Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Human Capital

BACKGROUNDER

Summary

The development of our nation's human capital through our education system is an essential building block for future innovation. Currently, the abilities of far too many of America's young men and women go unrecognized and underdeveloped, and, thus, these individuals may fail to reach their full potential. This represents a loss for both the individual *and* society. There are students with high potential from every demographic and from every part of our country, who with hard work and the proper educational opportunities, will form the next generation of science, technology, engineering, and mathematics (STEM) innovators. The National Science Board (Board) believes that the recommendations set forth in this report will help ensure a legacy of continued prosperity and engender a renewed aspiration towards equity *and* excellence in U.S. STEM education.

Key Indictors/Findings

- Longitudinal data show that intellectually talented individuals identified and trained at an early age generate a disproportionate number of Fortune 500 patents, peer-reviewed STEM publications, and other creative achievements, and comprise a disproportionate number of tenured faculty at top universities.[1]
- Evidence suggests that top U.S. students are eschewing careers in science and engineering (S&E), with particularly steep declines in engineering (25%) and mathematics (19%).[2]
- Students in other countries are outperforming our highest-achieving students. In the 2006 PISA, U.S. 15-year-olds in the 90th percentile (our top students) scored below their peers in 29 countries on mathematics literacy and below 12 countries on science literacy.[3]
- While the percentage of top U.S. students entering many S&E fields has declined in recent years, many of these same fields have become increasingly reliant on foreign-born talent.[4]
- Compared to students from higher-income backgrounds, students from lower-income backgrounds experience significant "achievement gaps" at the upper-end of academic performance. These income-based achievement gaps among high-achievers appear as early as first grade and continue throughout elementary, middle, and high school.[5]
- Achievement gaps between white or Asian/Pacific Islander students and minorities traditionally underrepresented in STEM exist at *all* levels, including significant achievement gaps among the highest-performing students.[6] For example, African American, Hispanic and

American Indian/Native Alaskan students are underrepresented in gifted and talented programs in K-12, attain lower standardized test scores, are less likely to take advanced mathematics courses or AP exams, attend less prestigious higher education institutions, and are less likely to graduate with a degree compared to whites and Asians/Pacific Islanders.[7]

Recommendations

To address this issue, the Board proposes three ***keystone recommendations*** (see below). Contained within each keystone recommendation are multiple specific ***policy actions*** for NSF, the Federal Government, and/or the nation. Additionally, the Board proposes a ***research agenda*** for each keystone recommendation. These research findings will inform policy-making in critical areas, such as how to nurture early interest in STEM, best practices for developing STEM related abilities, and means for improving teaching effectiveness.

I. ***Provide opportunities for excellence***. We must offer coordinated, proactive, sustained formal and informal interventions to develop students' potential. Students should learn at a pace and depth commensurate with their talents and interests and in a fashion that elicits engagement, intellectual curiosity, and creative problem solving—essential skills for future innovation.

II. ***Cast a wide net*** to identify and develop all types of talents in all demographics of students. Current assessments frequently fail to identify some students with the highest potential or students with certain types of abilities (e.g., spatial ability). To this end, we must develop and implement appropriate talent assessments at multiple grade levels and train educators to recognize potential, particularly among those individuals who have not been given adequate opportunities to transform their potential into academic achievement (e.g., low-income students, minorities traditionally underrepresented in STEM).

III. ***Foster a supportive ecosystem*** that nurtures and celebrates excellence and innovative thinking. Parents/guardians, education professionals, peers, and students themselves must work together to create a culture that expects excellence, encourages innovations, and rewards success.

Background for the STEM Innovators Project

To produce this report, in August 2008, the Board charged the Committee on Education and Human Resources to form an *ad hoc* Task Group on STEM Innovators. The Task Group was directed to identify strategies for increasing the number of future STEM innovators and synthesize recommendations for how the National Science Foundation (NSF), and possibly other Federal entities, might engage in fostering the development of these individuals. This report and the recommendations set forth herein are based on the findings from an expert panel discussion held on August 23-25, 2009, and a 2-year examination of the issue by the *ad hoc* Task Group.

