STEM IN VIRGINIA

Welcome to the STEM in Virginia Career Cluster Brief. Thanks to both statewide and Federal initiatives encouraging STEM research, as well as its proximity to Washington, DC, Virginia has strong academic, governmental, and private interests in the fields of **Science, Technology, Engineering, and Mathematics (STEM).** As a result, opportunities for careers in STEM are available statewide, and in a variety of workplace environments.

STEM will provided employment for **nearly**
100,000
Virginians by 2020.

While there are many excellent Governor's STEM Academies across the Commonwealth, STEM instruction remains a high priority for all high school CTE programs in Virginia. Not only are there careers in the specific fields included in STEM, but technological competence, and the problem solving and creative thinking encouraged in STEM courses, will only become increasingly important for today's young job-seekers, no matter what fields they pursue. This Career Cluster Brief highlights information about STEM innovation in Virginia, reveals important statistics about STEM employment, and addresses educational trends in these important fields.

STEM IN VIRGINIA: INNOVATION AND OPPORTUNITY

Virginia is a national leader in technology and innovation, a fact reflected in the high concentration of STEM occupations within the Commonwealth. Not only is Virginia's computer systems design and related services industry among the largest in the nation, but Virginia also received $3.56 billion in Federal research and development contracts in 2013—the third highest total state grant in the country—according to the 2014 *STEM Report Card* for Virginia, produced by The Alliance for Science & Technology Research in America. Many of these contracts are with the Departments of Defense, Transportation, Homeland Security, and Health and Human Services.

$3.56 billion
The amount in Federal research and development contracts received by Virginia in 2013

A strong economy in Virginia, therefore, depends on continued growth and strength of STEM-related occupations. Students prepared to pursue careers in science, technology, engineering, and mathematics are crucial for the economic vitality of the Commonwealth, as well as for national competitiveness. Moreover, the skills learned in STEM-oriented classes—skills such as problem solving and data analysis—help to train all students for success in the workforce.

For students already pursuing STEM coursework, as well as for those who are not yet certain about their interests, it may be both motivating and inspiring to learn about the wide variety of STEM opportunities across the Commonwealth, as highlighted below.

Budget priorities

Recognizing the crucial place of STEM occupations in Virginia, leaders in the Commonwealth have made it a priority secure its place as a leader in innovation and to continue to create highly skilled jobs by investing in STEM industries. The Center for Innovative Technology (CIT), founded in 1985, seeks to "create technology-based economic development strategies to accelerate innovation, imagination, and the next generation of technology" through partnerships with universities and businesses. Through the Research and Technology Strategic Roadmap, CIT has laid out areas for investment and tracks key indicators of Virginia's progress towards a robust technological economy.

In partnership with the Commonwealth Research Commercialization Fund, the CIT awarded $6 million in 2013 and 2014 to 81 different private and academic projects in areas identified through the *Strategic Roadmap*. These awards fuel research and development in fields such as **advanced manufacturing**, **cyber security**, **life sciences**, **nuclear physics**, and **energy**, while simultaneously encouraging market applications for the research findings.

The Strategic Roadmap also helps identify business ventures the Commonwealth wants to promote and cultivate. Citing the Strategic Roadmap, now-Governor Terry McAuliffe ran on a platform that included encouraging biotechnology firms to settle in Virginia. Recommending a combination of tax breaks and special loan programs, he called on the Commonwealth to actively pursue the well-paid jobs and economic investment associated with these firms.

STEM industries in Virginia

Virginia's STEM economy includes a diverse range of industries that rely on the skills promoted by this career cluster. Some of these industries include:

