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Information Technology in Science, Technology, Engineering and Mathematics (Stem) Discipline for the 21st Century: New Horizons

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ABSTRACT: There is little doubt that the United States faces a serious, and growing, challenge to develop and educate enough citizens who can perform jobs that demand skill in science, technology, engineering, and mathematics (STEM) domains. We do not have enough workers to fill the demand in the short run, and the problem is only likely to get worse in the long run. Addressing the "STEM challenge" is thus a concern of great national priority. President Obama noted that "Strengthening STEM education is vital to preparing our students to compete in the 21st century economy and we need to recruit and train math and science teachers to support our nation's students." (White House Press Release, September 27, 2010). Without high-quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living. The demand for engineers is rising. Yet we are faced with discouraging statistics on the number of students considering engineering careers, and disappointing math and science scores that place U.S. student's performance below many industrialized nations. America is simply not going to have the engineers it needs to stay competitive and remain a world a leader in innovation without more investment. Well-documented trends have been reported nationally of declining interest, poor preparedness, a lack of diverse representation, and low persistence of U.S. students in STEM (Science, Technology, Engineering and Mathematics) disciplines

A strong foundation in STEM education is essential for all residents of the nation to make informed decisions for themselves, their families and communities, and to prepare for rewarding employment and sustainable careers within growing and emerging industries that make up nation's knowledge and innovation economy. Our society is already faced with difficult decisions about the natural world: fossil fuel consumption and alternative energies, protecting the food water supply, and ensuring the quality of the air we breathe to name just a few. It is essential to ensure that all students understand why it is important to study these areas. Students need to be sufficiently STEM-literate to make informed decisions, illustrate the linkage between STEM education and national economy and provide an example to other students of the contributions they could make to society by entering the STEM program profession, and convene one or more task forces to develop and maintain a multi-decade roadmap for STEM education and the fields that require it, with a goal of ensuring continuing US leadership in knowledge and innovation

Recently, however, corporate, government, and national scientific and technical leaders have come together on a single goal with an Advanced STEM education Program to create, deploy, and apply STEM education in ways that radically empower all scientific and engineering research and allied education in the United States that would inevitably improve its future prosperity, social and economic conditions and in particular increase the ability of its citizens to compete for high-quality jobs

KEYWORDS: Information Technology, Science and Technology, STEM (Science, Technology, Engineering and Mathematics) Disciplines, Innovative Enterprises,

I. INTRODUCTION

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.

In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, all students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past. A particular need exists for an increased emphasis on technology and engineering at all levels in our Nation's education system. Business and industry leaders, governors, policy makers, educators, higher education officials, and our national defense and security agencies have repeatedly stated the need for efforts to reform the teaching of STEM disciplines in the Nation so that the United States will continue to be competitive in the global, knowledge-based economy

New tools have opened vast research frontiers and fueled technological innovation in fields such as biotechnology, nanotechnology, and communications. Recent concepts of infrastructure are expanding to include distributed systems of hardware, software, information bases, and automated aids for data analysis and interpretation.

A national crisis has been identified in the area of global technological competitiveness [1][2]. Statistics on the state of education in the United States indicate a decreasing trend in domestic students choosing to major in and successfully complete degrees in Science, Technology, Engineering and Mathematics (STEM) disciplines [3] . Leaders in STEM fields have recently called for major initiatives to be undertaken nationally to address these educational trends [1][4].

In engineering, the need for change has been highlighted by reports that argue that tomorrow's graduate will compete in an emerging global economy fueled by rapid innovation and marked by an astonishing pace of technological breakthroughs. STEM graduates will navigate a shifting societal framework enhanced by technologies that lengthen life spans; enable yet-to-be imagined means of communication; create wealth and economic growth through accelerated product development cycles; require multidisciplinary efforts in emerging areas; and link virtual teams from global locations. The thorough integration of technology with society will challenge the analytical skills, creativity, and leadership of STEM graduates; demand participation in public policy; and require ethical adaptations to constraints of developing countries. Political and economic relations between nations, the global marketplace, national security issues and multilingual influences will dramatically shape the STEM practice [5].

Recently, U.S. high-tech workers have seen trends unanticipated 10 to 20 years ago: the outsourcing of mainstream engineering and computing jobs, less reliance on U.S.-born PhD graduates, a mandate for technological fluency, and the need to retrain in order to successfully change careers multiple times. However, key stakeholders in industry, government, and academia are indicating accelerated interest and active commitment for innovative approaches to a national plan of action [6].

