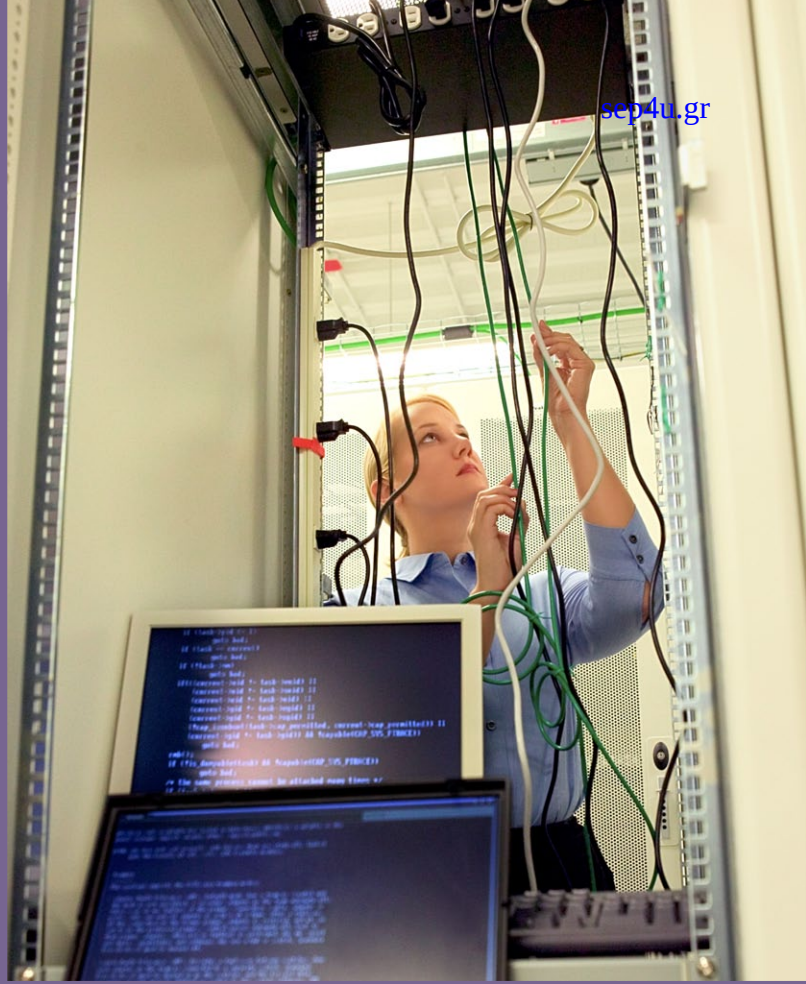

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STEM 101: Intro to tomorrow's jobs

"The future of the economy is in STEM," says James Brown, the executive director of the STEM Education Coalition in Washington, D.C. "That's where the jobs of tomorrow will be."

Data from the U.S. Bureau of Labor Statistics (BLS) support that assertion. Employment in occupations related to STEM—science, technology, engineering, and mathematics—is projected to grow to more than 9 million between 2012 and 2022. That's an increase of about 1 million jobs over 2012 employment levels.

This article provides an overview of STEM work, analyzing nearly 100 occupations from a list created by a committee comprising several federal agencies. The first section of the article offers a brief description of the life and physical sciences, computer science, engineering, and mathematics fields. The second section includes data showing selected STEM occupations with the most employment and projected job openings and growth. The third section discusses the rewards and challenges of STEM work. The fourth section describes how to prepare for a career in a STEM field. Resources for more information are listed at the end of the article.

Dennis Vilorio

What is STEM?

There is no universally agreed-upon definition of STEM. Experts generally do agree, however, that STEM workers use their knowledge of science, technology, engineering, or math to try to understand how the world works and to solve problems. Their work often involves the use of computers and other tools.

STEM occupations are identified in a variety of ways. This article uses a list based on the Standard Occupational Classification Manual to analyze occupations from six groups, including computer and mathematics; architecture and engineering; and life, physical, and social sciences. (See table 1 on page 4.) Healthcare occupations are excluded from this analysis, because they are described in a separate article in this issue of the *Quarterly*.

