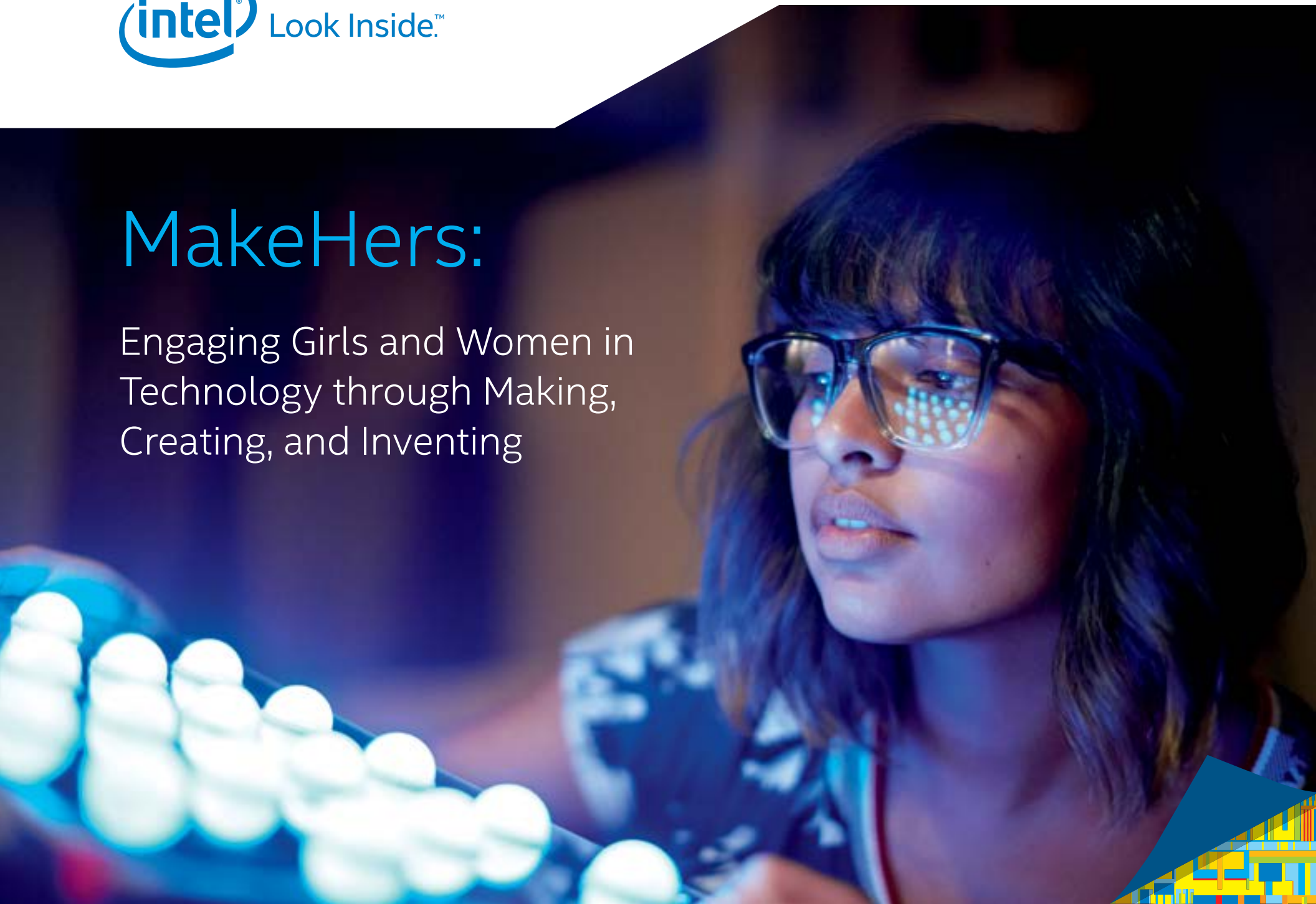
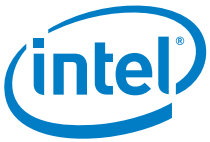


MakeHers:

Engaging Girls and Women in Technology through Making, Creating, and Inventing



For over 40 years Intel has been creating technologies that advance the way people live, work, and learn. Through the Intel Global Girls and Women Initiative, we are working to empower millions of girls and women around the world by closing the gender gap in education access, inspiring more girls and women to become creators of technology, and connecting girls and women to opportunity through technology access. Intel supports a range of programs, competitions, and resources that seek to inspire and empower more girls and women to create and build the technology of the future. We focus on programs that feature hands-on activities such as “Maker” and coding, involve peer mentors and role models, and connect technology and engineering careers to positive social impact.

http://www.intel.com/content/www/us/en/technology-in-education/girls-and-stem.html

For questions or comments about this study, please contact Renee Wittemyer (renee.wittemyer@intel.com)

Over the last 5 decades, Harris Polls have become media staples. With comprehensive experience and precise technique in public opinion polling, along with a proven track record of uncovering consumers’ motivations and behaviors, The Harris Poll has gained strong brand recognition around the world. The Harris Poll offers a diverse portfolio of proprietary client solutions to transform relevant insights into actionable foresight for a wide range of industries including health care, technology, public affairs, energy, telecommunications, financial services, insurance, media, retail, restaurant, and consumer packaged goods.

