

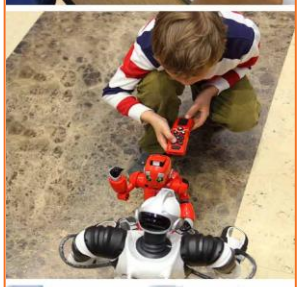


Specialized STEM Secondary Schools

THE PROBLEM

STEM is not just for scientists anymore. In today's economy, almost any job with decent pay requires STEM skills, and many jobs require advanced STEM abilities. But far too many U.S. residents are unprepared for the occupational demands of the 21st century. Formerly a world leader in math and science achievement, the United States now can't keep up. Fewer students enroll in STEM courses and master STEM content than young people in other countries. The problem is no mere point of pride; the lack of knowledge undermines the nation's economic productivity and global competitiveness.

Striking Statistics: Poor STEM Performance in U.S. Schools

Math[1]

* About 75% of U.S. students fail to become proficient in math by grade 8.
* More than 75% of U.S. students are behind in math by grade 12.

Science[2]

* Only 10% of U.S. 8th graders reach the advanced science level on the international TIMSS exam.
* By contrast, 25% of 8th graders in China and 32% of 8th graders in Singapore reach the advanced science level on the TIMSS.

The vast majority of U.S. students receive STEM education in traditional public high schools. Some do an excellent job, but the overall quality of STEM secondary education is mixed. Educators everywhere are struggling with how to improve STEM literacy and how to encourage more students to pursue college and careers in STEM fields.

Specialized schools still represent a tiny fraction of U.S. public education. However, they may not only produce better results than traditional programs; they also can serve as models for schools seeking to improve.

A growing number of states and districts are responding to this challenge with the creation of specialized STEM high schools and secondary programs. Such schools typically offer more rigorous curricula, more qualified teachers, more instructional time, and more resources than traditional high schools. Specialized schools still represent a tiny fraction of U.S. public education. However, they may not only produce better results than traditional programs; they also can serve as models for schools seeking to improve.

KEY RESEARCH

Research funded by the National Science Foundation has identified three categories of STEM-focused schools that possess the potential to meet U.S. educational goals in STEM areas:

- *Selective schools*, which enroll small numbers of highly motivated students with demonstrated talent and interest in STEM areas.
- *Inclusive schools*, which serve students from all backgrounds, focusing on low-income, minority, and other traditionally underrepresented youth.
- *Career and technical education programs*, which help a broad range of students explore the practical applications of STEM subjects and prepare for STEM-related jobs.

Selective Schools

These small, elite public schools are known for selecting—and producing—the cream of the STEM crop. Admission usually requires a written exam, and only top performers get in. A prominent, longstanding example is Stuyvesant High School, the New York City powerhouse whose graduates include four Nobel Prize winners and countless other STEM leaders.

Today, the United States has an estimated 90 selective public STEM high schools, many created in the wake of the 1983 warnings of *A Nation at Risk*.[3] Focusing on one or more STEM disciplines, selective schools aim to prepare gifted students to earn ambitious postsecondary STEM degrees and succeed in STEM careers. They typically provide expert teachers, advanced curricula, sophisticated lab equipment, and apprenticeships with scientists.

Most selective public STEM schools are self-contained programs in urban areas, drawing top students from across a district. Fifteen states offer residential schools attracting accomplished youth statewide. Virginia and Michigan bus students from low-income rural areas to regional half-day centers.

Example: Illinois Mathematics and Science Academy (IMSA)

The state pays tuition and most student expenses at the Illinois Mathematics and Science Academy, an internationally acclaimed three-year residential program near Chicago, in Aurora, Illinois. A rigorous admissions process requires math, science, and world language testing, consistently high grades, stellar recommendations, intense demonstrated interest in STEM, and potential for significant contributions in STEM fields.

IMSA offers more than 100 advanced courses in mathematics, science, the arts, and the humanities. Its 650 students all have personalized learning plans, geared to their individual interests and future goals and designed to help maximize their academic experiences. High-level research is a cornerstone of the program, and students routinely collaborate with other students, scholars, and scientists throughout the world. Many publish studies and present at professional conferences.

More than 99% of IMSA's 4,350 graduates since 1985 have enrolled in college.[4] Nearly two-thirds earn degrees in math or science—significantly more than the general population and more than four times higher than average for women. Alumni include leading researchers, engineers, teachers, and entrepreneurs, with accomplishments ranging from improving cancer detection devices to helping to start YouTube.