STEM Innovators Definition

"STEM innovators" are individuals who have developed the expertise to become leading STEM professionals and perhaps the creators of significant breakthroughs or advances in scientific and technological understanding. Their capabilities often include math and spatial abilities[8] alone or in combination with verbal aptitude, along with other factors such as creativity, leadership, self-motivation, and a diligent work ethic. These abilities are *not* fixed traits, but instead are often dynamic, and thus, can be developed over time with proper training.[9]

NOTES

[1] Lubinski, D., & Benbow, C. P. (2006). Study of mathematically precocious youth after 35 years: uncovering antecedents for the development of math-science expertise. *Perspectives on Psychological Science, 1*, 316-345.

[2] Zumeta, W., & Raveling, J. (2002). *The best and brightest: Is there a problem here?* (pp. 4-6). Washington, DC: Commission on Professionals in Science and Technology. Retrieved from: http://www.cpst.org/BBIssues.pdf. In this analysis, "highest achievers" refers to U.S. citizens scoring over a 750 on the GRE quantitative scale.

[3] Baldi, S., Jin, Y., Skemer, M., Green, P. J., & Herget, D. (2007). *Highlights from PISA 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context* (NCES 2008–016) (pp. 44, 49). National Center for Education Statistics, Institute of Education Sciences. Washington, DC: U.S. Department of Education. Retrieved from: http://nces.ed.gov/pubs2008/2008016.pdf. Note: The rank number represents the combination of OECD and non-OECD jurisdictions.

[4] National Science Board. (2003). *The science and engineering workforce – realizing America's potential* (NSB-03-69). Arlington, VA: National Science Foundation. Retrieved from: http://www.nsf.gov/nsb/documents/2003/nsb0369/nsb0369.pdf.

[5] Wyner, J. S., Bridgeland, J. M., & DiIulio, J. J. (2007). *Achievement trap: How America is failing millions of high-achieving students from lower-income families* (p. 11). Landsdowne, VA: Jack Kent Cooke Foundation. Retrieved from: http://www.civicenterprises.net/pdfs/jkc.pdf. Also see, Plucker, J. A., Burroughs, N., & Song, R. (2010). *Mind the (other) gap! The growing excellence gap in K-12 education*. Center for Evaluation and Education Policy. Bloomington, IN: Indiana University School of Education. Retrieved from: https://www.iub.edu/~ceep/Gap/excellence/ExcellenceGapBrief.pdf. This report examines the achievement gap—or what the authors call the "excellence gap"—based on gender, socioeconomic status, race/ethnicity, and English language proficiency.

[6] Plucker, J. A., Burroughs, N., & Song, R. (2010). *Mind the (other) gap! The growing excellence gap in K-12 education*. Center for Evaluation and Education Policy. Bloomington, IN: Indiana University School of Education. Retrieved from: https://www.iub.edu/~ceep/Gap/excellence/ExcellenceGapBrief.pdf.

[7] See the following three references regarding the underrepresentation of African American, Hispanic, and Indian/Native Alaskan students in gifted classrooms, AP classes, and achievement gaps at the "high end.": 1) Gándara, P. (2005). *Fragile futures: Risk and vulnerability among Latino high-achievers*. Princeton, NJ: Policy Evaluation and Research Center, Educational Testing Service. Retrieved from: http://www.ets.org/Media/Research/pdf/PICFRAGFUT.pdf. 2) Learning Point Associates. (2004). *All students reaching the top: Strategies for closing academic achievement gaps*. Naperville, IL: North Central Regional Educational Laboratory. Retrieved from: http://www.ncrel.org/gap/studies/allstudents.pdf. 3) Hoffman, K., & Llagas, C. (2003). *Status and trends in the education of blacks* (NCES 2003–034). Project Officer: T. D. Snyder. National Center for Education Statistics. Washington, DC: U.S. Department of Education. Retrieved from: http://nces.ed.gov/pubs2003/2003034.pdf.

[8] Lohman, D. F. (1994). Spatial ability. In R. J. Sternberg (Ed.), *Encyclopedia of intelligence* (p.1000). New York, NY: Macmillan Press. In this chapter, the author defines spatial ability as, "the ability to generate, retain, retrieve, and transform well-structured visual images." Note: Spatial ability includes mechanical reasoning.

[9] Dweck, C. S. (2008). *Mindsets and math/science achievement*. Paper prepared for the Carnegie-IAS Commission on Mathematics and Science Education. http://www.opportunityequation.org/resources/commissioned-papers/dweck/. This online article contains an excellent summary of original, scholarly research examining the theory of malleable intelligence and the effect of mindsets on math and science achievement.