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KENTUCKY'S STEM IMPERATIVE

COMPETING IN THE GLOBAL ECONOMY

The Final Report of the
Council on Postsecondary Education
STEM Task Force

The CPE STEM Task Force is generously co-sponsored
by the University of Kentucky

March 2007

Dear Fellow Kentuckians:

We are pleased to share with you the Council on Postsecondary Education's (CPE) Science, Technology, Engineering, and Mathematics (STEM) Task Force Report. At its November 6, 2006, meeting, the CPE charged the STEM Task Force with "developing a statewide P-20 strategic action plan to accelerate Kentucky's performance within the STEM disciplines."

The 110 members of the STEM Task Force are leaders within the government, business, and education sectors from across the Commonwealth. During the past three months, the STEM Task Force reviewed data, heard testimony, and examined a wide variety of national reports that identify the scope and seriousness of the STEM crisis in America.

These discussions have persuaded us that there is a national and state-level crisis in the STEM pipeline that must be addressed immediately. The future of the Commonwealth depends on how we respond and what actions we take to ensure that our citizens are actively engaged in solutions to this unprecedented crisis.

For too long, Kentucky has been content to wait and watch as other states make tough choices that result in progress for them and leftovers for us. Kentucky has the potential to be the state that others follow to remedy the STEM crisis. We believe that collaborative and coordinated strategies to resolve the STEM crisis must engage all sectors and all citizens.

We hope that you will review these recommendations and share your views on how we might proceed to ensure that our children have every opportunity to effectively compete in the increasingly global economy. This task force will continue to meet and discuss Kentucky's challenges and potential solutions because STEM disciplines hold the key to our future economic prosperity, including critical areas such as health care and sustainable energy.

The consequences are dire and far-reaching if we fail to take action. Thoughtful, bold, and timely action regarding the STEM disciplines will position Kentucky to succeed in the global competition for 21st century innovation, careers, and economic development. Finally, we invite you to join our collective efforts to secure Kentucky's future through the implementation and funding of these recommendations.

Lee T. Todd, Jr.
President
University of Kentucky

Thomas D. Layzell
President
Council on Postsecondary Education

John R. Hall
Retired Chairman & CEO
Ashland, Inc.

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"The United States takes deserved pride in the vitality of its economy, which forms the foundation of our high quality of life, our national security, and our hope that our children and grandchildren will inherit ever-greater opportunities. That vitality is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical innovations they produce. Without high-quality, knowledge-intensive jobs and innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living."

-Rising Above the Gathering Storm, 2006

EXECUTIVE SUMMARY

During the past four months (December 2006 – March 2007), the 110 members of the Council on Postsecondary Education (CPE) Science, Technology, Engineering, and Mathematics (STEM) Task Force have deliberated on the STEM crisis that Kentucky and the nation are currently experiencing. The STEM Task Force was charged by the Council with developing "a statewide P-20 strategic action plan to accelerate Kentucky's performance within the STEM disciplines." Task force members encourage the adoption of the following interrelated recommendations that create a bold and comprehensive plan for change. The approach to STEM education, STEM attainment, and the creation of knowledge economy jobs in the Commonwealth must change.

The CPE STEM Task Force echoes the urgent concerns voiced in almost 20 recent national reports that America's scientific, technological, and innovation capacity and leadership are seriously eroding. Diverse STEM stakeholders agree that fundamental change is necessary among:

> "…the entire community of stakeholders: those responsible for budgets, policies, and programs that affect research and education in STEM fields at the national, state, and local level; those responsible for the quality of STEM research in America's educational institutions; those potential employers of STEM graduates; and all citizens in a society in which science and technology have a significant impact on most aspects of our lives."
>
> *-Project Kaleidoscope Report on Reports II, 2006*

STEM TASK FORCE RECOMMENDATIONS

1. Energize and fund a statewide public awareness campaign to help Kentuckians understand the critical importance of STEM to their own economic competitiveness and to that of the Commonwealth.

2. Create incentives and a supportive environment for students, teachers, and institutions that pursue, succeed, and excel in STEM disciplines throughout the P-20 pipeline.

3. Implement international best practices in professional development programs for P-16 STEM teachers to increase the intensity, duration, and rigor of professional development.

4. Improve teacher preparation programs and encourage people with undergraduate and graduate STEM degrees to enter the teaching profession.

5. Revolutionize how STEM subjects are taught, learned, and assessed and implement a statewide research-based STEM curriculum that is aligned with global workforce and academic standards.

6. Engage business, industry, and civic leaders to improve STEM education and skills in the Commonwealth and create incentives for Kentucky businesses that employ and invest in STEM educated students.

