The U.S. Plan for Science, Math, and Technology Education

Md. Mokter Hossain
University of Nevada, Reno
E-mail: mokter@unr.edu
Michael G. Robinson
University of Nevada, Reno
E-mail: robinson@unr.edu

Abstract: Despite being the inventing country of the Internet, the United States ranks 15th overall in broadband adoption and ranks 28th in Internet speed in the world. Moreover, even with coherent actions taken by various institutions, the U.S. cannot produce a sufficient number of experts in science, math and technology fields to meet its' national and global needs. This situation is not satisfactory for educators and legislators to reach U.S. education goals. To improve this situation, President Obama has proposed several action plans. This paper presents a closer look at the U.S. plan for science, mathematics and technology education as well as some specifics regarding the effects of technology education in general over the last decade. Conclusions are made regarding whether the President's plan is too ambitious as well as whether the vision is comprehensive enough but still possible to execute.

Introduction

Science and technology have been powerful engines of prosperity in the United States since World War II but, currently science, technology and math education as well as the capability of the American workforce are in decline (Leshner, 2009). It seems hard to believe that despite being the inventing country of the Internet, in 2008 the United States ranked 15th in broadband adoption among 30 Organization for Economic Co-operation and Development (OECD) Nations after being 12th in 2006 (OECD Broadband Statistics, 2008). The first and second annual speedmatters.org reports of actual internet speeds of 50 states in the U.S. did not find any significant improvements in deploying high-speed broadband networks in the last few years. The third report showed that in 2009, 56.5% of the U.S. households (46% rural, and 67% urban and suburban) were subscribers to the broadband internet connection (Speed Matters, 2009). In 2006 and 2007 it was 42% and 47% respectively (Levine, 2007). The Pew Internet & American Life Project, 2009 survey report showed that in April 2009, 63% of adult Americans had broadband Internet connections at home, which was 15% higher than the previous year. The broadband internet service charge was increased to $39.00 in 2009 from $34.50 in 2008 (Horrigan, 2009). However, low cost Internet access could enable lower socio-economic consumers to get new Internet connection and existing users to effectively view and download text, audio and video content.

This rate of broadband adoption is not sufficient to reach the Jupiter Research's projected target of 70% by 2012 (Leggatt, 2007). Compared to the rest of the world, the U.S. ranks 28th in average Internet connection speeds; only nine-tenths of a mbps increase (from 4.2 mbps to 5.1 mbps) since the previous year. At this rate, it will take the U.S. another 15 years to catch up with current Internet speeds in South Korea. According to the report, in 2009, 74.1% of the U.S. population had internet access. In 2004 and 2007 that was 44.1% and 70.1% respectively. The surveys singled out the high cost of equipment and broadband access as some of the biggest barriers to U.S. broadband adoption. The above information indicates that the U.S. is not improving adequately in broadband deployment, speed and price when compared to other developed countries. This is not satisfactory for educators and legislators who are responsible for the policy and educational priorities needed to maintain U.S. competitiveness in the international arena through continued growth in science, mathematics and technology achievement.

Studies found that more people in the United States use the Internet than any other country in the world and most of them are students and teachers (Fusilier et al., 2005; Yi, 2008). According to a study in 2002, 73% of U.S. college students used the Internet more than they used the library for research activities. Seventy nine percent of them agreed "that Internet use has had a positive impact on their college academic experience" (Jones & Madden, 2002). Princeton Research Associates for the Pew Internet & American Life Project conducted nationwide telephone surveys, and analyzed how respondents penetrated the Internet. The results showed that all respondents (59%) of the general population did not go through the Internet more than college students (86%) (Jones & Madden, 2002).

Another alarming situation is that the mean math and science scores of U.S. 15-years-olds are also lower than some of the less developed countries, e.g. Czech Republic, Slovak Republic, Austria, Poland, and Hungary (TIMSS 2003a, 2003b, 2007a, 2007b). According to the Glenn Commission report (2000), the current preparation that U.S. students receive in science and mathematics is unacceptable; and as a result, young students in many less-developed countries now outperform their American counterparts in science and mathematics education (National Commission on Mathematics and Science Teaching for the 21st Century, 2000). In 2006, the Program for International Student Assessment reported that 15-year-olds in the United States ranked 17th on the science test and 24th on the math test when compared with teens from 29 other industrialized countries (Cavanagh, 2008). The U.S. also trailed at least 19 countries that produce more scientists and engineers. The fact that some less developed countries now perform better in math and science achievement than the United States is seen by many U.S. educators, business leaders, and politicians as a crisis (Ramirez, 2008).

