How to Overcome Barriers and Misconceptions of STEM Education in the United States

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Abstract: The United States is considered to be the leader of Science, Technology, Engineering, and Mathematics (STEM) education. Currently, American students' performance and enthusiasm in STEM education are inadequate for the U.S. to maintain its leadership in STEM professions unless the government takes more action to motivate a new generation of U.S. students toward STEM careers. Despite coherent actions taken by the government and various institutions, the U.S. cannot ensure the production of a sufficient number of experts in STEM fields to meet its' national and global needs. This paper starts with a deeper look at the basis of career choices by the U.S. students and the barriers and misconceptions about STEM education in the U.S.; and concludes with recommendations for how to overcome the barriers and misconceptions.

Introduction

As the world becomes more technologically developed, the economy, power, and leadership of the U.S. is becoming more heavily based on effective practice and the number of skilled workers in these fields, As a result, the success, security, and leadership position of a nation depends not only on the use of technology but also the number of native workers in STEM fields. The technology driven economy and skilled workforce in STEM fields is the driving force for innovation of a nation. The United States possesses the most innovative, technologically capable economy in the world. Despite a glorious record of achievement in technology, the U.S. lags behind many less developed nations in STEM education in elementary, secondary, and higher education. As the U.S. invests more money and effort to promote improvement in STEM education, the number of foreign students and workers in these fields is increasing significantly (Borjas, 2004; Kuenzi, 2008; National Center for Education Statistics, 2009).

In the proportion of 24-year-olds who earn degrees in STEM fields, the U.S. currently ranks 20th in the world (Kuenzi, 2008). Once, the leader in science and technology, the U.S. is now behind many countries on several measures in STEM education. Current progress is not satisfactory for the nation to address its ailing economic situation and continue global leadership in technology and innovation. It is assumed that many high-STEM-ability U.S. students fail to realize their full STEM potential at the high-school level, or many of them leave their career choice in STEM fields entirely at the college level. There exist a lot of magnet STEM programs nationwide that are largely responsible for developing much of the talent emerging from the public school system. These programs, however, are not necessarily available to underprivileged students, and some are being cut due to current budget restraints. According to Wasserman (2008), to retain these students in STEM and to enhance their high-school STEM experiences is simpler than recruiting additional students. These students could be considered as the low-hanging fruit in the National Science Board (NSB)'s efforts to produce the next generation of innovators. Sometimes their talent and potential are overlooked, under-developed, and underutilized. However, they should be a target group for the nation's strategy for developing a STEM workforce. This is apparently the only way to strengthen the economy and leadership of the nation; by preparing a substantive number of American citizens capable of working and leading in the nations science and technology sectors.

As the nation continues to advance through the first quarter of the 21st century, there is a growing need for educators to be less dependent on the foreign or foreign-born STEM workers, and to take appropriate actions to inspire and prepare native-born American students towards STEM education. The rest of the paper addresses the basis of career choices by U.S. students; and barriers and misconceptions toward STEM Education in the U.S. It closes with some recommendations to overcome these barriers and misconceptions.

Statement of the Problem

Despite coherent actions taken by educators, government, and various organizations, the U.S. cannot be certain of producing and certifying the quantity and quality of students, teachers, and professionals in STEM fields needed to meet the nation's current demand. The overall situation indicates it is unlikely the U.S. will maintain its local and global leadership in science, math, and technology professions unless federal planning takes remedial action to produce nationally or import enough experts in these fields. This is not a satisfactory outlook for American educators and legislators who are attempting to recover from the current economic hardship and to ensure sustainability as a high technology nation. A vital question is whether the U.S. education system and job markets are failing to motivate and encourage Americans students to pursue STEM education and careers in these fields.

Too many highly paid STEM jobs are now occupied by the foreign or foreign-born workers in the United States. The overall situation is a warning that it is less likely that the U.S. will maintain its local and global leadership in STEM professions unless the government takes remedial action to produce or import enough experts in these fields. Thus, the question arises as to whether the U.S. should continue its dependence on other countries for required STEM workers or take action to motivate more American middle and high school students toward the STEM pipeline. May be both are needed to generate enough scientists, technologists, engineers, and mathematicians to create the new ideas, products, and entirely new innovations in the 21st century.

