SRI International

STEM High Schools

Specialized Science Technology Engineering and Mathematics Secondary Schools in the U.S.

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Executive Summary

As the United States searches for approaches to shore up its eroding position in the world with respect to science, mathematics, and innovation, there has been renewed interest in secondary schools offering specialized curricula in science, technology, engineering, and mathematics (STEM). At the same time, demographic trends and STEM participation rates suggest that rather than relying exclusively on students who have already demonstrated high achievement to pursue STEM education, the U.S. needs to inspire, engage, educate, and employ as broad a population as possible in STEM-related fields.

These concerns have given rise to a new school concept—the “inclusive STEM school”—which offers a STEM-focused, college-preparatory curriculum to students from groups historically under-represented in STEM fields. A conceptual framework for STEM schools provides a set of dimensions that can be used to characterize schools in terms of their design principles, implementation practices, and outcomes for students. This conceptual framework guided the development of a survey, which was distributed to every identifiable STEM secondary school in the United States. Survey responses received from 203 schools (or 65 percent of the school registry) were analyzed to provide the first-ever nationally representative portrait of public STEM secondary schools.

Most STEM schools are organized as either stand-alone schools (43 percent) or as a school-within-a-school (38 percent). Graduation requirements in STEM schools, on average, are 3.42 years of science, 3.32 years of mathematics, .88 year of Computer Science, 3.62 years of English, 3.08 years of Social Studies, and 1.60 years of a world language. Eighty percent of STEM schools are public, noncharter schools, and 15 percent are charter schools.

Based on survey responses, the school sample was subdivided into selective STEM schools and those with a mission of inclusion. Their survey responses suggest that inclusive STEM schools are in fact reaching the intended underserved populations: 58 percent of their students qualify for free or reduced-price lunch; one-third are African American and one-third Hispanic. The corresponding percentages for selective STEM schools are 27 percent eligible for free or reduced-price lunch, 16 percent African American, and 11 percent Hispanic. Inclusive STEM schools are more likely than selective schools to describe their program as career and technical education (24 percent compared to 10 percent of the selective schools). They are less likely to be designated as a gifted/talented school (4 percent compared to 40 percent of the selective STEM schools).

In many ways, inclusive and selective STEM schools appear to be offering similar programs. Course requirements in inclusive and selective STEM schools are similar. Teachers at inclusive STEM schools are only slightly less likely than those at selective schools to have majors or advanced degrees in STEM fields, and they use similar instructional approaches. The inclusive schools are more likely to offer students the level of personalization that comes from remaining in intact groups with teachers over multiple years and to provide contact with mentors in STEM fields who mirror the students in terms of background. They are less likely than the selective STEM schools to offer a broad range of Advanced Placement courses. On the other hand, they are just as likely as selective schools to provide their students with opportunities to take college courses while in high school.

The report concludes with recommendations for implementation practices for inclusive STEM schools and with recommendations for further research and evaluation on this emerging phenomenon.

STEM Schools in the U.S.: Background

The concept of secondary schools offering specialized curricula in science, technology, engineering, and mathematics (STEM) is not new. Its roots can be traced to a set of elite schools that evolved out of trade schools established around the turn of the century (Hanford, 1997). The now-illustrious Stuyvesant High School, for example, was established in 1904 in New York City as a boys' trade school. During the 1930s the school shifted to an emphasis on academic science and mathematics and began using a competitive examination to select the most able from among the many students eager to attend. By the mid-1990s, Stuyvesant application and acceptance numbers cited by Hanford (1997) suggest that the school was accepting just 6 percent of applicants, making it more selective than Harvard University. The institution of advanced curricula and admission based primarily on test performance were emulated by two other elite STEM schools within New York City (Bronx High School of Science and Brooklyn Technical High School) as well as by similar schools in cities such as Baltimore and Chicago. Thus, a set of what Hanford (1997) described as "private schools, essentially, within the public sector" emerged to produce students well-prepared for further STEM education and careers. Still, specialized STEM high schools remained small in number and outside mainstream secondary education (Hanford, 1997).

Two political forces helped stimulate the establishment of mathematics and science secondary schools in the mid-20th century. The first of these was the U.S. desire to stay ahead of its Cold War competitor and the 1950s "space race," which sparked U.S. efforts to enhance students' science, technology, engineering and mathematics (STEM) education. Specialized secondary schools were one strategy for making sure that there would be a pipeline of science elites. The other impetus was school desegregation orders following the Brown v. Board of Education Supreme Court decision. Many large districts sought to retain white students and improve their district's racial balance by creating magnet schools or programs with an attractive set of additional education resources (Metz, 2003). Magnet schools often had a mission of serving "gifted students" or offered a specialized program with special facilities in an area such as performing arts--or mathematics and science.

In 1988, 15 schools devoted to STEM education established the National Consortium for Secondary Schools in Mathematics, Science and Technology (NCSSSMT). Over the next decade, consortium membership grew to over 100 schools (NCSSSMST, n.d.). Although the number of specialized STEM secondary schools and programs was rising, many of these schools targeted youth who already had been identified as gifted in the area or had shown promise through extra-curricular activities (competitions and science fairs). Some of these schools sought increased participation by under-represented groups, but admissions were based largely (or even solely) on performance on competitive examinations and enrollments of Hispanics and African Americans were typically low (Kaser, 2006).

Moving into the current century, calls for stepping up STEM education in the U.S. are being made with the rationalization that we need a more technically competent workforce to compete in the global marketplace and maintain the U.S. position as a world leader in innovation. Recent concern regarding STEM education has been fueled by the modest ranking of U.S. students in math and science compared to their international peers (Gonzales et al., 2004), and by the shortage of highly qualified teachers in math and science areas (Business-Higher Education

Forum, 2006). Industry leaders (Business-Higher Education Forum, 2006), state governors (National Governor's Association, 2007) and others have pointed to the predictable impact of these trends: the U.S. is not preparing sufficient numbers of students, teachers and professionals in STEM areas, putting at risk its ability to participate in the increasingly science- and technology-based global economy (EdWeek, 2008).

National concern about STEM education has motivated financial support for diverse STEM education activities. Over 200 distinct federal STEM education programs awarded a total of nearly $3 billion for STEM education in 2004, with most of the funds coming from the National Institutes of Health and the National Science Foundation (Kuenzi, 2008).

Approaches to providing stronger STEM education have included increasing STEM-focused college scholarships and improving K-12 science and math instruction (Atkinson, 2007). Set in a context of high school graduation rates averaging 69 percent (Swanson, 2008) with alarmingly low rates (60 percent) reported in urban schools, particularly those with high populations of African-American and Hispanic students, the challenge of meeting the workforce needs of the country and of ensuring an educated citizenry ready to tackle the complex, often quantitative, scientific and technological challenges of this century has sparked a strong STEM focus at the high school level.

Recent STEM Policy Initiatives

Echoing the need for stronger STEM education, several high-profile policy proposals have been put forward.

America's Competitiveness Initiative, announced by President Bush in 2006, emphasizes the importance of a strong secondary education system in improving American students' training in scientific and technical areas. Strategies promoted by the initiative include expanding Advanced Placement (AP) and International Baccalaureate (IB) programs, introducing math and science professionals as teaching faculty in high schools, appointing blue ribbon panels, initiating programs to improve math and science instruction in elementary and middle schools, and incorporating science assessments newly required under No Child Left Behind (NCLB). The 2007 legislation known as the *America Competes Act* was passed to enact the goals of the American Competitiveness Initiative.

Innovation America, launched in 2006 by the National Governors' Association (NGA), focuses on redesigning and improving state K-12 science, technology, engineering, and math (STEM) education systems. As part of this initiative, NGA released a document entitled, *Building a Science, Technology, Engineering, and Math Agenda* in February 2007, and released a request for proposals from states to develop Best Practices in Science, Technology, Engineering and Math (STEM) Centers. Colorado, Hawaii, Minnesota, Ohio, Pennsylvania, and Virginia won NGA grants to create STEM Centers.

In 2007, the National Academy of Sciences released a report entitled, *Rising Above the Gathering Storm*, calling for a comprehensive and coordinated federal investment in STEM education to bolster U.S. competitiveness in the world economy. This Congressionally requested report makes the following three specific recommendations for improving STEM education:

1) Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships

2) Strengthen the skills of 250,000 teachers through training and education programs at summer institutes, in master's programs, and in Advanced Placement (AP) and International Baccalaureate (IB) training programs

3) Enlarge the pipeline of students who are prepared to enter college and graduate school with a degree in science, engineering, or mathematics by increasing the number of students who pass AP and IB science and mathematics courses

These proposals support STEM education through promoting mathematics and science AP and IB courses and through strengthening the STEM teaching force both by attracting more qualified people to the field and by offering training in instructional techniques. They complement state and private foundation efforts to create specialized schools with learning environments that prepare students for the STEM fields. There is widespread agreement that STEM-focused schools can prepare students with demonstrated accomplishments for entry into the "pipeline" feeding into STEM college majors and careers. Concerns have been raised, however, about specialized STEM schools excluding all but the very brightest students from these sought-after STEM learning opportunities (Hanford, 1997).

Structure of this Report

The next section of this report describes the concept of an inclusive STEM school and presents a conceptual framework for STEM schools. This framework was used as the basis for developing a survey, which was sent to all known public STEM secondary schools in the U.S. The framework builds upon previous research on specialty STEM schools and on the instructional intervention literature more broadly. The third section of this report opens with a brief description of the survey methodology and then discusses survey results. Results are organized using the dimensions of the conceptual framework and are provided first for the survey sample as a whole and then separately for inclusive and selective STEM schools. The appendix contains the survey in its entirety and the response distribution for each item.

The Concept of an Inclusive STEM Secondary School

For purposes of this report and the school survey, a "STEM secondary school" is a stand-alone school, school-within-a-school, or program providing secondary students (grades 9-12) with coursework that prepares them for higher education in science, technology, engineering, or mathematics fields. Exhibit 1 displays the areas of study considered to be STEM academic fields in a recent American Council on Education investigation of minority student participation in STEM fields (Anderson & Kim, 2006).[1]

The essential difference between this approach and that of earlier efforts to feed the STEM career pipeline is the tenet that STEM talent can be developed *rather than being something innate that must be* identified.

What makes a STEM school or program inclusive? As noted in the prior section, college preparatory STEM schools traditionally have tended to employ highly competitive admissions processes, putting a heavy emphasis on performance on an entrance examination or other test. As an example, Subotnik et al. (2006) examined the entry requirements for 59 STEM specialty schools. Four-fifths of the schools (79 percent) use standardized or locally designed tests in their admissions process.

In response to the need to train tomorrow's workforce to compete and succeed in the technology-based global economy, the Bill & Melinda Gates Foundation has been among the proponents of inclusive STEM secondary schools. Rather than relying exclusively on students who have already demonstrated high achievement to pursue STEM education, the U.S. needs to inspire, engage, educate, and employ as broad a population as possible in STEM-related fields (CSEWI, 2008, NASA, 2006). The essential difference between this approach and that of earlier efforts to feed the STEM career pipeline is the tenet that STEM talent can be *developed* rather than being something innate that must be *identified*. The Foundation's hypothesis is that STEM schools do not have to be highly selective in terms of prior achievement or aptitude as measured by an entrance examination. Rather, strong teaching and student effort can prepare students from diverse backgrounds for STEM majors in college.

[1] In addition to the fields that ACE designates as STEM, the Gates Foundation's Grants Knowledge database also includes schools or programs that highlight media/arts technology or health practitioner training. These fields have been excluded from the working definition used for the survey and this report, except in cases of health programs preparing students for careers that require a bachelor's degree or more education.

Exhibit 1. STEM Academic Fields

- Mathematics
- Statistics
- Forestry
- Electrical, chemical, mechanical, civil or other engineering
- Engineering technology
- Electronics
- Natural resources
- Computer/information programming
- Physics
- Biophysics
- Geography
- Interdisciplinary studies including biopsychology
- Environmental studies
- Physical sciences
- Chemistry
- Biological science (including zoology)

Source: Anderson and Kim (2006)

In inclusive STEM schools the goal is to prepare all students for college-level STEM courses--that is to have them earn a high school diploma and become equipped to succeed in college STEM courses. This concept is a departure from prior American STEM specialty schools (as evidenced by Subotnik et al.'s review of their entry requirements) and requires fundamental changes in policies and practices.

Inclusive STEM Secondary Schools and the Conceptual Framework

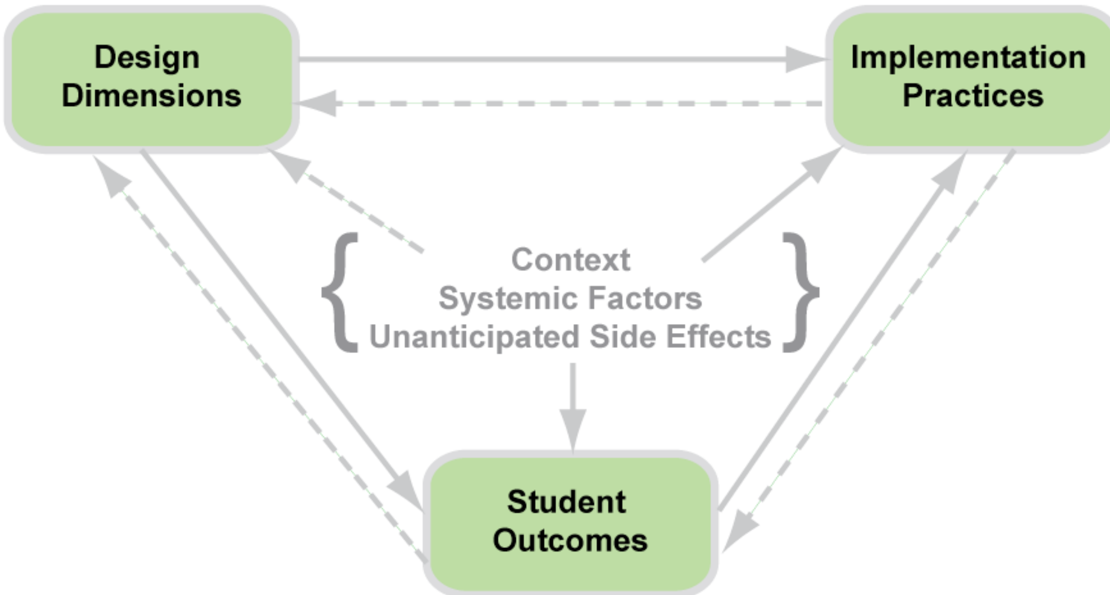
In this report, we use the term, "inclusive STEM school" to refer to the subset of STEM secondary schools seeking to serve students from groups historically under-represented in STEM fields. We define an "inclusive STEM secondary school" as a school, school-within-a-school, or school program accepting students primarily on the basis of interest rather than aptitude or prior achievement and giving students the preparation in mathematics and science needed to succeed in a STEM college major.