I have worked in the technology sector for more than a decade in senior leadership roles. I grew up in Turkey where, like many other places around the globe, girls and women are under-represented in the tech industry.

Encouraging girls and women to grow in leadership positions has been a personal focus and passion of mine throughout my career. I wish to inspire girls and women around the world to seek, explore and benefit from the many opportunities that technology affords.

This report is the first compilation of data on how girls and women participate in the maker movement. I am convinced this report provides key insights for policy makers, the development community and the technology industry.

Intel CEO Brian Krzanich is a big supporter of the "maker movement." We want to ensure that girls and women take part in this revolution—one that can help create new jobs and industries for decades to come. The belief is that making stuff, tinkering, inventing and building can bring ideas to life and spur creativity and personal growth for our next generation of leaders, while broadening participation in science, technology, engineering and math (STEM) in a new way.

Intel will continue to take action to engage and inspire girls and women to participate in computer science and engineering fields through hands on, applied maker activities. We look forward to working with stakeholders to expand and integrate maker activities into science, technology, engineering and math programs. Doing so will benefit girls and women all over the world to access opportunities to tinker, invent and create the future.

Aysegul Ildeniz

Vice President, New Devices Group

General Manager,
Strategy and Business Development

Intel will continue to take action to engage and inspire girls and women to participate in computer science and engineering fields through hands on, applied maker activities.

As the CEO of Girl Scouts of the USA, I lead a Movement that, like technology itself, has been at the forefront of tremendous change and advances for girls and women over the past 100 years.

Our mission has always been to ensure girls are equipped with the tools, skills, and experiences that will enable them to go out into the world and make it a better place. That means introducing girls to, and encouraging girls in, the fields that will make up the economy of tomorrow, from science, technology, engineering, and mathematics, to finance and beyond. It is crucial that we tap into the creativity, energy, and potential of girls and young women if our nation intends to meet the needs of our economic future.

The "do it yourself" nature of the growing "Maker Movement" has made it a conduit to that future for millions of people who have been traditionally unrepresented in STEM fields, including girls and young women. Girl Scouts works because, as the experts on girl leadership development, we have a deep understanding of how girls learn. Our programs encourage hands-on, inquisitive learning that helps girls develop confidence and new skills, and allows them to excel and achieve in STEM fields. Like the Maker Movement, our aim is to encourage collaboration and empathy in girls so that they discover their own talents and put them to use for the good of the world.

To help foster that confidence and expand girls' horizons, we seek out opportunities to highlight important research surrounding girls and STEM, and to connect girls with leaders in these fields. Our own Girl Scout Research Institute released *Generation STEM: What Girls Say about Science, Technology, Engineering and Math* in 2012, a report that spurred, from Washington to Wall Street, a crucial conversation about girls and their future in STEM fields.

With its groundbreaking new report, Intel is demonstrating how the Maker Movement has helped turn a generation of tech-savvy girls, nearly all of whom grew up in the digital age, into the leaders and entrepreneurs of the economy of tomorrow. In an increasingly diverse and interdependent global marketplace of ideas, where new technologies are creating new opportunities while driving new challenges, I cannot imagine a more important conversation to be having than how we activate the interests, abilities, and ambitions of girls in the STEM space.

The founder of the Girl Scout Movement, Juliette Gordon Low, once said, "The work of today is the history of tomorrow, and we are its makers." Today, our world is changing so fast that it is difficult to imagine that the end of the twenty-first century will look anything at all like its beginning. The future belongs to the creators and the innovators; to the people whose ideas and creativity will shape and change our world forever; to the makers. At Girl Scouts, we are excited about the prospect of turning today's girls into tomorrow's makers—and leaders in the ever-diverse and endlessly expanding world of STEM.

Anna Maria Chávez,
CEO Girls Scouts USA

Acknowledgements

Intel Corporation would like to thank the individuals and organizations who generously lent their time, knowledge and expertise to this study.

We thank the following individuals who contributed their time and expertise for interviews, data collection, source verification, case studies, user profiles, reviews of this report and more. Without their support, this study would not have been possible: Kylie Peppler, Indiana University Bloomington; Natalie Rusk, MIT Media Lab; Leah Buechley, Developer of the LilyPad Arduino toolkit, MIT Media Lab; Lisa Regalla, Maker Education Initiative, Steve Davee, Maker Education Initiative, Louisa Campbell, Parsons; Danielle Martin, Computer Clubhouse Network; Jannette Nelson, Computer Clubhouse Network; Yasmin Kafai, University of Pennsylvania Graduate School of Education; Marc Lesser, MOUSE; Alejandro Jiménez Espinosa, Computer Clubhouse Network , Mexico City, Mexico; Ann Eisenberg, University of Colorado Boulder; Annmarie Thomas, University of St. Thomas: Ruthe Farmer, National Center for Women Information Technology; Mimi Ito, Humanities Research Institute at the University of California, Irvine; Mike Eisenberg, Department of Computer Science, Institute of Cognitive Science, Center for Lifelong Learning and Design, University of Colorado, Boulder; Suha, Computer Clubhouse Network, Jordan. Dale Dougherty, President & CEO of Maker Media; Kun Jia; Becca Rose; Juliet Wanyiri, Foondi Workshops; Adriana, Sammy, Jocelyn, Madejah, students in Computer Clubhouse Network; Sho Sho Smith, Mothership Hackermom; Liz Henry, Double Union; Samantha King TechGyrls; Anna Fleming, Computer Clubhouse Network, CO; Alicia Browning, Computer Clubhouse Network, New Mexico; Suhyeon Yoon, Biologist; Linda Lobato, Machina; Tenaya Hurst; Laura Kassovic, MBIENT; Lenore Edman, Evil Mad Scientist; Miria Grunick; Kelley Roy, ADX; Kate O'Donovan; Kamla Modi and Adwoa Aidoo, Girl scouts; Silvia Lindtner; Parisa Khanipour Roshan; and Maura Max, Institute of Museum and Library Services; Catherine Wyman; and Amaris Benavidez.

