VITALSIGNS

Reports on the condition of STEM learning in the U.S.

LEFT TO CHANCE:

U.S. Middle Schoolers Lack in-Depth Experience With Technology and Engineering

Technology and engineering have played central roles in forming our national identity. We see the United States as a nation of tinkerers and inventors who have helped chart the course of global innovation for centuries. Only time will tell if we can continue to live up to this conception of ourselves. As technology and engineering come to affect almost every aspect of modern life, this is no small matter.

New data from the first-ever Nation's Report Card in Technology and Engineering Literacy (TEL) are not reassuring. Well less than half the nation's eighth-graders are on track to become proficient in a set of skills they will need to thrive in society and the workplace. Low-income and minority youth lag farthest behind.[1]

On closer examination, these findings should not surprise us. Change the Equation's analysis of survey data from TEL reveals that millions of American youth spend precious little time tinkering, troubleshooting, or doing the kinds of hands-on problem-solving that are at the heart of technology and engineering. Girls, minorities, and low-income students do least of all—dampening hopes to create a more diverse STEM workforce in future years. Without intentional strategies to expose many more young people to technology and engineering, we are leaving a critical aspect of students' education to chance.

Analyzing the TEL survey

This brief presents Change the Equation's analysis of results from survey questions TEL test takers answered after they completed the TEL assessment. A nationally representative sample of 21,500 eighth-graders in 840 U.S. public and private schools completed the survey, answering questions about how often they have learned about technology and engineering or taken part in technology and engineering activities, both in and out of school. It is beyond the scope of this brief to provide full survey results.

For more information about the TEL survey methodology, see nationsreportcard.gov.

> Millions of American youth spend precious little time tinkering, troubleshooting, or doing the kinds of hands-on problem-solving at the heart of technology and engineering.

CHANGE THE EQUATION™

Technology and engineering "literacy": It's not just for techies and engineers anymore

Of course, not everyone has to become an engineer or technology professional—though both are certainly in demand.[2] Rather, the TEL assessment gauges eighth-graders' technology and engineering *literacy*, focusing on the "knowledge and competencies … all students and citizens [need]."[3]

TEL's expansive definitions of technology and engineering support this focus on universal skills. Technology is "any modification of the natural world done to fulfill human needs or desires," which encompasses anything "from paper to the internet." Engineering is "a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants." People literate in these fields might not be able to design a bridge or program in Java, but they "can apply their understanding of technology principles to real-life situations."[4]

Master technology, or be mastered by it

Those who are literate in these fields can better understand and benefit from the major engines of economic growth[5] by taking full advantage of technology to address challenges in their jobs, their communities, and their lives. People who are not literate in engineering and technology are too often doomed to be replaced by the technologies they cannot command.

Those who understand technology and engineering are also best equipped to advocate for them as forces that promote the common good. At a time when even some of the world's most respected innovators worry that technology could bring as much peril as promise,[6] the nation needs citizens who can ensure that technology does not stray too far from its fundamentally humane purpose.

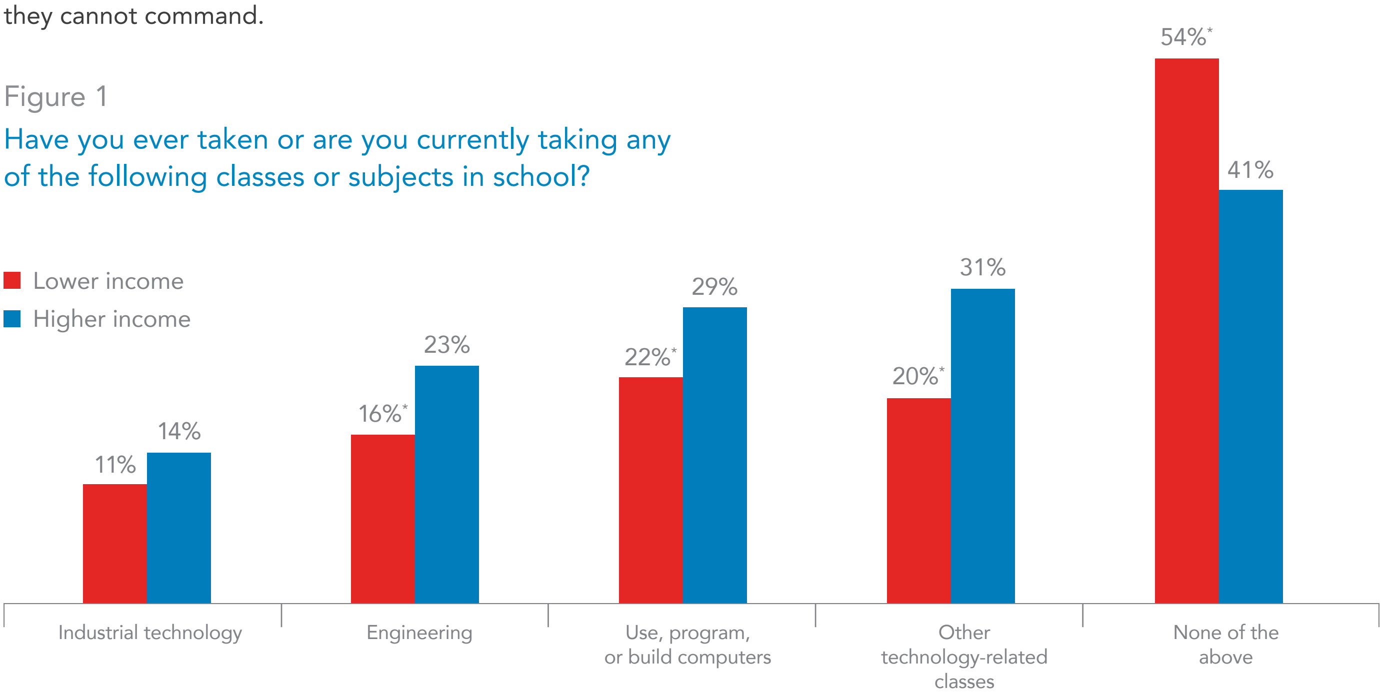
A vision of technology and engineering literacy embraced by employers