STEM fields are closely related and build on each other. For example, math provides the foundation for physics—and physics, in turn, for engineering. Engineers can apply their knowledge of physics to make high-tech devices that are useful for testing theories in physics. Advances in physics may then lead to advances in engineering and technology.

To better understand STEM, a brief description of each field follows.

Science

Science workers study the physical and natural world through observation and experimentation. "Science is a lens to interpret the world," says Julie Herrick, a volcanologist at the Smithsonian Institution National Museum of Natural History in Washington, DC. "My job is to expand knowledge." Science workers can also inform public policy, such as by providing data to support limits on the use of toxic chemicals.

The work of scientists often involves research, writing proposals and academic papers, and presenting findings. Science technicians collect samples, conduct experiments, and do other tasks to assist scientists in those efforts.

Workers rely on the scientific method to objectively test hypotheses and theories. The scientific method requires repeatable experiments that produce predictable and observable data. When the data matches a theory's predictions, the experiment supports that theory. Theories with the most supportive evidence are adopted but may continue to evolve, based on new evidence.

Disciplines in science are categorized based on the part of the universe they study: space sciences, earth sciences, life sciences, chemistry, and physics. For example, the life sciences study the living world, such as plants or the human body; disciplines include ecology, genetics, neuroscience, pathology, and nutrition.

(Continued on page 5)

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Table 1: STEM occupations, by occupational group

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Management
Architectural and engineering managers
Computer and information systems managers
Natural sciences managers
Computer and mathematics
Actuaries
Computer and information research scientists
Computer network architects
Computer network support specialists
Computer programmers
Computer systems analysts
Computer user support specialists
Database administrators
Information security analysts
Mathematical technicians
Mathematicians
Network and computer systems administrators
Operations research analysts
Software developers, applications
Software developers, systems software
Statisticians
Web developers
Computer occupations, all other
Mathematical science occupations, all other
Architecture and engineering
Aerospace engineering and operations technicians
Aerospace engineers
Agricultural engineers
Architectural and civil drafters
Biomedical engineers
Chemical engineers
Civil engineering technicians
Civil engineers
Computer hardware engineers
Electrical and electronics drafters
Electrical and electronics engineering technicians
Electrical engineers
Electro-mechanical technicians
Electronics engineers, except computer
Environmental engineering technicians
Environmental engineers
Health and safety engineers, except mining safety engineers and inspectors
Industrial engineering technicians
Industrial engineers
Marine engineers and naval architects
Materials engineers
Mechanical drafters
Mechanical engineering technicians
Mechanical engineers
Mining and geological engineers, including mining safety engineers
Nuclear engineers
Petroleum engineers
Surveying and mapping technicians
Drafters, all other
Engineering technicians, except drafters, all other
Engineers, all other
Life, physical, and social sciences
Agricultural and food science technicians
Animal scientists
Astronomers
Atmospheric and space scientists
Biochemists and biophysicists
Biological technicians
Chemical technicians
Chemists
Conservation scientists
Environmental science and protection technicians, including health
Environmental scientists and specialists, including health
Epidemiologists
Food scientists and technologists
Forensic science technicians
Forest and conservation technicians
Foresters
Geological and petroleum technicians
Geoscientists, except hydrologists and geographers
Hydrologists
Life, physical, and social science technicians, all other
Materials scientists
Medical scientists, except epidemiologists
Microbiologists
Nuclear technicians
Physicists
Soil and plant scientists
Zoologists and wildlife biologists
Biological scientists, all other
Life scientists, all other
Physical scientists, all other
Education, training, and library
Agricultural sciences teachers, postsecondary
Architecture teachers, postsecondary
Atmospheric, earth, marine, and space sciences teachers, postsecondary
Biological science teachers, postsecondary
Chemistry teachers, postsecondary
Computer science teachers, postsecondary
Engineering teachers, postsecondary
Environmental science teachers, postsecondary
Forestry and conservation science teachers, postsecondary
Mathematical science teachers, postsecondary
Physics teachers, postsecondary
Sales and related
Sales engineers
Sales representatives, wholesale and manufacturing, technical and scientific products

Source: 2010 Standard Occupational Classification (SOC) System, SOC Policy Committee recommendation to the Office of Management and Budget. Healthcare occupations are not included.