As a basis for developing a survey for STEM secondary schools, we developed a conceptual framework for describing specialized STEM schools that would help us think about areas in which inclusive and more traditional selective STEM schools might differ.

We describe this framework below along with some of the examples of STEM school practice that we found in the literature. The next section of this report describes the survey findings, providing the first ever national portrait of STEM secondary schools.

Our STEM schools conceptual framework drew upon and extends an evaluation framework proposed by the National Research Council (NRC) Committee that reviewed K-12 Mathematics Curricular Evaluations (Confrey & Stohl, 2004). This framework is comprised of three major components: program design dimensions, implementation practices, and student outcomes.

Exhibit 2. Primary Components of an Education Intervention



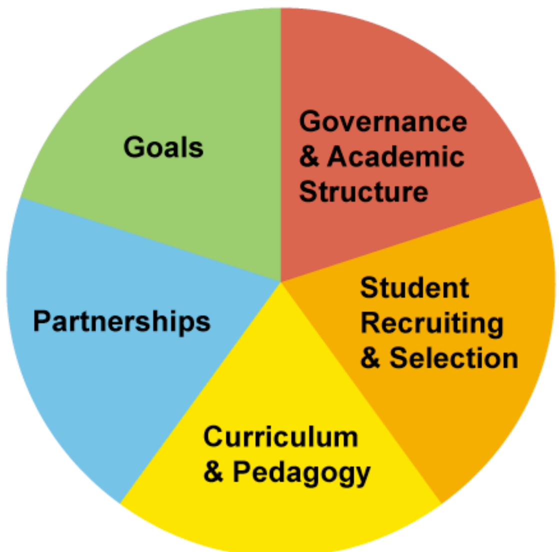
These components are commonly used in programmatic evaluation; we extended the framework to apply directly to the issues of STEM education in inclusive secondary school contexts. The framework was useful in guiding the development of the survey and the analysis of the data. In addition, the framework will assist us in delineating elements of STEM inclusive school organization and practices which may not be easily captured by a survey and will permit us to articulate recommendations for next steps in terms of further investigation using other methodologies.

The central idea conveyed in Exhibit 2 is that understanding, comparing or evaluating an educational program requires consideration of three basic components: the program's *design*, the *program as implemented*, and *student outcomes* (NRC, 2004). These components are moderated by contextual factors and other influences, such as the rest of the students' academic program, other life events, and the resources available in their communities.

The dimensions of STEM program *design* can be used to make comparisons among STEM programs, and hence offered an organizational structure for the school survey. A major purpose of the STEM survey was to identify the varieties and frequency of different types of programs. The dimensions of *implementation* can only partially be captured via surveys; questions about abstract qualities of implementation (such as the extent of "student-centered" instruction within the school) are subject to reporting biases. Information on *student outcomes* requires waiting for the inclusive schools to be sufficiently mature to have multiple graduating classes and would benefit from a different mode of data collection.

STEM School Design Dimensions

Exhibit 3. Design Dimensions of STEM Schools



Key elements of program design, as shown in Exhibit 3, include the goals of the STEM school or program, the governance and academic structure, the student recruiting and selection practices, the curriculum offered and pedagogy used in the classroom, and the school or program's partnerships with other institutions. We discuss each of these elements of program design in turn.

Goals. As suggested in the earlier discussion, different STEM schools and programs have different missions, ranging from providing gifted and talented students an elite STEM education experience, to bringing a broader set of students into advanced STEM studies, to providing students with STEM training for career preparation.

As noted above, concerns that the U.S. may be falling behind other countries in terms of production of an elite group of scientists, engineers, and mathematicians and a desire to get more talented students into the pipeline have stimulated the establishment of schools with the goal of feeding the *pipeline of STEM higher education elites* (Cavanagh, 2006). In the past, the underlying assumption was that we need to do a better job of identifying and encouraging those with STEM talent. This assumption led to a focus on early identification programs (such as the Johns Hopkins University Center for Talented Youth and Duke Talent Identification Program), competitions (Intel Science Talent Search) and special summer programs (the Ross Program).

More recent initiatives (National Research Council, 2007) embrace the more ambitious goal of *broadening participation in STEM*

In the employed labor force African-Americans make up only 4.4 percent of STEM workers and Hispanics make up just 3.4 percent (NSF, 2004).

higher education. This goal also addresses the need to produce more STEM professionals but does so by widening the pipeline, reflecting the belief that we can “democratize” participation in STEM professions by seeking alternative sources of talent. In 2004, only 8.3 percent of bachelor degrees in STEM fields were awarded to African-Americans, an increase of only 1.6 percent over 1994. Similarly, among Hispanics, the percentage was 7.1 percent, an increase of just 1.8 percent since 1994 (NSF, 2004). In the employed labor force African-Americans make up only 4.4 percent of STEM workers and Hispanics make up just 3.4 percent (NSF, 2004). The goal of broadening participation in STEM higher education responds not just to issues of social equity but also to the reality of a U.S. population that is becoming increasingly diverse (U.S. Census Bureau, 2007). As international participation in advanced STEM education increases (NSF, 2006), the United States will find itself unable to compete if it does not find a way to motivate and support a greater proportion of African American, Latino, and female students in STEH higher education. Contrary to popular belief, minority college-bound students express as much interest in STEM careers as Caucasian students do (College Board, 2005, cited in Summers & Hrabowski III, 2006). However, they continue to be underrepresented in STEM graduate programs as well as in the STEM workforce.

Other STEM schools have the goal of integrating academic learning with *career and technical education* (CTE). Traditionally CTE was a separate track of secondary education, often designed to serve the needs and interests of non-college bound students. More recently, however, policymakers are promoting career and technical education programs targeting high-growth industries such as computer networking and pre-engineering (NGA, 2007). These CTE programs incorporate academic subject matter that is both needed for college and relevant to the world of work in these careers. Such programs also strive to develop employability skills and workplace ethics as well as help students explore interests and careers as they progress through high school (ACTE Online, n.d.) Increasingly, innovative STEM programs are seeking to link CTE and academic programming in order to simultaneously meet the goal of college readiness and that of career and vocation motivation and awareness.

Governance and Academic Structure. The second dimension in the STEM school design model is governance and academic structure, two variables that capture the school’s funding and accountability and its internal organization.

Governance. Guiding the design and focus of schools, the governance system influences how a STEM school or program operates, as well as how the STEM school or program fits into a district’s or Charter Management Organization’s (CMO) strategic objectives for secondary education. Governance arrangements in STEM educational institutions can run the full gamut found in American education, with the associated influences on school funding, administration and governing body. STEM schools can be public, public charter, or independent charter. Magnet schools are typically public schools drawing students from a wider area than the school’s immediate geographic neighborhood.

Academic structure. Examples of STEM schools described in the literature suggest that they may exhibit more variability in terms of academic structure than do typical high schools. In addition to stand-alone secondary schools with distinct academic departments, there are STEM schools that include pre-secondary grades (for example, the Milwaukee Academy of Science), residential programs (such as the South Carolina Governor’s School of Science and Mathematics, a residential public school serving students from across the state), and schools offering portions of secondary program (e.g., grades 11-12 only, school-within-a-school programs, or summer and enrichment programs).

Some STEM schools also provide secondary-postsecondary combinations, such as dual enrollment, middle college, and early college high school. Dual enrollment schools provide opportunities for high school students to earn college credits for courses taken through a postsecondary institution. Courses are offered on a college campus or on a high school campus by college faculty or college-accredited teachers. Middle college is a form of dual enrollment which aims to increase college access for traditionally underserved students and decrease high school dropout rates by providing extensive academic and social support. Typically, community college courses are optional for 11th and 12th graders in middle college schools. Early College High Schools (ECHS) combine grades 9-14 into one institution, giving all students the opportunity to earn a high school diploma plus two years of college credit. ECHSs are designed to be small, autonomous high schools that blend high school and college into a coherent education program, especially for low-income, first-generation college-goers or traditionally underserved students. An example of an Early College High School is the Academy of Mathematics, Engineering, and Science Charter School, partnered with the University of Utah (Cavanagh, 2006; Martinez & Klopott, 2005; Subotnik, Rayhack, & Edmiston, 2006).

Student Recruiting and Selection. A third dimension along which STEM schools and programs vary is how they recruit and select students. We drew a distinction between *recruiting*, defined as seeking out students and encouraging them to apply, and *scouting,* which involves searching for talented individual students. The former approach is more compatible with the goals of inclusive STEM schools while the latter is more characteristic of selective institutions. Either of these strategies can be applied to seeking students generally or to seeking students from among groups historically under-represented in STEM fields.

The literature on specialized STEM schools includes descriptions of a number of strategies for recruiting students from under-represented groups. In addition to working cooperatively with local feeder schools, and linking to other informal STEM programs that serve minority students (e.g., local science centers, competitions, science camps), recruiting strategies described in the literature include targeted recruiting and bridge programs. *Targeted recruiting* involves identifying schools or other programs with large proportions of historically under-served students and concentrating recruiting activities in those locations. For example, High Tech High School in San Diego has worked with the African American church community in San Diego and with the San Diego Workforce Partnership's Youth Opportunity program to recruit students from lower-income and minority families.

Bridge programs offer intensive curriculum for small groups of students, as students rise between grade levels or between schools. Bridge programs may serve as a form of recruiting, but their principal goal is to improve the academic preparation of all participating students As an example, the Illinois Mathematics and Science Academy offers a residential summer program and a Saturday program for prospective, under-represented students to promote their interest in STEM subjects in general and in the school in particular. The summer program provides students with opportunities for group inquiry and problem solving as well as the residence hall experiences (Kaser, 2006).

In addition to recruiting students, STEM schools and programs also must *select* members of the incoming classes to fill a limited number of spaces. The most prevalent strategy among STEM schools studied by Subotnik, Rayhack, and Edmiston (2006) was competitive selection relying on standardized or locally developed tests; other criteria include prior achievement, teacher recommendations, and demonstrated interest and motivation.[2] Many STEM schools employ these mechanisms in various combinations (Kaser, 2006). Just two of the 59 STEM schools reviewed by Subotnik, Rayhack, and Edmiston use a nonselective lottery.

For the schools or programs that select students based on interest and motivation as part of the admission packet, typical application requirements include student essays on how they became interested in science, math, or engineering as a major; detailed descriptions of previous science projects; interviews; and written recommendations from teachers.

Curriculum and Pedagogy. A fourth dimension on which STEM schools vary is in their curricular and pedagogical approaches.

Curriculum. One element of curriculum variation is whether the school attempts to offer a full range of science and mathematics topics or elects to concentrate on preparation in a particular subfield (such as engineering or biotechnology). Examples of schools with such academic themes include Maritime and Science Technology High School in Miami and The School of Computer Technology at Atkins, located in Winston-Salem, NC.

Another type of curricular variation among STEM schools concerns the way in which they treat the integration of different disciplines or topic areas. Are the STEM disciplines taught as distinct and "siloed" fields, adding "layer cake" course sequences culminating in Advanced Placement or college level courses? Or are the STEM disciplines taught in a more integrated fashion, exploring connections between the fields?

All eight of the STEM schools reviewed by Kaser (2006) offer basic, intermediary, and advanced STEM courses in distinct STEM disciplines, such as Algebra and Advanced Algebra, Biology and Honors Biology, AP Computer Science, Mathematical Modeling, and Organic Chemistry. All of these schools also offer advanced courses for college credits.

In the last 20 years, an alternative strategy for sequencing STEM course work has emerged in which topics from a variety of subfields are integrated. In mathematics, this trend has led to the articulation of standards for mathematics in two forms: traditional and integrated. For example, the College Board's *Standards for College Success: Mathematics and Statistics*. and Achieve's *Secondary Mathematics Expectations* released high school standards in traditional (Algebra I, geometry, Algebra II, etc.) and integrated (algebra, geometry, statistics, and discrete mathematics topics taught each year) form.[3] Some states, likewise, provide two alternative approaches for

[2] Competitive admission policies are used by elite STEM schools internationally as well. For example, acceptance into governmental residential programs in Korea requires evidence of high performance in middle schools (achievement in the top 1-3%), good performance on entrance exams in mathematics, science, Korean, and English; and awards and honors in science competitions (e.g., Science or Math Olympiad) as well as a health exam and interview (Jin & Moon, 2006).
[3] Available at http://www.collegeboard.com/about/association/academic/academic.html and http://www.achieve.org/node/479.

sequencing mathematics topics, and recently the State of Georgia opted to require the use of an integrated approach. Similar issues of integrated course work are found in science, especially through efforts to increase attention to cross-disciplinary topics such as engineering.

Thus, there is no widespread consensus on whether and how different STEM disciplines should be integrated (Czeniak et al. 1999; Huntley, 1998; Hurley 2001). Geradts et al. (2006) promote the idea of bringing coherence to STEM education by stressing trans-disciplinary concepts such as "systems" and "modeling" as well as student ability to transfer knowledge and skills within and between disciplines. Based on this idea, a movement to define a concept of "transdisciplinary" STEM courses is surfacing and replacing the terms "multidisciplinary" or "interdisciplinary," terms that have been challenged because they take the boundaries of the current disciplines for granted *a priori.* Examples of the transdisciplinary approach to curriculum include CalSci (Science Framework for California Public Schools) in California and PING (Practicing Integration in Science Education) in Germany, which address social issues that go beyond traditional discipline-oriented subjects and require more than one discipline for solution.

STEM curricula vary also in the extent to which they take an applied orientation. Career and technical education (CTE) curricula are designed to provide training in specific technical fields (e.g., automotive technology, information technology, agricultural mechanics). These curricula are designed to train students for industry-defined positions and to equip them for advanced and continuing education in that field (Stone III, Alfeld, Pearson, Lewis, & Jensen, 2006). Examples include the requirement at McKinley Technology High School in Washington, D.C., for students to select a career and technical education focus (biotechnology, broadcast technology, or information technology) for their junior and senior years.

Pedagogy. Just as STEM schools and programs make curricular choices, they also choose among differing approaches to pedagogy. Schools and programs can select from or combine traditional, teacher-led forms of instruction; project-based learning; workplace or lab-based learning; and the use of technology-supported learning tools, to name a few prominent options.