Results

Research studies show that specialized STEM schools can make a difference. Their graduates pursue STEM fields in college at a rate nearly 50% higher than that of other students.[5] Compared with the national average, nearly 20% more selective STEM school graduates earn a STEM-related postsecondary degree within four years of graduating from high school.[6]

Studies identify these key factors: Talented high schoolers interested in math and science are more likely to pursue STEM college study when provided with challenging curricula, expert instruction, and peer stimulation. Participating in original research is perhaps the most powerful tool, particularly for young women. Internships and mentors also are critical. While no single factor may have a profound impact, programs

combining these features can open up postsecondary STEM pathways for students.

However, teens who attend STEM specialty programs not because of a deep STEM interest, but for the general academic challenge, do not earn STEM degrees in greater numbers.[7] Other studies have emphasized the importance of early interest in earning STEM degrees. In fact, students who indicated an interest in biology in the 8th grade were 1.9 times as likely to major in biology than those who did not express early interest; students who expressed an interest in physical sciences and engineering in the 8th grade were 3.4 times as likely to eventually major in these areas.[8] This shows the importance of developing early interest and ability in STEM subjects.

Inclusive Schools

While selective STEM schools play an important role in cultivating top talent, interest is growing rapidly in expanding intensive STEM education to a much broader population. This is the role of inclusive STEM schools, which are open to all. They aim to provide similar educational experiences as selective schools, but focus on youth from low-income families and racial/ethnic groups historically underrepresented in STEM fields.

Based on the idea that math and science talent can be developed—rather than being an innate ability people simply have or do not have—inclusive schools typically select students by lottery and build in supports for those with weaker academic backgrounds. Tutoring, advisories, and other services help prepare students for STEM majors in college.

Several states are developing networks to spur the creation of inclusive STEM schools and to share best practices with each other and with traditional public schools. The T-STEM initiative in Texas, for example, has opened more than 50 secondary schools since 2006 following the same guiding blueprint. The Ohio STEM Learning Network—which originated with Columbus-based Battelle, a national laboratory manager, the Ohio Business Roundtable, and the Bill and Melinda Gates Foundation—has opened 10 inclusive STEM schools geared to various economic regions of the state. With assistance from Battelle and the Gates Foundation, states including California, New York, and North Carolina are replicating Ohio's work.

Example: Delta High School, Tri-Cities area, Washington State

Among the new crop of inclusive public STEM schools is Delta High School in southeastern Washington State. The idea of local business leaders, the school opened in 2009 with about 100 freshmen—chosen by lottery—reflecting the demographics of the Kennewick, Richland, and Pasco School Districts it serves. By the fall of 2012, there will be 400 students in grades 9–12.

Delta is one of the first STEM-focused schools in the state and is a pilot project of the Washington State STEM Education Foundation. Funding comes from each of the three home school districts, supplemented with grants from the foundation and numerous other partners, including Battelle, Washington State University Tri-Cities, and Columbia Basin College, which provides campus space.

The core of Delta's program weaves together science, technology, engineering, mathematics, and humanities concepts through hands-on, problem-based instruction. The design features 90-minute classes, advisories to support academics and postsecondary transitions, career mentoring from STEM professionals, as well as internships, job shadows, and senior seminars. The school is highly personalized, emphasizing individual student-faculty interaction and building on student strengths and interests, with close monitoring of student progress.

The inaugural class graduates in 2013, but early outcomes look promising. Delta students outperformed Washington averages in reading and writing, scored 20% higher in math, and 30% higher in science in its first round of state-mandated testing in spring 2011.[9]

Results

There is still little broad evidence about the effectiveness of inclusive STEM schools, though early test scores in several states show some positive effects. T-STEM students, for example, score slightly higher on state math and science tests, are less likely to be absent, and take more advanced courses than their peers in comparison Texas schools.[10]

Clearly, more research is crucial to evaluation efforts as these schools mature. A key question is whether students retain interest in STEM fields to pursue STEM college work and careers—a subject under exploration with funding from the National Science Foundation.

Meanwhile, descriptive research reveals other useful information: Inclusive STEM schools are more likely than selective schools to serve large proportions of African American, Hispanic, and low-income students. Moreover, inclusive schools offer a greater level of personalization through strategies such as "looping" a teacher with the same students for multiple years and connecting students with professional mentors who mirror their racial and ethnic backgrounds. While inclusive schools are less likely than selective schools to offer a broad range of AP courses, they are just as likely to provide students with opportunities to take college courses while in high school.[11]

STEM-Focused CTE Schools

The purpose of career and technical education (CTE) is to motivate student learning through real-life applications related to jobs and to develop technologically proficient workers. It can be difficult to distinguish between STEM-focused CTE schools and other STEM programs. The reality today is that all CTE is related in some way to STEM fields.