The Basis of Career Choices by U.S. Students

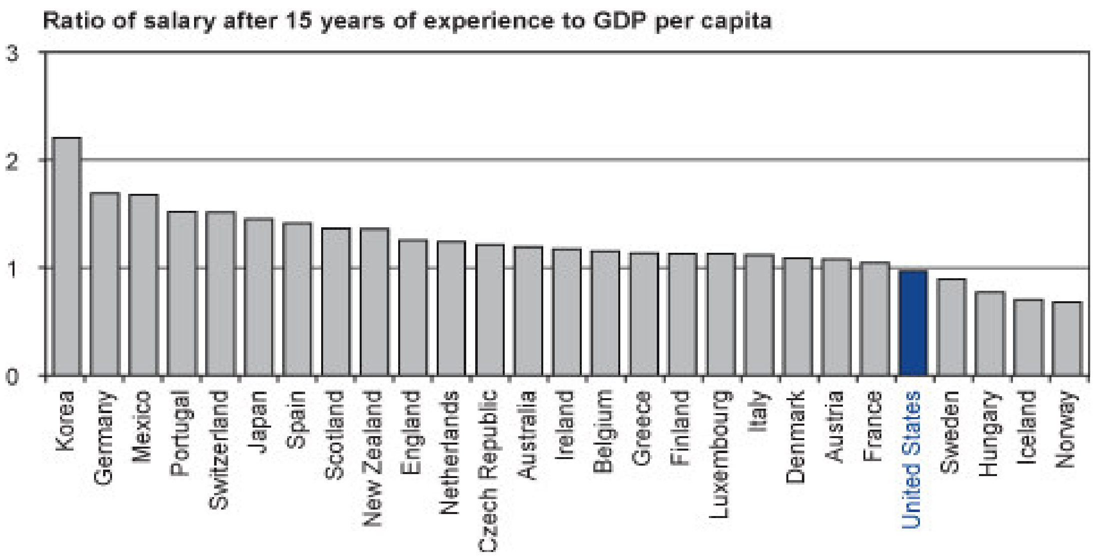
A great number of U.S. students believe that a college degree is an excellent advantage in finding a rewarding job. But many more do not consider postsecondary education as the optimal or even a possible choice. About one-half of U.S. students leave high school without the knowledge or skills needed to find and maintain a job, and one-third of them are not prepared for even entry-level work (Levinson & Palmer, 2005). Many American students and their parents believe that most of the STEM studies require significant investment and hard work in education. Students who do commit themselves from the very beginning of middle or high school and have the opportunities to take high school or vocational courses in science and mathematics do succeed in the STEM path in their future studies.

A 2004 study found that 72.2% of U.S. parents indicated that the basis of career choice should be based upon a combination of interests/abilities and the job market; 27.6% responded that career choices should be based solely upon interests/abilities, and only 0.2% stated that career choices should be based upon the labor market (Taylor, Harris, & Taylor, 2004). The study found more than 90% of parents had little to very little influence on their college-age children's career decision; fewer than 10% parents had a great influence on career decision making. Parental support and encouragement were found as influencing factors in children's vocational outcome. The study also found that regarding influence on students, the father and mother were ranked as the first two, the teacher as the third, and the counselor as the fourth in children's choice for career development. However, most of the parents did agree that they did not have or should not have more influence on their children's career decisions (Taylor et at., 2004).

According to a U.S. Bureau of Labor Statistics, in the 2005 FY, STEM workers, as a group, earned about 70% more than the national average, and every major group of STEM workers enjoyed overall median earnings that were above the national average. Fresh college and university graduates with a degree in STEM fields believe that they will not be paid adequately if they teach in a school or college. For instance, in 2005, biophysicists and biochemists, which often have a Ph.D., had median earnings of $71,000; biological technicians, who often have an associate degree or less education, earned a median of $34,270 (Terrel, 2007).