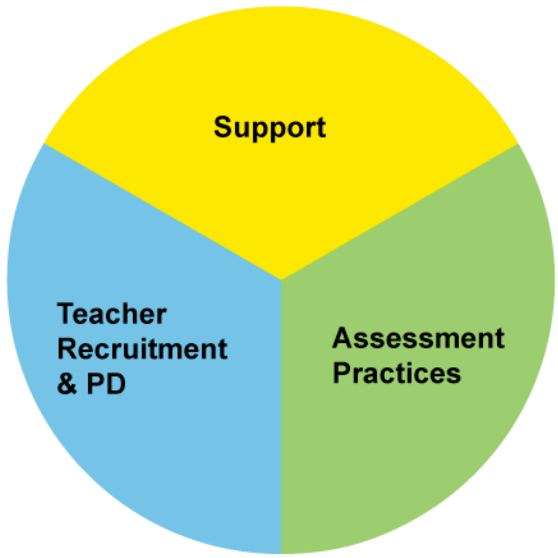
Many STEM schools offer internships, mentor programs and other learning experiences outside of school (e.g., science and STEM centers). The eight STEM schools reviewed in Kaser (2006), for example, all require a research project, mentorship, or internship.

Increasingly, technology is a part of the practice of STEM professions, and practitioner tools (such as GIS software) or simplified versions of them (such as Northwestern University's WorldWatcher) are finding their way into secondary STEM courses (Edelson & Reiser, 2006). Other technology-supported systems seek to apply cognitive science ideas about knowledge integration to an on-line support system combining information resources and scaffolds for student thinking with the goal of making complex ideas, such as thermodynamics, accessible to a broader set of students (Linn, 2006). An international comparative study noted that students were using appropriate technology tools for learning and for tasks involving design, creativity, problem solving, and application of knowledge, rather than learning technology as a school subject (Atkin, 1988).

Partnerships. Finally, an important dimension around which STEM schools differ is the extent to which they create and integrate partnerships with outside organizations into their design and operations. Partner organizations may include corporations, institutions of higher education, regional STEM Centers, and museums. These partnerships can range from loose associations with a few joint activities to partnering on essential functions such as operations, curriculum, and securing resources. From the schools' perspective, partnerships can provide both curricular and laboratory resources and can serve as an entrée for students into a professional STEM community, helping schools offer students more creative programs, role models, support, and continuity across school years and institutions.

Implementation

Exhibit 4. Elements of implementation



The second major component of the STEM school framework is implementation. This component addresses the ways in which an innovation or program unfolds in a particular setting. Implementation includes the ways in which intended program elements function within the context of the resources, setting, structures, and capacity of a particular site. Professional development is key to implementation as are the timeline and sequence in the plan for change. Classroom-based assessment practices provide information to the teacher on how his or her implementation of instruction is affecting student learning, thus playing a key role in using feedback for systemic adjustments. In this section, we discuss three specific implementation topics that research suggests have a major influence on successful school implementation: support structures, teacher recruitment and professional development, and assessment practices.

Support Structures. One category of implementation conditions concerns the academic support structures in place for students. These can include tutoring and special support classes, academic counseling and advising, and commitments of scholarships. *Tutoring* is a common support that cuts across the eight STEM schools reviewed in Kaser (2006), and may be offered during school (e.g., "study block"), lunch time, after school, on Saturdays, or during the summer. It may be offered by teachers, paid tutors, and / or peers. Some schools hire private companies (e.g., Back to Basics, Kaplan) to provide tutoring services. Additionally, some schools provide *special classes* for those who are in need of academic support.

Performance-based assessment practices, especially those incorporating technology, have an authentic fit with STEM disciplines.

Scholarship commitments are another key support for students within STEM secondary schools. For example, North Carolina School of Science and Mathematics provides state-backed tuition grants for all its graduates to attend a UNC-system university (Kaser, 2006).

Other student supports are not explicitly academic in nature but nevertheless foster academic success by addressing youth development needs. These may include counselors, nurses, internship coordinators, and mentors. Also in the category of non-academic programming are social-cultural activities and clubs, some of which may be directed specifically toward the interests of under-represented students.

Teacher Recruitment and Professional Development. Any STEM school needs to recruit qualified teachers with both STEM expertise and pedagogical skills, but an inclusive STEM school needs especially skilled teachers to work with a broad range of achievement levels, hold high expectations for all students, and hold a commitment to helping students advance whatever their entering knowledge and skill levels. Research on professional development in mathematics and science suggests that it is essential that teachers facing these challenges should receive ongoing professional development and support that is learner-centered as well as knowledge-centered (National Research Council, 2000). Professional development should also link directly to curricular programming and include both extended interactions and follow-up activities (Borko & Putnam, 1995). Some schools provide this kind of intensive, continuous professional development, but the majority do not (U.S. Department of Education, 2000).

Building in ways to work with groups of teachers from the same school or region supports better program implementation. Geraedts et al. (2006) stress the importance of teacher professional development and of teacher collaboration, and recommend that schools provide structures and facilities that support teacher collaboration through such measures as organizing around units of several subjects or by groups of students, rather than single-subject academic departments, and providing time for teachers to collaboratively develop instructional materials. These are phrased as recommendations and not STEM-specific. Reads as being off track, but with re-writing could be more linked in.

Assessment Practices at the Classroom Level. Performance-based assessment practices, especially those incorporating technology, have an authentic fit with STEM disciplines. Student projects are easily documented using portfolios or digital portfolios. In addition, technology can be used to support the administration and almost instant scoring of formative assessments—those conducted during instruction to inform additional instruction on the same concept or skill--so that teachers can use the information “in the moment” (Means, 2006).

Formative assessments help teachers shift in their purpose from topic coverage to student mastery (Wiliam, 2007). They can be used to obtain early and continuous feedback about how offerings are working both for students as a whole and for different subgroups within the classroom. Formative assessment data help teachers identify the ways in which intended program elements function within the context of the resources, the setting, the structures, the capacity, the professional development and the timeline, sequence and plan for change.

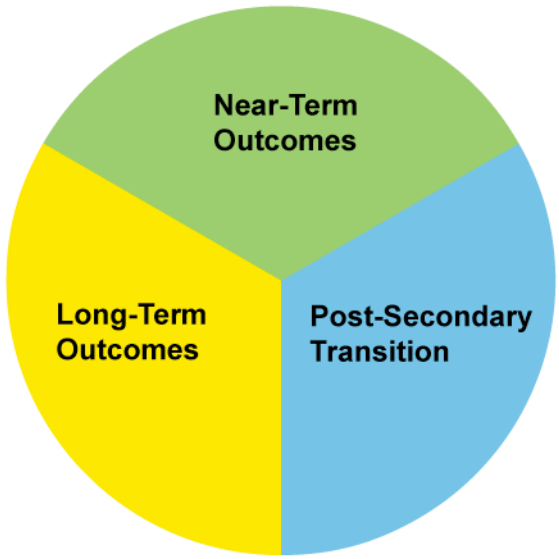
Minstrell's DIAGNOSER system (2000) is an example of an assessment designed for formative use. DIAGNOSER contains science assessment items carefully constructed such that each possible student response is associated with a different conception of the science concept being addressed. Students' responses to DIAGNOSER items provide teachers with information about the misconceptions that need to be corrected through further instruction. In mathematics, Ginsberg's (2004) m-Class software (Wireless Generation) supports teachers' use of diagnostic interviews with hand-held devices that collect, upload and display data on student thinking. Similar approaches based on learning trajectories are under development for rational number (Confrey, 2008).

Formative and performance-based assessment practices are the exception rather than the rule in the U.S., but some education systems put more emphasis on them. In France, for example, large-scale diagnostic assessments are given at the beginning of the year, rather than at the end, to help teachers identify what students have to learn and plan their instruction accordingly (Atkin, 1988).

Summative assessments (conducted at the end of a period of instruction to assess whether learning has occurred) can also play a role in a school's continuous improvement efforts. For example, the Missouri Academy of Science, Mathematics, and Computing developed the "Core Assessment of Science and Mathematics" with help from faculty at a local university, and uses it as a pre- and post-test, with administration first in the freshman year before fall classes begin, and again in the senior year two weeks prior to graduation, to document student achievement and demonstrate accountability to the school's stakeholders (Theodore & Pinizzotto, 2006). In general, however, the scarcity of good summative assessment instruments for the STEM content that schools actually teach, has impeded efforts to use summative assessment data to demonstrate progress and inform improvement efforts.

Outcomes

Exhibit 5. Student Outcomes



The third major component used to conceptualize STEM schools (in addition to the program's design and the program as implemented) is the outcomes experienced by students in these schools and programs. Outcomes can be broken into three groups: near-term outcomes, post-secondary transition outcomes, and long-term outcomes. (As shown in Exhibit 5.) Near-term outcomes concern student experiences while they are in secondary school. Near-term outcomes for which goals may be set and progress evaluated include earned credits; successful completion of STEM "gatekeeper" courses; successful completion of honors/AP/IB STEM courses; standardized test scores; prizes, awards, and external recognition; and portfolios of student work. Postsecondary transition outcomes describe student experiences and performance with respect to the move from high school to college. Measureable student transition outcomes include secondary graduation and dropout rates; college-ready graduation rates; college admissions; scholarship offers received; and college major intentions. Long-term outcomes look at student experiences in college and beyond. These include college entrance; college major selection; STEM credits accumulated; college graduation; and employment in a family-wage position in a STEM-related field.

Available research suggests that a career orientation in secondary education is associated with improved students outcomes on a number of measures. In a study of career academies, Maxwell (2001) looked at near-term, transition, and long-term outcomes. The study found that among students at risk of dropping out, those in career academies had lower drop-out rates, better attendance, increased academic course taking, and increased likelihood of graduating on time compared to students in traditional high schools. There was no difference in math or reading achievement scores, however. Maxwell (2002) reported that career academy students were less likely to enroll in college than those in traditional high schools, but when they did enroll in college, they had less need for remediation, and were more likely to graduate rather than dropping out. The career academies in Maxwell's study took students at greater academic disadvantage – they started with lower GPAs and had more hardships and lower SES than the students in the traditional high school sample.

The documentation of student outcomes for all schools, including STEM schools and programs, is fraught with challenges. It is important to note for STEM schools and programs that work to build diverse student bodies that outcomes should be tracked by student subgroups as well as the student body overall. However, designing a program to optimize performance on some outcomes may mean sacrificing others, especially when differential outcomes for different student groups are considered. Raising graduation standards, for example, can increase academic rigor, but often has the unintended side effect of increasing dropout rates. The complexity of the education system necessitates tracking multiple outcome measures for all important student subgroups in order to weigh the advantages and disadvantages of new programs and approaches.

Although student outcomes are presented here as one of three key components used to conceptualize schools, the survey used in this study of STEM schools and programs did not include questions on student outcomes. This was for two main reasons, one being that so many of the STEM schools in the survey database are too new to have data available on key student outcomes, and secondly because of the difficulty in gathering high-quality, comparable outcome data through a school-level self-report tool such as a survey. Instead, the survey focused on program design and program implementation, in order to describe the STEM schools and programs in the U.S.

Exhibit 6 summarizes our conceptual framework by displaying the three major components of an intervention, the dimensions within each component, and alternative approaches that STEM schools can use to address each dimension.

Exhibit 6. Elements of the STEM School Framework

Components/Dimensions	Alternative Approaches
Design	
Goals	Feed STEM elite pipeline Broaden participation in STEM higher education Provide career and technical education
Governance and Academic Structure	Public regular Public charter Proprietary Stand-alone school School-within-a-school Program Dual enrollment
Student Recruiting and Selection	Targeted recruiting Scouting Bridge programs Competitive admissions Lottery-based admissions
Curriculum and Pedagogy	Full range of science and mathematics Academic theme focus Transdisciplinary focus CTE curriculum Teacher-led instruction Project-based learning Internships and workplace learning Technology-supported learning
Partnerships	Institutions of higher education Regional STEM centers Corporations/businesses Museums/research centers
Implementation	
Support Structures	Tutoring Scholarship commitments Non-academic supports
Teacher Recruitment and Professional Development	Recruiting for STEM certification Alternative certification programs One-time workshops Ongoing professional development

Components/Dimensions	Alternative Approaches
Implementation (Continued)	
Assessment Practices	Formative assessment
	Performance assessments
	Summative assessment
Outcomes	
Near-term Outcomes	Earned credits
	Successful completion of "gatekeeper" courses
	Successful completion of honors, AP, or IB courses
	Standardized test scores
	STEM prizes or awards
	Portfolios of student work
Post-secondary Transition Outcomes	High school graduation
	College-ready graduation
	College admission
	Scholarship offers
	College major intentions
Long-term Outcomes	College entrance
	STEM college major
	STEM college credits accumulated
	College graduation
	Employment in STEM-related field

The STEM School Survey

Previous case study research provided insights into the designs and practices of U.S. STEM schools and helped inform the STEM school conceptual framework described in the last section. What case studies cannot do, however, is to provide a sense of the prevalence of different design features and implementation practices. The Bill & Melinda Gates Foundation commissioned SRI International and its consultants to compile a registry of U.S. STEM secondary schools and programs and to conduct a survey of those schools to ascertain basic information concerning their enrollment, staff, educational offerings, and student supports. The structure of the survey was drawn from the conceptual framework for secondary STEM schools and programs. The complete survey and distribution or responses can be found in the Appendix to this report.

Three main sources were used to identify STEM secondary schools and programs:

- National Consortium for Secondary Schools in Mathematics, Science and Technology (NCSSSMT) membership list
- Bill & Melinda Gates Foundation database of funded secondary schools, and
- The listing of STEM specialty schools studied by Subotnik, Raychack and Edmiston (2006), which was derived from web searches of the programs for talented youth provided by the Johns Hopkins University Center for Talented Youth.

After removing duplicate entries, schools that were clearly and exclusively middle schools, vocational-technical programs, or programs that focused only on health practitioner training, these sources yielded a list of 374 STEM secondary schools and programs which were contacted with a request to complete the STEM Secondary School Survey. Of the schools contacted, 59 of them determined that they did not meet the definition used by the survey. Examples of contacted schools or programs not meeting the criteria for inclusion in the survey sample include a career and technical center offering preparation for automotive, construction and culinary careers; a school with an applied agriculture and veterinary theme; and an Early College High School that provides general college preparation curriculum without a STEM emphasis.