TEL's vision of literacy in technology and engineering dovetails with skills employers value, such as the ability to apply knowledge to new situations, to identify and solve unexpected problems without a playbook, or to learn through ingenuity, failure and perseverance.[7]

The TEL survey gauges how much exposure eighth-graders have to environments and experiences, both in and out of school, that can promote this vision of learning. Do they ever have the opportunity to brainstorm designs in an iterative fashion to address a specific challenge, for example? Do they ever have to design something with limited time or resources? Do they often take things apart to see how to fix them? Do they build models to solve a problem? Do they create or edit digital media?

Figure 1

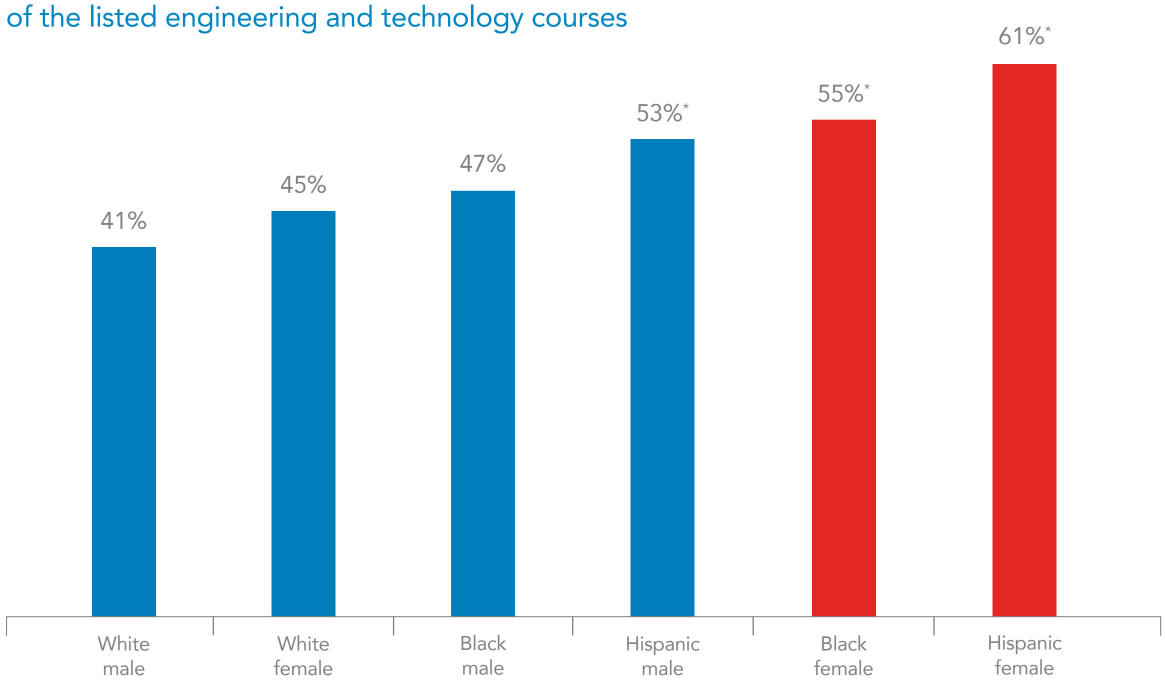
Have you ever taken or are you currently taking any of the following classes or subjects in school?



* Statistically significant difference from higher income

Figure 2

Percent of eighth-graders who report taking "none" of the listed engineering and technology courses



* Statistically significant difference from white male

Most eighth-graders have encountered some engineering or technology in school

At first blush, the data on students' overall exposure to technology or engineering do not seem dire, even if they provide little cause for celebration. Asked if they have "ever" studied engineering or technology concepts in their math, science, history, or social studies classes, 76 percent say yes. Statistically significant gaps separate lower-income[8] students (74 percent) from their higher-income peers (78 percent), but strong majorities of students from each race, income level, and gender say they have at least encountered the topics in school.

That, of course, is a low bar. Many fewer eighth-graders—roughly half (52 percent)—say they have ever taken a course that focuses on engineering or technology. Here, the gaps between lower- and higher-income students are stark. (See figure 1)

Girls of color face the worst odds of all. For example, more than three out of five Hispanic girls say they have never taken any of these courses. (See figure 2)

Yet course titles in and of themselves tell us relatively little about the actual experiences students have in school. Other TEL survey findings suggest that, if anything, these data on course participation overstate students' engagement in hands-on technology and engineering.

