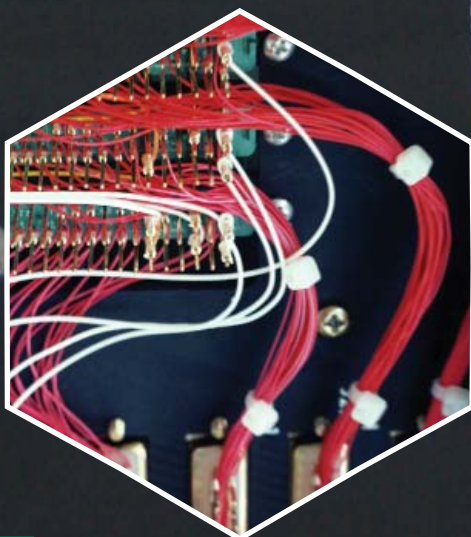




Science and Mathematics

A Formula for 21st Century Success



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The future prosperity and well-being of our state and its citizens depend on *how well we educate our children and youth*. The success of Ohio businesses in the innovation-based global economy demands that they have workers with advanced thinking, reasoning and problem-solving skills. In simple terms, Ohio's future will be defined by *its citizens' ability to think for a living*.

More than ever before, knowledge and skills in science and mathematics will be linked to success in the 21st century economy. No longer will basic arithmetic and a familiarity with a limited number of scientific facts be enough to get ahead – and to stay ahead – either in college or in the workplace. They will not be sufficient for Ohioans to become productive and informed citizens.

For this reason, the Science and Mathematics Education Policy Advisory Council's vision is clear:



VISION

Ohio will be a leader in the innovation-based global economy, and its citizens will have the high-level knowledge and skills in science and mathematics they will need for success.

Making this vision a reality will not be easy. But the task of educating our children well and providing opportunities for retraining our adult population – particularly in science and mathematics – is an imperative. Therefore:

- We envision a future where all Ohioans are aware of the importance of science and mathematics – they understand how these disciplines impact society and define individuals' opportunities in the workplace and throughout life, and they are committed to an education system that teaches our children and/or adult students to grasp and use ideas from these fields.
- We envision a future where scientific and mathematical ideas capture the interest of more Ohio students – more young people prepare for and pursue careers in science, technology, engineering and mathematics (STEM).
- We envision a future where Ohio recruits and prepares more high-quality science and mathematics teachers, creates improved working conditions and provides professional development opportunities to retain them in the classroom.
- We envision a future where educators and employers forge partnerships to build the talent base that business and industry need to succeed in regional, national and global markets.
- We envision a future where the state of Ohio has the capacity to drive sustained improvements in science and mathematics education, and serves as an advocate for public policies and private sector initiatives that are designed for this purpose.

THE COUNCIL'S CHARGE

Taking challenging courses and mastering high-level mathematics and science are the gateway to success in college, careers and citizenship. Similarly, for Ohio business and industry, a well-trained workforce with knowledge and skills in these subjects is the key to competitiveness in the global economy – the road to economic growth and prosperity.

In this context, the Ohio Board of Regents, Ohio Department of Education and Governor's Office created the Science and Mathematics Education Policy Advisory Council and directed it to recommend changes in public policy and educational practices that will allow Ohio to become a leader in developing world-class talent, particularly in the disciplines of science and mathematics. Specifically, the Council's charge was to ***develop findings and make policy recommendations to the Governor, to the Chancellor of the Board of Regents, and to the State Superintendent of Public Instruction respecting improvements in the P-16+ education system for mathematics and science education.***

The Council's Work: What We Did

Beginning in November 2005, the Council met six times as a whole and numerous times in committees to develop the recommendations included in this report. Co-chairs Karen A. Holbrook, President of The Ohio State University, and Julian M. Earls, retired director of the NASA Glenn Research Center and Executive in Residence, Nance College of Business Administration at Cleveland State University, directed the Council's effort to arrive at strategic policy recommendations that leverage significant and immediate change in Ohio's mathematics and science education arena.

The Council's 23 members represented the state's education, business and government interests and brought multiple perspectives and ideas to the discussion of ways to assure that mathematics and science education provides the foundation for a prosperous economic future in Ohio. Council members are identified at the end of this report.

Council members began their work by reviewing existing studies and reports from a broad range of organizations. From that collective enterprise, they reached an initial consensus – that their efforts should be targeted to the most critical issues for science and mathematics education, not to all of the possible matters of public policy and practice. They also concluded that their final report would focus on a limited set of strategies and action recommendations.

Three committees – Graduate Education/Business, P-16 Education, and Partnership and Advocacy – were formed in February 2006, and much of the work that followed was undertaken in these committees. Ultimately, Council members crafted their strategies and recommendations based on three criteria: (1) the issues are among the most crucial matters facing mathematics and science education in Ohio; (2) the issues need immediate attention, will lead to immediate improvements and establish the foundation for subsequent change; and (3) the Ohio Department of Education and Board of Regents can begin to implement the recommended actions quickly with manageable additions to their budgets. Two additional committees – the Report Committee and Recommendations Committee – formulated the recommendations and plans for the final report.

Mathematics and Science – The Keys to Success in Today’s World

By Julian M. Earls and Karen A. Holbrook, Co-Chairs

To attract and retain 21st century businesses – and to create and sustain high-skill, high-wage jobs – Ohio must meet its talent challenge. It must produce more workers with advanced knowledge and skills in science, technology, engineering and mathematics – the so-called STEM disciplines. Not meeting this challenge will have devastating consequences for the state’s economy, just as it will limit Ohioans’ opportunities in a fiercely competitive, global economy.

To be sure, the state of Ohio has made substantial progress in preparing its students to succeed in the 21st century economy, but there are growing indications that the gap between *workplace readiness* and *employers’ expectations* for entry-level workers is widening. Also, there is substantial evidence that foreign advances in the fields of mathematics and science are leaving Ohio and other states at a competitive disadvantage.

This is the reality that all Ohioans – and specifically, the state’s education policy leaders – must confront. Today, Ohio is not producing enough workers educated in the STEM disciplines. Our supply of qualified workers is not keeping pace with the demands of an innovation- and technology-driven economy. Yet, it will not be easy to dramatically increase the number of students who acquire greater thinking, reasoning and problem-solving skills in the fields of mathematics and science.

Why not? In part, it’s because of Ohioans’ anxiety about mathematics and science, as well as their lack of appreciation for these subjects as ways of thinking. The habits of mind and diligence required for the successful study of these disciplines are greatly valued by perspective employers, yet undervalued by people who don’t fully grasp what science and mathematics are all about and who erroneously believe they will never have a need for these subjects.

Yet, there is another reason why Ohio’s talent challenge will not be easily met. For a long time, Ohioans have been satisfied to educate a relatively small percentage of students very well, while a much larger population receives an education that is, simply stated, “good enough.”

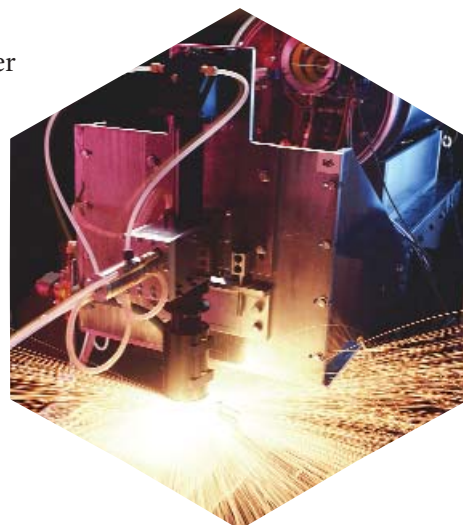
Today, such thinking is risky, if not dangerous. ***Good enough is no longer good enough.*** It will not allow us to improve and sustain the academic achievement of all Ohio P-12 students, ensuring that they acquire the knowledge and skills they will need to succeed in learning beyond high school. And it will not give Ohio the ready supply of highly-qualified workers – specifically in science and mathematics – to ensure the state’s competitiveness in today’s global marketplace.

That is part of the reality Ohio and its leaders must face. It is why the Ohio Board of Regents, Ohio Department of Education and Governor’s Office created the Science and Mathematics Education Policy Advisory Council (SAMEPAC), directing it to recommend changes in public policy and educational practices that will give Ohio the skilled workforce with the scientific and technical capabilities required for success in the 21st century economy.

As the Council’s co-chairs, we were privileged to engage with our 21 colleagues in a search for strategies that, once implemented, will allow all Ohio students to experience the meaning and

magic of science and mathematics, and to fulfill their dreams for higher knowledge and future success. Collectively, we looked hard at the problem and the range of solutions that are being executed across the country as well as in Ohio. We reviewed the best and most current research, and we listened to business decision makers and educators from throughout Ohio.

In just a few words, we concluded that *New York Times* columnist Thomas Friedman, author of *The World is Flat*, is right – that **“math and science are the keys to innovation and power in today’s world.”**¹ We also agreed with those who see a direct link between improving mathematics and science education and enhancing Ohio’s ability to prosper in a global economy.