With these reports and their predicted consequences in mind, it is imperative that NewYork Institute of Technology [NYIT] responds proactively to the needs for education in STEM and STEM-influenced fields. NYIT has long been recognized for strength in its STEM fields. In order to continue raising the profile of its educational programs nationally and internationally in all disciplines, it is imperative that (NYIT) respond proactively to the needs for education in STEM and STEM-influenced fields. In order to continue raising the profile of its educational programs nationally and internationally in all disciplines, NYIT must address numerous systemic and programmatic challenges that are fundamental to the education of our students. It is important to recognize that many of the issues of national technological competitiveness are closely linked to the types of educational programs that NYIT offers in its STEM majors and disciplines, and it is therefore imperative that these be addressed specifically. However, a strong foundation in STEM courses and experiences provides the foundation of numerous fields of study at NYIT. Indeed, there are proposed initiatives that will have an impact across the University, even though they are based in the need to improve the educational experience for students in STEM disciplines.

Although the US economy is doing well today, current trends indicate that the United States may not fare as well in the future without government intervention [7]. While many of our students excel in STEM subjects, we still have a reduction of achievement, interest, and skills gap. Latino and African-American students, who represent fast-growing

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segments of our population, still lag behind their white and Asian peers on key academic assessments and in their rate of participation in STEM career fields. Female students, while often demonstrating strong achievement levels in STEM subjects, too often express lower levels of interest in these highly rewarding careers, one example of an improving but still present interest gap.

This nation must prepare with great urgency to preserve its strategic and economic security. Rapidly emerging awareness in America that technology is not just a ubiquitous component of contemporary culture, but also one of the critical keys to global competitiveness. The publication The World is Flat convinced Americans that the U.S. is losing ground to China and India in the global economy. Friedman pointed squarely at the roles that STEM and STEM education play in the global competition for wealth and power [14]. Enabled by information technology, a qualitatively different and new Science, Technology, Engineering and Mathematics(STEM) infrastructure has evolved, delivering greater computational power, increased access, distribution and shared use, and new research tools, such as data analysis and interpretation aids, Web-accessible databases, archives, and collaboratories. Many viable research questions can be answered only through the use of new generations of these powerful tools. .

Because other nations have, and probably will continue to have, the competitive advantage of a low wage structure, the United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring. We have already seen that capital, factories, and laboratories readily move wherever they are thought to have the greatest promise of return to investors [8].

II. PROPOSED INITIATIVES

- It is imperative that a need to increase the level of academic preparation among the pool of students interested in STEM careers so they are prepared for the rigors of STEM education.
- Need to reform the pedagogy and culture of teaching in order to create exciting and engaging STEM learning experiences for all students on campus.
- Must develop strong mentoring and support programs for students in STEM majors to ensure that those students maintain their interest in STEM disciplines and experience success along the path to graduation. In addition to information about which courses to select for a given major, additional information about careers available in their selected field, insights about how to succeed, mentoring and advocacy for difficult academic experiences, and a more personal relationship with professors, advisors and other students.
- Enhanced mentoring of students both with respect to career information and academic advising
- Foster high-quality teaching with world-class curricula, standards, and assessments of student learning. Convene a national panel to collect, evaluate, and develop rigorous K–12 materials that would be available free of charge as a voluntary national curriculum.
- Specialty secondary education can foster leaders in science, technology, and mathematics. Specialty schools immerse students in high-quality science, technology, and mathematics education; serve as a mechanism to test teaching materials; provide a training.
- Summer internships and research opportunities provide especially valuable laboratory experience for both middle-school and high-school students.
- Increase research to advance instrument technology and build next generation observational, communications, data analysis and interpretation, and other computational tools.
- Expand education and training opportunities at new and existing research facilities.
- Stimulate the development and deployment of new infrastructure technologies to foster a new decade of infrastructure innovation.
- Develop the next generation of the high-end high-performance computing and networking infrastructure needed to enable a broadly based S&E community to work at the research frontier.
- Facilitate international partnerships to enable the mutual support and use of research facilities across national boundaries.

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- Protect the Nation's massive investment in S&E infrastructure against accidental or malicious attacks and misuse

Flat or declining research budgets for federal agencies and programs hamper long-term basic and high-risk research, funding for early-career researchers, and investments in infrastructure [9]. Yet all of those activities are critical for attracting and retaining the best and brightest students in science and engineering and producing important research results. These factors are the seeds of innovation for the applied research and development on which our national prosperity depends.