People who are not literate in engineering and technology are too often doomed to be replaced by the technologies they cannot command.

Eighth-graders have limited opportunities to tinker or troubleshoot in school

A mere 9 percent of eighth-graders attend schools that report placing "a lot" of emphasis on "figuring out how to fix something," and another 37 percent attend schools that tepidly report "some" emphasis. A full 49 percent attend schools that report little or no emphasis. Schools provide a very similar account of their emphasis on "finding the right people to work with or get help from to fix something." (See figure 3)

Most eighth-graders report that, in school, they seldom actually try their hand at fixing things. Only 42 percent say that, at least three times in their entire school careers, they have "figured out why something is not working in order to fix it." Just 26 percent report that, at least three times, they have "taken something apart in order to fix it or see how it works." A full 43 percent say they have never done so. (See figure 4)

Eighth-graders are moderately more likely to say they select and use tools or build models in school to solve problems, but here, too, such experiences seem few and far between for most students. (See figure 4)

Such activities are staples of how an engineer approaches real-world challenges, and they can also have a strong impact in schools. Decades of research suggest that people often learn best by testing solutions to real-world problems through hands-on trial and error.[9] If the TEL survey results are any indication, this research has had little impact on the nation's schools.

Figure 3

In your school, prior to or in eighth grade, how much emphasis is placed on teaching students: (school reported)

To figure out how to fix something

To find the right people to work with/get help from to fix something

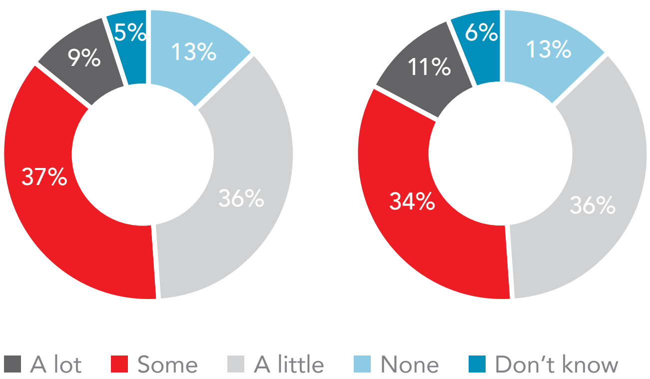


Figure 4

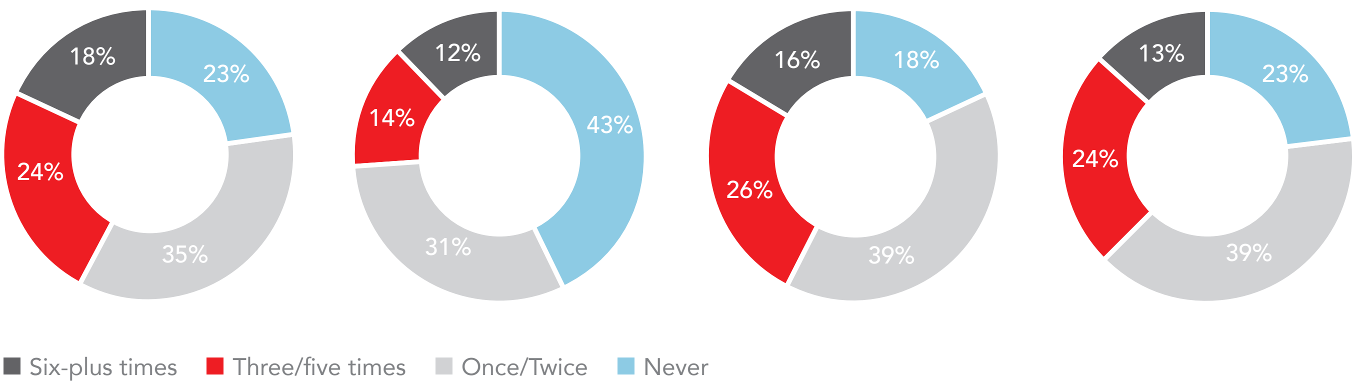
In school, how often have you ever done the following activities?

Figured out why something is not working in order to fix it

Taken something apart in order to fix it or see how it works

Used different tools, machines, or materials to see which are best for the given purpose

Built or tested a model to see if it solves a problem



Eighth-graders are more likely to tinker and troubleshoot outside of school than in school