The recommendations presented in this report build on the work of the Governor’s Commission for Higher Education & the Economy.² The urgency of our recommendations has been captured by *FORTUNE* Senior Editor-at-Large Geoffrey Colvin, who explains that the threat to the U.S. does not come from foreign companies, but from American workers who are unable to compete with workers in other countries. Colvin notes that the fundamental mover of economic development is science and technology and the fundamental prescription for improvement, regardless of who is asked, is to improve education.³

As you read the pages that follow, you will discover that the Council chose to focus its attention on a limited set of goal-based recommendations structured around five specific strategies that members believe will have a positive impact – in both the short and long term – on educational outcomes. We are not recommending additional studies, nor have we allowed our mission to “creep” into subjects beyond our charge (e.g., the debate about how to teach mathematics, the scope of appropriate topics to be explored in the science classroom or the debate between those who urge a tighter focus on basic mathematics skills and those who advocate a more comprehensive set of state standards).

Instead, our focus is on those actions that will support economic growth, strengthen the system of mathematics and science education, build upon existing programs and make high-level mathematics and science courses available to all Ohio students.

Briefly, the Council’s recommendations reflect five core strategies.

- **Public Awareness and Understanding of the Importance of Science and Mathematics.** We call for actions that expand Ohioans’ awareness and understanding of the importance of mathematics and science to their success in the 21st century workplace, and to the state’s future economic prosperity.
- **More Students Who Master High-Level Science and Mathematics and Pursue STEM-Related Careers.** We call for a series of actions to increase the number of students who take challenging courses and master high-level mathematics and science subjects, and pursue STEM (science, technology, engineering and mathematics) careers.

¹ Thomas Friedman, “Still Eating our Lunch,” *New York Times*, 16 September 2005, <http://select.nytimes.com/search/restricted/article?res=FA0C15FB35550C758DDDA00894DD404482>.

² Governor’s Commission on Higher Education and the Economy, *Building on Knowledge, Investing in People: Higher Education and the Future of Ohio’s Economy* (Columbus: Ohio Board of Regents, 2004).

³ Geoffrey Colvin, “America Isn’t Ready [Here’s What To Do About It],” *Fortune*, July 25, 2005, http://money.cnn.com/magazines/fortune/fortune_archive/2005/07/25/8266603/index.htm.

- **High-Quality Science and Mathematics Teachers and Instruction.** We call for changes in the ways that mathematics and science teachers are recruited, prepared, retained and developed throughout their careers, with the purpose being to ensure that every Ohio student has teachers who know their subjects and how to teach them, as well as teachers who care about their students and are committed to their success.
- **Increased Collaboration between Postsecondary Programs and Business.** We call for building partnerships that allow postsecondary instructional and research programs and the business sector to join in collaborative efforts to improve students' STEM-career opportunities, and to improve the education community's ability to meet the workforce needs of Ohio's technology- and innovation-driven businesses.
- **Greater State Capacity to Improve Science and Mathematics Education.** While acknowledging that local action will be required to ensure that all students have opportunities to acquire the high-level mathematics and science knowledge and skills that are the gateway to success in the classroom and careers, we call for changes – including the creation of the Institute for Mathematics and Science Education (IMSE) – that will enhance the state's capacity to drive improvement in mathematics and science learning, and to fuel economic growth.

We have been proud to serve as members of the Science and Mathematics Education Policy Advisory Council and we are committed to defending and advocating for our recommendations. In our advocacy, we will remind Ohio's leaders that efforts to improve mathematics and science education must be seen as part of a broader effort to raise the overall academic achievement of *all* Ohio students. One cannot be attained without the other.

In addition, we will urge the state's education policy leaders, educators and all Ohioans to see our recommendation as a whole, not as a menu of options from which to pick and choose without regard to the impact such an approach would have on the effectiveness of our action agenda.

To be sure, everything can't happen at once. There will be fiscal restraints and some of the actions we propose must be phased-in over time. Council members hope that the intent and design of our recommendations will be respected and that serious efforts will be made to implement our proposals in ways that expand Ohioans' interest and achievement in science and mathematics, and to strengthen the technological expertise that will shape our state's success in the 21st century economy.




Julian M. Earls

Julian M. Earls, Co-Chair

Karen A. Holbrook

Karen A. Holbrook, Co-Chair



SCIENCE & MATHEMATICS

Education Policy Advisory Council

Expand public awareness and understanding of the importance of mathematics and science to Ohioans' success in the 21st century workplace, and to the state's future economic growth and prosperity.

Improve the quality of mathematics and science education by recruiting, preparing and retaining a larger number of high-quality teachers.

Increase the number of students who take courses and master high-level mathematics and science subjects and pursue STEM careers.

Strengthen the interaction between postsecondary instructional and research programs and the business sector to improve students' STEM-career opportunities.

Build the state's capacity to drive improvement in mathematics and science learning, and to fuel economic growth by creating the Institute for Mathematics and Science Education.

**"... math and science
are the keys to innovation
and power in today's world."**

*Thomas Friedman
Author of **The World is Flat***

Public Awareness and Understanding of the Importance of Science and Mathematics

In its 2005 report, *Rising Above the Gathering Storm*, the National Academy of Sciences acknowledges that the U.S. still leads the world in scientific and technological innovation, but asserts that its advantages in the marketplace have begun to erode. Stating that foreign competition in mathematics and science is undermining the nation's pre-eminence in these areas, the Academy calls for a "major push to strengthen the foundations of America's competitiveness" and to preserve its position in the world.⁴

Describing the present situation as a "crisis" in mathematics and science education, the Academy's report concludes, "The ultimate goal is to create new, high-quality jobs for all citizens by developing new industries that stem from the ideas of exceptional scientists and engineers." For that purpose, it calls for the recruitment of 10,000 mathematics and science teachers a year, as well as the strengthening of the skills of a much larger number of teachers.

The Academy's position is that bolstering science and mathematics education will strengthen the nation's economy. The Academy is not alone in recognizing the significance of this connection. Numerous organizations – from The Education Trust, The Thomas B. Fordham Foundation and Achieve, Inc. at the national level to the Ohio Business Roundtable and its affiliates, the Business Alliance for Higher Education and the Economy and Tapping Ohio's Potential, in our own state – have recognized the critical link between higher levels of academic achievement and economic well-being for students, states and societies.

Unfortunately, there is growing evidence that many parents do not share this view of the relationship between mathematics and science and future economic well-being – both for individuals and the larger society. According to a national survey conducted by Public Agenda earlier this year, parents believe that the levels of mathematics and science content in today's school curricula are sufficient to meet workforce and personal needs. According to Public Agenda: "Most elected officials, corporate CEOs and education experts working for high school reform ... believe today's schools aren't as

Points of Agreement

A growing number of education stakeholders agree on three key points.

- Too many of our young people are leaving high school unprepared for what will be required of them to succeed in postsecondary education and the workforce.
- Expectations about what students should learn in high school must be raised dramatically.
- Whether students pursue a STEM degree or not, challenging courses in mathematics and science are the gateway to success in college, careers and citizenship. Research confirms that only 40 percent completing a minimum core curriculum in high school will earn a college degree, while 69 percent of those who take a high-level core curriculum will earn a college degree.

⁴ National Academy of Sciences, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academy Press, 2005).

challenging as they need to be and that students just aren't learning enough. But parents start from a vastly different mindset. Most are convinced their own children will be well prepared for college or work when the time comes.”⁵

What this research tells us is that most parents want their children to learn skills that will prepare them for good jobs in the future. But in Public Agenda's words, “that doesn't mean most parents are chomping at the bit for more math and science for their own child. Most say the amount of science and math their own child studies now is ‘right.’ Parents whose children are currently in high school are even more likely to be satisfied with the status quo. Paradoxically, given the level of leadership anxiety about math and science education in the United States today, the number of parents who worry about whether schools are teaching enough math and science has declined since the mid-nineties.”⁶

While survey research documents that many Ohioans are aware of the value of mathematics and science, that awareness does not translate into action. Too few Ohio students take rigorous mathematics and science courses; too few graduate from high school, let alone from college; and an insufficient number of them pursue STEM careers. For this reason, the Council believes a public awareness campaign is needed to alert Ohioans to the importance of acquiring knowledge and skills in mathematics and science, and to garner their support for public policies and educational practices that will prepare our children and young people for success in science- and technology-based careers.



STRATEGY #1

Expand public awareness and understanding of the importance of mathematics and science to Ohioans' success in the 21st century workplace, and to the state's future economic growth and prosperity.

The Council recommends two actions to carry out this strategy.

Recommendation 1: Develop and carry out a multi-year, research-based public awareness campaign focused on the importance of mathematics and science education to Ohio's citizens, as well as the state's future economic growth and prosperity.

Recommendation 2: Identify, coordinate, integrate and sustain community-based and statewide partnerships (i.e., advocacy networks) to improve mathematics and science education.

These first two recommendations support all elements of the Council's action agenda by providing a statewide groundwork of public understanding and support for mathematics and science education. Without a new culture or mindset, it will be difficult to garner support for and implement all of the Council's proposed actions.