(Continued from page 3)

Technology

Technology workers use science and engineering to create and troubleshoot computer and information systems. For example, some tech workers develop software applications and build and maintain computer networks and databases.

Technology work connects people, making all forms of communication—including business transactions, video sharing, and mobile browsing—faster and less expensive. The work often involves designing, testing, maintaining, and improving computer software, hardware, systems, and networks. "The goal is not only to solve a problem, but also to make that problem easier to solve in the future," says Dan Parsons, an IT manager in Portland, Oregon.

STEM technology refers to disciplines in computer and information sciences, including those related to operating systems, artificial intelligence, programming, cryptography, and mobile computing.

Engineering

Engineers and engineering technicians use math, science, and technology to solve real-world problems. The work often involves developing systems, structures, products, or materials. For example, a civil engineer might design a new train station to accommodate more passengers, and an environmental engineering technician might help create an environmental remediation device.

"Engineering makes things better and cheaper for everyone," says Patrick Holm, a project civil engineer in Olympia, Washington. "Without it, we couldn't live in the kind of society we know—with bridges, clean water, and cars."

Disciplines in engineering are often categorized by industry, such as aerospace, petroleum, or textiles. Major disciplines include civil, mechanical, industrial, electrical, and materials engineering.

STEM fields often build on each other. New knowledge leads to innovations, and vice versa.

Mathematics

Math workers use numerical, spatial, and logical relationships to study and solve problems. For example, an operations research analyst helps organizations identify practices that improve efficiency, and a mathematical technician applies standard formulas to technological problems in engineering and physical sciences.

Mathematics is the technical foundation for science, engineering, and technology. The work often involves finding patterns in data or abstract logic. These patterns can be used to draw general conclusions about data, to test mathematical relationships, and to model the real world.

Disciplines in math include algebra, statistics, calculus, game theory, and geometry.

Outlook and wages

Overall, STEM occupations are projected to grow faster than the average for all occupations. And wages in these occupations were generally higher than the median for all occupations in May 2013.

This section explores the outlook and wages of STEM, both in general and for selected occupations.

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Outlook

BLS projects overall STEM employment, as defined in this article, to grow about 13 percent between 2012 and 2022. This is faster than the 11-percent rate of growth projected for all occupations over the decade.

But projected employment growth varies by occupation. Knowing which occupations are projected to have the most job openings and fastest growth may help you narrow your career options.

Most job openings. An occupation's projected job openings result from two factors: the creation of new jobs and the need to replace workers who retire or otherwise permanently leave. Occupations with more job openings usually offer more employment opportunities.

As table 2 shows, many of these STEM occupations are related to technology. For example, BLS projects applications software developers to have more than 200,000 job openings between 2012 and 2022.

Table 2: Selected STEM occupations with many job openings, projected 2012–22

Occupation	Job openings, projected 2012–22	Employment		Median annual wage, May 2013	Typical entry-level education[1]
		2012	Projected 2022		
Software developers, applications	218,500	613,000	752,900	$92,660	Bachelor's degree
Computer systems analysts	209,600	520,600	648,400	81,190	Bachelor's degree
Computer user support specialists[2]	196,900	547,700	658,500	46,620	Some college, no degree
Software developers, systems software	134,700	405,000	487,800	101,410	Bachelor's degree
Civil engineers	120,100	272,900	326,600	80,770	Bachelor's degree
Computer programmers	118,100	343,700	372,100	76,140	Bachelor's degree
Sales representatives, wholesale and manufacturing, technical and scientific products[2]	111,800	382,300	419,500	74,520	Bachelor's degree
Network and computer systems administrators	100,500	366,400	409,400	74,000	Bachelor's degree
Mechanical engineers	99,700	258,100	269,700	82,100	Bachelor's degree
Computer and information systems managers[3]	97,100	332,700	383,600	123,950	Bachelor's degree
Industrial engineers	75,400	223,300	233,400	80,300	Bachelor's degree
Architectural and engineering managers[3]	60,600	193,800	206,900	128,170	Bachelor's degree
Web developers	50,700	141,400	169,900	63,160	Associate's degree
Electrical engineers	44,100	166,100	174,000	89,180	Bachelor's degree
Computer network architects[3]	43,500	143,400	164,300	95,380	Bachelor's degree