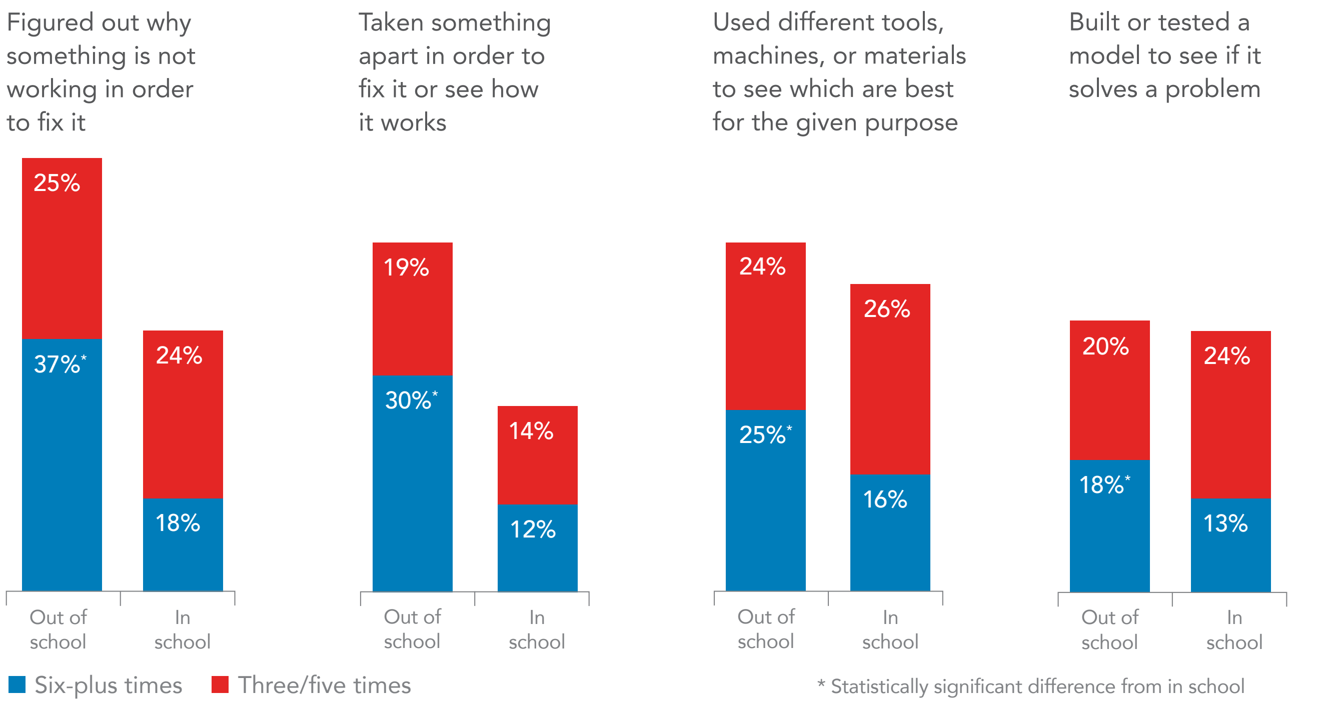
Facing limited opportunities in their schools to roll up their sleeves, take things apart, and explore how they work, students say they are more likely to do so when school is out. (See figure 5)

Even when tinkering or troubleshooting activities are sophisticated enough to require tools, machines or models, students remain somewhat more likely to do them outside of schools than in them. (See figure 5)

In absolute terms, these percentages are far from heartening. If we are to believe their own account, a large share of the nation's eighth graders has engaged in such activities no more than two times in their lives, whether in or out of school.

Figure 5

How often have you ever done the following activities?



Gaps in opportunity are larger outside of schools than in them

More eighth-graders engage in hands-on engineering outside of school than in school, but those eighth-graders are a much less diverse group. Figure 6 on the following page, which lays out the percentages of students who have participated in such activities at least six times, illustrates large inequities of income, race, and gender. The gray and red cells highlight gaps that are statistically significant. Each gray cell indicates an area in which minority students lag behind white students, lower-income students lag behind higher-income students, or girls lag behind boys. Each red cell, by contrast, indicates a statistically significant advantage for minority, lower-income, or female students over their white, higher-income, or male peers. Any disadvantages minorities, girls, and lower-income students face in school pale in comparison to what they face outside of school.

Not only are there more gaps outside of school, those out-of-school gaps are larger.[10] If anything, schools are softening the disadvantage low-income students, minorities,

Figure 6

Percentage of students who say they have done the following six or more times

TAKEN SOMETHING APART TO FIX IT OR SEE HOW IT WORKS							
	Income		Race/Ethnicity			Gender	
	Higher	Lower	White	Black	Latino	Male	Female
In school	11%	13%	11%	15%	11%	16%	8%
Out of school	32%	28%	33%	26%	25%	39%	21%
FIGURED OUT WHY SOMETHING IS NOT WORKING IN ORDER TO FIX IT							
	Income		Race/Ethnicity			Gender	
	Higher	Lower	White	Black	Latino	Male	Female
In school	19%	17%	18%	20%	16%	21%	16%
Out of school	41%	33%	42%	31%	30%	43%	31%
BUILT OR TESTED A MODEL TO SOLVE A PROBLEM							
	Income		Race/Ethnicity			Gender	
	Higher	Lower	White	Black	Latino	Male	Female
In school	15%	12%	14%	14%	11%	14%	13%
Out of school	19%	16%	20%	14%	13%	23%	12%
USED DIFFERENT TOOLS, MATERIALS, OR MACHINES TO SEE WHICH ARE BEST FOR A GIVEN PURPOSE							
	Income		Race/Ethnicity			Gender	
	Higher	Lower	White	Black	Latino	Male	Female
In school	18%	15%	18%	16%	13%	18%	15%
Out of school	28%	21%	29%	18%	19%	29%	20%

and girls face in some areas—if only slightly. Because so few eighth-graders frequently take part in school hands-on activities that promote engineering literacy, however, those mitigating effects can have an anemic impact at best.

Outside of school, girls of color fare especially badly, suffering disadvantage heaped upon disadvantage. To cite one finding not displayed in the table above, 44 percent of white boys, but only 19 percent of Hispanic girls, have taken something apart out of school more than five times in their lives.