The campaign should emphasize the link between mathematics and science education and future economic success, both for the state and its citizens. It should address the mathematics and science “phobia” that many Ohioans know firsthand – the anxiety that is based in people's difficulties in the classroom and in their misunderstanding of what these



⁵ Public Agenda, *Reality Check 2006: Are Parents and Students Ready for More Math and Science?* (2006): 3, <http://www.publicagenda.org/research/pdfs/rc0601.pdf>.

⁶ Ibid., 6

disciplines are about and how they are used in day-to-day living. In addition, the campaign – which the Council believes should be targeted to students, parents and families, educators, employers, community-based organizations, public officials and the general public – should stress the need for parents to encourage and support their children to pursue high-level mathematics and science courses.

Consistent with the recommendations of the Governor’s Commission on Higher Education & the Economy, the mathematics and science public awareness campaign should be coordinated with other marketing initiatives designed to raise Ohioans’ educational aspirations beyond high school. This means that communications and outreach initiatives cannot begin when students reach high school; rather, they need to target families when their children are young and should include the dissemination of career information to students in the middle-school grades.



This marketing campaign, as well as the market research that drives it, should be initiated by the three entities that created the Advisory Council – i.e., the Governor, Ohio Board of Regents and Ohio Department of Education. These policy leaders should collectively determine the outcomes to be achieved by this initiative and assign a single point of responsibility within state government for overseeing it. In addition, they should determine where to house the initiative, assuring that (1) the “host” organization is innovative and entrepreneurial, and (2) a broad range of stakeholder organizations are directly involved in its development and execution and provide the foundation for the ongoing advocacy network to sustain public understanding of the importance of mathematics and science education.

Ohioans’ Attitudes about Science and Mathematics

Polling data indicate that most Ohioans do not recognize that the rapid advance and application of technology and the impact of globalization require more rigorous and more extensive training, particularly in science and mathematics.

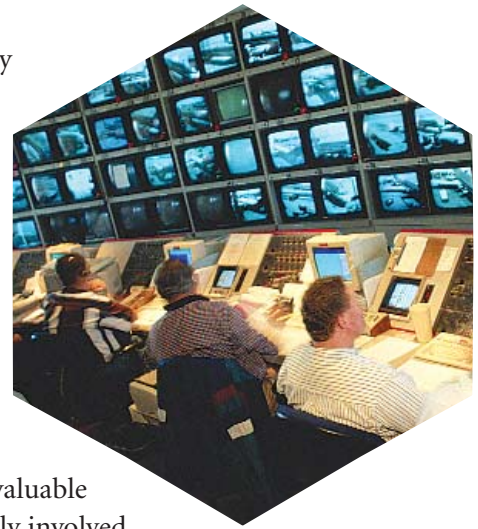
- A survey conducted in 2004 for the State Board of Education’s Task Force on Quality High Schools shows that less than half of those surveyed said that algebra, biology and chemistry should be required for graduation.⁷
- The results of a 2006 statewide survey conducted for the KnowledgeWorks Foundation offer a somewhat more positive perspective with a majority of respondents saying that the state should make four years of mathematics (including two years of algebra) and three years of science mandatory for all high school students. Yet, in that same survey, only 55 percent of respondents indicated that high schools should aim to prepare all students for college, which is down from almost 78 percent just two years earlier.⁸

⁷ Ohio State Board of Education Task Force on Quality High Schools for a Lifetime of Opportunities, *High-Quality High Schools: Preparing All Students for Success in Postsecondary Education, Careers and Citizenship* (Columbus: Ohio Department of Education, 2004).

⁸ KnowledgeWorks Foundation, *Public Priorities for the Future of Ohio Education* (Cincinnati: KnowledgeWorks Foundation, 2006).

In making this determination, these policy leaders should be guided by several considerations, including but not necessarily limited to the following:

- The marketing campaign and related research initiatives should be conducted by experienced professionals with proven track records in successful social marketing campaigns.
- Already established stakeholder groups, including the Ohio College Access Network (OCAN), Business Alliance for Higher Education and the Economy (BAHEE), Ohio Academy of Science, and Ohio Mathematics and Science Coalition (OMSC), should be recruited to play leadership roles in this initiative. All of these organizations are well positioned to bring valuable perspectives and guidance to the initiative and should be integrally involved.
- This marketing initiative should be sustained over a sufficient period of time to be successful and funded through private/non-profit community investments and new state appropriations. The Council believes that the OMSC is well positioned to play a critical role in identifying, coordinating and sustaining community-based and statewide advocacy networks to improve mathematics and science education.



CONFRONTING REALITY

- 60 percent of Ohio high school students enroll in upper-level mathematics courses, but only 28 percent enroll in upper-level science courses.

*The National Center for Public Policy and Higher Education, Measuring Up 2006:
The State Report Card on Higher Education, Ohio (2006):
<http://measuringup.highereducation.org/reports/stateprofilenet.cfm?myyear=2006&stateName=Ohio>.*

- 41 percent of recent Ohio high-school graduates enrolled for the first time as college freshmen take remedial mathematics and/or English, while 33 percent take remedial mathematics.

Ohio Board of Regents, Making the Transition from High School to College in Ohio (Columbus: Ohio Board of Regents, 2005).

- Because it offers too few economic opportunities, Ohio loses more young people between the ages of 20 and 34 (to other states) than any other state except Pennsylvania and it fails to attract a sufficient number to offset the loss.

Ken McCall, "Young Adults Fleeing Ohio: Dayton Hit Hard," Dayton Daily News, 24 September 2006.

More Students Who Master High-Level Science and Mathematics and Pursue STEM-Related Careers

For Ohio and the nation to successfully compete in the global economy – and for our young people to ensure that they are adequately prepared for the challenges they will face in the 21st century workplace – more students must pursue mathematics and science coursework and careers. For this purpose, the National Academy of Sciences has called for the training of more mathematics and science teachers to reach a million more students nationally with high-level mathematics and science courses.⁹ While this is one step toward increasing the number of students taking mathematics and science courses, it may be insufficient to increase their interest in taking such courses and in pursuing STEM-related careers.

For that reason, the Council proposes a more aggressive approach targeted at stimulating interest and reducing barriers *for all students*. Challenging higher level mathematics and science courses enhance students' success in postsecondary education and beyond. Students who take mathematics and science are more likely to stay in college and graduate, to be employed and to earn more money over the course of their lifetime.¹⁰ Recognizing that additional science and mathematics courses will improve the education of all students, the more rigorous high-school curriculum adopted by state legislators in December 2006 – the Ohio Core – calls for four years of mathematics, including algebra 2, and three years of lab-based science. The Council's recommendations support improvements that will both advance the state's economy and enhance the value the public places on mathematics and science education.

In Ohio, anyone interested in pursuing mathematics and science courses must be encouraged – from children currently in the elementary- and middle-school grades to adult workers returning to school to enhance job skills or pursue new careers. Women and minorities constitute an increasingly larger percentage of the workforce but traditionally have been underrepresented in STEM majors and careers. To increase the number of STEM workers overall, the obstacles that prevent women and minorities from entering these fields must be removed. Barriers to continuing education for Ohio workers confronting the changing needs of business and industry and seeking training in STEM areas also must be eliminated.

It is important to overcome the perception that STEM courses are only for a privileged few. A recent American Council on Education study found that black and Latino students were as likely to be interested in majoring in mathematics and science as white and Asian students, but were less likely to have the support and financial resources to complete their college education.¹¹ Studies have found that women excel in science coursework but need encouragement to pursue a career in science.

⁹ National Academy of Sciences, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, 2006).

¹⁰ Ohio Business Roundtable, *The Talent Challenge: What Ohio Must Do to Thrive, Not Merely Survive, in a Flat World* (Columbus: Ohio Business Roundtable, 2006), 19.

¹¹ Eugene Anderson and Dongbin Kim, *Increasing the Success of Minority Students in Science and Technology* (Washington, DC: American Council on Education, 2006).

Research also confirms that underrepresented students may need the flexible schedules, local access and academic guidance that two-year colleges can provide in order to stay in school and get their degrees.¹²

The bottom line? All talented and interested students must be nurtured and encouraged to pursue STEM courses and careers.



STRATEGY #2

Increase the number of students who take courses and master high-level mathematics and science subjects, and pursue STEM careers.

The Council recommends three major action steps to implement Strategy 2.

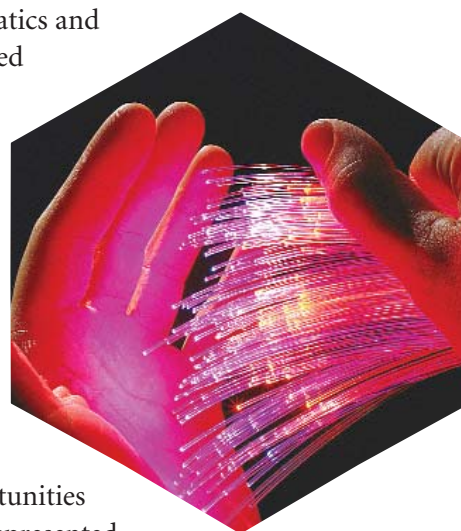
Recommendation 3: Expand and improve opportunities for students to participate in high-quality mathematics and science programs.