This study was led by Intel Corporation's Dr. Renee Wittemyer, Director of Social Innovation; Barbara McAllister, Director, Global Strategic Initiatives, Susan Faulkner, Senior Researcher, Intel Labs; Dr. Anne McClard, Senior Researcher, NDG UX, in collaboration with Kirrin Gill, the lead writer for the report, who provided content and editorial expertise to put the report together. Surveys were conducted by Nielson in the U.S., China, and Mexico, a team led by Amber Broughton, Dana Markow, and Erin Parker. Design and layout of the report was done by Wendy Pate.

We would like to offer a special thanks to a few individuals from Intel Corporation who contributed significant time in sharing their leadership and expertise to the production of this study: Jay Melican, Carlos Contreras, Suzanne Fallender, Dr. Jon Price, Gail Dundas, Alison Wesley, Gabriela Gonzalez, Karla Blanco, Alison Elmer, Cathleen Barton, Jonathan Williams, and Joseph Nsengimana.

Executive Summary

The Maker Movement refers to the recent wave of tech-inspired, do-it-yourself (DIY) innovation sweeping the globe. Participants in this movement, known as makers, take advantage of cheap, powerful, easy-to-use tools, as well as easier access to knowledge, capital, and markets to create new physical objects. This revolutionary change in how hardware is innovated and manufactured has great potential to change the future of computing, particularly for girls and women, a group traditionally underrepresented in Science, Technology, Engineering, and Math (STEM) fields.

Making offers multiple entry points to engage and interest girls and women in the computer science and engineering fields.

- Girls who make, design, and create things with electronic tools develop stronger interest and skills in computer science and engineering.
- The playful and creative nature of making provides an avenue for people to engage in scientific and engineering problems that have personal meaning for them.
- Since making is based on what is personally relevant to an individual, it allows people of all backgrounds to pursue their interests and to use technological tools to develop their own projects. It can create more channels for girls to positively identify with computer science and engineering fields.
- Through making, girls and women gain valuable technology skills and a familiarity with problem-solving related to computer science and engineering. Risk-taking and the process of becoming stuck and then "unstuck" is at the heart of making.
- Making enables those who may not be naturally tech-oriented to discover how technology and computing skills can help them achieve goals.

Enabling girls and women—who represent half of the world's population—to fully participate in the maker movement has important economic benefits. Participation in maker and STEM activities can help females develop skills and improve their earning potential. As a result, the STEM talent pool expands, fueling competition and innovation, and ultimately strengthening the global economy.

This report examines how participation in maker activities can help girls and women develop skills and provide a bridge to potential careers in computer science and engineering. It examines the nature and drivers of female involvement in the maker movement and considers how that involvement can be increased.

The study findings show:

Girls and women makers are more likely than male makers to come to making through multiple pathways including engineering, computer science, arts, and design.

- Female makers were more likely to have engineering or computer and information science degrees than any other credential. However, they were more likely to identify with arts and creation and describe themselves as coming to making via arts. Technology is often a means, not the end, for them.
- A 3-D printer is a key tool for women makers. Women in all countries surveyed are significantly more likely to use 3-D printers than men.
- Female makers in the survey are particularly motivated by social-service aspects of making. Among those surveyed, female makers in the US and Mexico are more likely

- than males to be motivated to make because they want "to help or to give."
- Female makers are more likely to rely on personal connections as resources throughout the making process and say that collaboration is a key part of making. Interacting and connecting with others is important to women makers.

Making is already popular with tweens and teens in the U.S., including both girls and boys:

- Girls and boys in the U.S. are equally likely to be "tech makers."
- One in four has made things with technology during the past year, and seven in 10 would like to learn to make something with electronics.
- All youth makers, both female and male, are more likely than other young people to describe themselves as independent, hardworking, solution oriented, and social.
- Nearly all parents surveyed believe that getting both girls and boys involved with making and creating things with electronic tools is a great way to build interest and skills in STEM, essential in building skills for a future career.

Girls and women face constraints to participating in making.

In general, female and male makers surveyed face similar challenges to making, such as lack of money, lack of information and lack of access to tools and materials. But females experience other challenges, as well.