[1] Unless otherwise specified, occupations typically require neither work experience in a related occupation nor on-the-job training to obtain competency.
[2] In addition to the education specified, this occupation typically requires moderate-term on-the-job training for workers to obtain competency.
[3] In addition to the education specified, this occupation typically requires 5 years or more of work experience in a related occupation.
Source: U.S. Bureau of Labor Statistics, Employment Projections program (employment, projections, and education data) and Occupational Employment Statistics survey (wage data).

Fastest growing. Nearly all STEM occupations discussed in this article are projected to grow between 2012 and 2022, according to BLS. And many STEM occupations are projected to grow faster than the average for all occupations. Some of these occupations are in technology; others are related to math and engineering. (See table 3.)

Between 2012 and 2022, BLS projects the fastest growing occupations to have many job openings relative to their employment size. But that doesn't necessarily mean that these occupations have high employment. Some occupations, such as biomedical engineers and mathematicians, have small employment levels and are projected to remain small, despite fast growth.

Occupations with both high employment and fast growth usually offer better opportunities than small occupations with slow growth. High-employment, fast-growth occupations include computer systems analysts, applications software developers, and systems software developers.

Wages

BLS data show that workers in the STEM occupations discussed in this article earned a

Table 3: Selected STEM occupations with fast employment growth, projected 2012–22

Occupation	Employment growth, projected 2012–22 (percent)	Employment		Median annual wage, May 2013	Typical entry-level education[1]
		2012	Projected 2022		
Information security analysts[2]	37%	75,100	102,500	$88,590	Bachelor's degree
Operations research analysts	27	73,200	92,700	74,630	Bachelor's degree
Statisticians	27	27,600	34,900	79,290	Master's degree
Biomedical engineers	27	19,400	24,600	88,670	Bachelor's degree
Actuaries[3]	26	24,300	30,600	94,340	Bachelor's degree
Petroleum engineers	26	38,500	48,400	132,320	Bachelor's degree
Computer systems analysts	25	520,600	648,400	81,190	Bachelor's degree
Software developers, applications	23	613,000	752,900	92,660	Bachelor's degree
Mathematicians	23	3,500	4,300	102,440	Master's degree
Software developers, systems software	20	405,000	487,800	101,410	Bachelor's degree
Computer user support specialists[4]	20	547,700	658,500	46,620	Some college, no degree
Web developers	20	141,400	169,900	63,160	Associate's degree
Civil engineers	20	272,900	326,600	80,770	Bachelor's degree
Biological science teachers, postsecondary	20	61,400	73,400	75,740	Doctoral or professional degree
Environmental science and protection technicians, including health	19	32,800	38,900	41,700	Associate's degree

[1] Unless otherwise specified, occupations typically require neither work experience in a related occupation nor on-the-job training to obtain competency.
[2] In addition to the education specified, this occupation typically requires less than 5 years of work experience in a related occupation.
[3] In addition to the education specified, this occupation typically requires long-term on-the-job training for workers to obtain competency.
[4] In addition to the education specified, this occupation typically requires moderate-term on-the-job training for workers to obtain competency.
Source: U.S. Bureau of Labor Statistics, Employment Projections program (employment, projections, and education data) and Occupational Employment Statistics survey (wage data).

median annual wage of nearly $76,000—more than double the $35,080 median wage for all workers in May 2013. Many of the top-paying occupations are related to engineering. (See table 4.)

Rewards and challenges

STEM work, like that of most jobs, is both rewarding and challenging. You might work on an interesting project that yields meaningful results, for example—but, to complete it, you might need to repeat an experiment many times or navigate complex government regulations.