First and foremost, Ohio must ensure that all students are exposed to a high-quality mathematics and science curriculum – and high-quality mathematics and science teachers – at an early age so they can determine their interest and aptitude in these areas. As students move through the early grades, they need support and encouragement. For low-income and minority students, in particular, early intervention services and extra supports are essential to prepare them for higher level STEM courses and careers. As students move into middle school and high school, they need rigorous coursework and highly qualified and effective mathematics and science teachers.

Additional recommended actions include the following:

- Create special-focus schools linked to public and private colleges and universities, or to other STEM organizations, that can provide interested students with concentrated learning opportunities in STEM disciplines.
- Use technology – such as online course delivery – to expand access to upper-level courses in high-school mathematics and science, including Advanced Placement (AP) courses, to small, rural school districts that lack financial or human resources to make such courses available in their school buildings.
- Refine and clarify Ohio’s academic content standards in mathematics and science to help schools and school districts develop a more focused and coherent curriculum compatible with the preparation needed to enter college and the workforce.
- Encourage the redesign of entry-level postsecondary STEM courses based on models of exemplary postsecondary teaching to attract and retain more undergraduate students in STEM disciplines.

K-12 students in urban and rural high-poverty schools should have the same access to higher-level mathematics and science as students in wealthy suburban schools. Unfortunately, students – particularly underrepresented students – do not have uniformly good teachers, support and encouragement, rigorous coursework, enrichment opportunities or financial support. As long as such gaps exist, students from underrepresented



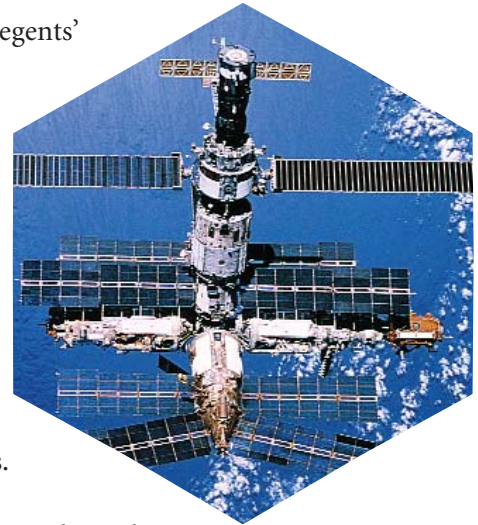
¹² Ben A. Barres, “Does Gender Matter?” *Nature* 442 (July 13, 2006), <http://www.nature.com/nature/journal/v442/n7099/full/442133a.html>; and Steve Giegerich, “Barrier Busters,” *Lumina Foundation Focus* (Winter 2006).

populations will continue to struggle when and if they enter college, and economically challenged minorities will continue to be underrepresented in STEM careers.

Recommendation 4: Expand school-based and extracurricular resources and programs to attract students to higher-level mathematics and science learning opportunities and STEM careers.

This recommendation focuses on building Ohio's capacity for attracting young people to higher-level mathematics and science courses and learning experiences and, ultimately, to careers in the STEM disciplines. Fortunately, there are many existing resources, programs and opportunities that can be tapped, expanded or replicated for this purpose.

Ohio should continue and expand the newly created Ohio Board of Regents' summer academies (House Bill 115), which are designed to attract students to STEM careers and mathematics and science teaching. The state should advocate for and support validated extracurricular programs that emphasize STEM subject areas and that are provided through informal science organizations, public and private universities, and other non-profit groups. Schools must build partnerships with these and other entities that give professionals in STEM careers opportunities to interact with and mentor students, beginning with the middle grades and continuing through postsecondary education.



Several programs in Ohio secondary schools provide effective models. One is ***Project Lead the Way***, a leading middle and high school pre-engineering program that offers a model curriculum and teacher training through its affiliation with some of the nation's leading colleges and universities. Another is Ohio's ***College Tech Prep*** program, which prepares students for careers in a variety of STEM fields beginning in high school. Most College Tech Prep students continue their education at a two- or four-year college or pursue targeted technical certification or apprenticeship programs.

In addition, there are many examples of informal science organizations, higher education institutions and non-profit organizations with the demonstrated ability to attract students to mathematics and science through enrichment programs. These include the Young Women's Summer Institute for middle-school girls sponsored by the Ohio Supercomputer Center, Kent State University and Wittenberg University. Other examples include workshops offered by science museums, zoos, parks and other venues.

To improve access to information about such programs for students, parents and schools, the state of Ohio should create and promote a statewide database of non-classroom options and opportunities for informing and mentoring students for STEM careers, including model mentoring programs for middle- and high-school students.

Recommendation 5: Eliminate barriers that prevent or discourage college-level students from taking and successfully completing STEM courses, or from pursuing STEM majors.

College and adult education students who want to take advanced mathematics and science courses, or to pursue STEM majors in college, encounter a number of obstacles. For some students, the obstacles are financial. For others, scheduling difficulties that prevent students from working and taking classes are the problem. Still others lack adequate academic support systems, including tutors, mentors and counselors.

Research findings indicate that full-time students who work fewer hours have a greater chance for success in college.¹³ With Ohio college costs among the highest in the nation, many students need financial support to successfully pursue their education. Ohio should increase that support – including scholarships, loans and loan forgiveness programs – for college students pursuing STEM careers or high-school teaching careers in STEM disciplines, to enable these individuals to study full-time.

There are fewer examples of programs designed to encourage and assist adult, nontraditional and underrepresented students who may have left college early and workers returning to school to enhance their skills or change careers. Many two-year colleges provide a model to all higher education institutions of the flexibility and extra supports needed to attract working-age adults. Also, certificate programs developed by two- and four-year institutions provide another source of continuing education for older students by offering selected courses to fulfill specific training needs.

Ohio needs this type of talent development for all levels of STEM jobs, not just those requiring advanced degrees. Toward that end, the state should undertake a coordinated effort to identify, expand and replicate exemplary programs in the state's colleges and universities (both public and private, and two-year and four-year institutions) that have shown to be effective in attracting, preparing and retaining students. The search for exemplary programs should pay special attention to proven strategies for reducing attendance barriers and raising success rates for low-income, minority, adult and other underrepresented students.

The state of Ohio should support local programs – including Jobs for Ohio Graduates (JOG) and dropout recovery programs that presently receive funding from the Ohio Department of Education – that help and encourage students who have left school to return and to earn high-school diplomas and postsecondary degrees in STEM fields.

CONFRONTING REALITY

- 2005 NAEP mathematics scores for eighth-graders indicate that all groups have improved, but the achievement gap between white, economically advantaged students and minority, economically disadvantaged students remains the same.

U.S. Department of Education, National Center for Education Statistics, The Nation's Report Card: State Mathematics 2005, Ohio, Grade 8, Public Schools, <http://www.nces.ed.gov/nationsreportcard/pdf/stt2005/2006454OH8.pdf>.

- African-American high-school students in Ohio are half as likely as white students to enroll in upper-level science courses, and two-thirds as likely to enroll in upper-level mathematics courses.

The National Center for Public Policy and Higher Education, Measuring Up 2006: The State Report Card on Higher Education, Ohio. <http://measuringup.highereducation.org/reports/stateprofilenet.cfm?myyear=2006&stateName=Ohio>.

- Just 24 percent of Ohio high school students take a rigorous core curriculum, which is the best predictor of college success.

Ohio Board of Regents, Making the Transition from High School to College in Ohio (Columbus, OH: 2005).

- In Ohio, 39 percent of 19-year-old students enroll in college, compared to 52 percent of their peers in the states that have the highest rates of college participation.

The National Center for Public Policy and Higher Education, Measuring Up 2006: The State Report Card on Higher Education, Ohio, <http://measuringup.highereducation.org/reports/stateprofilenet.cfm?myyear=2006&stateName=Ohio>.

¹³ Anderson and Kim, op.cit.

High-Quality Science and Mathematics Instruction

It is impossible to talk about improvement in education without talking about improvement in teaching. Asserting that “[t]he evidence is indisputable,” national education consultant Mike Schmoker cites research that found teaching has six to ten times as much impact on achievement as all other factors combined.¹⁴ Another study, acknowledging that teacher effectiveness varies markedly, concluded that teacher quality “is the single most important factor influencing gains in achievement – an influence greater than race, poverty, parent’s education, or any other factor associated with learning.”¹⁵

Clearly, improving the quality of teaching in Ohio’s mathematics and science classrooms will support this report’s recommendations to increase student interest and improve achievement in STEM courses. This must be a particular priority at the middle-school level where students first encounter classes that can have a profound effect on their future interest and achievement in mathematics and science. A growing body of evidence suggests that improving the quality of mathematics and science teaching will require “... [a] new set of incentives, including selective hiring, retention, and pay.”¹⁶

It is imperative that Ohio improve the *quality* of mathematics and science teaching –and that it attract and retain an adequate *supply* of high-quality teachers to meet Ohio’s current and future needs. At the present time, Ohio simply does not retain enough highly effective mathematics and science teachers. Without focused action, that gap is likely to widen before it closes. The Ohio Core curriculum, which will affect students who enter high school in the fall of 2010, calls for an additional year of mathematics, including algebra 2, and three required science classes that are lab-based. For that to be possible, Ohio must attract and retain a significantly larger number of qualified, effective mathematics and science teachers.