Digital media are ubiquitous, but students consume much more than they create

Eighth-graders report that they do not often use digital technology to create spreadsheets, presentations, or digital media, either in or out of schools. At best, only about half of students have done so more than a few times a year in school. The data look even worse out of school. (See figure 7)

The relative rarity of spreadsheets and presentations in and out of school may not come as a surprise, even

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Outside of schools, students' exposure to engineering and technology is left largely to chance.

though they are staples of the work world. Today's technology advocates may be more disappointed by the finding that students spend little time creating, editing, and organizing digital media. This finding flies in the face of a hope technology advocates have long held: namely, that digital technology would prompt many more students to create, rather than mostly consume, innovative digital products.

Other recent research bears out this finding and offers more insights into how young people use digital technology. A robust 2015 survey of U.S. tweens by Common Sense Media found that, of all the time they spent out of school using computers, tablets, and smartphones, tweens devoted only three percent to creating content. In fact, creating digital art, writing, making videos, creating/modifying games, coding, and creating digital music all fell to the very bottom of tweens' list of "favorite media activities," far below activities like playing games, using social media, watching videos, and listening to music. None of these creative activities earned the top spot for more than two percent of tweens, and most did not even reach one percent.[11]

Outside of schools, persistent "digital divides" continue to limit some young people's access to the digital tools they need to create or edit content. The TEL survey does not shed light on students' access to digital technology at home, but other recent research reveals that low-income and minority students are much less likely than their peers to have high speed internet and uninterrupted access to digital devices.[12] Teachers of lower-income students are much more likely to say these barriers inhibit teachers' ability to integrate technology into their classrooms and assign homework that incorporates technology in a meaningful way.[13] Future TEL surveys could explore these issues in greater depth.

Many students' exposure to technology and engineering is left largely to chance

The fact that out-of-school inequities match or often even dwarf those in schools should come as little surprise. Outside of schools, students' exposure to engineering and technology is left largely to chance. Those without family members in fields like engineering or the trades, for example, may have fewer opportunities to learn how to fix things and explore how they work. Those who lack access to computers, other digital devices, or high speed internet are in the worst position to teach themselves about digital media.

The vast majority of eighth-graders turn to their family, their friends, or even themselves to learn how things work or how to collect and share digital media. Well more than half say family members have taught them most about

Figure 7

How often do you use a computer or other digital technology for the following activities?

	CREATE SPREADSHEETS		CREATE PRESENTATIONS		CREATE/EDIT/ ORGANIZE DIGITAL MEDIA	
	Never/ almost never	Few times/ year	Never/ almost never	Few times/ year	Never/ almost never	Few times/ year
In school*	30%	33%	10%	37%	24%	26%
Out of school*	57%	22%	45%	27%	38%	21%

* Questions read "for school work" and "not related to your schoolwork."

Figure 8

Who taught you most about building things, fixing things, or how things work?

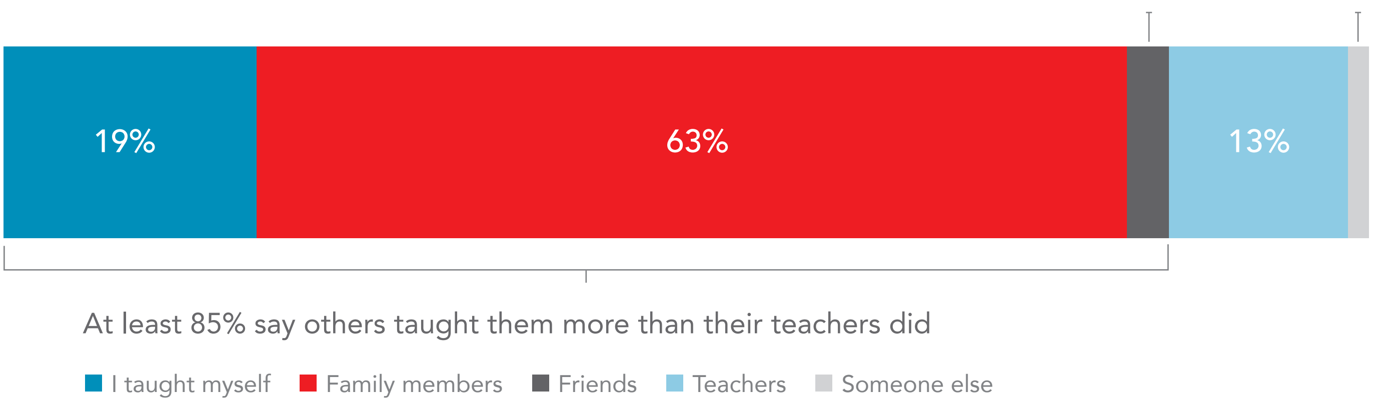
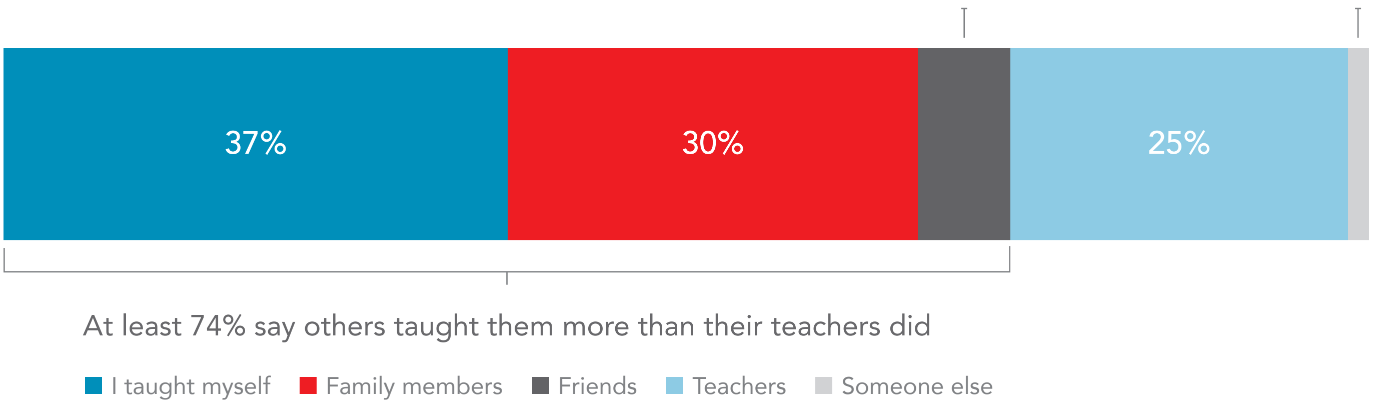