Rewards

Many STEM workers find their jobs intellectually stimulating. They enjoy collaborating with people who share their enthusiasm and working with cutting-edge technology. "STEM offers a cooperative, innovative, and exciting work environment that is unparalleled," says Aimee Kennedy, vice president for education and STEM learning at Battelle Memorial Institute in Columbus, Ohio.

Depending on the occupation, STEM work may be creative and produce tangible results. For example, a biologist might make a discovery in the laboratory and publish that

Table 4: Median annual wages in selected STEM occupations, May 2013

Occupation	Median annual wage, May 2013	Employment		Typical entry-level education[1]
		2012	Projected 2022	
Petroleum engineers	$132,320	38,500	48,400	Bachelor's degree
Architectural and engineering managers[2]	128,170	193,800	206,900	Bachelor's degree
Computer and information systems managers[2]	123,950	332,700	383,600	Bachelor's degree
Natural sciences managers[2]	116,840	51,600	54,500	Bachelor's degree
Astronomers	110,450	2,700	2,900	Doctoral or professional degree
Physicists	110,110	20,600	22,700	Doctoral or professional degree
Computer and information research scientists	106,290	26,700	30,800	Doctoral or professional degree
Computer hardware engineers	104,250	83,300	89,400	Bachelor's degree
Aerospace engineers	103,870	83,000	89,100	Bachelor's degree
Mathematicians	102,440	3,500	4,300	Master's degree
Nuclear engineers	101,600	20,400	22,300	Bachelor's degree
Software developers, systems software	101,410	405,000	487,800	Bachelor's degree
Chemical engineers	95,730	33,300	34,800	Bachelor's degree
Computer network architects[2]	95,380	143,400	164,300	Bachelor's degree
Engineering teachers, postsecondary	94,460	42,500	47,500	Doctoral or professional degree

[1] Unless otherwise specified, occupations typically require neither work experience in a related occupation nor on-the-job training to obtain competency.

[2] In addition to the education specified, this occupation typically requires 5 years or more of work experience in a related occupation.

Source: U.S. Bureau of Labor Statistics, Employment Projections program (employment, projections, and education data) and Occupational Employment Statistics survey (wage data).

STEM work may produce tangible results, such as a skyscraper designed to certain specifications.

research in a scientific journal. A civil engineering technician may help design a storage facility or other structure and then assist in working with the contractor who builds it.

Workers in STEM occupations also enjoy the variety of problems they solve. "Every problem is a unique challenge to figure out," Holm says. "Even if you use similar skills, the way you apply them is different."

Because many STEM fields involve rapid change, workers' professional development is also dynamic. "There's always something more to learn," says Herrick. "Don't expect an end."

Challenges

As rewarding as STEM work may be, it can sometimes be demanding and tedious. For example, projects may take hundreds of hours over weeks or months to complete. And routine tasks may include cataloging data, filling out paperwork, and documenting observations. "There's a lot of sitting in front of a computer," says Frances Tirado, a mathematical statistician at BLS in Washington, DC.

Other challenges vary, depending on the field. For example, many jobs in scientific research receive short-term financial support, so these workers often worry about funding. And engineering workers must juggle different priorities, from clients and the government, while keeping a project on schedule. "There are a lot of demands to satisfy," Holm says, "so you can't always do what you think is the best solution."

Despite the challenges, however, STEM workers often report feeling respected and fulfilled. "You feel that what you're doing is important and you matter as an employee," says Tirado. "People value your skills, listen to your ideas, and think that what you do is magic."

Getting started

STEM experts recommend that prospective STEM workers have a combination of skills, education, and experience for getting started in these careers.

Skills

Along with having a technical foundation, prospective STEM workers must have strong thinking and communication skills. "People focus so much on math and science that they often ignore these skills," Holm says. Ability to consider problems in different ways and then being able to explain a solution clearly is essential for success in STEM occupations.