STRATEGY #3

Improve the quality of mathematics and science education by recruiting, preparing and retaining a larger number of high-quality teachers.

The Council recommends four major actions to implement Strategy 3.

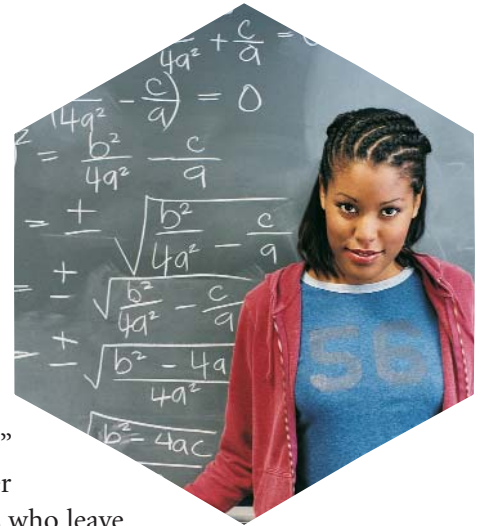
Recommendation 6: Improve the quality and effectiveness of teacher education and the transition of teacher candidates into careers through incentives and improved accountability.

¹⁴ Mike Schmoker, *Results Now* (Alexandria, VA: Association for Supervision and Curriculum Development, 2006), 9.

¹⁵ June Rivers and William Sanders, “Teacher Quality and Equity in Educational Opportunity: Findings and Policy Implications,” in *Teacher Quality*, eds. Lance T. Izumi and Williamson M. Evers (Palo Alto, CA: Hoover Institution, 2002), <http://www.hoover.org/publications/books/3009766.html>.

¹⁶ Eric A. Hanushek, “The Economic Value of Improving Local Schools,” *Proceedings of the Federal Reserve Bank of Cleveland Research Conference*, November 18 - 19, 2004 (Cleveland: Federal Reserve Bank of Cleveland, 2005), 72.

Ohio needs a committed and systemic approach to providing effective mathematics and science teachers in every school. This is not a short-term, quick fix. Deep and genuine changes simply will not happen in an immediate time frame. What *can* happen is change that is slow and incremental in the early years and then accelerates exponentially if sustained consistently over an extended time period. Such a scenario requires leadership and vision – at the policy maker, school district and school building levels – committed to transforming mathematics and science education.



The state must remedy the nonsystematic and loosely overseen way in which teachers are developed and supported. There is too much “leakage” in the existing system – too many candidates who fail to complete teacher education, too few who enter teaching, and too many beginning teachers who leave the profession in the first few years. These “leaks” are felt most acutely by school districts with the largest numbers of low-income and minority students.

The Council recommends that the state use incentives to make colleges and universities more accountable for the outcomes of their teacher education programs, as well as assuring more successful entry into the profession by beginners and increased retention of effective teachers. Specific action steps include the following:

- Provide higher subsidies or other incentives to teacher education programs that produce high-quality middle- and high-school mathematics and science teachers who enter the profession and teach in Ohio.
- Monitor and report on teacher education programs that successfully retain high-quality teacher education candidates through licensure and make the transition into the teaching profession, which is one of the research priorities of the Teacher Quality Partnership.

Recommendation 7: Provide greater incentives and create improved working conditions for mathematics and science teachers and teacher candidates to enter and continue in the teaching profession.

There are many dimensions to effective teaching: Teachers must have strong content-area expertise. They must have a solid grounding in pedagogy. Teachers must be able to apply standards-based learning and assessments. Also, they must master classroom management techniques and know how to accommodate individual learning differences. This range of knowledge, skills and expertise is acquired throughout a teacher’s career, and all teachers do not possess this knowledge to equal degrees.

Effectiveness should be measured by classroom performance, and effective teachers should be compensated and supported accordingly. Enhancing efforts to support and reward effective teachers is essential to *retaining* these teachers – a particular challenge in the mathematics and science areas, which have higher levels of teacher dissatisfaction and higher teacher turnover rates than other subject areas. Therefore, the state should:

- Develop financial and other incentives for school districts to pilot and evaluate differentiated compensation programs for teachers in hard-to-staff schools and subject areas.
- Develop financial and other supports such as sustained mentoring that bolster the effort of hard-to-staff schools to retain experienced, effective mathematics and science teachers.

Recommendation 8: Strengthen middle-grade licensure programs and middle- and high-school re-licensure requirements for mathematics and science teachers.

The most critical time segment of students' mathematics and science growth is middle school. This is a period when content ideas begin to reflect the thinking of the specific disciplines. It is when students are making critical decisions as learners about what they believe they *can do* in learning – and what curriculum and career choices they should pursue in subsequent years. It is a time when girls and minorities may be discouraged from pursuing mathematics and science by factors that have nothing to do with their achievement or potential.

The preparation of effective middle-grade and high-school teachers is, therefore, essential to the flow of students into STEM curricula and careers. Viewed from this perspective, perhaps the most urgent priority for Ohio is to stipulate high standards for middle-school teacher preparation and assure adequate provision of quality professional development for practicing middle- and high-school teachers. Toward this end, the Council recommends the following:

- Assure uniformly high standards for middle-grade and high-school mathematics and science teacher preparation programs.
- Require that teacher re-licensure requirements for middle and high school address the need for teachers to deepen their understanding of the subject matter taught and effective ways to teach it.

Recommendation 9: Improve program supports for teachers' continuing professional education so that school districts have access to highly effective teachers.

Mathematics and science are subjects for which student knowledge and understanding grow progressively through ensuing content. The cumulative effect of the good teachers a student has had, as well as the residual effect of poor teachers, is pronounced. For that reason, strengthening the support and delivery systems for building mathematics and science teachers' professional knowledge and improving their teaching effectiveness must be a priority for Ohio.

All teachers must have easy access to validated, high-quality, content-relevant professional training to improve their performance in the classroom. These resources should include opportunities to intern in real-world business settings. Ohio's continuing licensure standards should be revisited with the aim of making it more attractive for teachers to take coursework and professional training specific to their classroom assignments. The Council recommends the following:

- Provide statewide online and on-site courses in state-targeted mathematics and science content needed for teaching for elementary-, middle- and high-school mathematics and science teachers.
- Help school districts identify professional development needs, expand technical assistance for the analysis of student assessment data and create services to meet other documented professional development needs of individual teachers.
- Offer incentives to businesses and non-profit organizations that provide summer employment opportunities for teachers that enrich their mathematics or science content and real-world application knowledge.



CONFRONTING REALITY

- Ohio's teacher preparation supply pipeline is highly porous, losing teachers prior to licensure, prior to entry into an Ohio classroom, and leaving the classroom within the first five years of teaching. Factors that cause mathematics and science teachers to leave teaching are generally not being addressed by districts or the state.

Center for the Teaching Profession, Condition of Teacher Supply and Demand in Ohio 2004 and 2003 (Columbus: Ohio Department of Education, 2005).

- Research confirms that an effective teacher has the single greatest effect on improving student performance. Conversely, the impact of having three ineffective teachers in a row can be devastating to a student's subsequent achievement.

W.L. Sanders and J.C. Rivers, "Cumulative and Residual Effects of Teachers on Future Student Academic Achievement," Research Progress Report (Knoxville, TN: University of Tennessee Value-Added Research and Assessment Center, 1996), <http://www.heartland.org/pdf/21803a.pdf>.

- There is an inequitable and unbalanced supply of well-qualified, effective teachers in Ohio, varying by region and district typographies. Students most in need of effective teachers are least likely to have them.

Sithu Babu and Robert Mendro, "Teacher Accountability: HLM-Based Teacher Effectiveness Indices in the Investigation of Teacher Effects in a State Assessment Program" (AERA Annual Meeting, 2003).

- Low salary is a deterrent both to attracting and retaining high-quality, effective mathematics and science teachers, particularly for hard-to-staff schools. Currently, teacher salaries are not linked to teacher effectiveness.

Richard M. Ingersoll, "Is There a Shortage Among Mathematics and Science Teachers?" Science Educator, 12, 1 (Spring 2003).

- Mathematics and science teachers are significantly more likely to move from or leave their teaching jobs because of job dissatisfaction than are other teachers (40 percent of mathematics and science teachers compared with 29 percent of all teachers); and nationally, mathematics (16.4 percent) and science (15.6 percent) have the highest annual teacher turnover rates by field.

Richard M. Ingersoll, "Is There a Shortage Among Mathematics and Science Teachers?" Science Educator, 12, 1 (Spring 2003).

- An estimated 240,000 middle and high school mathematics and science teachers will be needed between 2000 and 2010 – and of this total, nearly 70 percent will be newcomers to the profession.