Another growing concern is that the U.S. is not preparing a sufficient number of students, teachers, and practitioners in the fields of Science, Technology, Engineering, and Mathematics (STEM) education. The U.S. has an excess of English teachers for every job, but cannot find enough qualified mathematics teachers (Golden, 2009). A majority of secondary school students fail to reach proficiency in math and science (Kuenzi, 2008; Olivos-Kah, 2006). This may be because of the fact that many science and math teachers in the U.S. have not majored or minored in these subjects and lack adequate content knowledge. According to the National Science Foundation, the proportion of 24-year-olds who earn degrees in STEM fields in the U.S. ranks 20th in the world. Once a leader in math and science education, the U.S. is now behind many other countries on several measures (Kuenzi, 2008). Current progress might be unsatisfactory for executing President Obama's plans to draw more good teachers to high-need schools, and give more emphasis to STEM education in the United States.

The rest of the paper presents a closer look at the U.S. plan for science, mathematics and technology education based on information from President Obama's campaign speeches and press releases from his advisors after he assumed office in January 2009. The paper closes with some discussion and conclusions regarding the feasibility of implementing the plan.

A Closer Look at U.S. Science, Math, and Technology Education

The results of the Trends in the International Mathematics and Science Study (TIMSS) 2007 showed that in science, U. S. fourth-grade students achieved an average score of 539 points, and eighth-graders an average score of 520. In mathematics, the fourth and eighth-grade scores were 529 and 508 respectively, compared with the international average of 500 for these grades and subjects (TIMSS, 2007a, 2007b). In 2003, the average science scores of U.S. fourth-graders and eighth-graders were 536 and 527 respectively; and the average mathematics scores were 518 and 504 respectively (TIMSS, 2003a, 2003b). In 1999, the average science and mathematics scores of U.S. eighth-graders were 515 and 502 respectively (TIMSS, 1999a, 1999b). In 1995, the average science scores of U.S. fourth-graders and eighth-graders were 542 and 513 respectively; and the average mathematics scores were 518 and 492 respectively (TIMSS, 1995a, 1995b). A closer look at the above studies is shown in *table 1*.

	Science Score		Mathematics Score	
Study	Fourth-grade	Eighth-grade	Fourth-grade	Eighth-grade
1995	542	513	518	492
1999*	-	515	-	502
2003	536	527	518	504
2007	539	520	529	508

*In TIMSS 1999 only eighth graders were tested.

Table 1: U.S. students' performance recorded in TIMSS 1995 – TIMSS 2007

Compared with 1995, in 2007 the average science scores for both U.S. fourth and eighth grade students were not measurably different; however, the average mathematics scores in these grades were slightly higher, 11 points for fourth grade, and 16 points for eighth-grade. A superficial reading of this report might mislead the reader to believe that the United States is doing well in science and mathematics. However, this would be a mistake since the United States is doing far worse in science and mathematics internationally when compared to average scores of many of the students in 35 other countries at fourth-grade level, and 47 other countries at eighth-grade level.

In the U.S. the 2007 National Assessment of Educational Progress found that 70% of U.S. eighth-grade students performed at or above the basic level in mathematics, and 31% performed at or above the proficient level (Digest from Education Statistics, 2007). Even the U.S. eighth graders in the best-performing states such as Massachusetts ranked significantly lower than the average eighth graders in the highest-achieving countries e.g., South Korea, Singapore, and Taiwan (Phillips, 2007). In 2003, the performance of U.S. 15-year-olds in mathematics literacy and problem solving, measured by the Program for International Student Assessment (PISA), was lower than the average performance of most of the OECD nations. In the assessment, a greater percentage of U.S. students scored below the average level. And even a lower percentage of them scored above the average percentage level of OECD countries (Digest of Education Statistics, 2007). On PISA 2006, the U.S. 15-year-old students ranked 28th in math literacy and 27th in science literacy. Moreover, the U.S. ranked 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering (Kuenzi, 2008). In summary, when compared to other industrialized nations, the science and mathematics achievement of U.S. students and the rate of STEM degree attainment seems lower than expected for a nation considered the world leader in scientific innovation.