- Lack of mentorship is the second-ranked challenge with one in three women citing it as a barrier to making.
- One in six has been excluded for being a woman.
- One in six lives in a culture where making is considered inappropriate for girls and women.
- One in 14 doesn't feel safe going to maker activities.

The maker movement is gaining excitement and momentum. Action is needed to take advantage of this momentum to increase participation and diversity in making, at large. This study's goal is to make the point that broadening a participation in making is critical, particularly for groups historically underrepresented in computer science and engineering fields.

The study outlines a set of recommendations for action for key stakeholders, with a focus on parents, educators, policymakers, and the private sector. The goal is to:

- Interest more participation in STEM, particularly computer science and engineering fields of girls and women and underrepresented minorities.
- Increase the size of the "well" of people for the computer science and engineering pipelines, by engaging underrepresented groups in making activities.

A Call to Action:

Broadening participation and diversity in the maker movement requires commitment to action across public, private, and civil society sectors. By taking action, stakeholders have the potential to activate 25,000 aspiring makers from underrepresented groups over the next two years by introducing maker activities into existing STEM programs, such as informal after-school clubs and groups focused on girls and underrepresented minorities. To support this, stakeholders must collaborate and coordinate efforts to encourage making. They must also build links between home and school and between formal and informal learning environments. The following recommendations focus on the factors that influence engagement in making. They are based on existing strategies from STEM programs that work to encourage participation, combined with the unique characteristics of maker activities. To successfully achieve the call to action requires the recommendations be tailored to particular groups being targeted and each country context in their implementation. They are also contingent on coordinated and collaborative action across the public and private sectors.

Key Recommendations to Engage Girls and Women in Making

- **Build** more girls- and women-inclusive maker environments in public places like libraries and schools.
- **Design** maker spaces that enable open-ended investigation of projects meaningful to girls and women.
- **Develop** initiatives that give girls more access to makers their own age and female mentors.
- **Encourage** parents to "embrace the mess" and engage in making with their children.
- **Align** making activities, such as coding and making hardware, with current trends and personal interests to attract girls.
- **Include** facilitators in maker spaces to create a safe, supportive, inclusive environment for girls and women.

The report's findings were drawn from a number of secondary and primary sources:

- A survey of makers in the U.S., China, and Mexico conducted on behalf of Intel by the Harris Poll;
- Two general population surveys of youth and adults in the U.S., also conducted on behalf of Intel by Harris Poll;
- Interviews with experts in the field;
- Ethnographic research on girls and women engaged in the maker movement; and
- Literature reviews on the maker movement and the gender gap in STEM.

By taking action, stakeholders have the potential to activate 25,000 aspiring makers from underrepresented groups over the next two years by introducing maker activities into existing STEM programs, such as informal after-school clubs and groups focused on girls and underrepresented minorities.

Glossary of Terms

For the purposes of this report, terms are defined as described below.

- **3D printer:** 3D printers create three-dimensional objects by building them up, layer by layer. Instead of just one layer of ink, 3D printers use plastic, paper, metal, nylon and numerous other materials to add a third dimension to an object. A 3D printer needs a Computer Aided Design (CAD) file, which breaks down the whole object into fine slices for each of these successive layers. Commercial enterprises and individuals use 3D printing to create a variety of things—from products for practical use to those for pure enjoyment.
- **Do it yourself (DIY):** DIY is the method of building, modifying, or repairing something without the aid of experts or professionals. DIY has been described as behaviors where "individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions, including those drawn from the natural environment."
- **Maker culture:** Maker culture is a technology inspired branch of the DIY movement, which promotes learning-through-doing in a social environment. It is a culture of do-it-yourselfers, hobbyists, and inventors who run the gamut from those who create simply for fun and whimsy to those who spawn product ideas and launch serious entrepreneurial pursuits. In the maker community, making things combines form with function. People of all ages are banding together to share ideas, ingenuity, innovation, and invention. Typical interests enjoyed by the maker culture include engineering-oriented pursuits such as electronics, robotics, 3D printing, as well as more traditional activities such as metalworking, woodworking, and traditional arts and crafting. There is a strong focus on using and learning practical skills and applying them creatively.
- **Makers:** People who range from traditional artisans to computer hackers and encompass crafters, musicians, artists, cooks, students, welders, scientists, engineers, software developers, and circuit benders. They use tools like microcontrollers, 3D printers and open source hardware, and create with mediums such as wood, textiles, metal work, electronics, and legos. For the purposes of the survey in this report, makers were defined as people who make physical objects with electronic tools for their own purposes or with their own designs. To be screened into the online survey, makers needed to have used one of these tools in the past year: microcontroller, laser cutter, computer development board, open source robotics, 3D manufacturing tools, or a 3D printer.

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"Maker programs give girls the confidence and growth mindset to make choices about their lives in thoughtful and meaningful ways. Through the making process, girls are exposed to a variety of different areas such as art, science, technology, music and engineering that could potentially spark an interest that leads to a STEM career. But the most important skills that girls walk away with are persistence, communication, resilience, social skills, working with others, creativity and confidence that they can apply to any part of their lives and to any career."