National Commission on Mathematics and Science Teaching for the 21st Century, Before It's Too Late: A Report to the Nation (Washington, DC: U.S. Department of Education, 2000).

Greater Collaboration between Postsecondary STEM Programs and Business

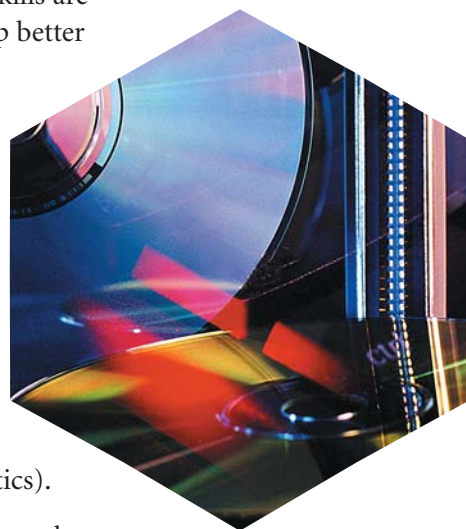
Businesses, schools and institutions of higher learning have been involved with each other since the late 1800s, and their relationships began to evolve into formal partnerships in the 1970s. In large part, these new relationships were a response to the perceived crisis in American public education, the limited skills of many entry-level workers and the demands of an economy that increasingly relies on workers who have the knowledge and skills that permit them to *think for a living*.

Traditionally, these partnerships have been viewed from the perspective of their benefits to education – for example, improved classroom teaching and learning, exposure to new learning technologies, opportunities for teachers to hone their skills by working with real-world problems in business environments and structured work experiences that allow students to learn in nontraditional instructional settings. Yet, today’s business-education partnerships are increasingly built on a recognition that cooperation can help businesses meet both immediate and long-term needs, and that the ultimate beneficiaries of these alliances are the students for whom collaboration means improved career opportunities.

The Council believes that Ohio’s long-term economic prosperity requires more effective collaboration between the state’s business and education communities, especially higher education. In part, its thinking is grounded in an understanding that one of the biggest challenges in today’s economy is providing sufficient skilled workers to fill business needs, particularly at the graduate, professional and certificate levels. And for Ohio, this is an especially important challenge since it is not producing enough skilled workers, and too many of those it does produce leave for jobs elsewhere, often because they have an opportunity for an internship or education outside the state.¹⁷

Ohio’s higher education community must understand what STEM skills are needed by businesses, and the state’s business leaders have to develop better mechanisms for communicating their needs and for finding skilled Ohio workers. This fact has been confirmed by several groups, including the Governor’s Commission on Higher Education & the Economy (CHEE). In its final report, the Commission also called for the creation of the Business Alliance for Higher Education and the Economy (BAHEE) to serve as an advocate for Ohio colleges and universities to contribute to the state’s economic growth. BAHEE, now part of the state’s business-education infrastructure, already has identified development of Ohio’s talent base in STEM disciplines as “priority one,” and it has defined its “strategy one” as requiring students to take rigorous and challenging courses (including courses in science and mathematics).

The private sector must find new ways to connect with university researchers to align research efforts with business needs. In addition, it must find new conduits to bring STEM graduate and doctoral talent into high-tech business fields, just as it must cultivate



¹⁷ Ohio Business Roundtable, op. cit., 8.

support through the development of a highly trained and technically competent workforce. Strategy 4 is designed to help achieve this objective.



STRATEGY #4

Strengthen the interaction between postsecondary instructional and research programs and the business sector to improve students' STEM-career opportunities, and to improve the education community's ability to meet the workforce needs of Ohio's technology- and innovation-driven businesses.

The Council believes that business and higher education must be sensitive to each other's needs and that improved communication will lead to greater mutual understanding about how they work together to solve difficult problems. Therefore, it recommends two major actions to implement this strategy.

Recommendation 10: Establish university-business advisory councils to develop and promote research goals and graduate study programs that are mutually beneficial to higher education and the state's employers, and provide internships and other nontraditional learning experiences for university and college students and teachers in STEM-related disciplines.

Recommendation 11: Develop a Web-based clearinghouse for regional and statewide internship and externship opportunities to ensure that students in STEM academic programs acquire the requisite skills for entry into and for successful careers in Ohio's job market.

The Council recommends that businesses and universities improve communication and interaction through advisory councils and internships, both of which will enable educators and employers to better understand each other's needs and capabilities. Through the advisory councils, businesses can learn more about the research under way at universities, and university faculty can better understand the practical concerns of business and how they can provide their students with the skills needed for STEM careers.

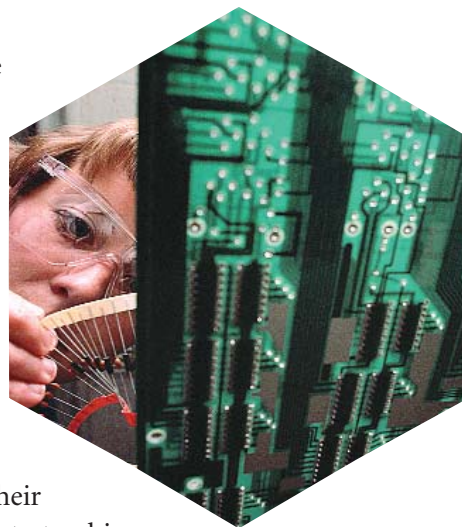
Internships allow businesses to harness the talent of Ohio students and teachers, just as they give students and teachers valuable real-world experience. Students are more likely to stay in STEM careers – and in Ohio – if they have an internship in the state. A study conducted at West Virginia University identified the benefits to this kind of collaboration between business and education. Recruiting young workers gives them an incentive to stay in the region, enables the business to realize a greater return on investment in higher education, and may attract new industries to the area as the stock of skilled workers increases.¹⁸



¹⁸ B. E. Lego, *Formal and Informal Recruitment of College Graduates: Implications for Economic Growth and Development in West Virginia* (Morgantown, WV: Agricultural and Resource Economics, 2002).

Internships benefit students in other ways. According to a Penn State University study, engineering students who participate in internships, either credited or noncredited, are likely to get more job interviews on campus and on-site, receive more job offers and be hired at a higher salary. This is particularly the case for women and minorities.¹⁹

Through externships, teachers have an opportunity for hands-on learning and professional development and are more likely to remain in the classroom. Externships are one of the important strategies recommended to improve teachers' content knowledge and enhance professional learning of mathematics and science teachers. Teachers who participate in externships not only improve their content knowledge, but also renew their interest in and commitment to teaching and share their renewed enthusiasm with their students. A recent study found that students of science teachers who had summer externships performed significantly better on tests of science knowledge and reasoning, and externships can be an important tool in retaining mid-career teachers.²⁰



To support internship and externship programs, the Council recommends that the state establish a Web-based clearinghouse for regional and statewide learning opportunities. Properly designed and executed, this Web site would serve as a one-stop shopping center for employers, students and teachers who want to participate in internship and externship experiences.

Finally, it is important to emphasize that not all STEM jobs require advanced degrees. Many students and adults changing careers can enter STEM careers by completing a certificate program (selected courses offered to acquire a particular skill) or a two-year degree. In fact, many companies are looking for exactly this level of education before locating a business in the state. The Council recommends that such programs be promoted and encouraged.

The Council recommends that the Third Frontier Internship program be broadened to include support for graduate students majoring in science, engineering and mathematics to encourage them to enter careers involving technology commercialization. In addition, the Council recommends two other actions:

- Align STEM instructional programs and create new courses at Ohio's colleges and universities – in collaboration with business – to ensure that students develop the skills needed by the state's employers.
- Emphasize high school and two-year college programs that improve the education-business pipeline through the development of high-level technical skills to support Ohio employers.

¹⁹ M. K. Schuurman, R. N. Pangborn, and R. D. McClintic, "The Influence of Workplace Experience During College on Early Post Graduation Careers of Undergraduate Engineering Students," *Proceedings of the 2005 WEPAN/NAMEPA Joint Conference*, (2005).

²⁰ Rhea Borja, "Real-World Experiences," *Education Week* 25, 43 (July 26, 2006), 31.

CONFRONTING REALITY

- 90 percent of the fastest growing occupations require some education beyond high school.
- Ohio manufacturers will continue to offer jobs, but expect to have difficulty filling them with skilled workers.
- American manufacturers say that approximately 60 percent of workers are poorly prepared for the workforce.
- In 2002, Ohio ranked 40th among all states in percent of the state's population with a bachelor's degree or higher.
- From 1997 to 2003, Ohio's gross state product (GSP) increased by 7.3 percent ranking it 46th among the 52 states and territories. The average increase for the United States was 13.6 percent.

SOURCE FOR THESE DATA: *Ohio Business Roundtable*. The Talent Challenge: What Ohio Must Do to Thrive, Not Merely Survive, in a Flat World (*Columbus: Ohio Business Roundtable, 2006*).

Greater State Capacity to Improve Science and Mathematics Education

A study conducted as part of the Third International Mathematics and Science Study (TIMSS) concluded that curriculum in the United States is a mile wide and an inch deep. The same can be said for the mechanisms that are used to drive and support mathematics and science education in Ohio.