7. Develop an ongoing, coordinated, statewide STEM initiative that maximizes the impact of resources among state agencies, schools, colleges and universities, and businesses and is focused on developing and attracting STEM-related jobs to Kentucky.

8. Target energy sustainability problems and opportunities in Kentucky and the nation as a primary objective of statewide STEM enhancements.

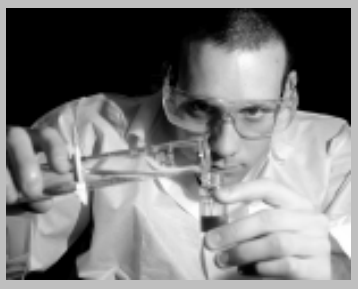
INTRODUCTION

The creation of the CPE STEM Task Force emerged from the CPE Research, Economic Development, and Commercialization Policy Group, chaired by Mr. John R. Hall, retired chairman and CEO of Ashland, Inc. At its August 2006 retreat, CPE focused its attention on the importance of the STEM disciplines to the development of Kentucky's "talentforce" and the creation of knowledge economy jobs. STEM disciplines provide the foundation for future statewide advancements in commercialization and innovation and support existing businesses and enterprises that rely on mathematics, science, technology, and engineering expertise.

In November 2006, the Council took formal action to approve the convening of a STEM Task Force comprised of leaders from government, business, P-12, and higher education sectors within the Commonwealth of Kentucky.

> "The CPE STEM Task Force is charged with developing a statewide strategic action plan to accelerate Kentucky's performance within the STEM disciplines. Recommendations and accountability measures also need to explore the relationship between STEM production and the creation of knowledge economy or "talentforce" jobs, the commercialization of intellectual property, and innovation within Kentucky."
>
> *CPE Meeting Minutes, November 6, 2006*

The long-term, overarching goal of the *Kentucky Postsecondary Education Improvement Act of 1997* is to significantly improve the quality of life and standard of living for all Kentuckians. Question 5 of the CPE Public Agenda for Postsecondary and Adult Education reads: "Are Kentucky's people, communities, and economy benefiting?" In order to improve the economy of Kentucky, we must increase the educational attainment of Kentucky's citizens and prepare Kentuckians for the 21st century workplace. The STEM disciplines hold the key to the future prosperity of the Commonwealth.



The STEM disciplines hold the key to the future prosperity of the Commonwealth.

CPE STEM TASK FORCE PROCESS AND TIMELINE

The CPE STEM Task Force is comprised of 110 leaders from the executive and legislative branches of state government, P-12 and higher education, and the business, nonprofit, professional, and organizational sectors of the Commonwealth of Kentucky.

- August – October 2006 – John Hall, Chair of the Research, Economic Development, and Commercialization Policy Group, recommended formation of CPE STEM Task Force
- November 2006 – CPE approved establishment of STEM Task Force; UK President Lee Todd appointed as chair
- December 2006 – First meeting of the CPE STEM Task Force
- January 2007 – Second meeting of the CPE STEM Task Force
- February 2007 – Third meeting of the CPE STEM Task Force
- March 2007 – CPE STEM Task Force report and recommendations released
- April – August 2007 – STEM Task Force study groups meet to develop implementation action plans for the STEM Task Force recommendations
- September 2007 – Implementation action plans released
- September – December 2007 – Budget planning processes incorporate STEM Task Force recommendations

"It is easy to be complacent about U.S. competitiveness and preeminence in science and technology. We have led the world for decades, and we continue to do so in many research fields today. But the world is changing rapidly, and our advantages are no longer unique. Some will argue that this is a problem for market forces to resolve—but that is exactly the concern. Market forces are already at work moving jobs to countries with less costly, often better educated, highly motivated work forces and more friendly tax policies."
-Rising Above the Gathering Storm, 2006

BACKGROUND

In 1989, the American Association for the Advancement of Science (AAAS) published a report entitled *Science for All Americans* that examined the challenges inherent in educating science literate K-12 students. Experts in science, mathematics, and technology collaborated to define science literacy and provide recommendations on effective science learning and teaching. The report also called for the establishment of national standards for science education and provided resources and recommendations regarding science education reform within K-12 and higher education settings.

Almost 20 years later, the call for science and technology literacy has been replaced by an increasingly urgent message regarding the national crisis in mathematics and science in the United States. Beginning at the turn of the century with *The Glenn Commission* (September 2000), the economic impact of America's eroding supremacy in the STEM disciplines has been studied and documented.

> "We as a nation must take immediate action to improve the quality of math and science teaching in every classroom in the country. If we delay, we put at risk our continued economic growth and future scientific discovery."
> *-The Glenn Commission, 2000*

The United States is facing a national STEM crisis reflected in the declining number of American students who receive science degrees. Thirty years ago the United States ranked third worldwide in the number of science graduates; now we rank 17th. Additionally, Asian universities produce eight times more engineering bachelor's degrees than the United States. Of the 2.8 million university degrees in science and engineering granted worldwide in 2003, 1.2 million were earned in Asian universities, 830,000 in European institutions, and 40,000 in American universities and colleges.