According to a 1999-2000 study on STEM Education in the United States, administered by Scientists and Engineers for America (SEA), many U.S. students are taught by science and math teachers without an undergraduate or graduate major or minor in the relevant fields. Among middle-school teachers, 51.5% of those who taught math and 40% of those who taught science did not have a major or minor in these subjects. Among high-school teachers, 14.5% of those who taught mathematics and 11.2% of those who taught science did not have a major or minor in these subjects (SEA, 2008). According to another 2007 report from the Washington-based Council of Chief State School Officers, only 61% of the nation's math teachers in grades 7-12 have a major in that subject. In some states, the percentage of math teachers with a college major in math or science is much lower than the nationwide average (Cavanagh, 2008). Due to low remuneration but high accountability and workload, nearly 50% of beginning science and math teachers leave their jobs in the first five years (NSTA, 2008; Woullard & Coats, 2004). Moreover, possibly due to lackluster performance in science and mathematics, Americans are also behind other developed countries in most of the sciences, engineering, architecture, medical science, economics, most of the trades, and many areas of the arts. Experts warn that the United States' apathetic performance in math and science can complicate the troubles of the nation's already ailing economical situation (Ramirez, 2008).

Effects of Technology on U.S. Education Including Science and Mathematics

Over the last decade, U.S. schools have been rapidly acquiring access to computers and the Internet in their classrooms. According to the United States Department of Education, in 2002, 90% of children between the ages of 5-17 used computers and more than 90% of students in the 12-18 age group used the Internet. By 2003, over 90% of middle and high school students reported using a computer at school (Larid, DeBell, & Chapman, 2006). Definitely, these students will use the computer and the Internet more than any other age group and will expect a learning environment that includes the following: 1) technology integrated home/teamwork and assignments; 2) multiple focal points; 3) action and interaction; 4) visual and dynamic movement and materials that will increase their learning capacity; and 5) make their study interactive and lively (Blake & Markovic, 2008). In 2004, U.S. school districts reportedly spent $7.87 billion on technology equipment during the 2003-2004 school year. Consequently, the student-per-instructional computer ratio dropped to 3.8:1, and the student-per-Internet-connected computer ratio dropped to 4.1:1 (Hew & Brush, 2007). At least 25 states now have online schools or organizations providing web-based courses to students. The Internet and interactive computer-based multimedia and animated tools are transforming the teaching-learning processes. A larger number of schools, colleges and teacher training institutes have moved to broaden educational training through online courses including courses in science and mathematics. The number of K-12 students taking online courses increased 47% from 2005-06 to 2007-08, putting the total number of students engaged in such courses at more than one million (Patrick & Thomas, 2009).

However, technology has not reached its potential in preservice teacher instruction nationwide. Many newly graduated teachers often do not have sufficient experience to use computers in teaching-learning processes (Kurz & Middleton, 2006). Many preservice teachers feel that after graduation they are not well prepared to teach with technology (Carlson & Gooden, 1999). In a study conducted by Smith and Shotsberger (2001), most preservice teachers identified technology as important in math education; however, due to lack of knowledge, some of them were uncomfortable discussing the specific use of technology for instruction. Another study showed that teacher preparation for technology integration was minimal (Watts-Taffe, Gwinn, Johnson, & Horn, 2003). Another study on preservice teachers' perception of the teacher's role in the classroom with computers found that there was a significant difference between preservice teachers' choice of teacher-centered computer use and student-centered

computer use (Wang, 2002). Another recent study to measure preservice teachers' technology beliefs, skills and barriers to the use of technology found that preservice teachers feel confident in their ability with basic computing operations and simple search strategies to find information on the Web (Brush, Glazewski, & Hew, 2008). However, the study revealed that many technology preparation classes only adequately prepare preservice teachers with lower-level technology skills that do not provide preservice teachers with adequate knowledge to provide sufficient technology-based instructions in their classrooms. Their study also indicated that current technology preparation of preservice teachers in classes at a Southwestern university failed to demonstrate meaningful methods for integrating technology within a curriculum.