Thinking skills. Critical and creative thinking help STEM workers in problemsolving to detect mistakes, gather relevant information, and understand how different parts or systems interact with each other.

STEM workers also need thinking skills to develop innovative, cost-effective solutions. Workers who think creatively may approach a problem differently—for example, by adapting knowledge from other disciplines. "Oftentimes, you're the last resort for a problem because no one else could solve it," Tirado

Technical ability is essential to STEM work, but communication skills are also important.

says. "Creativity can help you come up with a solution no else could."

Communication skills. Communication skills are important for working well with others and conveying information clearly, both orally and in writing. "Flaws in communication are a common source of conflict," says Parsons. "You'll usually work with or for someone else, so having these skills will make you stand out."

Communication skills include technical writing, public speaking, interpersonal communication, and the ability to explain difficult concepts simply. Learning some of these skills may seem intimidating at first, but practice helps. For example, you can improve your public speaking skills by practicing in front of small groups until you feel comfortable with a bigger audience.

Education and training

Many STEM occupations require at least a bachelor's degree. More technical and advanced jobs, including those in research, usually require a master's or doctoral degree.

But STEM isn't only for people who have a bachelor's or graduate degree. Many occupations typically require an associate's degree, and a small number require either some college but no degree or a high school diploma or equivalent.

Although you may already know which specific occupation you want to pursue, don't fret if you are unsure. Some disciplines, such as math and physics, are useful in many STEM fields. "Students should follow what they want to do," Brown says. "There are lots of options in STEM, in whatever area you're interested in."

Workers in some STEM occupations may need training after they are hired to gain competency in the occupation. Others may need licensure, depending on the type of work that they do.

High school diploma. You don't have to wait until college to prepare for a STEM career. Most high schools offer a variety of math and science classes, for example. STEM workers recommend pursuing challenging ones—such as Advanced Placement (AP) courses—to improve your transcript and adjust to the demands of STEM work. "Take as many rigorous classes as you can," Kennedy says, "as early as you can."

Surveying and mapping technicians is an example of a STEM occupation typically open to high school graduates.

Associate's degree. An associate's degree is awarded upon completion of an

undergraduate program that typically lasts at least 2 years.

Occupations that require an associate's degree include chemical technicians, computer network support specialists, and mechanical drafters.

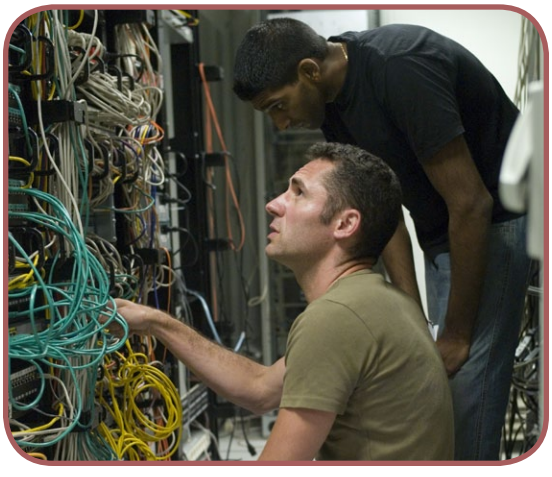
Bachelor's degree. A bachelor's degree usually requires 4 years of undergraduate study. Many STEM occupations require this degree, including actuaries, civil engineers, and information security analysts.

But don't become so focused on one discipline that you overlook the importance of developing a broad, well-rounded education. "You get problems from anywhere," says Tirado, "so you need to know a little about everything." Use college electives to sample other STEM disciplines or completely different areas of study, such as the humanities.

Graduate degree. Still other STEM occupations typically require a master's or doctoral degree.

A master's degree usually requires 1 or 2 years beyond a bachelor's degree. Many master's programs also require students to write a research paper, known as a thesis. STEM occupations that typically require a master's degree include epidemiologists, hydrologists, and statisticians.

A doctoral degree usually requires at least 3 years beyond a bachelor's degree. To receive a doctoral degree, students must often complete a dissertation, a lengthy research project that contributes new knowledge to the field. Occupations that require a doctoral degree include animal scientists, computer and information research scientists, and physicists.