Thirty years ago the United States ranked third worldwide in the number of science graduates; now we rank 17th.

Other states and regions of the United States and other countries are aggressively pursuing attainment within the STEM disciplines.

Other states and regions of the United States and other countries are aggressively pursuing attainment within the STEM disciplines. A new term, "Chindia," has been coined to describe the regional combined efforts of China and India to advance knowledge economy opportunities through vigorous support for advanced graduate education in the STEM disciplines.

> "Neither China nor India has yet produced many important breakthroughs in science or technology. But it is only a matter of time before India and China are at the forefront in technological innovation. They boast the world's greatest numbers of new scientists and engineering graduates, mounting R & D expenditures, and deepening ties with top foreign tech companies and schools."
>
> *-Chindia, 2007*

American authors such as Thomas Friedman in *The World is Flat* and Richard Florida in *The Flight of the Creative Class* have documented the current and future impact of an increasingly global economy that threatens the socio-economic welfare of American citizens.

> "For most of the post-WWII period, the U.S. was in fact unrivaled in its scientific and technological prowess. In the last five to ten years, this once-predominant position has begun to decay, and in some places rapidly. In 1999, the U.S. Council on Competitiveness warned that the U.S. could not rest on its laurels, since "other nations are accelerating their own efforts" as America's "innovation infrastructure" begins to show signs of decay. Since 1999, things have only gotten worse."
>
> *-The Flight of the Creative Class, 2005*

America's Academic Competitiveness. On February 8, 2006, President Bush and Congress implemented two new student grant programs for Pell-eligible (grants awarded to undergraduate students based upon high financial need) American students – the *Academic Competitiveness (AC) Grants* and the *Science and Mathematics Access to Retain Talent (SMART) Grants* which were created within the *2005 Higher Education Reconciliation Act*. Designed to encourage students to pursue more rigorous courses in the STEM disciplines and in critical languages, the grants provide additional funding to base Pell awards. As is illustrated by the chart that follows, the larger awards are reserved for students who major in the STEM or critical language areas.

Year	Base Pell	SMART Grant	Total $ Per Year
Freshman	$400 to $4,000	$750	$1,150 to $4,750
Sophomore	$400 to $4,000	$1300	$1,700 to $5,300
Junior	$400 to $4,000	$4000	$4,400 to $8,000
Senior	$400 to $4,000	$4,000	$4,400 to $8,000
Total- 4 yrs.	$1,600 to $16,000	$10,050	$11,650 to $26,050

SMART grants are awarded on a "first come – first serve" basis to full-time American students who qualify for Pell awards based upon the completion of the Free Application for Federal Student Aid (FAFSA). States that currently require a more rigorous high school curriculum (four years of mathematics and four years of science to graduate) are better positioned than Kentucky to have students receive the SMART grants. It is important to note that the 2006 adoption by the Kentucky Board of Education of a more rigorous high school curriculum within the Commonwealth is well aligned with national efforts to strengthen the STEM pipeline.

Kentucky's STEM Performance. The STEM disciplines are essential to the economic prosperity of Kentucky's citizens and communities. STEM disciplines fuel innovation, per capita income, and the creation of 21st century jobs. Yet, Kentucky continues to perform poorly compared with other states, according to the Progressive Policy Institute.

- Kentucky is 47th in workforce education.
- Kentucky is 47th in the number of scientists and engineers.
- Kentucky is 45th in the number of patents issued.
- Kentucky is 42nd in the number of high tech jobs.
- Kentucky is 39th in industry investment in R & D.
- Kentucky is 33rd in the number of fastest growing companies.

Not surprisingly, Kentucky also ranks low in the percentage of STEM economy jobs. Kentucky ranks 41st in the U.S. in the number of science and engineering occupations and 44th in the number of high tech businesses in the state.

In September 2006, the Kentucky Science and Technology Corporation released a report entitled *Kentucky Per Capita Income Analysis* based upon research completed by SRI International.

While Kentucky's per capita income has grown steadily over the past three decades, its ranking nationally has remained virtually unchanged.

Dramatic acceleration of performance within the STEM disciplines is critical to the improvement of Kentucky's per capita income as we strive to compete in the increasingly global economy.

"While Kentucky's per capita income (PCI) has grown steadily over the past three decades, its ranking nationally has remained virtually unchanged. For example, in 1970, Kentucky ranked 44th among all U.S. states in per capita income. Nearly 35 years later, in 2004, Kentucky was still ranked 44th. Kentucky's average per capita income ($27,151) in 2004 was 82.2 percent of the U.S. average ($33,041).