Figure 9

Who taught you most about using computers or other digital technology for collecting and sharing information?



"building things, fixing things, or how things work." The remaining students are more likely to credit themselves (19 percent) than their teachers (13 percent) for teaching them these engineering skills. (See figure 8)

Eighth-graders are even more likely to consider themselves essentially self-taught in technology. A plurality, 37 percent, say they taught themselves most of what they know about "using computers or other digital technology for collecting and sharing information." Teachers, by contrast, were most influential for only 25 percent of students. (See figure 9)

By eighth grade, most students' experience with engineering and technology activities has been an accident of birth and circumstance.

TEL's critical lessons for engaging more girls in technology and engineering

TEL is an object lesson in how to encourage girls to pursue technology and engineering.

One of the TEL assessment's most notable findings is that girls outscored boys by a small but statistically-significant margin. Yet herein lies a paradox. Girls are less likely to say they have engaged in many of the important hands-on activities addressed in the TEL survey: figuring out why something is not working, taking things apart, using tools, and building models to solve problems. Why the apparent disconnect?

Part of the answer lies in the portion of the test where girls enjoyed the largest advantage over boys: the test's

Educators who harness TEL's vision of literacy in technology and engineering may well attract many more girls to those fields.

Information and Communication Technologies (ICT) subscale, which focuses on "accessing, creating, and communicating information and … facilitating creative expression."[14] Girls have outperformed boys in other tests of ICT skills, possibly because girls tend to perform better in reading and communication.[15] Yet even in other areas of the assessment, girls scored on par with boys—no great accomplishment in absolute terms, but better than their lagging participation in hands-on activities would suggest.

This apparent paradox also conceals a larger lesson about the strength of the TEL framework and what we can learn from it. TEL plays to girls' strengths by situating its tasks in narratives about improving communities or helping people. These are precisely the contexts that, according to decades of research, are most likely to interest girls in subjects like technology and engineering.[16]

Educators who harness TEL's vision of literacy in technology and engineering may well attract many more girls to those fields. The TEL results are an important reminder that we are squandering much of the nation's female talent. If we could give more girls compelling reasons to enter their garages, workshops, and makerspaces to explore solutions to real-world problems through hands-on engineering activities, the nation would be much richer for it.

Concrete strategies for ensuring widespread literacy in technology and engineering

We cannot simply leave young peoples' technology and engineering literacy to chance. The challenges we face require strong, coordinated efforts among government, education, and community leaders at the federal, state, local levels.

Fortunately, conditions are ripe for such efforts. A growing number of states have been integrating technology and engineering literacy into their vision for what every student should learn. Still, it would be far too easy to let this moment slip by. State and local priorities can change quickly in today's volatile political environment. Advocates need to keep state and local leaders' attention firmly on concrete and practical strategies for promoting and attaining widespread literacy in technology and engineering:

- **First, focus on state standards.** States should include technology and engineering literacy in states' academic standards for what students should know and be able to do in science. At least one third of U.S. states have already adopted standards that explicitly address technology and engineering literacy as TEL defines it, and others would do well to follow suit, either by adapting other states' standards or creating their own.[17] Standards are among the most critical tools for encouraging broad access to opportunity, because they aim to affect all students in public schools, regardless of race, income, or gender.

- **Improve state assessments.** By themselves, standards are not enough to ensure that technology and engineering literacy become part of students' experience in school. States must create or adopt tests that measure students' mastery of those standards, or schools may have little incentive to heed the standards. Armed with new information on their children's performance on such tests, parents could become more effective advocates for better hands-on education opportunities in their children's schools.

  Most traditional state tests are still ill-suited to the kinds of open-ended tasks TEL emphasizes, despite recent advances in assessment technology. As a sophisticated computer-based test that uses real-world simulations, the TEL assessment itself could be one model for a new generation of state science tests.

