summary Data Tables; subset of states

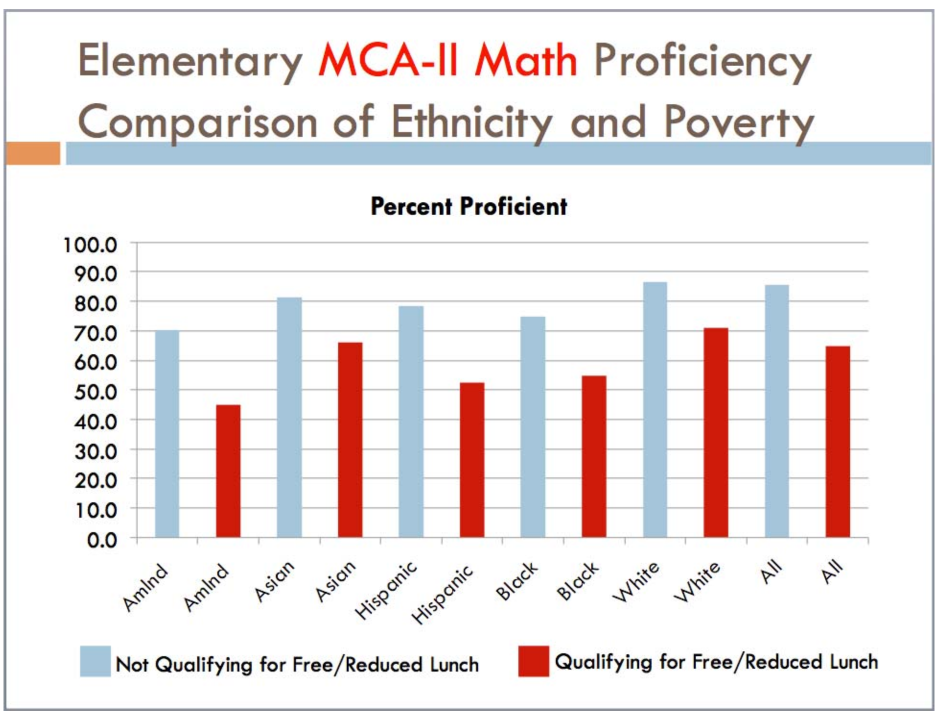
The following displays are from the SciMathMN/Michigan State University analysis of the MN TIMSS testing participation in 2007.





The following two graphs represent the 2009-10 MCA II data from Anoka-Hennepin (the largest suburban MN school district).





Recommendations from the P-16 Education Partnership STEM Instruction Workgroup 2009

Recommendations:

1. Culture: Inspire the spirit of STEM by connecting STEM education activities from preK through postsecondary education and community activities, creating a culture of STEM learning in students, schools, families and communities.

Improving STEM activities in Minnesota schools will not be sufficient to achieve our goals. STEM should be valued in school and in the entire community. Minnesota should use a broad range of tools to convey to students, parents, teachers, and the community that the state values STEM learning and STEM fields.

2. Curriculum: Build preK to postsecondary STEM curriculum focused on mastery of core STEM concepts and skills which are supported by frameworks that connect academic standards with classrooms and community learning opportunities.

Minnesota STEM standards and curriculum must be benchmarked to international standards and exemplary STEM schools recognized. There must also be a concerted state effort to encourage the use of similar curriculum and fund professional development to incorporate effective curricula in schools across the state. A STEM liaison position needs to be created and funded to help teachers and administrators to communicate with other school districts to ensure that STEM instruction is consistent across districts. Schools should be encouraged to bring language arts, math, science, and social studies together to explore big ideas and issues that interest students. All stakeholders should foster a team culture among teachers and develop a STEM network among schools and school districts.

3. Instruction: Identify and adopt effective, evidence-based instructional practices that engage students and teachers in inquiry-based learning and investigation and integrate STEM subjects with other parts of the curriculum.

Science and engineering should be regularly taught in such a way that students acquire a meaningful understanding of science and design/engineering in a coherent sequence in elementary school. In secondary school, Minnesota should identify a smaller number of key standards so that students can acquire a deeper understanding of the subject matter and so that there will be enough time for teachers to incorporate project-based programs that inspire students to explore further inquiry. Funding should be made available to permit teachers and students ‘real-life’ experience in the application of STEM knowledge and skills.

4. Teacher Preparation and Professional Development: Teacher preparation programs should adopt teaching and learning methods for initial preparation and professional development of teachers that develop reflective practitioners who continue to improve their knowledge and skills.

The state must support and encourage science induction programs and make more time available for teachers to work together. The science and mathematics academies should be utilized to promote STEM learning across the state. Further, the science and mathematics academies current emphasis on middle school needs to be expanded to also include elementary science instruction. The STEM liaison should assist each school to find the appropriate professional development program.

5. Assessment: Identify and adopt methods of assessment that effectively support student learning and continuous improvement of STEM instruction.

Minnesota needs to recognize the message assessments send to our students and apply the principles of effective assessment to the evaluation of learning in Minnesota schools. The Instruction Group recommends training and support for instruction that engages students in STEM topics and inspires students to explore STEM in multiple environments. In order to support this recommendation, a student's knowledge and skills must be assessed using multiple tools.

6. Learning Environments: Assure that all Minnesota students have access to quality school-based (formal) and out-of-school (informal) STEM learning environments that exemplify the value that Minnesota places upon science, technology, engineering and mathematics education.

The student learning environment must be expanded beyond the classroom to incorporate after school and out of school programs. The STEM liaison will coordinate classes and informal learning programs. While the state should expand the learning opportunities, classrooms must have basic supplies available for their students. Equip elementary classrooms with the equipment and spaces that are needed to support inquiry and the doing of science and engineering. Equip secondary classrooms with technologically current laboratory equipment and supplies to create an appropriate STEM learning environment in their classrooms.

7. Equal Opportunity: Develop effective methods to close the STEM achievement gap for ethnic and socio–economic groups and ensure STEM proficiency for all Minnesota students.

Teachers should acquire the capacity during their professional preparation and through ongoing professional development experiences to engage all of their students in STEM learning by applying culturally competent pedagogies and using culturally relevant materials and curriculum. Quantitative goals must be set and tracked reducing Minnesota's ethnic achievement gap. The state and local businesses should support opportunities for students and community mentors and advisors to participate in STEM program such as GEMS; that encourage girls to pursue STEM careers. The state should also encourage Environmental learning centers to incorporate more STEM topics in their informal learning environments to create more access for rural Minnesotans to informal STEM learning opportunities.