-Kentucky Per Capita Income Analysis Final Report, 2006

Dramatic acceleration of performance within the STEM disciplines is critical to the improvement of Kentucky's per capita income as we strive to compete in the increasingly global economy. The international marketplace includes cheaper labor and less restrictive immigration and taxation laws than the United States. The global economy already is having an impact on the profile of American jobs and professions.

The U.S. Bureau of Labor Statistics provides national indicators of job growth and decline, such as these figures for the ten-year period between 2004 and 2014.

Growth of 27 percent or more:

- computer science
- database administration
- software engineering
- biomedical engineering
- environmental engineering
- healthcare
- medical research
- internet publishing

The following jobs are predicted to decline significantly during the same time period:

- agriculture
- manufacturing
- textile and apparel production

Manufacturing, which represents 260,000 well-paying jobs and 20 percent of the Kentucky gross product, is by a 2:1 margin the largest contributor to the Kentucky economy. While the Kentucky manufacturing sector is losing jobs, those jobs are primarily "low-skill" jobs. They are being replaced by "high-tech" or advanced manufacturing jobs that require workers who, at a minimum, graduate from high school and preferably attend a Kentucky Technical College System (KCTCS) institution and /or a university/ college offering a four-year degree program. Advanced manufacturing jobs, like those created by the presence of Toyota and its supplier network, will require a steady stream of workers educated in STEM disciplines.

In order to adequately prepare Kentuckians to compete for the new and expanding jobs of the 21st century, we must enhance the P-20 STEM pipeline.

Kentucky's P-12 STEM Performance. According to the National Science Foundation, Kentucky is lagging behind many states on P-12 measures of mathematics and science.

- Fourth grade performance (2005)
  - mathematics: ranked 40th in the nation
  - science: ranked 16th in the nation
- Eighth grade performance
  - mathematics: ranked 35th in the nation
  - science: ranked 18th in the nation
- Public high school students taking AP exams
  - U.S. Average: 20.9%
  - Kentucky: 15.5% (Ranked 29th in the nation)
- Percentage of students who scored 3 or higher on at least one AP exam
  - U.S. Average: 13.2%
  - Kentucky: 7.7% (ranked 38th in the nation)

The Kentucky pipeline in the STEM disciplines is leaking. In fall 2004, 16,003 Kentucky high school graduates entered Kentucky's public colleges and universities underprepared in mathematics. Statistically, unless these students receive developmental assistance during their first year, more than half of them will not return for their second year. By contrast, about 80 percent of mathematically prepared students return for a second year of college.

Kentucky's Higher Education STEM Performance. Kentucky continues to rank very low in national comparisons of the number of STEM degrees awarded, according to the National Science Foundation.

- Bachelor's degrees conferred in science and engineering (2003)
  - U.S. average: 7.82 per 1,000
  - Kentucky: 4.75 per 1,000 (ranked 49th in the nation)
- Science and engineering degrees as share of degrees conferred (2003)
  - U.S. Average: 29.7%
  - Kentucky: 22.7% (ranked 48th in the nation)

Analysis of the actual number of STEM degrees awarded by Kentucky's public and independent universities underscores the crisis even more clearly. During the eight years between 1997/98 and 2004/05, only 923 additional STEM degrees (baccalaureate, master's, and doctoral degrees combined) were awarded by Kentucky's eight public and 19 independent institutions.

THE DEFINITION OF THE PROBLEMS

Problem Statement 1: **Kentucky currently is producing inadequate numbers of STEM literate students throughout the P-20 pipeline. Kentucky needs to strengthen the STEM pipeline from kindergarten through doctoral level preparation.**

> "In 2000, nearly 40 percent of U.S. high school students had not taken any course work in science more challenging than general biology."
>
> *-Math and Science Education in a Global Age: What the U.S. Can Learn From China, 2006*

The number of students graduating from STEM programs at American universities has remained largely flat during the past 20 years. The demand for science and engineering workers has quadrupled in the U.S. during the same time period.

National Science Foundation data indicate that Kentucky elementary students rank 40th in fourth grade mathematics performance and that eighth grade students rank 35th compared to other states.

According to the Council's recent Developmental Education Task Force Report, "the proportion of undergraduates underprepared in mathematics who received developmental education services ranged by institution from 64 percent to 96 percent." (*A Plan for Improving College Readiness and Success, page 10*)

Kentucky is producing inadequate numbers of middle and high school teachers within the STEM disciplines. The need for adequately prepared P-12 STEM teachers has increased with the recent adoption of more rigorous standards for students completing high school, including four years of mathematics and four years of science. Rural schools and schools with high percentages of students from low socioeconomic backgrounds face additional challenges in hiring highly qualified STEM teachers.