- **Provide better curriculum and teaching materials.** Teachers need strong curricula and teaching materials in technology and engineering to meet new standards. Fortunately, such curricula and materials already exist. **STEMworks**, Change the Equation's honor roll of rigorously-vetted STEM education programs and resources, includes powerful curriculum and teaching materials that feature hands-on, real-world, open-ended tasks. Curricula and programs like **Engaging Youth through Engineering**, **Engineering is Elementary**, **Engineering the Future**, and **Project Lead the Way** have already proven their impact, and they carefully align themselves to states' content standards.

These curricula excel in developing skills central to TEL's definition of technology and engineering literacy. Trained reviewers have carefully evaluated the extent to which program curricula encourage students to define problems, develop and use models, plan and carry out investigations, analyze and interpret data, and design solutions.[18]

School district leaders or teachers who would like to review curricula not in STEMworks can also turn to the EQuIP Rubric[19] for science lessons and units, which includes criteria for evaluating how well these materials incorporate engineering literacy.

- **Offer teacher professional development in technology and engineering literacy.** Teachers also need strong professional development to teach such curricula effectively. Organizations that provide excellent K-12 engineering and technology curricula, like those featured in STEMworks, typically also provide professional development to help teachers promote the kinds of hands-on, project-based learning that are most likely to foster technology and engineering literacy. States should invest in professional development that promotes that sort of instruction while meeting high standards for professional learning.[20]

- **Give young people access to better facilities and materials, both in and out of schools.** All young people need places where they can build, take apart, examine, test, fix, and invent things. These places do not necessarily need to have all the latest equipment, but they do need to offer materials and equipment that few young people have at home.

  Schools do not have to tackle this challenge alone. State and school district leaders should collaborate with partners such as business leaders who can donate used equipment or community leaders who can help transform public spaces in libraries or community centers into public workshops and makerspaces.

- **Create out-of-school learning opportunities for more young people.** State governments, private and corporate foundations, community groups, and others should work together in an all-hands-on-deck effort to expand access to such opportunities in the nation's most vulnerable communities. Just as important, they should ensure that public and private dollars go to programs and strategies that are most likely to make a difference. Again, Change the Equation's STEMworks honor roll is a valuable source of independently-vetted STEM programs that have proven their effectiveness.

- **Take advantage of federal resources.** The federal Every Student Succeeds Act (ESSA) provides resources to help states and local communities carry out many of the strategies above. ESSA allows states to use federal funding to integrate technology and engineering literacy into their state tests. U.S. Education Department officials encourage state and district education agencies to use federal funds from Title II of ESSA for professional development "to support educators as they implement new courses, such as … engineering."[21] The Department also explicitly allows states and school districts to use federal funds to "increase student access to materials and equipment needed to support inquiry-based pedagogy and active learning," which could enrich makerspaces and similar facilities.[22] Finally, ESSA makes federal resources available for out-of-school activities through the 21st-Century Community Learning Center initiative, which in recent years has funneled more than $1 billion annually to out-of-school programs that reach children in struggling communities.

  Education Department officials and federal legislators have taken pains to make funding available to leaders who embrace the vision of education embodied in TEL, but they do not require states to use the funds this way. It is up to STEM education advocates to keep the vision of technology and engineering literacy front and center in states' education strategies.

An agenda for shared prosperity

For years, employers have been alarmed by the looming scarcity of computer scientists and engineers, but the TEL results suggest that the talent shortage is in fact even more far-reaching than that. Young people who are illiterate in technology and engineering will probably never become computer professionals or engineers, but they will also lack something more fundamental: the ability to master many of the challenges that will confront them in their lives, their jobs, and their communities.

As technology continues to co-opt the most routine physical and intellectual jobs, more of the remaining jobs will require people who can diagnose problems, examine them from different perspectives, test possible solutions, and figure out what works best. To develop these skills, more young people need frequent opportunities to tinker and troubleshoot, to design, dismantle, and create. Fostering young people's technology and engineering literacy is a critical strategy for carrying the nation's founding ideals of equal opportunity and shared prosperity well into the 21st century.

1 U.S. Department of Education, National Center for Education Statistics, Technology and Engineering Literacy Assessment, 2015. Only 43 percent of all test takers were "proficient or above" on the TEL assessment. Rates of proficiency or above were 18 percent for black students, 28 percent for Hispanic students, and 25 percent for students eligible for free or reduced-price lunch through the federal school lunch program.

2 See, for example, Change the Equation, *Engineering Emergency: African Americans and Hispanics Lack Pathways to Engineering,* Washington, DC, 2014; Change the Equation, "STEM Springboard: New STEM Grads Get Ahead," 2014.

3 U.S. Department of Education, *Abridged Technology and Engineering Literacy Assessment Framework,* 2014.

4 Ibid

5 The strong relationship between advances in technology and strong economic growth has been observed for well more than half a century, beginning at least with Robert Solow's seminal 1957 work, *Technical Change and the Aggregate Production Function.*

6 Luminaries such as Stephen Hawking, Elon Musk, and Bill Gates have warned that people should worry about the potential for artificial intelligence to endanger humanity. As Hawking puts it, "we need to make sure the computers have goals aligned with ours." See Sam Shead, "Beware the Machines: Stephen Hawking Warns Computers Will Overtake Humans within 100 Years," *Techworld,* May 12, 2015, accessed May 11, 2016; See also Peter Holley, "Bill Gates on Dangers of Artificial Intelligence: 'I Don't Understand Why Some People Are Not Concerned'," *Washington Post,* January 29, 2015, accessed May 11, 2016.