Lisa Regalla,
Maker Education Initiative

1 Context and Approach

Background

Makers, creators, tinkerers, and inventors are increasingly everywhere, evidencing a remarkable sociological shift: the democratization of creation. Technological innovation and lower costs enable individuals to design, customize, test and share creations as never before possible. Independent inventors and designers are part of a growing wave of tech-inspired, do-it-yourself (DIY) innovation known as the maker movement. They use tools like 3D printers, microcontrollers, and laser cutters to make a vast array of products for work and play, to wear and eat, ranging from robots to 3D printed cookies.

This movement has been hailed as the beginning of a new industrial revolution—an era of personal fabrication[1]—that has profound implications in our lives and livelihoods. Every year hundreds of thousands of people take part in the maker spaces and Maker Faires that are popping up around the globe. They work, share, and play together on designs that range from feats of fantasy and fun to solutions to some of the world's most serious problems. For sheer fun, makers have created 3-D printed fiddles, pianos with keys made of bananas, USB charger kits made of tins, and even a large-scale Rube Goldberg-type machine using a bowling ball instead of a marble. Others have sought to improve lives by making lifesaving devices affordable, including low-cost incubators and a prosthetic hand that costs only $50, compared to custom-built models that cost $42,000.

Projects such as these teach important new skills. The maker movement emphasizes cross-disciplinary approaches rather than specialization, the process rather than the end product, and a communal effort rather than work in isolation. The skills it enables makers to develop—experimentation, problem-solving, and collaboration—are critical for success in the future global economy. It also helps makers get a practical, hands-on understanding of technology, manufacturing, engineering, and programming. Many of today's makers are motivated to create for fun, rather than work; even so, the valuable skills they gain prepare them for a wider array of professional options, as well as the possibility of developing their own businesses.

The maker movement appeals to educators because it engages students in activities that naturally involve science, technology, engineering, and math (STEM) concepts. Further, because it enables people to pursue their own interests and develop their own maker projects, the movement attracts people from diverse backgrounds and starting points, and organically engages them in the process of learning computer science and engineering skills. The movement's creative energy, collaborative culture and cross-disciplinary approach appeal to a wide audience including groups traditionally underrepresented in STEM, such as girls and women. Enabling a broad diversity of talent, particularly girls and women (who represent half of the world's population), to fully participate in this movement

Methodology and Research Approach

Survey of Makers in U.S., China, and Mexico

- **Method:** Online survey conducted by Harris Poll on behalf of Intel between April 10 and May 5, 2014 among a total of 963 Makers.
- **Qualified respondents:** Adults, 18+, residents of U.S., China, or Mexico, make physical objects with electronic tools for their own purposes or with their own designs.
  - **US: n=347; including 106 women**
  - **China: n=306; including 152 women**
  - **Mexico: n=310; including 137 women**

Survey of U.S. Youth and Adults*

U.S. Youth Survey

- **Method:** Online survey conducted by Harris Poll on behalf of Intel between April 14 and 24, 2014 among a total of 1,213 U.S. Youth (627 girls and 586 boys), including 284 Tech Makers.
- **Qualified respondents:** Youth, ages 8-18, residents of the U.S.

U.S. Adults Survey

- **Method:** Online survey conducted by Harris Poll on behalf of Intel between April 15 and 17, 2014 among a total of 2,051 U.S. adults including 440 parents of children under 18 living in their household.
- **Qualified respondents:** Adults, ages 18+, residents of the U.S.

Expert Interviews

- **Method:** Interviews with experts in STEM, making
- **Respondents: 20+** Experts identified through publications, word-of-mouth and literature on STEM, girls and STEM, and making.

Ethnographic Research with Female Makers and Girls' Programs

- **Method:** Interviews, participant observation in Maker spaces including: TechGyrls, Double Union female hackerspace Mothership Hackermoms.
- **Respondents:** Women participating in Maker spaces or self identified as "makers": Girls ages 8-18, residents of U.S.
- **Interviews:** (in person or phone) conducted with female makers in in Mexico, the U.S., China, Ireland, and Kenya to create maker profiles.

* Indicates the samples have been weighted to be reflective of the respective populations

Making can be an effective pathway to attract underrepresented groups in computer science and engineering fields. The playful and creative nature of making provides an avenue for people to engage in scientific and engineering problems that have personal meaning for them.

has immense potential benefit. Involvement in making and the development of technology skills can lead to future education and employment opportunities, as well as increased earning potential. At the same time, the STEM talent pool expands, fueling competition and innovation, and ultimately strengthening our global economy.

Objectives and approach

This report examines the maker movement, with a focus on how it can engage girls and women in computer science and engineering and provide a bridge to participate in careers in STEM fields. It explores how girls and women are currently involved in the movement in order to understand the nature and drivers of their engagement, and to consider how this involvement can be increased. Past studies have looked at the maker community, behavior and attitudes. A 2012 Maker market survey showed the maker community to be 82 percent male,[2] and a 2013 Maker Faire attendee study showed participants to be 68 percent male.[3] This study attempts to provide the first in-depth look at the role of women and girls in maker activities by looking at a broad swath of maker spaces and communities where females participate, in the U.S., China, and Mexico, as well as profiles of makers in some other countries. The study builds on surveys of the general population of adults and youth in the US, interviews with experts, academics and practitioners (addressing such topics as gender, STEM, learning sciences, and making) and building off secondary literature. Relying on analysis of primary and secondary research, it specifically aims to identify:

1. How females are engaged in making—that is, the characteristics and trends that define the current state of girls' and women's involvement in making

Some Favorite Projects of Makers Surveyed

Home and Smart Appliance

"A kit I put together that is a slow on/slow off dimmer that simulates a sunrise." (U.S.)