At the postsecondary level, Kentucky needs to produce greater numbers of highly educated students with doctoral degrees. According to the National Science Foundation (NSF), in 2005, Kentucky ranked 28th in the number of doctoral degrees awarded (462 in all disciplines) compared with #1 ranked California that produced 5,225 doctorates across all academic disciplines. NSF data for STEM doctorates conferred indicate that, in 1997, 214 doctoral degrees were awarded in science and engineering by Kentucky institutions compared with 185 doctoral degrees awarded in the same areas in 2003.

The need for adequately prepared P-12 STEM teachers has increased with the recent adoption of more rigorous standards for students completing high school, including four years of mathematics and four years of science.

Problem Statement 2: **Kentucky's P-8 teachers face unique challenges in acquiring and maintaining expertise in mathematics and science. Teacher preparation programs as well as professional development opportunities for STEM teachers need to be strengthened dramatically.**

STEM-related fields are dynamic. They evolve rapidly as new discoveries are made and as research challenges established assumptions. Professional opinions differ regarding the efficacy of teacher preparation models that range from four-year education degrees to programs that require a teacher to have a degree in a content discipline before taking a fifth year dedicated to educational pedagogy and practice. Different higher education institutions have different requirements for elementary education certification, especially in mathematics. This varies from one course in mathematics education (methods) to three higher level mathematics content courses.

However, in the areas of mathematics and science, it is imperative that teachers possess in-depth understanding and currency in the relevant content area. Teacher preparation programs and degree programs in the STEM disciplines need to be strengthened at our colleges and universities to ensure that P-12 students receive appropriate rigor and content to meet 21st century education and workplace expectations. In addition, there is a critical shortage of university mathematics educators to prepare teachers, especially at the elementary and middle grade levels.

Beginning in the fourth and fifth grades, students are introduced to increasingly complex mathematical and scientific material that requires educators to have mastered STEM-related content. In addition, a classroom teacher's enthusiasm for mathematics and science has been found to influence a child's interest in these areas. Teachers must have ready access to quality, ongoing professional development in order to stay current in their fields and to teach at the highest levels.

> "Far higher proportions of science and math teachers in East Asia have degrees in their disciplines than their U.S. counterparts. Fewer than 60 percent of U.S. eighth grade science teachers have majors in a science discipline and only 48 percent of eighth grade math teachers have a math major. Chinese schools do not expect a single elementary school teacher to teach all subjects; specialist science teachers are employed as early as third grade. A tradition of mentoring by master teachers and weekly professional development in schools continually improves teacher performance."
>
> *-Math and Science Education in a Global Age: What the U.S. Can Learn from China, 2006*

Despite some notable progress in P-20 curricular alignment, much work remains to be done to better align high school programs and college expectations.

***Problem Statement 3*: Collaboration among STEM professionals within P-20 education is not currently sufficient to produce widespread improvement in Kentucky's STEM performance. Improved collaboration between P-12 and higher education is critical to the creation of an adequate STEM pipeline within Kentucky.**

Despite some notable progress in P-20 curricular alignment, much work remains to be done to better align high school programs and college expectations. Several local and national collaborative projects between P-12 and higher education demonstrate encouraging progress and can serve as models of "best practice."

The Appalachian Mathematics and Science Partnership (AMSP) Model for Institutional Collaboration with School Districts is a National Science Foundation model program currently housed at the University of Kentucky and involves six other Kentucky colleges and universities. The principal goal of the AMSP is to reform the nation's mathematics and science education system through the establishment of effective collaborations between school districts and institutions of higher education. One of the most effective AMSP programs is the Partnership Enhancement Project (PEP), a mini-grant ($30,000) program that enables direct and specific collaboration between school districts and postsecondary institutions. Preliminary research findings support the value of individualized interventions that reflect the unique perceived needs of the respective school districts. AMSP is particularly focused on the social impact of improved educational attainment to advance knowledge-based workforce development within Appalachia.

At the national level, the Meyerhoff Scholarship program at the University of Maryland, Baltimore County, is dedicated specifically to improving the pipeline of minority students who pursue graduate degrees in the STEM disciplines. The program targets high-achieving minority high school students who must be nominated by their high school administrators, counselors, or teachers. Meyerhoff Scholars receive full tuition, room, and board scholarships, have regular academic and career mentoring, attend an intensive Summer Bridge program, and conduct research early in their postsecondary careers. In addition, family involvement is stressed and required. The Meyerhoff Scholarship program develops strong ties with the secondary schools in Maryland and participates actively in the redesign of science teaching in high schools and at the undergraduate level.