The U.S. Plan to Improve the Situation

In the past, the United States has been able to produce an adequate number of teachers to meet its educational demands (Woullard & Coats, 2004). However in 2001, *Education Week* predicted that because of the projected increase in student enrollment, increased teaching workload, high accountability, low remuneration and the integration of technology in the classroom, the United States might have not enough teachers to fill the schools (Woullard & Coats, 2004). By 2008, this became a reality in science, math and technology education in the United States. The current progress is not yet satisfactory if American educators and legislators are to achieve the U.S. Projection of Education that will require 4.2 million elementary and secondary teachers by 2017 (Hussar & Bailey, 2008). According to Alan I. Leshner, the Chief Executive Officer of the American Association for the Advancement of Science (AAAS), and Executive Publisher of the journal, *Science*, federal research and development had declined, in real terms, for the past few years before President Obama took office (Leshner, 2009). However, President Obama pledged to double federal funding for public charter schools (increase by $500 million) to upgrade school technology and to award merit pay for teachers, including higher salaries, especially for math and science teachers (Helman, 2008).

The evidence indicates that President Obama has a comprehensive plan to make real changes in the U.S. education system. In one of his election campaign speeches, he offered a dismal picture of the state of American education. He warned that U.S. elementary school students were not receiving enough instruction in science and math education to compete in the global economy and to obtain advanced STEM degrees. The president elect emphasized that college and university students in the U.S. are lagging behind their Asian counterparts. In a radio address on December 2008, President-elect, Barack Obama, expressed his opinion that in "the country that invented the Internet, it is unacceptable that the United Sates ranks 15th in the world in broadband adoption." He also added, "every child in the United States should have the chance to get online" (Ash, 2008). He promised to allocate enough money from his 'economic-stimulus plan' to place more computers in schools and provide both homes and schools with widespread broadband access (Ash, 2008).

Because of the lack of skilled applicants, a lot of jobs are going unfilled in the United States and are being offered to foreigners (Helman, 2008). After being elected, President Obama and his advisors promoted a comprehensive education plan which calls for expanding early education opportunities for all children, providing the opportunity for every child to get Internet access, improving teaching quality, supporting school innovation, and putting a college education within reach of many more students (Helman, 2008).

In a speech he gave on education in March 2009, the President called for linking teacher pay to performance, rolling out more charter schools to increase parents' choices, and closing schools that do not make the grade. In addition, President Obama noted that:

> I'm calling on our nation's governors and state education chiefs to develop standards and assessments that don't simply measure whether students can fill in a bubble on a test, but whether they possess 21st century skills like problem-solving and critical thinking and entrepreneurship and creativity. (Tucson, 2009)

He proposed training thousands of science and math teachers, boosting early-childhood education, and providing scholarships for those who teach in schools with the greatest needs. He also said he wants to ensure that state assessments measure higher-order thinking skills (Golden, 2009). It is hoped, this will allow children to be more familiar with the subject matter and have a chance to take upper level math courses, such as algebra, geometry and calculus, before they graduate. However, he suggested that the first step to accomplish this might be to provide career paths for older workers such as retirees, and people from the military to come back to teach in the nation's schools. He also declared his plan to encourage young and energetic math and science teachers by giving them better compensation (Leshner, 2009). Moreover, according to John P. Holdren, Obama's assistant secretary of science and technology and director of the White House Office of Science and Technology Policy:

> ... the United States is capable of sustaining high-quality K-12 science and math programs. We simply are not providing equal educational opportunities for all of America's children. Now is the time to tackle the science education problem if we want long-term, stable improvements in our national economy and quality of life. (Leshner, 2009)

In an interview with *Business Week* in March, 2009 the U.S Education Secretary, Arne Duncan, discussed the Obama Administration's priorities and strategies to improve schools. He agreed that the U.S. has many candidates for jobs in teaching English, but not enough qualified ones in science and math teaching. The secretary thinks this is a great problem for the United States and he hopes to pay math and science teachers differently. Presumably this means more. He also expressed the Obama administration's priorities and strategies on early exposure in more advanced math and science in middle school, rather than late in high school (Golden, 2009).

In another interview on March 2009, Secretary Duncan described in more detail the Obama Administration's visionary plan for a public school program extension. He envisioned making the U.S. public schools into community centers for the students, teachers, parents and community people by extending school hours (open 12-14 hours a day, 6-7 days a week, and 12 months a year) (Todd, 2009). In the extended school hours, a wide variety of after school activities: arts, sports, chess, drama, debate, music, academic enrichment programs for parents, GED, ESL, family literacy nights and potluck dinners could be administered in cooperation with private groups, like the Boys and Girls Club or the YMCA. He expects this to be an effective way to give opportunities to children with two-parent working families or single moms working one or more jobs to achieve their desired goals (Todd, 2009).