After corrections based on school input, the STEM School Registry contained 315 schools and programs. The schools in the survey sample came from 35 different states and the District of Columbia and ranged in size from 13 to nearly 4,500 students. All were public schools, and 92 percent were tuition free (3 percent charge tuition for all students and another 6 percent for some students, such as those coming from outside the school's district). Of the 315 schools replying to the STEM school survey, 209 had received support from the Bill & Melinda Gates Foundation. (Typically this support was not in the form of funds provided directly to the school. Rather an intermediary organization, such as a charter management organization or a local education foundation, received Gates Foundation funds that were used to support STEM secondary programs.)

The survey data collection period of November 2007 through May 2008 yielded responses from 203 schools or programs, yielding a response rate of 66 percent. The response rate for schools that had received Gates Foundation funding was 58 percent (n = 122) while that for other schools

was 76 percent (n = 81). Thus, while a majority of STEM schools in the survey sample have received support from the Gates Foundation, this condition appears to be true for the population of STEM secondary schools as well.

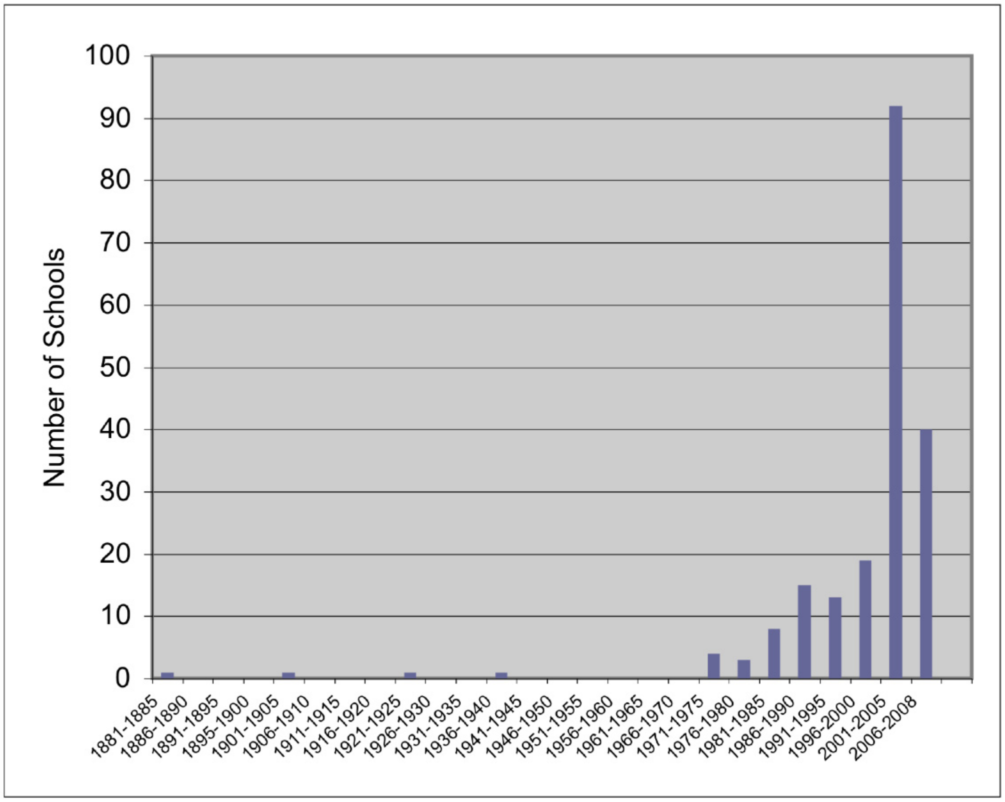
Survey Findings: All STEM Schools Surveyed

Design Dimensions

Goals. In responding to the survey question about their school's mission, 89 percent of respondents identified their school's mission as "preparing students for college majors and subsequent careers in STEM fields." Thus, the schools are quite uniform in terms of the kinds of outcomes they want for their students. When asked to choose the most fitting from a set of alternative descriptions of their school's focus, 55 percent of STEM schools describe their focus as "preparing underrepresented/ minority students for the successful pursuit of advanced STEM studies", and 24 percent describe it as "providing gifted and talented students with accelerated and advanced STEM coursework." Thus, there is considerable variation among STEM schools in terms of whether they are trying to maximize the potential of those who have already demonstrated talent or to develop talent among students who are otherwise unlikely to pursue STEM fields in college. (This distinction is related to that between inclusive and selective STEM schools. Separate survey results for the two school types are reported later on in this section.)

This difference in the schools' goals appears to be related to the year in which a school was established. The oldest of the schools in the survey sample was nearly 125 years in age, but the median year of opening was 2003, and more schools opened in 2004 than any other year. Exhibit 7 shows the distribution of school opening years among the survey sample.

Exhibit 7. Year of Opening for STEM Secondary Schools



When we examined the school's focus for schools established in different historical eras, we found that STEM schools established in 1999 or earlier were most likely to have a focus on gifted and talented students while those founded in 2000 or later were most likely to seek to serve under-represented and minority students. This relationship is demonstrated in Exhibit 8.

Exhibit 8. STEM School Focus by Year of Opening

Focus	Year of Opening 1999 or earlier n = 56	2000-2003 n = 41	2004-2007 n = 99
Gifted and talented students	59%	20%	6%
Underrepresented/ minority students	25	51	73
Other*	16	29	21

* The typical explanation of this choice was "we serve both."

Governance and Academic Structure. The survey responses suggest that most STEM schools are organized as either stand-alone schools (43 percent) or a school-within-a-school (38 percent).[4] Other forms of organization, used by small percentages of STEM schools, include district science centers where students from multiple schools take their science classes.

In terms of governance structure, 80 percent of STEM schools are public, noncharter schools and 15 percent are charter schools. None of the schools responding to the survey described itself as private. A third of STEM schools describe themselves as magnet schools or magnet programs within schools.

Recent policy initiatives aimed at easing the transition between secondary and post-secondary education appear to have influenced STEM schools: 37 percent describe themselves as part of a secondary-postsecondary combination program, such as dual enrollment, early college high school, or middle college.

STEM secondary schools and programs typically focus on serving students in grades 9-12. Only 14 percent of responding schools indicated that they serve other grades.

The majority of STEM secondary schools (73 percent) describe their academic organization as traditional, discipline-based departments. However, 31 percent do subdivide their grades into smaller groupings (sometimes called "houses" or "families") and 24 percent use "looping" (with students staying with the same teachers for 2 years or more).

[4] Schools-within-a-school might be called a career academy, small learning community, or a program.

Sixty-three percent of the STEM schools reported having more applicants than openings.

Student Recruiting and Selection. When asked to describe the area from which they recruit students, 31 percent of STEM schools say that they draw students from the neighborhood in which the school is located.[5] Expanding out from the neighborhood, 55 percent of STEM schools report that they draw students from the district within which they are located; 33 percent say that they draw students from several districts; and 10 percent report a wider draw (either an entire state or a national or international pool). The 10 percent of schools with a state, national, or international draw overlap to a considerable extent with the 9 percent of STEM schools that have residential programs.

Sixty-three percent of the STEM schools reported having more applicants than openings. Those schools receiving more applications than openings were asked to describe the criteria that they use in selecting students. Prior achievement (for example, GPA or successful completion of algebra) is considered by 63 percent of STEM schools making selection decisions. Score on an examination is a factor for 56 percent. An interview and recommendations are considered by 64 percent. A student's ethnicity or neighborhood of residence is considered by 44 percent. The relative weight given to these factors varies between selective and inclusive STEM schools, or course, and these differences are described later in this report.

The mean number of students per grade ranges from 132 (for 12th grade) to 148 (for ninth grade) with an average grade 9-12 enrollment of 457. Of these students, 54 percent are male and 46 percent are female; 45 percent are eligible for free or reduced-price lunch. Overall, the schools report 43 percent of their students are White, 26 percent African-American, 19 percent Hispanic, and 10 percent Asian or Pacific Islander.[6]

Curriculum and Pedagogy. Graduation requirements in STEM schools, on average, are 3.42 years of science, 3.32 years of mathematics, .88 year of Computer Science, 3.62 years of English, 3.08 years of Social Studies, and 1.60 years of a world language. Most STEM secondary schools (62 percent) also require participation in research projects; some (33 percent) require internships or enrollment in one or more college courses (25 percent).

STEM schools are expected to offer more advanced, rigorous coursework in science and mathematics. At the same time, the small size of the average STEM school may well limit its ability to offer a broad range of such courses. On average, STEM schools offer 1.96 AP science courses and 1.46 AP mathematics courses. About half of STEM schools offer AP Computer Science. Few offer International Baccalaureate (IB) courses.

In terms of academic program, 37 percent of responding schools indicated that they have a special academic theme, such as biotechnology or computer science.

[5] The survey item asked respondents to "select all that apply."

[6] Demographic composition varies dramatically by school type, however, as discussed below. For this reason, these overall averages are not typical of individual schools.

Schools' responses to survey items concerning their instructional approaches are shown in Exhibit 9. Given these schools' STEM specialization, it is not surprising that the overwhelming majority report that they emphasize lab-based science learning and use of technology-supported learning tools. More surprising is the widespread emphasis on project-based learning (85 percent). The popularity of this instructional approach was unexpected, given past research suggesting that mathematics teachers tend to be more traditional than other teachers in terms of their pedagogy (Ravitz, Becker, & Wong, 2000).

Of course, survey data are self reports, typically from principals rather than teachers, and survey questions concerning topics as abstract as pedagogy are open to multiple interpretations.

Exhibit 9. Instructional Approaches Used in STEM Schools

Instructional Approach	Percent Schools Emphasizing	Percent of Courses Using*
Lab-based science learning	97%	61%
Technology-supported learning tools	94	74
Project-based learning	85	62
Workplace learning	55	32

* Percent of courses within those schools that emphasize the approach.

Implementation

Support Structures. STEM schools offer their students a number of supports, which may be particularly important for students from groups under-represented in STEM or who would be the first in their families to attend college. Tutoring or special classes for students needing extra academic support are offered by 97 percent of STEM high schools, and the schools estimate that an average of 49 percent of their students participate in such programs at some time. More than two-thirds of STEM schools (69 percent) offer test preparation classes for college entrance examinations, and an average 46 percent of students at the schools offering these classes participate in them.

Supports for the affective or motivational preparation of students are somewhat less common than academic supports. Forty-one percent of STEM schools have regularly scheduled times for interactions with STEM professionals with demographic backgrounds similar to those of the students (47 percent of students participate at schools with the programs). Thirty percent emphasize motivation and support programs such as AVID and MESA: an average of 33 percent of the students at the schools with such programs participate. As noted above, 37 percent provide access opportunities to take college courses, an option that may provide benefits in terms of motivating students as well as providing exposure to advanced academic content.

Teacher Recruiting and Professional Development. Students in STEM high schools or programs are served, on average, by 46.31 full-time and 15.11 part-time teachers. STEM schools report that an average of 82 percent of their STEM teachers have college majors or advanced degrees in STEM fields. Fifty-five percent of STEM schools reported that they provide joint planning time for teachers who work with the same students.

All of the selective schools and 77 percent of the inclusive described their mission as "preparing students for college majors and subsequent careers in STEM fields."

How Selective and Inclusive STEM Schools Differ

The above description provides a portrait of the state of STEM specialty high schools in the U.S. in general during the 2007-08 academic year. Given the emergence of the inclusive STEM school concept and the major role that Gates Foundation philanthropy has had in supporting the creation of such schools, one would expect that the average statistics are a blend of data from traditional selective and newer inclusive schools. In the next stage of survey analysis, we developed criteria for identifying a school or program as having either a selective or inclusive approach to STEM education, so that we could describe their survey responses separately.

Schools' responses to survey items concerning their selection criteria, goals, and target student population were used to distinguish selective and inclusive STEM schools. Details of this classification process are provided in Appendix B. Below we describe survey responses separately for selective and inclusive schools, emphasizing areas on which they differ.

Design Dimensions

Goals. Since the school's stated mission and focus were among the factors used to identify the two types of schools, they naturally differ in these respects. The difference was marked in terms of school focus: when asked to choose the statement that best describes their focus 59 percent of the selective schools and none of the inclusive schools said that it was "providing gifted and talented schools with accelerated and advanced STEM coursework." Among inclusive STEM schools, 90 percent chose the statement "providing underrepresented/minority students with preparation for the successful pursuit of advanced STEM studies."

The two school types were less different in terms of their stated mission: All of the selective schools and 77 percent of the inclusive described their mission as "preparing students for college majors and subsequent careers in STEM fields."

Governance and Academic Structure. The survey reveals some characteristics that differentiate selective and inclusive schools. Inclusive STEM schools are, on average, younger than the selective schools, with a median opening year of 2004 in contrast to 1994, the median year in which the selective schools opened. Most of the STEM schools are public noncharter schools, but there are more charter schools among the inclusives (23 percent compared to 1 percent of the selective schools). The inclusive schools are more likely to be organized as regular stand-alone schools (56 percent compared to 33 percent of the selective schools), but the two types are about equally likely to describe themselves as a "school-within-a-school" (37 percent of selective schools and 31 percent of inclusive schools).

Selective STEM schools are more likely to be designated as a gifted/talented school (40 percent compared to 4 percent for the inclusives) and to be designated a magnet school or program (44 percent versus 27 percent).

Inclusive STEM schools are two and half times more likely than the selective schools to describe themselves as career and technical schools (24 percent versus 10 percent). Inclusive STEM schools emphasizing career technical education (CTE) see this emphasis not as a reflection of limits to their students' potential but rather as a response to their students' economic needs:

> We have a program with a strong emphasis and support for technical training. As a school that finds its self pulling from a large inner-city population and with an increasing number and percentage of students coming from poverty, providing students with career skills and job training makes college possible. Our . . . academy integrates both college preparatory and career-technical education to provide students with the broadest possible exposure. We realize that many of our students must work to support their families and if through our career focus they can obtain a higher paying job then that makes college even more of a possibility.