High schools in Kentucky also are implementing the national Project Lead the Way (PLTW) pre-engineering curriculum to prepare students for advanced education and careers in engineering and engineering technology. Academic assessment results from the Kentucky PLTW schools demonstrate students' enhanced mathematics and science achievement compared to students who are not taking the program.

Problem Statement 4: **Salaries for P-12 STEM teachers are not sufficiently competitive to attract STEM graduates to the teaching profession. A variety of incentives for P-12 STEM teachers need to be explored to encourage STEM degree holders to enter the teaching profession.**

> "When the salaries of college graduates are compared, education majors in the U.S. come out at the very bottom. Despite recent increases in teacher salaries the gap between teachers and other college graduates has remained large. University graduates who majored in physical science earned 78 percent more and economics majors earned 92 percent more than education majors over the course of their working lifetime. Majors in social sciences other than economics earned 27 percent more than education majors and humanities majors earned 5 percent more. Relative to those with graduate degrees in education, those with MBAs earned 65 percent more, those with law degrees earned 104 percent more, and those with advanced degrees in physical science earned 75 percent more."
>
> *-Secondary Education in the United States: What Can Others Learn From Our Mistakes?*

On March 7, 2007, Bill Gates, chairman of Microsoft, testified before the U.S. Senate committee hearing on strengthening American competitiveness.

> "Our goal should be to double the number of science, technology, engineering, and mathematics graduates in the United States by 2015. This will require both funding and innovative ideas. We must renew and reinvigorate math and science curricula with engaging, relevant content. For high schools, we should aim to recruit 10,000 new teachers and strengthen the skills of existing teachers. To expand enrollment in postsecondary math and science programs, each year we should provide 25,000 new undergraduate scholarships and 5,000 new graduate fellowships. America's young people must come to see science and math degrees as key to opportunity. If we fail at this, we won't be able to compete in the global economy. Even as we need to improve our schools and universities, we cannot lose sight of the need to upgrade the skills of people already in the workforce."
>
> *-Testimony of Bill Gates at U.S. Senate, March 7, 2007*

America's young people must come to see science and math degrees as key to opportunity.

***Problem Statement 5*: Kentucky's economy as reflected by comparative per capita income (PCI) rankings has not significantly changed in the past 35 years while many of our surrounding competitor states have increased their relative rankings. Kentucky needs to consider strategies and policies that could rapidly accelerate the state's economic development as reflected by PCI.**

Various national studies and reports have established the link between the STEM disciplines and economic prosperity.

> "The committee identified two key challenges that are tightly coupled to scientific and engineering prowess: creating high quality jobs for Americans and responding to the nation's need for clean, affordable and reliable energy."
>
> *-Project Kaleidoscope Report on Reports, 2006*

On an international level, perhaps the tiny country of Ireland best represents the dramatic positive changes that can result from an aggressive and strategic approach to improved economic prosperity.

> "Today, we see in the example of Ireland how quickly a determined nation can rise from relative hunger to burgeoning prosperity. In the 1980's, Ireland's unemployment rate was 18 percent and during that decade 1 percent of the population – mostly young people – left the country, largely to find jobs. In response, a coalition of government, academic institutions, labor unions, farmers, and others forged an ambitious and sometimes painful plan of tax and spending cuts, and aggressively courted foreign investors and skilled scientists and engineers. Today, Ireland is, on a per capita basis, one of Europe's wealthiest countries. In 1990, Ireland's per capita GDP of $12,891 (in current U.S. dollars) ranked it 23rd of the 30 member countries of the Organisation for Economic Co-operation and Development (OCED). By 2002, Ireland's per capita GDP had grown to $32,646, making it 4th highest among OECD member countries."
>
> *-Rising Above the Gathering Storm, 2006*

The Kentucky Science and Technology Corporation's PCI study concluded that

> "…despite Kentucky's 20-year average rate of PCI growth that is slightly higher than the national average, it is projected to take 154 years for Kentucky's PCI to converge with the U.S. average PCI – assuming national trends stay the same and with no major changes in Kentucky's economic landscape."
>
> *-Kentucky Per Capita Income Analysis, 2006*

***Problem Statement # 6*: The United States needs to create sustainable energy sources to eliminate our dependence on foreign energy resources. Kentucky's history, natural resources, and expertise and innovative research within the energy sector represents an opportunity for the Commonwealth to provide leadership in solving a serious national problem.**

> "Kentucky's natural resources and America's need for energy independence create the opportunity for us to be an international leader in energy diversification. We can lead the development of businesses and jobs that provide alternatives to imported oil. America has a problem and Kentucky can provide the solution. Energy independence is good for national security and for Kentucky's economy."
>
> *-Lee T. Todd, Jr., Lexington Herald-Leader Editorial, March 5, 2007*

As one important facet of Kentucky's knowledge-based economic development strategy, innovative renewable energy research and commercialization holds great promise. Kentucky's universities are already engaged in collaborative energy research, commercialization ventures are emerging, and the existing energy sector provides current and future STEM-related employment.