Hands-on experience can help you decide whether you want to pursue a STEM career.

Experience

In some STEM occupations, work experience in a related occupation is required at the entry level. For example, computer and information systems managers usually need at least 5 years of experience, first honing their technical skills in lower-level roles before moving to management.

Even in occupations that don't require it, however, work experience often sets you apart. "Companies want to bring you up to speed so you can be productive quickly," says Holm. "But there are so many skills you don't learn in school that you can only learn on the job."

STEM workers advise you to look for internship, volunteer, and research opportunities as early as possible: while you are still in school, not waiting until afterward. Your career advisor or counselor may have information about businesses that offer these types of opportunities.

Before applying for such positions, be sure to document in a résumé or portfolio your experience and accomplishments. Highlight school or work assignments that confirm your qualifications and that help set you apart from other candidates.

Getting experience before graduation also can help you determine whether a STEM career will be right for you. "It's important to find something that excites you," Herrick says, "because working in STEM means making an investment in a passion."

As you broaden your experience, you should also broaden your network. "Your network is more important than your résumé," says Brown, and should include mentors, business colleagues, and instructors. Develop a network by meeting people through work, volunteer, and internship positions; joining a club or working on a research project; and participating in job fairs, industry events, and online discussion boards.

Work experience can teach valuable lessons, such as how to cope with stress and persevere despite difficulties. "You must be

comfortable knowing that you will struggle and won't know all the answers," says Tirado. "But, as a result, you're going to learn much more and become a better worker."

For more information

The BLS *Occupational Outlook Handbook* (*OOH*) has detailed profiles for hundreds of occupations, including those discussed in this article. Profiles include information about job duties, wages, typical education, job outlook, and more. The *OOH* is available online at **www.bls.gov/ooh**.

Current and recent articles in the *Occupational Outlook Quarterly* that feature occupations in STEM include:

- "Healthcare: Millions of jobs now and in the future" in the spring 2014 issue at **www.bls.gov/ooq/2014/spring/art03.pdf**
- "Working with big data" in the fall 2013 issue at **www.bls.gov/ooq/2013/fall/art01.pdf**
- "My career: Web operations engineer" in the summer 2013 issue at **www.bls.gov/ooq/2013/summer/mycareer.pdf**
- "You're a *what*? Ornithologist" in the summer 2013 issue at **www.bls.gov/ooq/2013/summer/yawhat.pdf**
- "Math at work: Using numbers on the job" in the fall 2012 issue at **www.bls.gov/ooq/2012/fall/art01.pdf**
- "You're a *what*? Psychometrician" in the fall 2011 issue at **www.bls.gov/opub/ooq/2011/fall/yawhat.pdf**

BLS has other information and data about STEM occupations. For a list of the 184 occupations included in many federal government STEM studies, visit **www.bls.gov/soc/Attachment_C_STEM.pdf**. For current employment and wage data, search STEM occupations at **www.bls.gov/oes**. And for employment projections between 2012 and 2022, visit **www.bls.gov/emp**.

For more general data on STEM, contact:
National Science Foundation
National Center for Science and Engineering Statistics
4201 Wilson Blvd., Suite 965
Arlington, VA 22230
(703) 292-8780
www.nsf.gov/statistics
ncsesweb@nsf.gov

Additional information about specific STEM fields or disciplines is available from professional associations and industry groups. For example, broad information is available from large associations, such as the American Mathematical Society (**www.ams.org**) for mathematicians and the IEEE (**www.ieee.org**) for technology workers. Small, discipline-focused associations, including the American Society of Civil Engineers (**www.asce.org**) and National Science Teachers Association (**www.nsta.org**), provide more specialized information.

Some states offer online educational and career resources for their residents. For example, STEM Georgia has information about competitions, schools, and underrepresented groups—such as women and minorities—at **www.stemgeorgia.org**. A few professional associations, such as the Society of Women Engineers, **www.swe.org**, offer scholarships and awards to these underrepresented groups into STEM.

To learn more about STEM education, contact:
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