"A smart security system for the family." (China)

"A personalized crib for my first baby with a retro game theme, music programmed with a clock and calendar to be able to program music at certain hours and dates like birthdays, etc." (Mexico)

Clothing and Jewelry

"A light up Batman sweater—it was cozy Batman, and blinky. All things I love." (U.S.)

"A smart necklace that is a fashion accessory, as well as a music channel receiver. Connect to the Internet to listen to beautiful music." (China)

"I like creating costumes with programmable LEDs for theater and shows." (Mexico)

Entertainment

"A robotic panda that plays music from its belly." (U.S.)

"A cute musical flower toy. As time went on, it grew and blossomed statically and dynamically. It was truly beautiful." (China)

"My favorite project to date has been the creation of armor, helmets, ships, etc. from video games and/or movies that work in real life." (Mexico)

Collected from survey of Makers conducted by Harris Poll

2. Factors that influence making—the challenges girls and women face in participating in these informal maker activities and factors that enable their entry and ongoing participation in the movement

3. What can be done—a call to action to public-sector leaders, educators, parents, private sector, and other key stakeholders, with recommendations and specific interventions for better engaging girls and women as makers

The findings in this report draw from a number of secondary and primary sources:

- **A survey of makers in the US, China, and Mexico,** conducted on behalf of Intel by Harris Poll. The survey was conducted between April 10 and May 5, 2014, among a total of 963 makers. Qualified respondents were adults, 18+, residents of the U.S., China, or Mexico, who make physical objects with electronic tools for their own purposes or with their own designs. In the U.S., there were a total of 347 people surveyed, including 106 women; in China, a total of 306, including 152 women; and in Mexico, a total of 310, including 137 women. Participants were recruited from a variety of sources, including the Harris Poll Online Panel, banner ads on websites frequented by those who use electronic tools to create things, referrals from leaders of various maker online communities and forums, and subscribers to MAKE Magazine. Survey data are unweighted and therefore representative only of the individuals surveyed.

- **Surveys of youth and adults in the U.S., including parents,** conducted on behalf of Intel by Harris

Makers Solving Big Challenges

Newborn resuscitation

A "bubble CPAP" machine to resuscitate newborns is typically expensive—costing up to $6,000—and requires a trained professional and a stable source of electricity. Using a Nalgene bottle and household aquarium pumps, Jocelyn Brown designed an affordable, easy-to-use, battery-run version of the machine for only $160. This machine has the potential to save the lives of countless newborns in developing countries. Brown and others are working to bring the device to hospitals across Malawi, Zambia, Tanzania, and South Africa. The CPAP Device was featured at the White House Celebration of Global Development Innovation in February 2011.
Source: http://www.forbes.com/sites/rahimkanani/2014/02/17/5-brilliant-social-innovators-youve-never-heard-of-until-now/

Low-cost, lever-powered wheelchair

Around 20 million people in developing countries are in need of a functioning wheelchair, one that can ride on rough urban and rural terrain and be maintained with easily available parts and tools. To help resolve this issue, Professor Amos Winter and his team at MIT built the Leveraged Freedom Chair, a cheap, lever-powered wheelchair, from bicycle parts based on input from disabled individuals in Tanzania. The chair works on all kinds of terrain, costs less than $200 and can be repaired easily, even in remote rural areas. A former MIT student, Tish Scolnik, is working to bring the Leveraged Freedom Chair to market in India, working with Indian businesses, Jaipur Foot and Pinnacle Industries, through the manufacturing, assembly, and distribution processes.

Source: http://d-lab.mit.edu/scale-ups/LFC

Maura Max ,
Deputy Director for Libraries
United States Institute of Museum and Library Services
Washington, D.C.

"We know that the maker movement is capturing the imagination of libraries and museums and helping us think about new ways to engage learners. IMLS is investing in making at the institutional and national levels with funding for research and projects that place museums and libraries at the center of this participatory, hands-on learning movement.

This year we awarded $13 million in grants for STEM activities in libraries and museums, this includes support for maker-related projects. We are also working with the Pittsburgh Children's Museum, Chicago Public Library, the North Carolina State University Library and the Exploratorium to develop a makers toolkit for all libraries and museums. These commitments build on a long history of IMLS-supported programs that engage learners in hands-on creative activities with tools as diverse as soldering irons and sewing needles leading to the creation of everything from high fashion to low riders.

Libraries and museums nationwide are helping get people excited about making, reaching out to girls and minorities who are underrepresented in STEM careers, and just having a great time letting creativity reign."