As one important facet of Kentucky's knowledge-based economic development strategy, innovative renewable energy research and commercialization holds great promise.

RECOMMENDATIONS

1. **Energize and fund a statewide public awareness campaign to help Kentuckians understand the critical importance of STEM to their own economic competitiveness and to that of the Commonwealth.**

   Potential strategies include:

   - Build public ownership of the problem and its solutions, especially among educators, parents, and community leaders.
   - Publicize Kentucky's need to cultivate our STEM intellectual capital to create a 21st century "talentforce" and grow knowledge economy jobs within the Commonwealth.
   - Increase student awareness of STEM career possibilities, particularly those within the Kentucky energy sector, through the development of future sustainable energy solutions.
   - Encourage students to excel in STEM classes and pursue careers in STEM fields. For example, summer workshops, K-12 involvement with college/university level research, and interactions with scientists, engineers and researchers could be utilized to motivate students in the STEM pipeline.
   - Engage P-8 parents to ensure their understanding of the importance of STEM achievement to their children's academic career and success.

2. **Create incentives and a supportive environment for students, teachers and institutions that pursue, succeed, and excel in STEM disciplines throughout the P-20 pipeline.**

   Potential strategies include:

   - Investigate differential investment for STEM subjects, including but not limited to differential compensation, technology infrastructure, laboratory equipment, discretionary funding, supplies, field trips, professional travel allowances, and mathematics and science coaches and mentors.
   - Provide or expand instructional laboratory space and opportunities for hands-on experiments in every school, college, and university.
   - Increase opportunities for students to gain exposure to STEM careers through the Individual Learning Plans (ILPs) process, Gifted Student Services Plans (GSSPs), mathematics and science competitions and clubs,

internships, research assistantships, and other practical experiences outside the classroom.
- Create new college scholarships for STEM majors, including pre-service elementary as well as middle grades and secondary teachers with a minor or area of concentration in mathematics or science.
- Maximize existing opportunities (e.g., financial rewards for STEM course taking and achievement, federal SMART grants) for students in the STEM pipeline.
- Reduce student disincentives to take rigorous STEM courses through such strategies as revising Kentucky Educational Excellence Scholarships and Governor's Scholarships.
- Work with middle and high school guidance counselors to encourage students to pursue STEM subjects and STEM-related careers.
- Collaborate with the Kentucky Community and Technical College System (KCTCS) to encourage STEM certificate students to pursue STEM degrees.

3. **Implement international best practices in professional development programs for P-16 STEM teachers to increase the intensity, duration, and rigor of professional development.**

Potential strategies include:

- Expand professional development resources statewide, such as additional days of paid professional development in the school year.
- Provide teachers and faculty with job-embedded mentoring and support and opportunities for practical application of knowledge outside the classroom, including exchange programs with business, industry, and higher education.
- Ensure access to content-specific professional development for STEM subjects regionally and at the state level.
- Provide opportunities and incentives to enable K-12 educators to remain current in the STEM disciplines.
- Consider the addition of a certification or endorsement for P-12 coaches, mentors, or other teacher leaders in mathematics and science.
- Base all professional development activities on research and proven best practice.

4. Improve teacher preparation programs and encourage people with undergraduate and graduate STEM degrees to enter the teaching profession.

Potential strategies include:

- Reward postsecondary STEM faculty for involvement in K-12 classrooms.
- Encourage, support, and reward the development of college and university mathematics education and science education faculty.
- Raise educator standards and credentialing requirements to ensure adequate STEM knowledge across the elementary, middle, and secondary panels.
- Require education majors in STEM disciplines to take more coursework in their content area, including mathematics and science education, and ensure that these courses are offered by all teacher preparation programs, including those in elementary education.
- Create more flexible alternate routes to teacher certification for STEM professionals in the private sector and remove barriers to second careers in teaching.
- Require and encourage universities to provide more career-friendly programs for teacher preparation and advancement, including evening and weekend classes that are geographically or electronically accessible throughout the state.
- Extend the Kentucky Higher Education Assistance Authority Best in Class loan forgiveness program to elementary teachers with a minor or area of concentration in mathematics or science. (See http://www.studentloanpeople.com/what_best_in_class.html.)

5. Revolutionize how STEM subjects are taught, learned, and assessed and implement a statewide research-based STEM curriculum that is aligned with global workforce and academic standards.

Potential strategies include:

- Integrate a comprehensive, standardized, internationally benchmarked P-16 STEM curriculum to make use of the latest instructional techniques and technologies such as the GE STEM curriculum implemented in Jefferson County.
- Emphasize depth of learning as well as breadth of learning in STEM subjects.