- **Aerospace:** NASA was one of the largest Federal departments to contract with Virginia firms for research and development in 2013. As an industry, aerospace directly employs more than 9,000 Virginians and contributes $7.5 billion per year in economic output, according to the 2014 *STEM Report Card* for Virginia.
- **Biotechnology**: Virginia is home to eight research parks designed to foster university-business-federal partnerships. Here, researchers from hundreds of private companies, leading universities, and federal labs work side-by-side on the latest findings in biotechnology. One such park, the Virginia BioTechnology Research Park, adjacent to Virginia Commonwealth University in Richmond, employs 12,000 people and is estimated by the *Virginia Biotechnology Research Partnership Authority* to have had an economic impact on the region of $3.8 billion in last 20 years.
- **Defense and Security:** Much of the federal investment in STEM fields is fostered by the proximity to Washington, D.C. According to the 2014 Virginia *STEM Report Card*, four out of the five top recipients of Federal research and development contracts in 2013 were defense and security firms.
- **Nuclear Physics:** Virginia is one of twelve states to host a national laboratory funded by the U.S. Department of Energy. The Thomas Jefferson National Accelerator Facility, or Jefferson Lab, focuses on a variety of scientific endeavors—**nuclear physics**, **cryogenics**, **radiation detectors**, and **free-electron lasers**, to name a few—and their applications to the challenges of modern society. The facility employs 800 highly-skilled individuals and is integral to the training of future nuclear physicists.

EDUCATION, EMPLOYMENT & EARNINGS: ANALYZING DATA FROM STEM

18%

Expected Growth in Science, Technology, Engineering, & Mathematics Jobs by 2020.

Occupations in science, technology, engineering, and mathematics comprise between 2 and 3 percent of jobs in Virginia. This cluster is expected to grow by 18 percent through 2020, providing employment for more than 100,000 workers.

STEM professionals play a crucial role in economic growth and development with their contributions to scientific research and technological innovation. The sector offers diverse career pathways of varying levels of growth; for example, strong growth is projected for jobs opportunities in biomedical engineering, while opportunities for Food Scientists and Technologists are projected to decline very slightly by 2020.

The STEM career cluster is divided into two primary pathways: Engineering/Technology and Science/Mathematics. The following sections analyze data for the different occupations within STEM in terms of the 3 E's: **education, employment,** and **earnings**.

Education:

Educational attainment within the science, technology, engineering, and mathematics cluster does not show a large amount of variation. A majority of its occupations require an advanced academic degree, with 98 percent requiring a Bachelor's degree or more. Figure 1 shows the predominant level of education within the two STEM pathways.

Ninety-seven percent of occupations in Science and Mathematics and 90 percent of Engineering and Technology jobs require a Bachelor's or more. In addition to a Bachelor's degree, some professions may require further qualifications; for example, Engineering Managers are typically reported to require prior work experience, while Other Life, Physical, and Social Science Technicians are expected to have extra training and certification. Environmental Engineering Technicians, on average, appear to have the fewest educational requirements, with most of the workers having either some college or an associate's degree.