7 For employer surveys on skill demands and gaps, see, for example, Hart Research Associates, *Falling Short? College Learning and Career Success,* Washington, DC: American Association of Colleges & Universities, 2015; The American Management Association, *Critical Skills Survey,* 2012; Francesca Levy and Jonathan Rodkin, "The Bloomberg Job Skills Report: What Recruiters Really Want.," *Bloomberg.com,* Bloomberg, 2015, accessed May 6, 2016; The Society for Human Resource Management, *Critical Skills Needs and Resources for the Changing Workforce,* Alexandria, VA, 2008. For leading educators' views of skills promoted by hands-on engineering activities in K-12, see, for example, Stager, Gary, "What's the Maker Movement and Why Should I Care?" *Scholastic Magazine,* 2014, accessed May 10, 2016; Christine Cunningham and W.S. Carlsen, Precollege engineering education, *Handbook of Research on Science Education,* Vol. II, N.G. Lederman, and S.K. Abell, eds, Routledge, 2014; Janet Kolodner, Design Research on Learning Environments, Learning by Design: Iterations of Design Challenges for Better Learning of Science Skills, *Cognitive Studies,* 9(3), 338-350.

8 For this analysis, we define "lower-income" students as students who are eligible for free or reduced-priced lunch in the national school lunch program. We define "higher-income" students as those who are not.

9 See, for example, National Research Council, *How People Learn: Brain, Mind, Experience, and School: Expanded Edition,* Washington, DC: The National Academies Press, 2000.

10 In cases where there are gaps both in and out of school, the out-of-school gap is larger in all but two cases: 1. The gender gap for taking something apart to fix it and see how it works; 2. The income gap for building or testing a model to solve a problem. Gaps are measured in relative rather than absolute terms.

11 Victoria Rideout, *The Common Sense Census: Media Used by Tweens and Teens,* San Francisco: Common Sense Media, 2015.

12 John B. Horrigan, "The Numbers behind the Broadband 'Homework Gap,'" Pew Research Center RSS, April 2015; Victoria Rideout and Vikki Katz, *Opportunity for All? Technology and Learning in Lower-Income Families,* The Joan Ganz Cooney Center at Sesame Workshop, Winter 2016.

13 Purcell, Kristen, Alan Heaps, Judy Buchanan, and Linda Friedrich. "How Teachers Are Using Technology at Home and in Their Classrooms." Pew Research Center Internet Science Tech RSS. February 28, 2013.

14 U.S. Department of Education, *Technology and Engineering Literacy Assessment Framework.*

15 In most of the 21 countries participating in the *International Computer and Information Literacy Study,* girls outperformed boys. The United States did not participate. See Julian Fraillon, John Ainley, Wolfram Schulz, Tim Friedman, and Eveline Gebhardt, *Preparing for Life in a Digital Age: The IEA International Computer and Information Literacy Study International Report,* 2013. In the Programme for the International Assessment of Adult Competencies (PIAAC), U.S. women outscored U.S. men in the Problem Solving in Technology-Rich Environments test, an assessment that, like TEL, focuses on technological literacy and problem-solving. See M. Goodman, R. Finnegan, L. Mohadjer, T. Krenzke, and J. Hogan, *Literacy, Numeracy, and Problem Solving in Technology-Rich Environments Among U.S. Adults: Results from the Program for the International Assessment of Adult Competencies 2012: First Look* (NCES 2014-008), U.S. Department of Education, Washington, DC: National Center for Education Statistics, 2014.

16 See, for example: Catherine Ashcraft, Elizabeth Eger, and Michelle Friend, *Girls in IT: The Facts,* National Center for Women & Information Technology, 2012; Girl Scout Research Institute, *Generation STEM: What Girls Say about Science, Technology, Engineering, and Math,* 2012; National Academy of Engineering, *Changing the Conversation: Messages for Improving Public Understanding of Engineering,* National Academies Press, 2008.

17 The influential Next Generation Science Standards "integrate engineering design into the structure of science education by raising engineering design to the same level as scientific inquiry when teaching science disciplines at all levels, from kindergarten to grade 12." Their definition of "engineering design" incorporates a broad conception of technology and engineering literacy very close to TEL's conception: engineering is "any engagement in a systematic practice of design to achieve solutions to particular human problems," and technology "describes all the ways that people have modified the natural world to meet their needs and wants." Next Generation Science Standards, Appendix 1—Engineering by Design in the NGSS, April 2013.

18 See Change the Equation's STEMworks Design Principles Rubric at changetheequation.org.

19 See the EQuIP Rubric for Lessons & Units: Science at nextgenscience.org. EQuIP stands for Educators Evaluating the Quality of Instructional Products.

20 See, for example, Learning Forward's Standards for Professional Learning at learningforward.org.

21 Nadya Chinoy Dabby, Johan Uvin, Ann Whalen, Michael Yudin, *Joint "Dear Colleague Letter,"* U.S. Department of Education, April 13, 2016.

22 Ibid.

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Change the Equation works at the intersection of business and education to ensure that all students are STEM literate by collaborating with schools, communities, and states to adopt and implement excellent STEM policies and programs. CTEq's coalition of members are working toward universal STEM literacy by advocating for state policies and practices that are known to produce STEM-literate high school graduates; ensuring high standards for all students; and supporting evidence-based high quality STEM learning programs.

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