These mechanisms – which can only loosely be called a system – tend to be fragmented, nonuniform and marginally directed toward strategic, long-range improvements. While this process is appropriately structured around a set of academic content standards, assessments and accountability measures, it does not include a connected, integrated support system that enables deeper and more lasting changes.

The Council believes the current process needs to be improved. In years past, it has worked well enough for Ohio, at the K-12 level, to perform slightly above national norms in mathematics and science. But the state lags substantially in comparisons at the higher education level and its economy is not performing as well as it should. For these reasons, Council members have concluded that “good enough” isn’t sufficient; they have agreed that Ohio cannot afford to continue driving improvements in mathematics and science education solely through its historic policy levers and infrastructure.

Like Ohio, other states have recognized that their economic futures and well-being are linked to the performance of their educational systems, especially in mathematics and science. But they are not standing still, relying on obsolete policy systems and infrastructures that were designed to meet the needs of another age. Instead, they are retooling their education systems to power their economies and to create new and exciting futures for their citizens.

At least three states – Texas, North Carolina and California – have made serious commitments to education infrastructure designed to focus and support continuing improvements in science and mathematics education. Each state has a center emphasizing one or more aspects of policy analysis, data-based improvement support or delivery of high-quality professional development.



The Ohio Resource Center for Mathematics, Science, and Reading (ORC)

Established by the Ohio Board of Regents and funded by the Ohio General Assembly, ORC has the largest collection of online mathematics and science resources in the state. The Center provides links to peer-reviewed online instructional resources that have been identified by a panel of Ohio educators and exemplify best or promising practices. The resources are correlated with Ohio’s academic content standards and with applicable national content standards. ORC also disseminates information to a wide variety of user audiences and assists in implementing, institutionalizing and sustaining these P-16 practices across Ohio.

This is a commitment that the state of Ohio must make and it's the basis for the Council's fifth strategy.



STRATEGY #5

Build the state's capacity to drive improvement in mathematics and science learning, and to fuel economic growth, by creating the Institute for Mathematics and Science Education (IMSE).

To power their economies, many states are investing in education and technology infrastructure. In Illinois, for example, policy makers are making significant investments in biotechnology, information technology and university-based research. Georgia is invigorating its economy through the Georgia Research Alliance and by investing in collaborative research labs and technology transfer programs. Michigan is creating a "life sciences corridor," while Ohio is expanding the state's high-tech research and technology commercialization capabilities through the Third Frontier Initiative.

The Council applauds this initiative, and its fifth strategy – with the creation of a statewide Institute for Mathematics and Science Education (IMSE) – is intended to complement that investment. The Council recommends two major action steps to implement this strategy.

Recommendation 12: Establish the Institute for Mathematics and Science Education (IMSE) by linking the Ohio Resource Center with other data and policy study entities.

The purpose of the IMSE will be to collect and analyze data about mathematics and science education, and to provide informed policy analysis for use by state education policy leaders and local school districts. Most critically, the Institute will generate the data, resources and assistance required for the effective matching of educational outcomes with statewide and regional economic development needs. The Council recommends that the IMSE be:

- Directed to prepare and issue periodic data analyses, needs assessments and other policy reports on the condition of mathematics and science education, including a supply and demand study on mathematics and science teachers, to the state's education policy leaders.
- Commissioned to work with appropriate state agencies to create instructional products and other resources needed to make strategic mathematics and science education improvements statewide.
- Authorized to provide input to the mathematics and science advocacy network and marketing campaign to build public awareness, understanding and support for mathematics and science education and STEM careers.

The Council urges policy makers to build the IMSE along with the corresponding regional delivery network around existing programs and entities, particularly the Ohio Resource Center for Mathematics, Science, and Reading.

State agencies in Ohio have many segmented, individual programs, each trying to improve some aspect of the mathematics and science pipeline. What it lacks is the power of an integrated longitudinal plan, a dedicated staff pursuing that plan and a linked infrastructure to supply necessary supports for effective implementation. An independent data, policy and resource center – the Institute for Mathematics and Science Education – can provide the focus required to address long-term objectives for science and mathematics education. It can achieve goals that individual state agencies find difficult.

Recommendation 13: Connect the Institute for Mathematics and Science Education with regional delivery and support systems to drive strategic improvements in P-12 STEM education across the state.

The benefits of an effective regional delivery network are clear. The network will create the collaborative capacity to bring groups of people together to focus on state and regional priorities (e.g., formation of business-education advisory committees). In addition, it will provide a continuing delivery conduit for professional development and other initiatives through IMSE.

The linked, regional entities (e.g., Centers of Excellence for Mathematics and Science, TIMSS Consortia and the agencies that make up the Educational Regional Service System as defined by H.B. 115) will support both school districts and institutions of higher education as they implement mathematics and science initiatives. They also will function as brokers of proprietary-based services for the long-term technical support required to enable deep change. With the creation of this network, the state agencies will coordinate the funding of professional development to avoid duplication of services and focus more specifically on the development, validation and assessment of training outcomes. An eventual “suite” of materials, products and services will become available for school districts to contract for customized services from network providers.

The Council believes that this level of infrastructure investment by the state will provide much-needed support for regional university collaboratives, just as it will facilitate school districts’ participation in regional delivery networks. It will result in a more effective and focused use of the leadership capacity that exists within state agencies, universities and consortia.

Such an investment will enable training and use of a reservoir of persons not currently engaged in support of system-wide improvements – that is, arts and sciences faculty and master teachers – who do not have an easy way to connect with state priorities. In addition, it will bring a rich mixture of content expertise, academic/business application perspectives, and clinical practice and experience to focus on classroom and student performance.

This kind of statewide infrastructure already is emerging. Through a collaboration of state and local agencies, Ohio is developing new systems, such as the Data Driven Decisions for Academic Achievement. This infrastructure will allow school districts to look at their own data, as well as information from other databases, to identify ways to improve the academic performance of their students. So fortunately, efforts in this area will not need to start from scratch.

CONFRONTING REALITY

- Mathematics and science improvement efforts within state agencies, universities and districts occur through funding from various state and federal sources. Today, these initiatives are only loosely connected to long-term strategic planning for the state, since they tend to be driven more by funding streams than by longer-term system goals.
- Data are collected through many state agency channels. But they may not be aggregated and subjected to further analysis, and too often they are not shared across agency boundaries in ways that allow them to be used in policy making as it relates to science and mathematics.
- There are significant gaps in reliable mathematics and science teacher data and analyses to make good policy decisions. This is particularly acute in teacher preparation, factors affecting entry into the profession and the effects of teachers on student learning.

Sustaining Ohio's Science and Mathematics Policy Agenda

In its 2005 Annual Report, the Federal Reserve Bank of Cleveland asked a simple question: “Why do residents of some states have higher incomes than residents of other states?” It followed up with a second question: “Why have these income differences persisted for the past 75 years?”

To answer these questions, the Federal Reserve Bank commissioned an analysis of the patterns of per capita income growth across the United States from the 1930s to 2004. The results of that analysis led the study’s authors to conclude: “[O]ver the long run, factors like innovation and a skilled labor force appear to make a big difference in explaining why some states have grown more than others.”²¹



This research confirms the Council’s belief that investments in knowledge building – through education and research – are the key to Ohio’s success in the 21st century’s innovation-based global economy. It supports the conviction that Ohio’s future prosperity will be shaped by its citizens’ success in acquiring the high-level knowledge and skills in science and mathematics that are associated with the development and commercialization of new technologies and with advancements in the STEM-based industries that are driving economic growth today.

Early in their deliberations, Council members agreed that Ohio’s students must improve their performance in mathematics and science. For this purpose, the Council focused on the factors that encourage young people to pursue STEM careers and take higher level mathematics and science courses. Students need exposure to excellent mathematics and science teaching at an early age so they can determine their interest and aptitude in these areas. Then, in order to continue, students need support and encouragement as well as rigorous coursework and superior teachers.

The Council agreed that K-12 students in urban and rural high-poverty schools should have the same access to high-quality mathematics and science courses – and to opportunities to pursue STEM careers – as students in higher wealth suburban schools. Finally, the Council acknowledged that success demands the building of a full and active partnership among the education and business communities and state government, just as it requires action to ensure that high-quality instruction in mathematics and science is an integral part of all secondary, postsecondary and workforce training programs.

This is the basis for the 13 recommendations highlighted in this report. Yet, two questions remain to be answered. ***First, where will the dollars needed to make this investment in science and mathematics education come from? And second, where should the work begin?***

²¹ Federal Reserve Bank of Cleveland, “Altered States: A Perspective on 75 Years of State Income Growth,” in *2005 Annual Report* (Cleveland: Federal Reserve Bank of Cleveland, 2006).