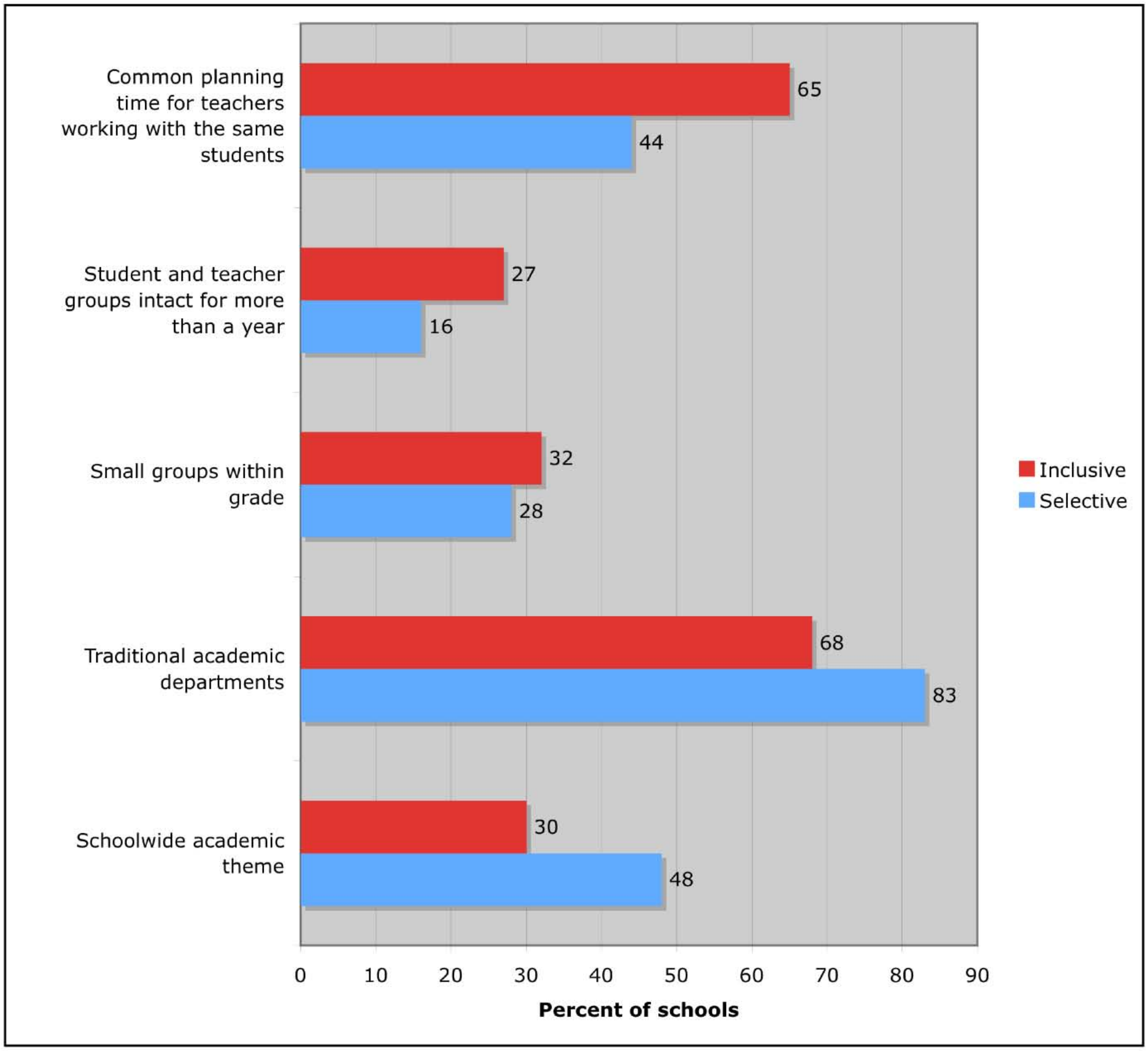
Exhibit 10 summarizes the data on school characteristics by exclusivity category.

Exhibit 10. STEM School Characteristics by School Type

Characteristic	Selective n = 80	Inclusive n = 71
Residential program	18%	1%
Career technical school	10	24
Gifted/talented school	40	4
Magnet school or program	44	27
Secondary/postsecondary combination	39	37

In terms of academic structure, inclusive STEM schools appear to be somewhat more likely than selective STEM schools to be using reform-oriented structures intended to provide students with more personal attention, as shown in Exhibit 11. Inclusive STEM schools are somewhat more likely than selective schools to maintain intact groups of students and teachers for two years or more (27 percent versus 16 percent). They are also more likely to provide common planning time for teachers of different disciplines who teach the same students (65 percent versus 44 percent) and are less likely to be organized into traditional departments (68 percent versus 83 percent of the selective schools). The inclusive STEM schools are less likely than the selective schools to feature a schoolwide academic theme (30 percent versus 48 percent).

Exhibit 11. Academic Structures in Selective and Inclusive STEM Schools



Student Recruiting and Selection. The majority of STEM schools, whether inclusive or selective, require their students to come from a certain district or subdistrict (69 and 73 percent, respectively). Given this requirement, it is not surprising that both types of STEM schools are most likely to describe themselves as drawing students from the districts within which they reside. Even so, roughly a fifth of selective schools describe themselves as drawing students from state, national, or even international sources (19 compared to 2 percent of inclusive schools).

The majority, but by no means all of both inclusive and exclusive schools report have more applicants than openings. The percentage of schools reporting more applicants than they can admit is 64 percent for selective schools and 54 percent for inclusive schools. Among these, the mean number of applications per ninth-grade opening is 5.12 for selective schools and 2.88 for inclusive schools.

Schools with more applicants than openings were asked to portray their selection criteria by distributing 100 points across seven possible criteria (including an option for "other"). The mean of weighting (percent of points) ascribed to each selection factor by selective and inclusive schools is shown in Exhibit 12. Selective schools weigh prior achievement and examination scores most heavily in choosing their student bodies; inclusive schools rely more on random-selection mechanisms such as lotteries.

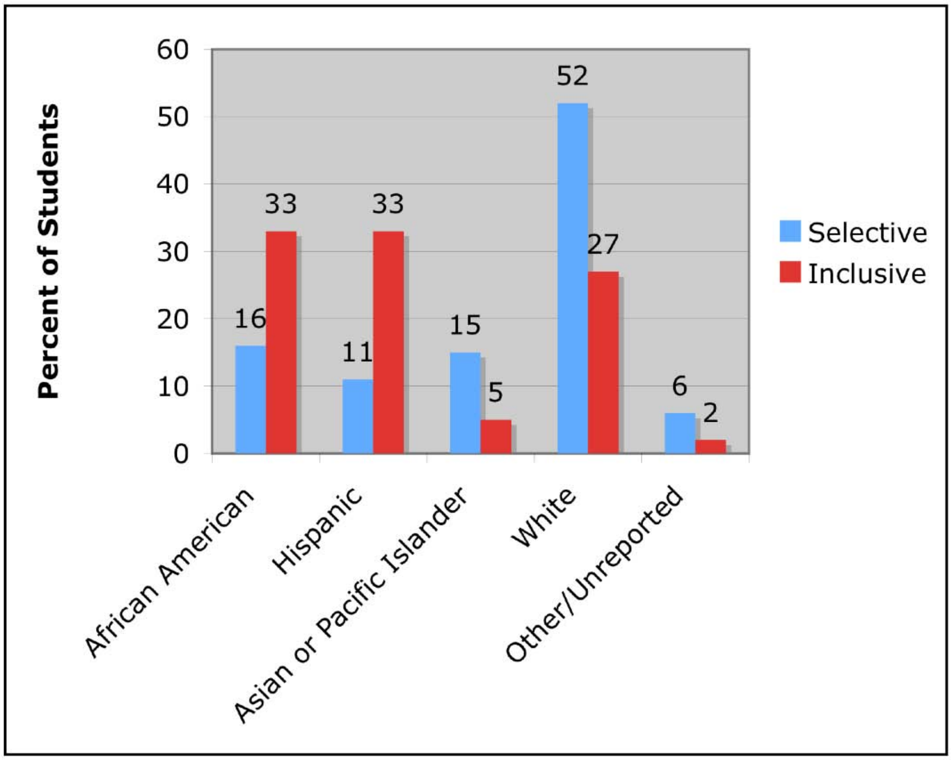
Exhibit 12. Mean Weighting of Selection Factors by School Type

Selection Factor	Selective n = 80	Inclusive n = 71
Prior achievement (e.g., GPA, courses taken)	38%	12%
Examination score	37	2
Interview and recommendations	16	17
Chance (i.e., lottery)	4	61
Student ethnicity or neighborhood of residence	4	20
First come, first served	0	3
Other	20	18

The different missions and student selection practices of the two school types displayed in Exhibit 12 result in very different student bodies. At the inclusive schools, 58 percent of students qualify for free or reduced-price lunch compared to 27 percent in selective schools.

Exhibit 13 compares the demographic composition of inclusive and selective STEM schools. Inclusive schools have higher proportions of African American students (33 percent compared to 16 percent for selective STEM schools) and of Hispanic students (33 percent compared to 11 percent for selective schools). A greater proportion of the students at selective STEM schools are white (52 percent compared to 5 percent for inclusive schools) and Asian or Pacific Islander (15 percent compared to 5 percent within inclusive schools). The proportions of males and females at the two school types are comparable.

Exhibit 13. Student Ethnic Backgrounds in Selective and Inclusive STEM Schools



Curriculum and Pedagogy. Forty-eight percent of selective STEM schools and 30 percent of inclusive STEM schools report that their school has one or more specialized academic themes, such as computer science or biotechnology. Common themes for both selective schools and inclusive schools include computer science, biotechnology, engineering, and information technology.

When asked to describe in their own words the characteristics that distinguish their school from other STEM schools, respondents for selective schools were most likely to write about opportunities to take college courses while in high school and extended student research projects (each cited by 11 schools or 14 percent of the selectives). Among inclusive schools, the most commonly cited distinguishing feature was having a school theme (10 of 71 inclusives or 14 percent) followed by unusual course requirements (such as two engineering courses), student supports (such as field trips and mentors), and use of technology (cited by 7 schools each).

Inclusive STEM schools are less likely than selective schools to be organized into traditional academic departments. This organizational difference may give them more flexibility to move beyond disciplinary silos into a transdisciplinary approach, but the survey did not measure this directly.

Inclusive schools appear somewhat more reform-oriented in their practices. They report slightly more use of small group structures and looping, where students remain with particular teachers for more than one year, and more joint planning time for teachers who work with the same set of students.

The most noticeable difference between the two types of schools in terms of course offerings is that the inclusive schools offer fewer AP courses…

Inclusive and selective STEM schools responded similarly to many of the survey questions concerning curriculum and pedagogy. Inclusive school graduation requirements mirror those of exclusive schools in terms of number of years required in each subject. Twenty percent of inclusive schools (compared to 27 percent of exclusive schools) require enrollment in a college course; 30 percent of inclusive schools and 28 percent of selective schools require an internship.[7]

Inclusive schools' instructional approaches as captured by their reported likelihood of employing project-based learning, workplace learning, technology-supported learning and lab-based science appear similar to those of selective schools.

The most noticeable difference between the two types of schools in terms of course offerings is that the inclusive schools offer fewer AP courses across the subject areas, with an average of .85 AP mathematics courses compared to 2.28 in selective schools; 1.20 AP science courses compared to 3.04 in selectives; and no AP computer science compared to an average of .81 in selective schools. From the data, one cannot discern if the more restricted AP offerings in inclusive schools is due to a lack of teaching capacity, misgivings about the value of AP courses, concern about student readiness for the AP curriculum, or a lack of student demand. In responding to an open-ended survey item, one school described its preference for enrolling students in actual college courses rather than AP:

> Giving support and active involvement are a community college and two four year institutions. During the senior year of the program STEM students will attend one of these institutions during second semester earning minimally 12 college credits. In lieu of AP or IB programs, we prefer that students have this college experience (concurrent enrollment).

[7] Enrollment in a college course is offered at 97 percent of inclusive schools and 86 percent of selective schools.

Partnerships. Survey respondents were asked to indicate whether they had strong partnerships that included an influence on academic program, with various types of external institutions. The responses of selective and inclusive STEM schools are contrasted in Table 5.

Exhibit 14. Partnerships by School Type

Type of partner	Selective n = 80	Inclusive n = 71
University or 4-year college	44%	41%
Community college	30	41
Industry/business	33	37
Science center or research lab	16	13
Career technical school	15	8

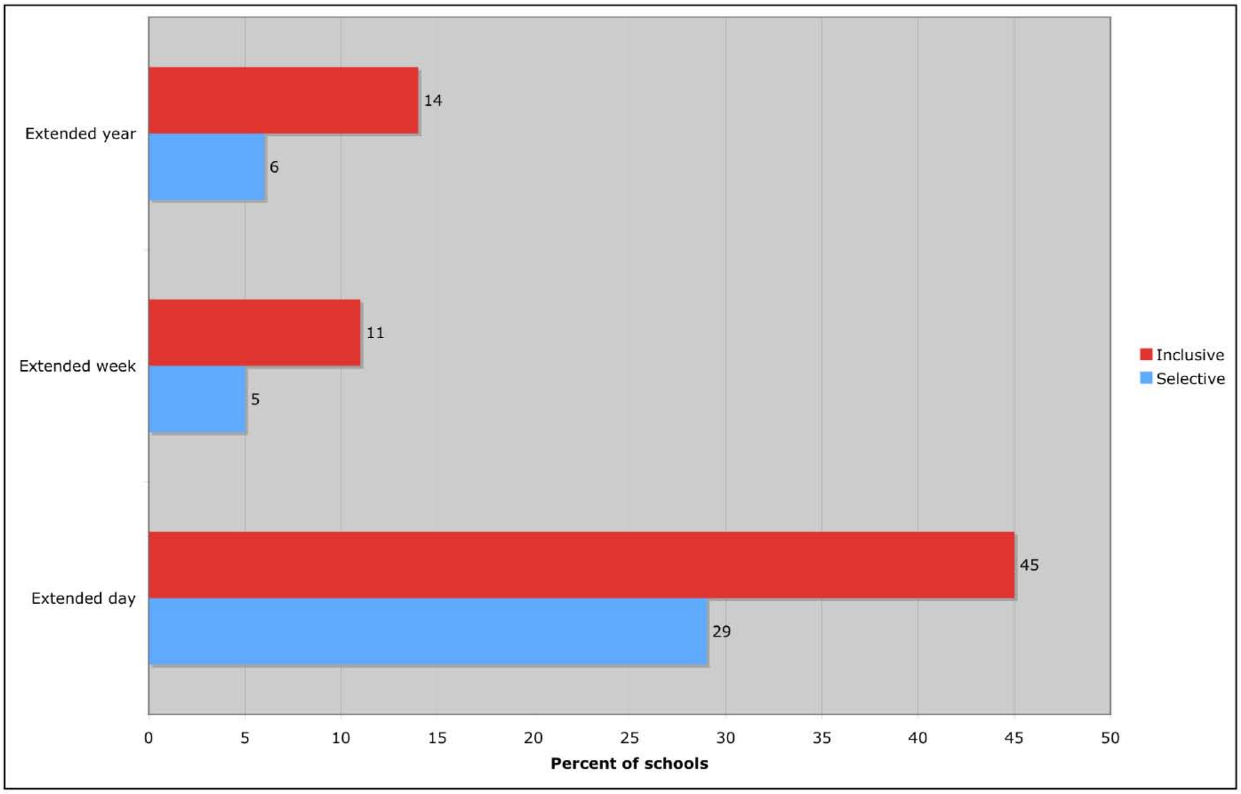
As seen in the table, many of the STEM schools have partnerships with institutions of higher education. Inclusive schools are more likely than selective schools to be associated with community colleges; both types of schools are similar in their likelihood of partnering with four-year colleges and universities. The two types of schools have similar likelihoods of having a strong business partner (37 percent of inclusive schools and 33 percent of selective schools). One of the inclusive schools described such a partnership:

> [The school] has an active 65-member business advisory board . . . .The members serve on 5 standing committees and have offered extensive job shadowing, mentoring, interviewing, and other support to students. They also raise money for scholarships for students each year. This supportive Business Advisory Board allows our students to interact regularly with the local professional community. Students develop a network of business contacts well before they graduate from high school. These business contacts allow our students to be successful beyond graduation.