- Encourage universities to partner with industry to provide professional science master's degrees tied to industry needs.
- Upgrade assessment strategies for student learning in the STEM disciplines, such as standardized end-of-course exams and full use of the ACT Educational Planning and Assessment System (EPAS).
- Create curricular, research, and innovation opportunities in sustainable energy for STEM students throughout the pipeline.
- Improve the quality of teaching in STEM disciplines at colleges and universities, including support for the development of mathematics education and science education faculty.
- Incorporate innovative and interactive technology-based STEM learning tools and methodologies throughout P-20 education.
- Establish a statewide STEM competition at the elementary, middle, and high school levels to recognize and celebrate accomplishment in STEM learning and application.

6. <u>Engage business, industry, and civic leaders to improve STEM education and skills in the Commonwealth and create incentives for Kentucky businesses that employ and invest in STEM educated students.</u>

Potential strategies include:

- Develop vertical teams such as expanded P-16 Councils to facilitate the local collaboration of P-16 educators, businesses, and government and to facilitate collaborative learning such as Advanced Placement and International Baccalaureate programs, the Academy of Mathematics and Science in Kentucky, and informal educational opportunities.
- Create opportunities for STEM educators and students to apply classroom knowledge to real-world applications in the workplace.
- Create opportunities for P-16 students to participate in STEM clubs and competitions such as science fairs, robotics competitions, American Math Competitions, and Math Counts.
- Contribute leadership expertise and support for the STEM public awareness campaign.
- Expand and improve STEM workforce development and training programs so they teach the skills needed in today's knowledge economy, especially at the Area Technology Centers.

- Provide leadership in developing a statewide strategy for energy sustainability and independence.
- Increase corporate grant and in-kind funding of STEM education and expand the reach of programs statewide.
- Explore incentive programs for businesses that commit to hiring STEM graduates from Kentucky institutions and invest in Kentucky STEM research and education.
- Explore corporate education partnerships that enable co-teaching of STEM courses, internships for teachers, professional development for teachers by corporate practitioners of STEM, and possible technology assistance and technology donations.

7. **Develop an ongoing, coordinated statewide STEM initiative that maximizes the impact of resources among state agencies, schools, colleges and universities and businesses and is focused on developing and attracting STEM-related jobs to Kentucky.**

Potential strategies include:

- Propose a concurrent or simple resolution calling for continued study of the state's STEM crisis to result in enabling legislation and potential funding recommendations for the 2008 legislative session.
- Create a standing body of education, business, economic development, government, and nonprofit professionals to oversee and coordinate STEM initiatives at the statewide level.
- Coordinate initiatives with the Kentucky Center for Mathematics (see http://www.kymath.org) and the Committee for Mathematics Achievement.
- Create a designated STEM leadership position within state government to ensure sustained progress and statewide collaboration for STEM-related initiatives.
- Advocate and raise funds for STEM education resources from government and the private sector.
- Develop a report card that uses rigorous program assessment to measure Kentucky's progress in implementing STEM initiatives.
- Collect and disseminate global best practices focused on STEM instruction.
- Provide incentives for faculty and students to help catalyze STEM company formation or growth in the Commonwealth according to the "Statewide Strategy for Economic Development."

8. Target energy sustainability problems and opportunities in Kentucky and the nation as a primary objective of statewide STEM enhancements.

Potential strategies include:

- Explore the development of P-12 curricular offerings related to energy sustainability.
- Increase funded research for sustainable energy-related innovation and commercialization.
- Create a monetary prize to be awarded to Kentucky innovators who solve important energy sustainability problems similar to the X Prize for scientific innovations that benefit society.

The Commonwealth's future prosperity and ability to compete in a global economy depend on a statewide pipeline of STEM educated workers in combination with the creation of 21st century "talentforce" jobs.

CONCLUSION

The CPE STEM Task Force report outlines the national crisis that America is facing with respect to the STEM pipeline. Education is the primary driver of economic development in Kentucky. The Commonwealth's future prosperity and ability to compete in a global economy depend on a statewide pipeline of STEM educated workers in combination with the creation of 21st century "talentforce" jobs.

The CPE STEM Task Force recommendations are designed to create a starting point for future action that involves leveraging current human and fiscal assets and developing new opportunities for Kentucky's citizens. The STEM Task Force invites your comment and your participation in securing Kentucky's future.

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ONLINE RESOURCES

The following report resources are available on the Council Web site at http://cpe.ky.gov/news/reports/cpe_reports/stem:

- Biographies of STEM Task Force Members
- Institutional STEM Reports
- Summaries of Sector Recommendations
- Full STEM Task Force Report

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