THE NEED TO IMPROVE STEM LEARNING

Science, mathematics, engineering, and technology are cultural achievements that reflect people's humanity, power the economy, and constitute fundamental aspects of our lives as citizens, workers, consumers, and parents. As a previous NRC committee found:[4]

> The primary driver of the future economy and concomitant creation of jobs will be innovation, largely derived from advances in science and engineering. . . . 4 percent of the nation's workforce is composed of scientists and engineers; this group disproportionately creates jobs for the other 96 percent.

An increasing number of jobs at all levels—not just for professional scientists—require knowledge of STEM.[5] In addition, individual and societal decisions increasingly require some understanding of STEM, from comprehending medical diagnoses to evaluating competing claims about the environment to managing daily activities with a wide variety of computer-based applications.

Several reports have linked K-12 STEM education to continued scientific leadership and economic growth in the United States.[6] At the same time, there are many reasons to be concerned about the state of STEM learning in the United States in the face of research that suggests that many students are not prepared for the demands of today's economy and the economy of the future. For example, as measured by the National Assessment of Educational Progress, **roughly 75 percent of U.S. 8th graders are not proficient in mathematics when they complete 8th grade.**[7] Moreover, there are significant gaps in achievement between student population groups: the black/white, Hispanic/white, and high-poverty/low-poverty gaps are often close to 1 standard deviation in size.[8] A gap of this size means that the average student in the underserved groups of black, Hispanic, or low-income students performs roughly at the 20th percentile rather than the 50th percentile. U.S. students also lag behind the highest performing nations on international assessments: for example, only 10 percent of U.S. 8th graders met the Trends in International Mathematics and Science Study advanced international benchmark in science, compared with 32 percent in Singapore and 25 percent in China.[9]

Employers in many industries lament that job applicants lack the needed mathematics, computer, and problem-solving skills to succeed,[10] and international students fill an increasing portion of elite STEM positions in the United States. Indeed, in 2007, "international students constituted more than a third of the students in U.S. science and engineering graduate schools," and more than 70 percent of those students currently remain in the United States after earning their degrees.[11] However, an increasing number of foreign students are finding viable career options in their home countries. This is particularly true for China and India, which, in December 2009, provided 47 percent of the approximately 248,000 foreign science and engineering students in the United States,[12] thereby limiting the talent pool available to U.S. employers.

GOALS FOR U.S. STEM EDUCATION

Questions about effectiveness can be addressed only in the context of the purposes or goals one wants to measure. Three broad and widely espoused goals for K-12 STEM education in the United States capture the breadth of the purposes for STEM education and reflect the types of intellectual capital needed for the nation's growth and development in an increasingly science- and technology-driven world. These goals are to increase advanced training and careers in STEM fields, to expand the STEM-capable workforce, and to increase scientific literacy among the general public.[13]

These three goals are not mutually exclusive. Moreover, because they are broad long-term goals for STEM education in the United States, numerous intermediate goals are encompassed in and central to all of them. Among others, the intermediate goals include learning STEM content and practices, developing positive dispositions toward STEM, and preparing students to be lifelong learners.[14]

GOAL 1: Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields.

During the past century, the STEM fields propelled the United States to the forefront of an innovation-based global economy. Indeed, more than half of the tremendous growth to per capita income in the 20th century can be accounted for by U.S. advances in science and technology.[15] Several reports have drawn a direct line between the nation's competitiveness and K-12 STEM education to support the next generation of scientists and innovators.[16] Thus, one goal for STEM education focuses on the flow of students into STEM majors and careers.

An important dimension of this goal is to increase the participation of groups that are underrepresented in the sciences, especially blacks, Hispanics, and low-income students who "disproportionately fall out of the high-achieving group" in K-12 education.[17] It is important to provide opportunities for highly talented students from these groups because "changing immigration patterns, the rapid improvement of education and economies in developing countries, and a heavy focus on talent development—and competition for the talented—in both developing and developed countries [have] drastically changed the playing field for American education."[18] Indeed, only 10 percent of all STEM doctorates are awarded to nonwhite, non-Asian students, although these groups now represent one-quarter of the U.S. population.[19] The changing demographics in the United States will require increased

participation by domestic nonwhite and non-Asian students in STEM. Efforts in K-12 to serve these groups will play a major role in addressing this crucial issue.

GOAL 2: Expand the STEM-capable workforce and broaden the participation of women and minorities in that workforce.

Although there is a clear need to increase the number of students who obtain advanced degrees in the STEM disciplines, it is equally important to the U.S. economy to increase the number of people who are prepared for STEM-related careers, such as being K-12 teachers in the STEM disciplines, medical assistants, nurses, and computer and green energy technicians.[20] These careers generally require vocational certification with specialized STEM knowledge, an associate degree, or a baccalaureate degree with a major in a STEM field.[21] The current demand for STEM-capable workers surpasses the supply of applicants who have trained for those careers. Moreover, 16 of the 20 occupations with the largest projected growth in the next decade are STEM related, but only 4 of them require an advanced degree.[22] Given these unmet needs for a STEM-capable workforce, the nation's economic future depends on preparing more K-12 students to enter these fields.

GOAL 3: Increase STEM literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines.

Personal and societal decisions in the 21st century increasingly require scientific and technological understanding. Whether about health, the environment, or technology, a certain level of scientific knowledge is vital to informed decision making. Thus, another goal of STEM education is to increase STEM literacy—defined as the knowledge and understanding of scientific and mathematical concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity for all students. [23] Targeting all students, not just those who will pursue postsecondary education or careers in STEM or STEM-related fields, will better prepare citizens to face the challenges of a science- and technology-driven society.

Schools and districts might not consciously adopt and work toward these three broad goals for STEM education. Instead, they may have their own, intermediate goals for success, such as increased enrollment in STEM courses, achievement test scores, high school graduation rates, college or career readiness, and matriculation into postsecondary institutions. Scientific research provides little evidence about how to accomplish the three broad goals. Research is even limited with respect to the intermediate goals, including goals related to accountability, when success is often measured at the school or district level.