Implementation

Support Structures. Inclusive schools intentionally accept students who are less advanced than those admitted to selective schools, and they appear to take steps to close the gap. As shown in Exhibit 15, inclusive schools are more likely than exclusive schools to provide their students with some form of extended programming (longer days, weeks, or years of instruction).

Exhibit 15. Extension of Instructional Time, by School Type



In some cases, such programming may not have been part of the original school design, but may have been instituted after a need became apparent. One recently opened inclusive school described:

> As the year has progressed it has become evident that plans need to be made to implement a summer bridge program for mathematics.

In terms of facilities, inclusive STEM have slightly fewer laboratories, most notably in physics, and report less satisfaction with the quality of their labs than exclusive STEM schools do.

Exhibit 16 compares the two types of schools in terms of other types of student support services. The differences between inclusive and selective STEM schools in terms of availability and participation in these services are not as large as one might expect. Selective schools are similar to inclusive schools in their likelihood of providing tutoring services and college test preparation. Inclusive schools are somewhat more likely than selective schools to schedule interactions with STEM professionals with demographic backgrounds similar to those of the students and to offer motivational programs such as MESA or AVID.

Teacher Recruiting and Professional Development. Inclusive and selective STEM schools have similar teacher-student ratios (1 teacher to 10.5 students for selective schools and 1 teacher to 11.0 students for inclusive schools). Inclusive schools have a somewhat smaller proportion of their STEM teachers with majors or advanced degrees in STEM fields (78 percent compared to 87 percent for exclusive STEM schools). Other studies of small high schools suggest that they tend to place more emphasis than other high schools do on a teacher's youth development orientation (Shear et al., 2008). Inclusive STEM schools are somewhat more likely than selective schools to support their teachers' professional development by giving them common planning time (65 percent of inclusive schools give common planning time to teachers who work with the same students compared to 44 percent of selective schools).

Exhibit 16. Student Support Services by School Type

Support service	Selective n = 80		Inclusive n = 71	
	Percent emphasizing the service	Percent of students receiving the service*	Percent emphasizing the service	Percent of students receiving the service*
Tutoring or special classes for students needing academic support	93%	46%	98%	55%
College admission test preparation	61	51	73	45
Motivation and support program (e.g., AVID, MESA)	25	27	35	36
Regularly scheduled interactions with STEM professional with demographic backgrounds similar to those of the students	32	40	47	51

* Within those schools that emphasize the service.

Implications and Recommendations

While STEM specialty schools have been around for a long time, it is clear from the survey data that the pace of their development has accelerated dramatically in concert with the influx of Foundation support. Half of all STEM schools and 64 percent of those with the goal of broadening participation in STEM higher education and careers were founded after 2003.

The concept of an "inclusive STEM school" is emergent. Based on the literature review and the survey, we were able to propose a definition for this concept and to distinguish inclusive STEM schools from the more selective STEM schools in the survey sample. Underlying the differences in the two types of schools is the fundamental assumption underlying inclusive STEM schools that talent in STEM can be developed in students who bring interest and motivation even if they don't come to high school with high prior achievement. Compared to the selective STEM schools, the inclusive STEM schools serve much larger proportions of African American and Hispanic students and of students eligible for free and reduced-price lunch.

In many structural respects, the inclusive STEM schools appear to have successfully implemented programs similar to those of the selective STEM schools. Their course requirement expectations are similar, their teachers are only slightly less likely to have majors or advanced degrees in STEM fields, and they use similar instructional approaches.

In other ways, inclusive STEM schools show evidence of their recognition that their students may need extended instructional time and experiences that differ from those offered by traditional STEM schools. The inclusive schools are more likely to offer the level of personalization that comes from remaining in intact groups with teachers over multiple years and to provide contact with mentors in STEM fields who mirror the students in terms of background. They are less likely than the selective STEM schools to offer a broad range of Advanced Placement courses. This limitation in their offerings may well reflect the restrictions inherent in a small teaching staff or a choice to focus on career-technical education (CTE), however, rather than any reservations about their students' ability to do college-level work. Inclusive STEM schools were just as likely as selective schools to offer students the option of enrolling in college courses.

One area in which the survey revealed a unique and potentially valuable difference is that inclusive STEM schools put more emphasis on career and technical preparation. For example, in Broward County, Florida, Atlantic Technical Magnet High School has established a program with Toyota Motor Sales in which students are trained in a state-of-the-art automotive lab that is continuously upgraded with new technological advances. They obtain certification recognized by the National Automotive Technician Education Foundation; 100 percent of the graduates are successfully placed in high-wage jobs. Inclusive STEM schools also show evidence of an increased use of STEM professionals as role models, especially selecting those who provide role models mirroring their students' racial or ethnic background.

Recommendations for Schools

Survey findings describe "what is" but provide little insight into "what should be." For the latter purpose, we draw on the research on effective teaching and learning and capacity-building within schools.[8]

Continue active recruiting and refinement of selection and induction processes. The survey responses indicate that inclusive STEM schools are more likely than selective schools to draw on students from the geographic area around the school, but their recruitment and application processes may still make their populations atypical, in ways that put some students at a disadvantage. We recommend that inclusive STEM schools continue to enhance their efforts to incorporate vigorous recruiting and preparation programs targeting historically underserved groups. Dropping selection based primarily on test scores is not sufficient in and of itself to get the message of opportunity to as wide a group as possible or to maximize the likelihood of success for those students who do attend the STEM school. We encourage inclusive STEM schools to develop or get involved with existing summer programs for middle school students from under-represented groups and with bridge programs. STEM schools can help provide science and math content for summer programs and through these activities can both identify youth with an interest in these areas and help prepare these students for a rigorous secondary curriculum.

Consider transdisciplinary or career and technical education approaches to curriculum. From the literature review and survey, we have identified two emerging opportunities for enhancing STEM curricula. Both of these are transdisciplinary approaches with the potential to support the development of students who are better prepared to forge connections among what they learn and to bridge academic content with adaptable skills related to career and technical education. Transdisciplinary approaches at some inclusive STEM schools focus on modeling and systems taking into consideration changes in professional practices in the STEM workplace. For example, students at the Maine School of Science and Mathematics are taking an on-line and site-based computational biology course, through which they are witnessing the power of combining computer science and biology.

Another transdisciplinary approach is to focus curriculum and instruction around the development of design skills. These skills are foundational for the subsequent pursuit of engineering, and they have also been identified as effective in motivating interest among a wide range of students and providing a context for acquiring new concepts and skills (Kolodner, 2002). These skills include identifying a problem, designing a solution, and testing and improving the design. These skills will fuel the innovations and advances of tomorrow's society. There are opportunities for adding engaging design approaches from engineering, and technologies for complex problem solving and rich visualizations to STEM curricula. Some inclusive STEM schools have profited from pursuing these options. For example, at Cypress Bay High School in Weston, Florida, an engineering firm is helping environmental science classes restore a habitat. Other such programs include the University of Texas College of Engineering DTEACH program (Design, Technology and Engineering for America's Children)

[8] These recommendations reflect the thinking of the authors and the literature cited in Chapter 2. They do not necessarily represent the views of the Bill & Melinda Gates Foundation.

and the Engineering the Future: Science, Technology and the Design Process (EtF), a full-year course for students in the first two years of high school. Completion of EtF earns academic credit equivalent to an introductory course in physics, biology or chemistry. EtF, developed by the Boston Museum of Sciences National Center for Technological Literacy, is considered the premier high school-level engineering course; it focuses on how technology and citizens influence each other by the design choices made.

Strategies to make STEM curricula more transdisciplinary and design oriented should be carefully articulated to enhance and coordinate with college readiness. Further, the Foundation should consider how it might enhance the availability of high-quality STEM teaching materials that foster such integration.

We see promise also in the career technical education concept, but do suggest two caveats. First, it is critical that inclusive STEM schools aim for, and achieve, college readiness while providing opportunities for career development or industry certification. Second, it is important to ensure that the attention to career and technical preparation is infused into the science and mathematics classrooms rather than treated as a separate activity.

Focus on student understanding of key STEM concepts. Survey responses revealed that inclusive STEM schools offer fewer AP courses than do the selective schools, thus suggesting that they have not obtained the same level of course rigor as measured by one commonly used indicator. We recognize, however, that the AP designation is only one way to gauge rigor, and in fact, the quality of the AP courses in science and mathematics has come under criticism (Gollub, Bertenthal, Labov, & Curtis, 2002). Inclusive STEM schools are giving their students experience with college courses, especially those offered at community colleges, and we encourage continuation of this practice. But neither provision of AP courses nor dual enrollment opportunities, either singly or in combination, will fulfill the inclusive STEM school's fundamental obligation to provide high-quality instruction focusing on key STEM concepts and skills in a way that fosters students' deep understanding and ability to use those concepts and skills for future learning. Fulfilling this obligation requires a special kind of teaching staff and instructional approaches that make use of assessments for learning, the topic of our next two recommendations.

Recruit STEM teachers who are knowledgeable, committed, and pedagogically skilled. Effective teachers know their subject matter and know how to teach their subject matter. This latter capacity, sometimes referred to as pedagogical content knowledge, is particularly important when dealing with learners who may have knowledge gaps or who may have encountered difficulties in classrooms of teachers using conventional knowledge transmission approaches. Finding well-qualified teachers in mathematics and science specialties is notoriously difficult. Inclusive STEM schools have the additional challenge of finding such teachers who are also committed to developing STEM understanding and talent in students who were not at the top of their class in middle school. Many new charter schools are turning to young college graduates to find the zeal they are looking for. They must be careful to make sure that they are not sacrificing pedagogical content knowledge in the process.

Assist STEM teachers in utilizing a range of assessments (e.g., formative, diagnostic, interim, summative) to improve student learning. Improvement in STEM schools will be fostered by designing and implementing a comprehensive mathematics and science assessment system that is coherent, balanced, and integrated. A comprehensive system must consider the appropriate array of outcomes of STEM learning (e.g., conceptual growth, skills, contextual problem solving, representational fluency, inquiry over time, information analysis, collaboration, reasoning, communication, and affect) that will provide valid and timely feedback concerning the multiple purposes of STEM instruction. It must recognize the multiple purposes of assessment so that it provides instructional guidance, supports educational decision making, measures continuous growth, and monitors system progress and accountability. Creating a successful comprehensive system also requires one to maximize the potential of technology to enhance this system (e.g., data storage and retrieval, representation and display, communication, tracking students' learning trajectories, analytics). Finally, successful development and deployment of a comprehensive system requires careful consideration of what knowledge, skills, and dispositions the education community needs to measure with validity, given its multiple goals (effectively promoting equity, improving and focusing instruction, evaluating programs, identifying students' needs for intervention, and positively impacting student learning). We use the term *assessment* in a very broad sense, including any type of information about student performance in mathematics, data derived from informal questioning and observation of students, analysis of evidence in student work, homework and seatwork, traditional tests and quizzes, diagnostic assessments to data derived from district, state, and national or international assessments.

Provide extensive, ongoing professional learning opportunities for school staff. An effective STEM school will recognize the need for ongoing staff development. Professional development is needed to refresh and enhance STEM knowledge in relation to changes in the fields. STEM staff also must keep abreast with new developments in the learning sciences, both in relation to the concepts taught and new approaches to "cyberlearning" in a networked world. STEM schools need to consider the organizational and structural changes necessary to support continuous professional learning, including building in opportunities for joint staff planning, implementation of new initiatives, and evaluation. Ways to bring new teachers on staff up to speed on topics of career and technical education and transdisciplinary approaches must be designed into the professional development system as teachers, administrators, and support staff work together to meet the needs of a diverse student body. The "personalization" of inclusive schools will require that these STEM schools improve ongoing communication, student advising, and guidance to serve the needs of their students.

Leverage partnerships to enrich STEM curricula, internship and mentorship opportunities, and student motivation. Another potential lever for enhancing student outcomes in STEM schools is creative leveraging of partnerships with external organizations/ The inclusive schools' reports of increased numbers of partnerships, with industry and business, community colleges, and career and technical schools, provide them with an infrastructure that could support intensification of the relationship between academic programming and vocational/technical preparation. For example, at Treasure Valley Mathematics and Science Center (TVMSC) in Boise, Idaho, Micron Technology, Inc. and its associated foundation supply guest speakers and assign e-mentors and research-based internships for all the TVMSC students. At Urban Assembly Institute of Math and Science for Young Women, partnerships with MOUSE

(Making Opportunities for Upgrading Schools and Education), and with Girls Inc. provide encouragement to young women to pursue mathematics- and science-related fields.

Exhibit 17. Recommended Strategies for Inclusive STEM Secondary Schools

- ✓ Continue active recruiting and refinement of selection and induction processes.
- ✓ Consider transdisciplinary or career and technical education approaches to curriculum.
- ✓ Focus on student understanding of key STEM concepts.
- ✓ Recruit STEM teachers who are knowledgeable, committed, and pedagogically skilled.
- ✓ Assist STEM teachers in utilizing a range of assessments (e.g., formative, diagnostic, interim, summative) to improve student learning.
- ✓ Provide extensive, ongoing professional learning opportunities for school staff.
- ✓ Leverage partnerships to enrich STEM curricula, internship and mentorship opportunities, and student motivation.