Recommended Funding Strategies

Recommended Actions	Anticipated Benefits	Sources of Funding		
		Current/ Reallocated Resources	Private/ Community Investments	New State Investments
1 Develop and carry out a multi-year, research-based public awareness campaign	Enhanced awareness, understanding and support for science and mathematics education as a tool for economic growth		X	X
2 Identify, coordinate, integrate and sustain community-based and statewide partnerships to improve mathematics and science education		X	X	
3 Expand and improve opportunities for students to participate in high-quality science and mathematics programs	More talented students kept in the science and mathematics pipeline; new opportunities for students in STEM careers; greater equity of STEM-related opportunities for secondary and postsecondary students, particularly women, minorities and students from low-wealth districts; more and better trained technology workers; Ohio seen as more attractive to businesses seeking to locate in the state	X		X
4 Expand school-based and extracurricular resources and programs		X	X	X
5 Eliminate barriers that prevent or discourage college-level students from taking and successfully completing STEM courses, or from pursuing STEM majors		X		X
6 Improve the quality and effectiveness of teacher education	Better preparation of science and mathematics teachers; greater effectiveness of middle-school teachers; more teachers retained in Ohio; better data on teacher education system; teacher compensation linked to need and effectiveness; better retention of teachers where they are needed most; improved ability to systematically address program weaknesses; improved articulation of teacher education programs with business needs	X		X
7 Provide greater incentives and create improved working conditions for science and mathematics teachers and teacher candidates		X	X	X
8 Strengthen middle-grade licensure programs and middle- and high-school re-licensure requirements for science and mathematics teachers		X		
9 Improve program supports for teachers' continuing professional education		X	X	X
10 Establish university-business advisory councils to develop and promote research goals and graduate study programs that are mutually beneficial to higher education and the state's employers, and provide internships and for students and teachers in STEM-related disciplines	Improved communication and understanding; better recruitment of students into STEM professions; better coordination of university programs with business needs; more effective training of students for STEM jobs	X	X	
11 Develop a Web-based clearinghouse for regional and statewide internship and externship opportunities		X		X
12 Establish the Institute for Mathematics and Science Education (IMSE) by linking the Ohio Resource Center with other research, data and policy study entities	Improved capacity to drive changes statewide; better use of public and private dollars for delivery of validated programs; greater technical assistance to districts for school improvement; better long-term professional development	X	X	X
13 Connect the Institute for Mathematics and Science Education with regional delivery and support systems		X	X	X

From the start, Council members agreed that their recommendations should be carried out wherever possible by leveraging existing resources and by drawing from both public and private sources when new funding is required. Yet, they also understood that funding issues ultimately will have to be resolved by Ohio's education policy leaders in collaboration with key decision makers in the state's education and business communities. But to help all of these stakeholders, the Council has suggested – in the chart on page 27 – how public and private entities might share responsibility for moving Ohio toward its goal.



The second question – Where should the work begin? – has already been answered. Very simply, the job of executing Ohio's agenda for improving science and mathematics education has already begun.

In recent years, state and local leaders – both in and outside the education community – have worked to improve the performance of Ohio schools and the students they serve. Important steps have been taken in many areas, particularly to strengthen the state's academic content standards, assessments and accountability system. Progress also can be seen in the areas of teacher preparation, teacher standards and school facilities, just to mention a few.

All of these reforms have important implications for mathematics and science education, and Ohioans should take pride in the fact that their children achieve at higher levels than those in most states. But Ohio still has a long way to go if our children and youth are to have the knowledge and skills they will need to succeed in the 21st century economy.

Several new and expanded initiatives confirm that the Council is **not alone** in its determination to meet this challenge. For example:

- **The Ohio Resource Center for Mathematics, Science, and Reading** has established a Web site that features peer-reviewed, best-practice lessons correlated with the state's academic content standards. The Web site averages more than one million hits each month, where teachers, parents and students can find more than 2,000 online mathematics and science education resources.²²
- By offering pre-engineering curricula, software and teacher training, **Project Lead the Way** is helping schools forge new generations of engineers in response to U.S. industry's need for a high-tech workforce.²³
- The **SMART Consortium and High Aims Consortium** are working in a number of Ohio communities to rectify critical shortcomings in K-12 mathematics and science education. Both initiatives are committed to attaining world-class standards in these critical disciplines.²⁴
- Ohio's **Teacher Quality Partnership**, a consortium of Ohio's 50 colleges and universities that offer teacher preparation programs, is engaged in a multi-year research study designed to identify how the preparation and development of new teachers – and the development of teachers already in the classroom – affect their success as measured by the academic achievement of their students.²⁵

²² See <http://www.ohiorc.org>.

²³ Project Lead the Way, *Overview of Ohio Initiative* (Project Lead the Way unpublished report, 2006).

²⁴ For the SMART Consortium, see <http://www.smartconsortium.org>. For the High Aims Consortium, see <http://www.highaims.org/>.

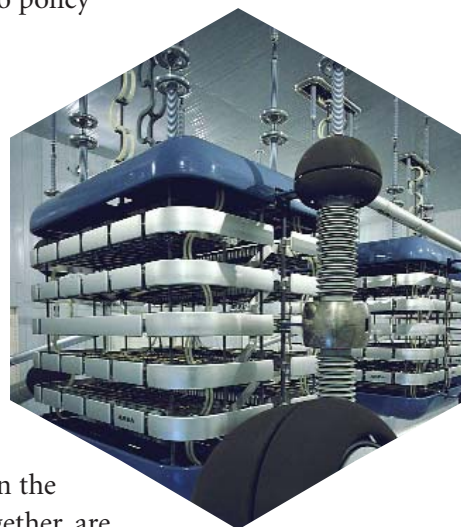
²⁵ See <http://www.teacherqualitypartnership.org/index.php>.

- The **Ohio Department of Education** has undertaken a Mathematics Initiative and a Science Initiative to improve mathematics and science education in Ohio. As a part of these initiatives, Mathematics and Science Program Models have been developed for grades 9 through 12 that describe courses and course sequences that fully meet the Academic Content Standards and provide options for all students. ODE's FY 2008-09 budget request includes funds to undertake similar work at the middle-school level. The Department is building on the professional development work begun in the Ohio Mathematics Academy Program, Ohio Science Institutes, sustained continuing education provided through Ohio universities and support organizations, and federally funded Math Science Partnership projects.
- The **Ohio Board of Regents** has launched several initiatives to prepare Ohioans for careers in science, technology, engineering, mathematics and medicine. These include plans to create up to ten regional summer academies that focus on foreign language and STEM-related disciplines – academies that will prepare eleventh- and twelfth-grade students to pursue college-level courses with a focus on secondary teaching in these subject areas. Other initiatives will provide scholarships for prospective mathematics and science teachers and support for underrepresented populations in Ohio's colleges and universities. The Regents are asking the state legislature to provide funding for these initiatives, as well as for the expansion of the existing mathematics and science education infrastructure, in the FY 2008-09 budget.
- The **Ohio Business Roundtable** has established two new affiliates, the Business Alliance for Higher Education and the Economy and Tapping Ohio's Potential "to position Ohio as a magnet and national leader in attracting, cultivating, training and producing the next generation of skilled scientists and engineers to create tomorrow's innovations," with the goal of doubling the number of STEM baccalaureate degrees produced by Ohio-based colleges and universities by 2015. With its affiliates, the BRT also is working with Ohio policy makers to build, finance and develop a world-class system of regional STEM schools across Ohio, as well as a residential statewide STEM Academy.

Together, all of these initiatives reflect a growing consensus that Ohio's future economic prosperity depends on a solid foundational knowledge base and outstanding talent in the STEM disciplines. More importantly, they point to a broad and enduring commitment to meet Ohio's talent challenge – ***and to respond positively to Thomas Friedman's admonition that mathematics and science are the keys to innovation and power in today's world.***

From the beginning, this vision has guided the Council. It has been the groundwork for the Council's 13 recommendations that, taken together, are designed to position Ohio as a leader in the innovation-based global economy and to give its citizens the high-level knowledge and skills in science and mathematics they will need for success.

The work to turn Ohio's science and mathematics education policy agenda into action has begun. The time to move forward uncompromisingly to achieve this vision is now.



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Julian M. Earls and Karen A. Holbrook
Co-Chairs

Science and Mathematics Education Policy Advisory Council Members

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Executive in Residence, Nance College of Business
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Jayshree Shah

Biology Teacher
South Point High School

William Steenken

Retired Engineer
General Electric Aircraft Engines

Lisa Suarez Caraballo

8th Grade Bilingual Mathematics Teacher
Luis Munoz Marin Middle School

Jonathan L. Tafel

Vice Chancellor, Educational Linkages and Access
Ohio Board of Regents

Andrew Tonge

Chairperson, Department of Mathematical Sciences
Kent State University

Gil Van Bokkelen, Recommendations Committee Chair

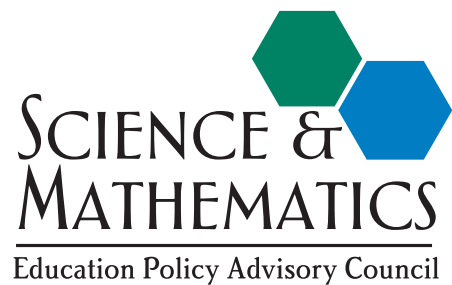
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Economy



1929 Kenny Road
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614/247-6342

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