Poll. The Survey of U.S. Youth was conducted online between April 14 and 24, 2014, among a total of 1,213 U.S. youth (627 girls and 586 boys), including 284 tech makers defined by participation in one of five activities (activities specified in Appendix). Qualified respondents were youth, ages eight to 18, who were residents of US. The data have been weighted to reflect the composition of the U.S. 8-18 year-old population. The U.S. adult survey was conducted online between April 15 and 17, 2014, among a total of 2,051 U.S. adults, including 440 parents of children under 18 living in their household. Qualified respondents were adults, aged 18 and above, who were residents of U.S.

- **Interviews with makers and experts** in the field. We interviewed more than 20 experts on the topic of making from academia and the nonprofit sector. We also interviewed female makers in Mexico, the US, China, Ireland, and Kenya, performed Internet research on female makers, and have included 13 maker profiles of girls and women in this report.
- **Ethnographic research** on girls and women engaged in the maker movement in after school clubs, female maker spaces, and general maker spaces.
- **Literature reviews** on the maker movement, gender, and STEM.

The appendix to this paper provides further details about the methodology for these research efforts.

What is the maker movement?

What is the maker movement? Who are makers and what do they do? Maker culture is a technology-inspired branch of the DIY movement, which promotes learning through doing in a social environment.[4] But the movement seems to defy strict definition and includes many types of traditional arts and crafts that don't involve technology.[5]

Makers range from traditional artisans to computer hackers, and encompass crafters, musicians, artists, cooks, students, welders, scientists, engineers, software developers, and circuit benders. They use tools like Arduino microcontrollers, 3D printers, and open source hardware, and create with mediums such as wood, textiles, metalwork, electronics and Lego bricks. They are also involved in areas like DNA, for example,

exploring 3D printing of human organs using stem cells.

Makers offer a dizzying array of products, including fully functional 3D printed hammers made from paper, DIY Braille printers using Lego bricks, e-textiles embedded with electronic hardware and LEDs, and an open-source, Arduino-controlled knitting machine. They develop innovative solutions like cell phone-based sensors for detecting carbon dioxide and work to dramatically reduce the cost of existing technologies, for example, by creating some of the capabilities of a $10,000 scanning/tunneling microscope for a few hundred dollars.[6] Young people are also involved, making their own digital printers and creating things like marshmallow cannons.

While making usually involves technology, such as digital fabrication with 3D printers, development boards, and laser cutters, it has also promoted a renewed interest in manual crafts and the DIY culture. Many areas of making involve a combination of traditional crafts and new technologies. Design of e-textiles, for example, involves traditional aspects of textile crafts, as well as new materials like conductive fibers, sensors for light and sound, and actuators like LEDs and speakers.[7] New computational construction kits, such as Makey Makey, designed by MIT students, make programming accessible by enabling people to create computer interfaces with ordinary objects capable of conducting electricity.[8] If you want to make a piano, for example, Makey Makey allows you to use fun items, such as bananas, for your piano keys. Users need no prior programming experience and can create projects using preset ports on the Makey Makey board.[9]

“My work blends technology with art and craft. What is so exciting about this approach is that this provides

The 3D Printing Revolution

3D printing is one of the most popular trends in making, particularly among women. This report finds that women surveyed by Harris Poll are significantly more likely to be using 3D printers than men.

Just what is it and how does it work?

3D printers create three-dimensional objects by building them up, layer by layer. Instead of just one layer of ink, 3D printers use plastic, paper, metal, nylon and other materials to add a third dimension to an object. To work, a 3D printer needs a Computer Aided Design (CAD) file, which breaks down the whole object into fine slices for each of these successive layers.

What’s it used for?

Commercial enterprises and individuals are using 3D printing to create a multitude of things, from products for practical use to those for pure enjoyment. 3D printing is used to produce sculpture, product prototypes, jewelry, machine parts, and cookies, to name just a few. Numerous companies are using commercial 3D printers to adapt and change prototypes quickly and at low-cost. Using 3D printing, Nike can now quickly alter a prototype of a sneaker design, reprinting it almost immediately, instead of waiting for weeks, as in the past. 3D printing has also been used to scan and print replicas of priceless artifacts, such as Tutankhamun’s mummy, so they can be handled without fear of breakage, facilitating research. Individual consumers can even print a 3D replacement part for their home washing machine. To do so, they simply go online and download the CAD file for the part they need. They can then print it on a personal 3D printer or visit a local fabrication business to have it printed there.

What’s the revolution?

3D printers are becoming more and more affordable—only $300 to $2,000 for personal models—so their use is becoming increasingly widespread. 3D printing is now poised to touch almost every aspect of our lives. In manufacturing, 3D printing is bringing us from Henry Ford’s era of the mass production line into a new age of customized production. Anyone will be able to be an inventor, as small, specialized producers will be able to develop their ideas and reach a market through the Internet. In construction, inexpensive 3D-printed models of complex architectural drawings have replaced labor-intensive, hand-made models. And massive-scale 3D printers are creating concrete structures, with the aim of eventually producing full buildings. In medicine, new bioprinters may soon print human tissue and, eventually, entire organs and bones.