The Research Agenda Ahead

While the STEM school survey data provide many insights into the organization, supports, and curricula of inclusive STEM schools, there are many critical aspects of schooling that surveys cannot capture well. Research on historically underserved students demonstrates that much of what determines school success hinges on classroom interactions between students and teachers. The nature of instruction and the ways in which inclusive school teachers are motivating and supporting students in tackling more rigorous STEM content need to be understood. The foundation may want to commission white papers or research syntheses around the topic of effective approaches for teaching advanced skills to students from historically underserved backgrounds. An even greater contribution could be made by funding research on classroom teaching and learning in inclusive STEM schools. Such research could not only inform the field but also help the schools articulate and refine their approaches.

The STEM school literature review, survey database, and survey interpretations reported here provide a solid foundation for a national conversation about—and with—STEM schools. This is an important contribution. Nevertheless, what remains to be undertaken is the examination of the other two major components of an intervention—implementation and outcomes. It is apparent that the published literature is sparse in terms of studies of implementation of inclusive STEM schools and that our survey, based on broad reports from a single respondent, needs to be bolstered with more in-depth, site-based, and possibly case-based, studies of inclusive STEM schools. For example, the question of whether the difference between inclusive and selective STEM schools in the proportion of staff with STEM majors is due to the presence of more instructional staff in other areas in which students need support or represents less formally well-trained staffing in inclusive schools needs to be addressed. Similarly, inclusive STEM schools' strategies for providing professional development and support for their teachers are critical issues.

Now that significant numbers of inclusive STEM schools have been established, policymakers and practitioners want to know:

- Are they able to deliver on the assumption that they can develop STEM talent?
- How do they succeed with students with a wider range of entering achievement levels?
- Which combination of approaches is most effective and why?

The Foundation is in an ideal position to take the next steps in researching implementation and outcomes within the growing body of STEM schools. The implementation and outcomes portions of the intervention conceptual framework provided in this report suggest particular practices (e.g., classroom assessment) and outcomes (e.g., STEM credit accrual, college entrance) that we believe warrant in-depth study. Exhibit 18 suggests some more specific research questions. Studies in these areas could provide a basis for identifying the practices that should be supported and emulated within the growing network of inclusive STEM schools.

Exhibit 18. Examples of STEM School Research and Evaluation Questions

Are inclusive STEM schools able to prepare students from historically under-represented groups for success in:

- college preparatory mathematics and science courses?
- college entry?
- STEM college courses and majors?

How successful are inclusive STEM schools in nurturing academic engagement and STEM interest in students from historically under-represented groups?

What techniques are inclusive STEM schools using to foster student engagement and STEM interests?

How are inclusive STEM schools dealing with curriculum content? What aspects of transdisciplinary curricula are in evidence? How are technical career and more traditionally academic curriculum content balanced and intertwined?

What instructional approaches are used in the science, mathematics, engineering and technology classes within inclusive STEM schools? To what extent are the schools using project-based learning? What kinds of formative assessment practices occur in the classroom?

How are inclusive STEM schools supporting their teachers in learning to work with students with many different levels of preparation?

What roles are partnerships playing in enhancing students' motivation and learning in inclusive STEM schools? What lessons have been learned about effective partnering?

How do inclusive STEM schools identify and support students who are struggling?

Which curriculum, instructional, partnering and support approaches are associated with better results in terms of key student outcomes?

How are STEM schools sharing resources and developing social networks among themselves and their teachers?

What programs and forms of intervention prior to enrollment in STEM high schools are most effective in ensuring fairness and effectiveness in intensifying recruitment strategies towards inclusion?

References

ACTE Online (N.D.) *What's Career and Technical Education?* Available at: http://www.acteonline.org/career_tech/index.cfm

Anderson, E., & Kim, D. (2006). *Increasing the Success of Minority Students in Science and Technology.* Washington, D.C.: American Council on Education.

Atkin, J. M. (1998). The OECD study of innovations in science, mathematics and technology education*. Journal of Curriculum Studies, 30*(6), 647-660.

Atkinson, R. D., Hugo, J. D., Lundgren, D., Shapiro, M. J., & Thomas, J. (2007). *Addressing the STEM Challenge by Expanding Specialty Math and Science High Schools.* Washington, D.C.: The Information Technology and Innovation Foundation.

Black, P., & Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, *80*(2), 139-148. Available at http://www.pdkintl.org/kappan/kbla9810.htm

Borko, H., & Putnam, R. T. (1995) *Expanding a Teacher's Knowledge Base: A Cognitive Psychological Perspective on Professional Development*. New York: Teachers College Press.

Business-Higher Education Forum. (2006, Winter). Collaborating to address the math and science teacher shortage: A state-university-business partnership. *BHEF 2006 Issue Brief*.

California Space Education and Workforce Institute (CSEWI). (2008). *High Stakes: STEM Education*. Pasadena, CA: Author.

Cavanaugh, S. (2006, December 6). Math, science academies favored to challenge top-tier students: Funders see graduates as helping U.S. stay competitive [Electronic Version]. *Education Week*, retrieved from http://www.edweek.org/ew/articles/2006/12/06/14academies.h26.html

Confrey, J., & Maloney, A. (2006). A Theory of Mathematical Modeling in Technological Settings, in Henn, H-W. & Blum, W. (eds.) *ICMI Study 14: Applications and Modeling in Mathematics Education*.

Confrey, J., & Stohl, V. (2004). *On Evaluating Curricular Effectiveness: Judging the Quality of K-12 Mathematics Evaluations*. Washington, DC: National Academies Press.

Czerniak, C. M., Weber, W. B. J., Sandmann, A., & Ahern, J. (1999). A literature review of science and mathematics integration. *School Science and Mathematics, 99*(8).

Dillon, P. (2008). A pedagogy of connection and boundary crossings: methodological and epistemological transactions in working across and between disciplines. *Innovations in Education and Teaching International, 45,* No. 3, August 2008, 255–262.

Edelson, D. C., & Reiser, B. J. (2006). Making authentic practices accessible to learners: Design challenges and strategies. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences*, (pp. 335-354). Cambridge: Cambridge University Press.

Education Week. (2008, March 27). The push to improve STEM education. *Education Week.* Retrieved from http://www.edweek.org/ew/articles/2008/03/27/30intro.h27.html

Elmore, R. (2002). *Bridging the Gap between Standards and Achievement*. Washington, DC: Albert Shanker Institute.

Geraedts, C., Boersma, K. T., & Eijkelhof, H. M. C. (2006). Towards coherent science and technology education. *Journal of Curriculum Studies, 38*(3), 307-325

Gibbons, M., et al. (1994) *The New Production of Knowledge—The Dynamics of Science and Research in Contemporary Societies.* London, UK: Sage.

Gollub, J. P., Bertenthal, M. W., Labov, J. B., & Curtis, P. C. (Eds.) (2002). *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools.* Washington, D.C.: National Academy Press.

Gonzales, P., Guzman, J. C., Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., & Williams, T. (2004). *Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003*. U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Hanford, S. (1997). *An Examination of Specialized Schools as Agents of Educational Change.* New York: Columbia University.

Huntley, M. A. (1998). Design and implementation of a framework for defining integrated mathematics and science education. *School Science and Mathematics, 98*(6), 320-327

Hurley, M. M. (2001). Reviewing integrated science and mathematics: The search for evidence and definitions from new perspectives. *School Science and Mathematics, 101*(5), 259-483.

Jin, S.-U., & Moon, S. M. (2006). A study of well-being and school satisfaction among academically talented students attending a science high school in Korea. *Gifted Child Quarterly, 50*(2), 169-184.

Kaser, J. S. (2006). *Mathematics and Science Specialty High Schools Service a Diverse Student Body: What's Different?* Pittsburg, PA: Learning Research and Development Center, University of Pittsburgh.

Kolodner, J. L. (2002). Facilitating the learning of design practices: Lessons learned from an inquiry into science education. *Journal of Industrial Teacher Education, 39*(3).

Kuenzi, J. J. (2008). *Science, Technology, Engineering and Mathematics (STEM) Education: Background, Federal Policy and Legislative Action.* Washington DC: Congressional Research Service.

Lesh, R. A., & Doerr, H. M. (2003). *Beyond Constructivism: Models and Modeling Perspectives on Mathematics Problem Solving, Learning, and Teaching.* Mahwah, NJ: Lawrence Erlbaum.

Linn, M. C. (2006). The knowledge integration perspective on learning and instruction. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences*, (pp. 243-264). Cambridge: Cambridge University Press.

Martinez, M., & Klopott, S. (2005). *The Link between High School Reform and College Access and Success for Low-income and Minority Youth*. American Youth Policy Forum and Pathways to College Network.

Maxwell, N. L., & Rubin, V. (2002). High school career academies and post-secondary outcomes. *Economics of Education Review, 21*, 137-152.

Maxwell, N. L. (2001). Step to college: Moving from the high school career academy through the 4-year university. *Evaluation Review, 25*(6), 619-654.

Means, B. (2006). Prospects for transforming schools with technology-supported assessments. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences*, pp. 505-520. Cambridge: Cambridge University Press.

Metz, M. H. (2003). *Different by Design: The Contact and Character of Three Magnet Schools.* New York: Teachers College Press.

National Aeronautics and Space Administration. (2006). *NASA Education Strategic Coordination Framework: A Portfolio Approach*. Washington DC: Author

National Council of Teachers of Mathematics. (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: Author.

National Governors' Association. (2007, February). *Building a Science, Technology, Engineering and Math Agenda*. Washington, DC: Author.

National Research Council. (2000). *How People Learn: Brain, Mind, Experience, and School.* Washington, DC: National Academy Press.

National Research Council. (2004). *Engaging Schools: Fostering High School Students' Motivation To Learn.* Washington, DC: National Academy Press.

National Research Council. (2004). *On Evaluating Curricular Effectiveness: Judging the Quality of K-12 Mathematics Evaluations*. Washington, DC: National Academies Press.

National Science Foundation. (2006). *Science and Engineering Indicators, Volume 1.* Arlington, VA: Author.

National Science Foundation, Division of Science Resources Statistics. (2004). *Women, Minorities, and Persons with Disabilities in Science and Engineering*. Arlington, VA: Author. NSF 04-317.

National Science Teachers Association. (1996). *National Science Education Standards*. Washington DC: Author.

Ravitz, R. L., Becker, H. J., & Wong, Y. T. (2000). *Constructivist-Compatible Beliefs and Practices among U.S. Teachers.* Teaching, Learning, and Computing: 1998 National Survey, Report #4. Irvine, CA: University of California, Irvine, Center for Research on Information Technology and Organizations.

Resnick, L. (Ed.) (1987). *Education and Learning to Think*. Report of the Committee on Mathematics, Science and Technology Education, Commission on Behavioral and Social Sciences and Education, National Research Council. Washington, D.C.: National Academy Press.

Resnick, M., & Wilensky, U. (1998). Diving into Complexity: Developing Probabilistic Decentralized Thinking Through Role-Playing Activities. *Journal of Learning Sciences, 7*, pp. 153-172.

Shear, L., Means, B., Mitchell, K., House, A., Gorges, T., Joshi, A., Smerdon, B., & Shkolnick, J. (2008). Contrasting paths to small school reform: Results of a 5-year evaluation of the Bill & Melinda Gates Foundation's National High Schools Initiative. *Teachers College Record 110*(9), pp. 1986-2039.

Stone, J. R., III, Alfeld, C., Pearson, D., Lewis, M. V., & Jensen, S. (2006). *Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in Career and Technical Education.* St. Paul, MN: National Research Center for Career and Technical Education.

Subotnik, R. F., Rayhack, K., & Edmiston, A. (2006). *Current Models of Identifying and Developing STEM Talent: Implications for Research, Policy and Practice* Washington, DC: American Psychological Association.

Summers, M. F., & Hrabowski III, F. A. (2006). Diversity enhanced: Preparing minority scientists and engineers. *Science, 311*, 1870-1871.

Swanson, C.B. (2008). *Cities in Crisis: A Special Analytic Report on High School Graduation.* Editorial Projects in Education Research Center.

Theodore, R., & Pinzzotto, R. F. (2006). Documenting student achievement in science, mathematics, and computing: An outcome-based assessment. *NCSSSMST Journal, 11*(2), 16-19.

U.S. Census Bureau. (2007, May 17). Minority population tops 100 million. *U.S. Census Bureau News*.

U.S. Department of Education. Office of the Under Secretary, Planning and Evaluation Service, Elementary and Secondary education Division. (2000). *Does Professional Development Change Teaching Practice? Results from a Three-Year Study.* Washington, D.C.

Wells, M., Hestenes, D., & Swackhamer, G., 1995. A modeling method for high school physics instruction. *American Journal of Physics, 63*, 7, 606-619.

Wiliam, D. (2007). Keeping learning on track: Formative assessment and the regulation of learning. In F. K. Lester, Jr. (Ed.), *Second Handbook of Mathematics Teaching and Learning* (pp. 1051-1098). Greenwich, CT: Information Age Publishing.