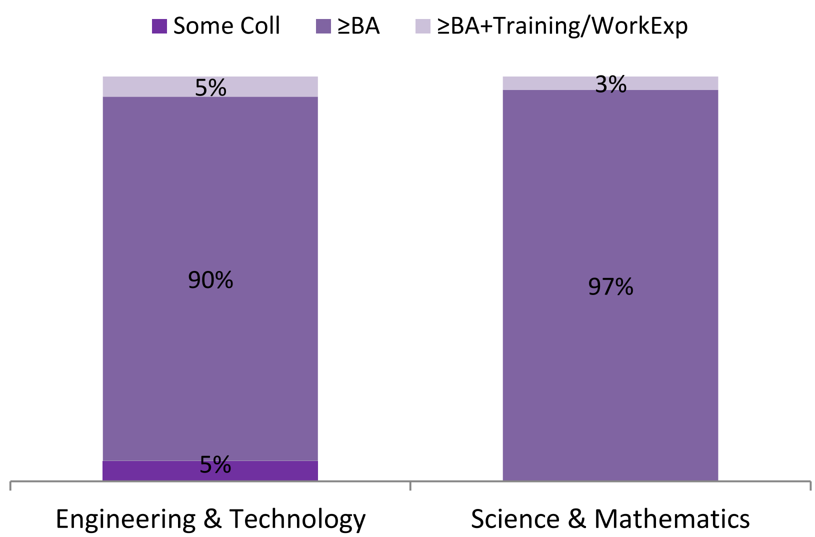

Figure 1: Predominant Education Level for STEM

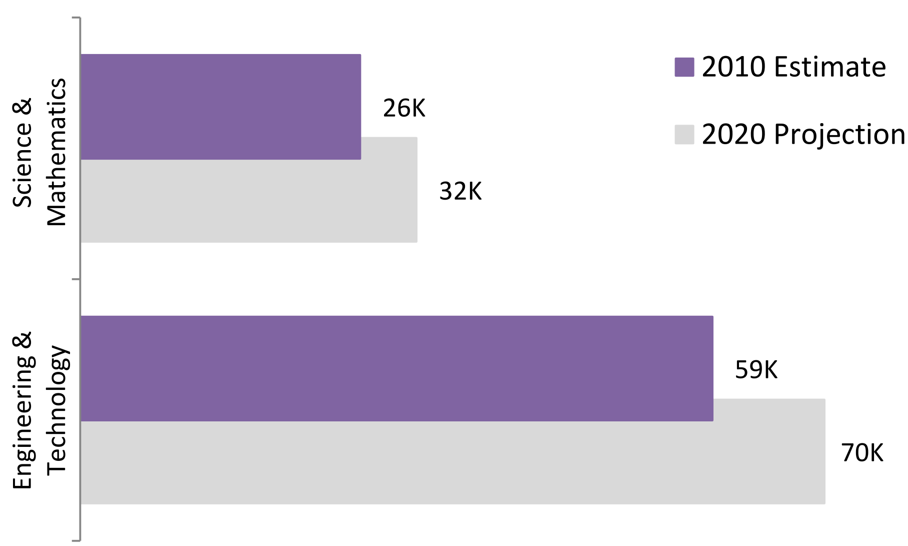

Figure 2: Employment in Virginia for STEM

Employment:

By 2020, employment for both STEM pathways is expected to grow, as per Figure 2. Engineering and Technology will employ nearly 70,000 workers, while Science and Mathematics will have over 30,000 jobs (representing approximately 20 percent growth over 2010 levels). Among individual occupations, Civil Engineering currently employs the largest number of people and will have nearly 12,000 workers by 2020.

By the end of this decade, the entire cluster is expected to yield more than 101,000 employment opportunities.

Earnings & growth:

Comparing the top wage-earning occupations for each STEM pathway as shown in Figure 3, career growth for Engineering and Technology seems to be the most promising in terms of current employment, wages, and job opportunities. Engineering Managers earn the highest median wage of approximately $128,000; followed by Aerospace Engineers with a median salary exceeding $120,000. Job growth for workers within science, technology, engineering, and mathematics varies quite a lot across sub-specialties; however all occupations but one (Food Scientists & Technologists) are expected to expand by 2020. The overall sector will have close to 4000 annual job openings over the next several years.