However, many students who graduated with a STEM degree believe that teaching in a middle and high school is more socially responsible but is not paid adequately. For instance, median salary offered for the fresh college graduates for teaching in elementary public schools was $30,000, and the median salary for fresh secondary teachers was $36,000. By contrast, the median salary offered to fresh college graduates in certain STEM-related fields, including physics, computer science, accounting, and engineering, is currently more than $60,000 (PCAST, 2010). Moreover, most of the teaching positions demand a teaching license and or a teacher education degree that many STEM graduates do not want to acquire.

Figure 1
Secondary teachers' salary relative to GDP in OECD nations



Source: Organization for Economic Cooperation and Development, 2007 reported in PCAST, 2010

In addition, STEM teachers' salaries do not keep pace with salaries paid to other STEM professions (PCAST, 2010). For instance, between 1993 and 2003, the median salary for high school science and mathematics teachers increased by 8% adjusted for inflation, while, during the same period, the salary for other STEM professions increased by 21 to 29 percent (National Science Board, 2008). In international comparison, teachers in the U. S. are paid less than in many developed countries, even though they have to do more challenging and responsible duties, and work more hours on average (Organization for Economic Co-operation and Development, 2009). According to the finding of PCAST (2010), "relative to per capita GDP, the U.S. ranks in the bottom third of OECD countries in terms of teacher salary." Figure 1 shows that the U.S. teachers' are paid less than half of Korean teachers, and lag behind more than half of the 33 OECD countries including Mexico, Japan, Czech Republic, Italy, Austria, and France. Thus, it is very likely that many graduates with a STEM degree either do not choose a teaching position or leave within the first few years of their teaching career to a non-teaching position.

Barriers and Misconceptions toward STEM Education in the United Sates

According to the National Center on Education and the Economy (NCEE, 2006), "the core problem in U.S. STEM education and training systems is that they were built for another era, an era in which most workers needed only a rudimentary education" (p. 8). The NCEE believes that teachers who educate elementary to high school level students get their information and attitudes about STEM disciplines from college and university level courses taken in the teacher education programs. However, technology has not reached its potential in teacher education curricula nationwide. Many newly graduated teachers often do not have sufficient experience to use computers in teaching-learning processes (Kurz & Middleton, 2006). A study showed that teacher preparation for technology integration was minimal (Watts-Taffe, Gwinn, Johnson, & Horn, 2003). Amore recent 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 (Brush, Glazewski, & Hew, 2008).

It is also thought that U.S. STEM education faces barriers and misconceptions that greatly hinder students' motivation and achievement at all levels. Most of the barriers are related to curriculum, credit and funding issues, lack of qualified teachers, inadequate policies to recruit and retain STEM-Educated teachers, difficulty to retain teachers with a STEM background, difficulty in conducting research while teaching in the classroom, difficulty in continuing to learn about STEM areas while teaching in the classroom, lack of adequate preparation for teachers in higher education, classroom time constraints and difficulty in attracting and keeping kids in STEM careers, etc.

These barriers fueled by some of the following misconceptions against STEM education in U.S. public schools. These include the following long list: STEM education is just another "fad" in education and will soon go away; colleges will not accept credits for high school courses called STEM; technology means the ability of basic computing and Internet browsing, STEM education consists only of the two bookends – science and mathematics; STEM education addresses only workforce issues; technology education and engineering are disparate and troublesome; mathematics education is not part of science education; engineers and technology education teachers cannot teach science or mathematics; STEM education include a lot of laboratory work or the scientific method; all STEM educated students will be forced to choose technical fields because they do not have a liberal arts foundation; etc (Setda.org, 2008). In addition, STEM studies seem to be very hard for many students.