To prosper in the Global Economy of the 21st Century a series of actions are needed that will help restore the national investment in research in mathematics, the physical sciences, and engineering. The proposals concern basic-research funding, grants for researchers early in their careers, support for high-risk research with a high potential for payoff, and the establishment of prizes and awards for breakthrough work in science and engineering [12].

III. PRINCIPAL FINDINGS AND RECOMMENDATIONS

Information technology and other technologies have enabled the development of many new Science and Engineering(S&E) tools and made others more powerful, remotely usable, and connectable. The new tools being developed make researchers more productive and able to do more complex and different tasks than they could in the past. An increasing number of researchers and educators, working as individuals and in groups, need to be connected to a sophisticated array of facilities, instruments, databases, technical literature and data. Hence, there is an urgent need to increase Federal investments to provide access for scientists and engineers to the latest and best S&E infrastructure, as well as to update infrastructure currently in place. The challenge is immense, and the actions needed to respond are immense as well. 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. To address those challenges, this research proposes four basic recommendations that focus on the human, financial, and knowledge capital necessary for US prosperity.

The four recommendations focus on actions in K–12 education

- Increase America's talent pool by vastly improving K–12 science and mathematics education.
- Sustain and strengthen the nation's traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life.
- Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.
- Ensure that the United States is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high-paying jobs based on innovation by such actions as modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.

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The Next Dimension

The exponential growth in computing power, communication bandwidth, and data storage capacity will continue for the next decade. IT drivers smaller, cheaper, and faster will enable researchers in the near future to:

- Establish shared virtual and augmented reality environments independent of geographical distances between participants and the supporting data and computing systems.
- Integrate massive data sets, digital libraries, models, and analytical tools from many sources.
- Visualize, simulate, and model complex systems such as living cells and organisms, geological phenomena, and social structures.

With the advent of networking, information, computing, and communications technologies, the time is approaching when the entire scientific community will have access to these frontier instruments and infrastructure. Many applications have been and are being developed that take advantage of network infrastructure, such as research

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collaboratories, interactive distributed simulations, virtual reality platforms, control of remote instruments, field work and experiments, access to and visualization of large data sets, and distance learning [10].

Extraordinary advances in the capacity for visualization, simulation, data analysis and interpretation, and robust handling of enormous sets of data are already underway in the first decade of the 21st century. Computational resources, both hardware and software, must be sufficiently large, sufficiently available, and, especially, sufficiently flexible to accommodate unanticipated scientific and engineering demands and applications over the next few decades

Needs for research tools are diverse, ranging from high-speed, high resolution imaging technology to study gene development and expression to a suite of complex instruments that enables the simulation, design, and fabrication of novel nano and micro-scale structures and systems [11]. In addition, substantial investment is needed to enable engineering participation in grid activities, to facilitate collaborations between engineering and computer science researchers, and to develop tools including improved teleoperation and visualization tools, integrated analytical tools to support real-time analysis of processes, multiscale modeling, and protocols for shared analytical codes and data sets.

IV. CONCLUSION

The recommendations and the actions proposed to implement them merit serious consideration if we are to ensure that our nation continues to enjoy the jobs, security, and high standard of living that this and previous generations worked so hard to create. The United States faces an enormous challenge because of the disparity it faces in labor costs. Science and technology provide the opportunity to overcome that disparity by creating scientists and engineers with the ability to create entire new industries much as has been done in the past.

It is easy to be complacent about US 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 changing infrastructure technology has simultaneously created a challenge and an opportunity for the U.S. Science Technology Engineering and Math (STEM) program. The challenge is how to maintain and revitalize an academic research infrastructure that has eroded over many years due to obsolescence and chronic underinvestment. The opportunity is to build a new infrastructure that will create future research frontiers and enable a broader segment of the STEM community. The challenge and opportunity must be addressed by an integrated strategy. As current infrastructure is replaced and upgraded, the next-generation infrastructure must be created. The young people who are trained using state-of-the-art instruments and facilities are the ones who will demand and create the new tools and make the breakthroughs that will extend the STEM envelope. Training these young people will ensure that the U.S. maintains international leadership in the key scientific and engineering fields that are vital for a strong economy, social order, and national security.

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