Appendix A
Stem School Survey

Bill & Melinda Gates Foundation
Science-Technology-Engineering-Mathematics (STEM)
School Survey

Exclusive: n = 80
Inclusive: n = 71
Full Sample: N = 203

School Structure & Characteristics

1. **What is your school's current governance structure?** *(Select one.)*

Governance Structure	Exclusive	Inclusive	Full Sample
Public non charter	91%	73%	80%
Charter (public)	1	23	15
Private	0	0	0
Other	8	4	4

2. **Which of the following best describes your school or program?** *(Select one.)*

School Program	Exclusive	Inclusive	Full Sample
Regular, standalone school	33%	56%	43%
School-within-school (e.g., career academy, small learning community, program taken as part of the student's secondary curriculum)	37	31	38
District science center, where students from other schools take their STEM courses	5	0	2
Summer/after-school/enrichment program (not part of the core academic program)	0	0	0
Other	25	13	17

3. **Do any of these special characteristics apply to your school?** *(Select all that apply.)*

School Characteristics	Exclusive	Inclusive	Full Sample
Residential program	18%	1%	9%
Career technical school	10	24	16
Gifted/talented school	40	4	19
Magnet school or magnet program within a school	44	27	33
Secondary-postsecondary combination (e.g., dual enrollment, early college high school, middle college)	39	37	37

4. **What year was your STEM school or program opened?**

Year School Opened	Exclusive	Inclusive	Full Sample
Mean of years	1990	2003	1998
Mode of years	2004	2004	2004
Range of years	125	27	125

5. **Which of the following is more central to your STEM school or program's mission?** *(Select one.)*

Program's Mission	Exclusive	Inclusive	Full Sample
Preparing students for college majors and subsequent careers in STEM fields.	100%	77%	89%
Preparing students for technician jobs in STEM industries through career-technical education.	0	6	2
Other	0	17	9

6. **Which of the following is most descriptive of your STEM school or program's focus?** *(Select one.)*

Program's Focus	Exclusive	Inclusive	Full Sample
Providing gifted and talented students with accelerated and advanced STEM coursework.	59%	0%	24%
Providing underrepresented / minority students with preparation for the successful pursuit of advanced STEM studies.	14	90	55
Other	28	10	22

7. **How would you describe the area from which your students are drawn?** *(Select all that apply.)*

Student	Exclusive	Inclusive	Full Sample
Neighborhood in which the school is located	19%	35%	31%
This district	43	63	55
Several districts	33	32	33
This state	16	1	7
National or International	3	1	3

Teaching Staff

8. **How many teachers work full time and how many work part time in your school or program? Provide the number for teachers of ALL disciplines and for those in STEM disciplines.** *(If you share a teacher with another school, count that teacher as part-time.)*

Discipline	Exclusive		Inclusive		Full Sample	
	Full-Time	**Part-Time**	**Full-Time**	**Part-Time**	**Full-Time**	**Part-Time**
MEAN Number of teachers of **ALL disciplines**	54.39	18.12	38.84	14.07	46.31	15.11
MEAN Number of teachers of **STEM disciplines**	4.65	2.5	3.82	1.37	4.09	1.96

9. **What proportion of your STEM teachers has college majors or advanced degrees in a STEM field?**

Proportion with Degree in STEM	Exclusive	Inclusive	Full Sample
Mean	87%	78%	82%

Enrollment

10. Across all grade levels, how many students were enrolled in your STEM school or program around the first of October 2007? (*If you are a school-within-school or small learning community, answer specifically for your school or program.)*

Number of students around October 1st, 2007	Exclusive	Inclusive	Full Sample
Mean	565.92	418.01	456.77

11. How many high school students were enrolled in each of the following grade levels around the first of October 2007? If you expect enrollment to increase in the future, how many students will your STEM school or program have at full implementation?

Grade	Exclusive		Inclusive		Full Sample	
	Mean Number of Students					
	Around October 1st, 2007	At full implementation	Around October 1st, 2007	At full implementation	Around October 1st, 2007	At full implementation
9th	194.12	155.41	149.51	141.78	167.88	148.46
10th	185.83	146.87	129.16	132.33	154.30	139.75
11th	171.71	154.74	121.49	132.21	143.31	140.84
12th	156.39	143.49	109.74	119.43	128.73	131.89

12. Is your STEM school or program serving grades other than grades 9-12 in fall 2007?

Proportion serving grades other than grades 9-12 in fall 2007	Exclusive	Inclusive	Full Sample
Yes	8%	16%	14%
No (*Skip to question 14*).	93	85	86

13. Indicate the other grade levels in your school or program in fall 2007. *(Select all that apply.)*

Other Grade Levels	Exclusive	Inclusive	Full Sample
1st	1%	1%	3%
2nd	1	1	3
3rd	1	1	3
4th	3	1	4
5th	3	1	4
6th	5	10	10
7th	8	8	11
8th	8	7	10

14. Across grades 9-12, what percentage of your STEM school or program's fall 2007 students qualify for free or reduced-price lunches?

Free or Reduced-Price Lunch	Exclusive	Inclusive	Full Sample
Mean	27%	58%	45%

15. Around the first of October of 2007, what was the composition of your STEM school or program's student body in grade 9-12? *(Provide a response for each item.)*

Ethnicity	Exclusive	Inclusive	Full Sample
a. African American	16%	33%	26%
b. Hispanic	11	33	19
c. Asian or Pacific Islander	15	5	10
d. American Indian or Alaska Native	1	<1	1
e. White	52	27	43
f. Other / Unreported	3	1	2

Gender	Exclusive	Inclusive	Full Sample
a. Male	51	53	54
b. Female	49%	47%	46%

Outreach & Financial Aid

16. What, if anything, does your school or program do to recruit groups that are under represented in STEM fields (African-Americans, Hispanics, females)? *(Describe below.)*

17. What, if any, types of bridge programs does your school offer for incoming underrepresented students (e.g., summer courses or orientation)? *(Describe below.)*

18. Does your STEM school or program charge tuition for any students?

Charge Tuition	Exclusive	Inclusive	Full Sample
Yes, for all students	5%	0%	3%
Yes, for a subset of students (e.g., students from outside of the district)	10	3	6
No	85	97	92

19. Does your STEM school or program provide scholarship or financial aid to underrepresented students?

Financial Aid	Exclusive	Inclusive	Full Sample
Yes	14%	14%	15%
No	85	85	85

Admissions

20. Which of the following describe admissions priorities for your STEM school or program?

	Admission Priorities	Exclusive	Inclusive	Full Sample
		Yes	**Yes**	**Yes**
a.	Student must belong to a *particular school district or subdistrict* to attend the school.	73%	69%	65%
b.	Student's neighborhood, gender, SES, or ethnicity is considered in order to *obtain desired representation* in the school.	22	38	26
c.	Student from the *attendance area* within which the school is located receive priority for admission.	31	43	37
d.	Other distribution criteria are used. (*Describe below.*)	86	43	62

21. Does your school or program typically have more applicants for grades 9-12 than available openings?

Applicants vs. Openings	Exclusive	Inclusive	Full Sample
Yes	64%	54%	63%
No (skip to question 23.)	36	46	37

22. **Below is a list of factors that may influence the selection of students at your STEM school or program. Allocate 100 points across the seven items to indicate the relative weight given to each of these factors.** *(Give an item a 0 if it does not factor into the selection process. Remember that the total must add up to 100.)*

Factors for Selection	Exclusive	Inclusive	Full Sample
a. Mean for prior achievement (courses taken, GPA)	38%	12%	25%
b. Mean for score on an examination	37	2	20
c. Mean for interview and recommendations	16	17	16
d. Mean for chance (a lottery)	4	61	37
e. Mean for student ethnicity or neighborhood of residence	4	20	12
f. Mean for first come, first served	0	31	18
g. Mean for other *(Describe below.)*	20	18	23

23. **How many openings and applicants did you have during the last admission cycle at each grade level?** *(Provide a response for each item.)*

Grade	Exclusive		Inclusive		Full Sample	
	Mean Number of Students					
	Number of Apps	**Number of Openings**	**Number of Apps**	**Number of Openings**	**Number of Apps**	**Number of Openings**
9th	782.67	152.85	367.20	127.53	457.92	134.16
10th	73.51	32.34	88.58	69.38	81.13	57.78
11th	107.33	56.73	78.10	68.41	85.64	64.73
12th	49.65	28.32	51.28	46.66	50.28	45.48

School or Program Schedule & Instructional Approach

24. Does your STEM school or program extend the amount of instructional time beyond what is typical in high schools? *(Select all that apply.)*

Extra Instructional Time	Exclusive	Inclusive	Full Sample
No	65%	51%	64%
Yes, extended day (Students spend more than 6 hours a day in classes.)	29	45	31
Yes, extended week (Students attend for more than 5 days a week such as weekend classes.)	5	11	6
Yes, extended year (Students attend for more than 180 days a year.)	6	14	8

25. Does your school or program have one or more specialized academic themes within STEM (e.g., computer science or biotechnology)?

Specialized Academic Themes	Exclusive	Inclusive	Full Sample
Yes	48%	30%	37%
No	52	70	63

26. a) Does your STEM school or program have one or more strong institutional partners with <u>direct influence on your instructional offerings</u>? *(Select all that apply.)*

Institutional Partners	Exclusive	Inclusive	Full Sample
No (Skip to question 27)	51%	49%	51%
Science center or research lab (e.g., regional center providing resources to educators, lab attended by students from participating schools for science courses)	16	13	13
Industry/business	33	37	36
Community college	30	41	36
University or 4-year college	44	41	42
Career technical school (a school that provides training in specific technical fields)	8	15	12
Other *(Describe.)* ____________ ____________	14	20	16

b) Please name up to five institutional partners, and briefly describe the nature of these partnership(s).

27. List the normal sequence of courses that most of your students take in mathematics and science.

Grade	Mathematics Courses	Science Courses
9th Grade		
10th Grade		
11th Grade		
12th Grade		

28. For which sciences does your STEM school or program have a laboratory on site that is adequately equipped for instruction? *(Select all that apply.)*

Laboratory on Site	Exclusive	Inclusive	Full Sample
Biology	94%	86%	89%
Chemistry	94	82	85
Physics	89	69	77
Other *(Specify.)* ________	48	37	39

29. How would you describe your lab facilities?

Laboratory on Site	Exclusive	Inclusive	Full Sample
Exemplary	38%	19%	25%
Adequate	49	61	57
Inadequate *(if inadequate, please indicate the major problem you face with the lab facilities)*	13	20	18

30. How many different Advanced Placement (AP) and International Baccalaureate (IB) courses did your STEM school or program offer in school year 2006-07 in each of these areas?

Courses	Exclusive		Inclusive		Full Sample	
	Mean Number of Courses					
	AP Courses	IB Courses	AP Courses	IB Courses	AP Courses	IB Courses
Mathematics	2.28	0.15	0.85	0.04	1.46	0.13
Science	3.04	0.15	1.20	0.04	1.96	0.16
Computer Science	0.81	0.00	0.23	0.00	0.49	0.01

31. How many years of course credit are required for graduation in each of these subject areas? *(Note that a semester counts as half a year.)*

Mean number of years of course credit required for each Subject	Exclusive	Inclusive	Full Sample
Mathematics	3.37	3.28	3.32
English	3.70	3.65	3.67
Science	3.84	3.14	3.42
Social Studies	3.06	3.11	3.08
Computer Science	0.77	0.92	0.88
World Language	1.54	1.73	1.60
Other	4.00	4.52	5.03

32. Are any of the following learning experiences offered to students in your STEM school or program? *(Select one response in each item.)*

Learning Experiences	Exclusive			Inclusive			Full Sample		
	Required	Optional	Not Offered	Required	Optional	Not Offered	Required	Optional	Not Offered
Enrollment in college courses	27%	59%	14%	20%	77%	3%	25%	67 %	9%
Internship	28	62	10	30	58	13	33	57	10
Job shadowing or work site visits	25	52	23	25	57	19	26	56	18
Mentoring	18	65	17	24	54	23	23	61	17
Research projects	70	27	4	57	34	9	62	31	7

33. What, if anything, does your STEM school or program do to foster continuity and coherence across courses and grades (e.g., multidisciplinary courses or projects, curriculum aligned across grades, rituals used in all classes)? *(Describe below.)*

34. During school year 2006-07, did your STEM school or program use any of the following structures? *(Select all that apply.)*

Structures	Exclusive	Inclusive	Full Sample
Traditional academic-discipline-based departments	83%	68%	73%
Grades subdivided into small groups such as “houses” or “families”	28	32	31
Student groups that remain with the same teachers for 2 years or more (e.g., looping)	16	27	24
Regularly scheduled joint-planning time for teachers who work with the same students	44	65	55

35. Does your STEM school or program strongly emphasize any of the following instructional approaches? *(Select one response in each item.)*

Instructional Approaches		Exclusive		Inclusive		Full Sample	
		Emphasized?	If Yes, what percent of required courses use this approach?	Emphasized?	If Yes, what percent of required courses use this approach?	Emphasized?	If Yes, what percent of required courses use this approach ?
		Yes	Mean %	Yes	Mean %	Yes	Mean %
a.	Project-based learning	86%	65%	83%	68%	85%	62%
b.	Workplace learning	47	38	55	26	55	32
c.	Technology -supported learning tools	94	76	94	78	94	74
d.	Lab-based science learning	99	72	99	58	97	61

36. Does your STEM school or program offer any of the following student support services?
(Select one response in each item.)

	Support Services	Exclusive		Inclusive		Full Sample	
		Emphasized?	If Yes, what percent of students receive this service?	Emphasized?	If Yes, what percent of students receive this service?	Emphasized?	If Yes, what percent of students receive this service?
		Yes	Mean %	Yes	Mean %	Yes	Mean %
a.	Tutoring or special classes for students needing academic support	93%	46%	98%	55%	97%	49%
b.	Test (PSAT, SAT or ACT) preparation classes	61	51	73	45	69	46
c.	Motivation and support program such as AVID or MESA	25	27	35	36	30	33
d.	Regularly scheduled time for interactions with STEM professionals with demographic backgrounds similar to that of students	32	40	47	51	41	47

37. Please describe any other characteristics of your school or program that distinguishes it from other STEM schools or programs.

Appendix B
Identifying
Selective and Inclusive STEM Schools

Responses to survey items were coded as follows:

- Schools were asked to assign weights to the various factors they consider in selecting students. The factors that the school uses to select students were divided into those traditionally associated with selectivity (score on an examination or prior achievement as indicated by GPA) and those that are more likely to admit under-represented students (interview and recommendations, lottery, student ethnicity or neighborhood of residence, first come-first served). If the sum of the weights given to the first set of selection factors was greater than or equal to the sum of the weights given to the latter factors, we assigned +1; if the sum was less than the sum of nonselective factors, we assigned -1.

- If preparing students for college majors and subsequent careers in STEM fields is more central to the school's mission than preparing students for technician jobs in STEM industries through career technical education, we assigned +1 to the school; if the reverse, we assigned -1.

- If the school's focus was described as providing gifted and talented students with accelerated or advanced STEM coursework, we assigned +1; if the focus was described as providing underrepresented minority students with preparation for the successful pursuit of advanced STEM studies, we assigned -1.

Each school's codes for these items were summed, producing a scale with a potential range from -3.0 to +3.0. Those schools with a total score of +1.0 or above were categorized as "selective" while those with totals of -1.0 or below were classified as "inclusive." This process resulted in identification of 80 selective and 71 inclusive STEM secondary schools. Fifty-two schools, with total exclusivity indices of 0, were not classified. Table 3 shows the relationship between receipt of support from the Bill & Melinda Gates Foundation and a school's exclusivity classification.

Exhibit 19. School Survey Sample, by School Type and Gates Foundation Support

	Selective	Inclusive	Unclassified	Total
Has received foundation support	28	55	38	121
Has not received foundation support	52	16	14	82
Total	80	71	52	203

Of the 71 inclusive schools or programs in the survey sample, 55 (or 77 percent) had received Foundation support. Many of these schools would likely not exist without the Foundation's efforts in this area. This pattern suggests that the Foundation is changing the landscape of STEM specialty schools in ways that stress providing opportunity to students who would not otherwise receive this kind of education.