There are severe troubling weaknesses, gaps and disconnection among the quality of math and science instructions in the early grades, the performance of high school students on international tests, and the content and harshness of pre- and in-service teacher education programs in the colleges and universities in the United States (Sanders, 2004). Too many elementary and middle school students are not being equipped to achieve expected goals in science and mathematics. A significant number of elementary school teachers lack confidence in their ability to teach mathematics and science. The problem is particularly severe in the elementary grades and also serious for middle and high schools (National Center for Education Statistics, 2009). During the 2007-08 school year, only 56% of K-12 public school science and mathematics teachers held undergraduate and/or graduate degrees in science or science education, or mathematics or mathematics education (PCAST, 2010).

Among the nation's estimated 426,000 middle and high school STEM teachers, each year about 25,000 of them leave their teaching profession (Ingersoll & Perda, 2010). While reasons for leaving job are numerous, nearly two-thirds of them cite job dissatisfaction as their reason for leaving. Due to low remuneration but high accountability and workload, and lack of professional support, more than 40% of beginning science and math teachers leave their jobs in the first five years (Ingersoll & Perda, 2010; National Science Teacher Association, 2008; Woullard & Coats, 2004). Although many of them reenter teaching in different schools or locations, or switch to a different branch of STEM careers, to counter the net turnover rate of STEM teachers, the U.S. still needs to attract more students to STEM fields and ensure an ongoing annual average need for 25,000 new STEM teachers (PCAST, 2010).

The issues are not only due to the quantity and quantity of STEM teachers. There is a crucial issue of quality of teacher education programs as well. Many pre- and in-service teacher education programs prepare their graduates with insufficient skills on technology usage. As a result, many newly graduated teachers do not have sufficient experience to use computers in the teaching-learning processes (Kurz & Middleton, 2006). A 2008 study found that many technology preparation classes adequately prepare preservice teachers with lower-level technology skills but do not provide preservice teachers with adequate knowledge to provide sufficient technology-based instructions in their classrooms (Brush et al, 2008). Even, among teachers who obtain college or university degrees, many do not acquire a strong background in technology integration with pedagogical training, and even among the small fraction of teachers trained deeply in pedagogy in STEM fields, there is a little evidence to evaluate the quality of instructions they received in STEM content or STEM pedagogy (PCAST, 2010).

Discussion and Conclusions

The U.S. federal government has pursued some of these initiatives and if they are successfully implemented by 2020, the U.S. will once again have the prospect for the highest proportion of college graduates in the world. The tax credit and grant programs are some of the programs initiated to make U.S. college education more affordable. They can greatly enhance the U.S. ability to compete for the high-wage, high-tech jobs of the future and to foster the next generation of the STEM workforce (Obama, 2009). The U. S. 2010 budget provided $115 million for the Department of Energy (DOE) to launch a program jointly with the National Stock Exchange (NSE) to inspire tens of thousands of American students to pursue STEM careers, particularly in clean energy (Johnson, Chubin, & Malcom, 2010). Even as the United States focuses on low-performing students, it should devote considerable attention and resources to all of our most high-achieving students from across all economic and ethnic groups. In the words of President Obama, "We must educate our children to compete in an age where knowledge is capital, and the marketplace is global." (Obama, 2009)

To overcome the barriers, misconceptions, and problems of STEM education, we needs to target STEM education components for students at all levels from elementary to graduate levels. We particularly need to target the preservice teachers who will become the future STEM undergraduate, graduate or faculty school teachers. To meet the needs of a scientifically and technologically literate work-force, meaningful preparation of STEM teachers needs to be considered an undoubted necessity. To increase young students' interest and enthusiasm in STEM careers there are some actions that can be taken. They include the following: Organizing fundraising events with the community or other projects that increase budgeting and math skills; teaching youth at science summer camps or after-school programs; getting students to join math and science clubs; exploring technology hobbies among school children; helping them to participate in science fairs; basic computing and internet browsing; including them in internet forums and social networking; giving them books and magazines on science and mathematics; motivating them to pursue science and engineering careers; and helping them to learn about computer parts; etc (Setda.org, 2008). Moreover, students pursuing degree or certification courses in STEM related subjects should be given additional scholarships or financial support by the government or concerned institutions.

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