STEM subjects can be incorporated into any CTE delivery model, including regional career technical centers, CTE high schools, or career academies in comprehensive high schools. Most address STEM-related work, ranging from auto-technology to nursing to financial management. Fewer focus specifically on engineering.

Example: Sussex Technical High School, Georgetown, Delaware

A model for other STEM-focused CTE programs, Sussex Technical High School is a national-award-winning school for the rural county of Sussex, in southern Delaware. Founded in 1961 as a part-time school, Sussex now serves about 1,300 full-time students chosen by lottery. Almost one-third come from low-income families. Among its achievements, the school has the state's highest rating—"superior"—based on test scores in math, reading, science, and social studies. Another important data point: approximately 98% of students graduate.[12]

The school provides a comprehensive educational program integrating technical education with core academic courses, referred to as "techademics."[13] Each student receives training in one of 15 technical areas aligned with local business needs in automotive technologies, health/human services technologies, communications/information technologies, and industrial/engineering technologies.

During freshman year, students take core academic courses and explore a variety of technical fields to help choose a career path. Students then select one program of study for grades 10–12. Senior year culminates with a STEM "exhibition of mastery," where each student creates a significant technical product, prepares a research paper, and makes a formal presentation for administrators, teachers, and business/industry representatives to evaluate. Seniors also have many opportunities for work-based learning in their trade.

Results

There are many examples of highly regarded CTE schools and programs, but little research to support broad conclusions about their effectiveness, particularly in comparison with alternatives. As with other expanding STEM models, the few studies show some positive findings, though preliminary and qualified, about each type of CTE program.

For example, a rigorous study of mathematics content found positive effects: "There is evidence that integrating math in CTE courses can increase the STEM knowledge of CTE

participants. Using a contextual approach, students who learn to use math to solve authentic work-based problems improve their understanding of mathematics."[14] The study found no loss in occupational knowledge, suggesting that CTE need not conflict with academic achievement.

RECOMMENDATIONS

It is clear that there are many more interesting models of specialized STEM secondary education than just a decade ago. While the field awaits the results of effectiveness research underway, it would be worthwhile for educators to visit a variety of STEM programs and seek to replicate in their own schools what appears to be working best so far. These include:

- Grounding STEM education in "real-life" practical problems, especially related to the workplace
- Student participation in original research projects
- Student internships and mentorships with STEM professionals
- Tutoring, advisories, and other individualized supports for students with weaker academic preparation

[1] National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Washington, DC: U.S. Department of Education.

[2] Gonzales, P. et al. (2008). *Highlights from TIMMS 2007: Mathematics and science achievement of U.S. fourth- and eighth-grade students in an international context*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

[3] National Commission on Excellence in Education. (1983). A Nation at Risk: The Imperative for Education Reform. *U.S. Department of Education*, Washington, D.C. Retrieved March 29, 2012 from: http://www2.ed.gov/pubs/NatAtRisk/index.html

[4] See www3.imsa.edu/about.

[5] National Research Council. (2011). *Successful STEM education: A workshop summary*. Alexandra Beatty, Rapporteur. Committee on Highly Successful Schools or Programs for K-12 STEM Education, Board on Science Education and Board on Testing and Assessment. Washington, DC: The National Academies Press.

[6] Rena Subotnik et al. (2001). *Study of the impact of selective SMT high schools: Reflections on learners gifted and motivated in science and mathematics*. Paper presented at the National Research Council's Workshop on Successful STEM Education in K–12 Schools, Washington, DC, May 10–12, 2011.

[7] Ibid.

[8] Ibid.

[9] Test results available at http://washingtonstemeducation.org/organization/our_projects/. For more information on Delta High School, see http://www.thedelthahighschool.com.

[10] Young, V. et al. (2011). *Inclusive STEM schools: Early promise in Texas and unanswered questions*. Paper presented at the National Research Council's Workshop on Successful STEM Education in K–12 Schools, Washington, DC, May 10–12, 2011.

[11] Means, B. et al. (2008). *STEM High schools: Specialized science technology engineering and mathematics secondary schools in the U.S.* Menlo Park, California: SRI International.

[12] Delaware Department of Education, Sussex Technical High School Profile: http://profiles.doe.k12.de.us/SchoolProfiles/District/Default.aspx?checkSchool=0&districtCode=40&district=Sussex%20Technical

[13] See http://www.sussexvt.k12.de.us/hs/.

[14] Stone III, J. R., et al. (2008). Rigor and relevance: Testing a model of enhanced math learning in career and technical education. *American Education Research Journal*, *45*, 767–795.

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