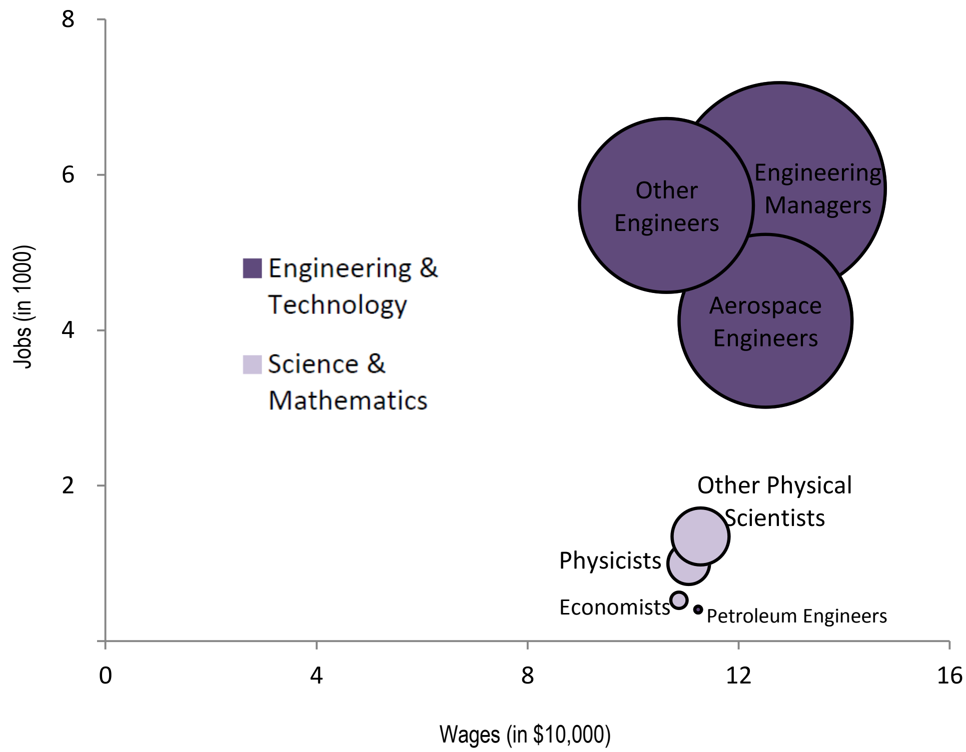

Figure 3: Select Occupations with High Median Wages 2010-2011
(Size of circle represents annual number of job openings in the specific occupation)

STEM: SPOTLIGHT ON TECHNOLOGY SKILLS

With rapidly changing technologies available and frequently required in many of today's occupations—even *outside* of those strictly designated as STEM—it can be challenging to discern the best skills and techniques to teach in the classroom. However, even though the specific software capabilities and packages may evolve or change over the course of a student's high school career, many of the practices and strategies a student needs to needs to learn will remain constant. Furthermore, many of the skills required to master emerging technologies dovetail with critical science and engineering capabilities, such as creativity and problem-solving. Teaching and fostering these high-level skills will encourage competence and confidence in students, whatever field they pursue.

According to the International Society for Technology in Education, in order "to learn effectively and live productively in an increasingly global and digital world," students should be able to:

- Demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology;
- Use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others;
- Apply digital tools to gather, evaluate, and use information;
- Use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources;
- Understand human, cultural, and societal issues related to technology, and practice legal and ethical behavior; and
- Demonstrate a sound understanding of technology concepts, systems, and operations.

Such goals may be met with a variety of learning and teaching techniques, which may differ based on content area. However, consistent themes in effective STEM education include: a focus on applied, collaborative and problem-solving-based learning; strong school tech-support systems; and the intentional cultivation of technology "ownership" among students. Each is described below:

Hands-on learning techniques

As described, and advocated, by a number of education experts and institutes, *Project-Based Learning* is a pedagogical approach designed to engage students in long-term skills development through collaborative work on a single, complex project. Often used in engineering classroom environments, this form of "cognitive apprenticeship" requires students to think critically, creatively, and cooperatively as they work toward a common project goal, such as thorough investigation of deceptively simple questions such as, "How can we move this go-kart faster?" While research on Project Based Learning is not definitive, it is often employed in CTE programs, and is frequently heralded by groups such as Edutopia, Buck Institute for Education, and the Southern Regional Education Board as a means of promoting creative thinking and innovation, particularly as compared with rote memorization.

Beyond computer access

In addition to providing access to computers in a classroom environment, it is critical that teachers and other school personnel have the technical support required to effectively implement software and computer-based learning. The presence of strong professional IT support; specific teacher knowledge and interest in finding new, applicable technologies; or student-based volunteer groups for all-purpose trouble-shooting will not merely enhance the technology experience in the classroom but are, in fact, essential for a strong technology curriculum.

Cultivating student potential

Student volunteers or groups that actively address school technology needs serve the dual purpose of improving classroom experience, and promoting student interest and sense of "ownership" for those considering careers in STEM. Student help desks might arise from a group of students interested in serving as tech support assistants in exchange for volunteer or academic credits, or could extend from a one- or two-semester technology skills classroom curriculum. By allowing students to implement their knowledge in a hands-on, real-time environment, schools will not only encourage workplace readiness skills, but also foster the critical and creative thinking so necessary in the world of science, technology, engineering, and mathematics.