On March 26, 2009 U.S. Education Secretary Duncan highlighted Obama's education budget proposal for FY 2010. It provided for Pell Grants to dramatically increase college students' access and affordability to financial aid while making them simpler, more reliable, and more efficient (Babyak, Bradshaw, & Glickman, 2009). The proposed American Recovery and Reinvestment Act (ARRA) will provide an additional $17 billion for Pell Grants in Fiscal Years 2009 and 2010; the current year funding is $16.2 billion with 6.1 million participating students. With the stimulus package the Pell Grants would be increased by $500 to $5,350 to be given to seven million students each year. According to the 2008 Federal Education Tax Benefits Guide, the maximum amount of Hope credit in 2008 was $1,800 per student (NASFA, 2008).

Under the new plan, the credit would be raised to $2,500 and it could be used to cover the cost of tuition and textbooks. It is likely that by ensuring affordable and accessible higher education to all American young people, the Obama government wants to make sure that the United States is prepared to compete in a technology driven information-age economy. There is hope that, Obama's proposed budget will call for a historic investment to make college more affordable and accessible and to help more students succeed once they get there. Presumably, a greater number of students attending college with increased middle school and high school preparation in math, science and technology should increase the possibility that more students will also study for and enter careers in STEM fields.

Discussion and Conclusions

Although much of it is not new, Obama's education plan is imaginative and comprehensive enough to make necessary changes in the U.S. education system if successfully carried out. However, elected on a platform of hope and great changes, President Obama has inherited a horrible worldwide economical crisis, especially in the U.S. and more recently in the European Community, that is having a clear effect on the pace and scale of expected reform. A vital question is whether Obama's education plan is executable or if is it too ambitious to implement when currently millions of Americans struggle to complete high school, with 3 in 10 dropping out. Moreover, only two of every five American adults have a two- or four-year college degree (Steele, 2009).

According to Donald G. Knezek, the chief executive officer of the Washington-based International Society for Technology in Education, "Obama is the first American President who truly understands and embraces information and communication technology, connectivity and the power of the World Wide Web, and the democratization of information, knowledge, and 21st century communications." He hopes that the Obama Cabinet will make math and science education a national priority, and provide U.S. schools with the tools to educate 21st century learners (Ash, 2008). Many Americans applaud President Obama for his visionary plan to create standards and assessments that ensure American students have high content knowledge, e.g., mathematics and science, and the ability to apply that knowledge to be successful citizens, workers and leaders in tomorrow's world. Although, it is fair to say that public resistance to federal education standards will need to be overcome.

Furthermore, to ensure their goals for lifetime success through education, Obama's Cabinet, advisors, and U.S. educators must take into account what is happening inside classrooms and should consider how the current

system of teaching-learning can be improved. A realistic assessment is also needed to determine how the current system can be adjusted to increase its alignment with new and improved science and math curricula and teaching-learning tools to achieve Obama's ambitious learning goals. An ongoing system should be established to motivate more K-12 students to enroll in more science and mathematics courses. Also, the quality of existing and preservice science and math teachers in K-12 grades must be improved through better pay, better working conditions, more in service training and other work incentives. Definitely, the actual outcome may not be seen for a generation; however, appropriate legislative actions should be taken immediately to open the possibility for changes.

K-12 students, especially in middle schools, should be nurtured and provided with suitable role models and shown practical applications of math and sciences in their lives. They should learn how math and science are related to their non science and math interests in art, music, fashion or sports. A more widespread use of the Science, Technology and Society (STS) teaching philosophy would be useful for helping make science and mathematics more interesting and relevant to students and perhaps increase the prospect of more middle school students to pursue more science and mathematics in high school (Robinson & Ochs, 2008). However, legislators and educators are not the only people who can solve this problem. U.S. math and science educators must incorporate and welcome the integration of math, science, technology and media experts to work toward a comprehensive education solution. Increased parental support and involvement in K-12 education will also be a key factor.

Like millions of Americans, we hope that Obama's advisors in education as a whole, and specifically in science, mathematics and technology will find a way to make the public better understand that math, science and technology education are highly valued, respected, and essential for all American children, not just for those in selected schools or to prepare students for STEM careers. All of American society, not just students and teachers, must be involved if we are to remain competitive internationally in science, mathematics and technology driven economic areas. Increased funding for science and math education at all levels, as well as more state and federal research and development will be needed along with more and better trained math and science teachers.

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