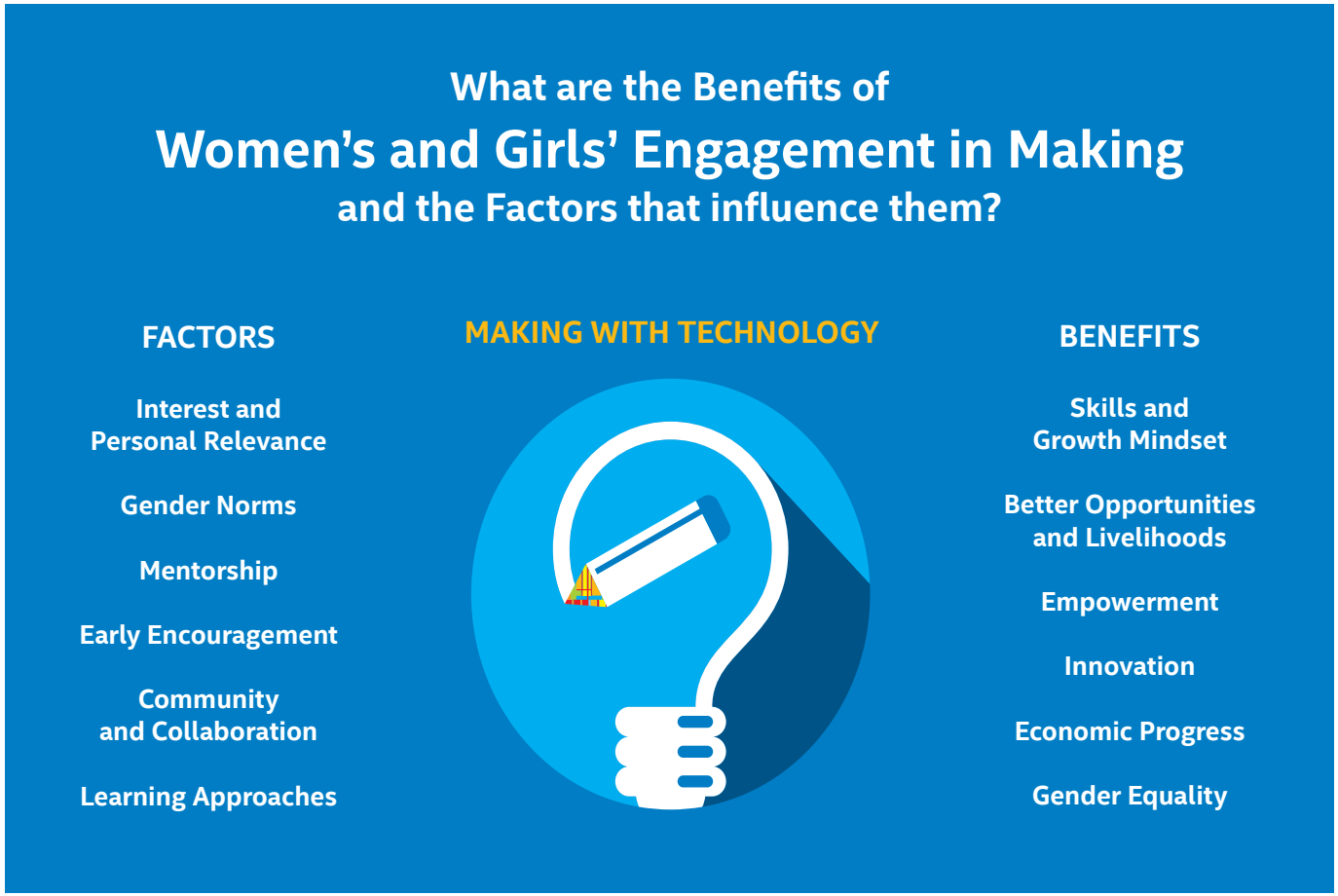
Reference:

Fleming, M. “What is 3-D printing: An Overview.” 3-D Printer.net, accessed Aug 28, 2014. http://www.3-Dprinter.net/reference/what-is-3-D-printing

people with alternative cultures where they can have STEM experiences. You don't have to be a nerdy techie to write programs or build electronics. You can explore STEM content and ideas in a more comfortable context and culture—the context of fashion, art or biology for instance. I believe that the best way to increase diversity in STEM is to seed new subcultures where STEM can happen and a person can keep her own identity—as artsy, outdoorsy, a people-person, or feminine."

- Leah Buechley, Developer of the LilyPad Arduino toolkit

The maker movement is extensive and rapidly expanding. Spaces where makers can meet and work together in person and online are proliferating, enabling makers to pursue a wide range of interests. Makers can meet face to face in physical spaces that are known as maker spaces, hackerspaces, fablabs, techshops,



and 100k garages, to name just a few of the existing variations. These spaces provide an opportunity for new and experienced makers to work together, enabling learning through a mentorship or apprenticeship model. In addition, every year there are numerous Maker Faires, events where makers can share their inventions. These are held across the globe attracting hundreds of thousands of people. In 2013, 195,000 people attended two flagship Maker Faires in the Bay Area and almost 100 independently-produced Mini and Featured Maker Faires around the world, including in Tokyo, Rome, Santiago, and Oslo.[10] The White House held its first Maker Faire on June 18, 2014, involving international agencies, government departments, the private sector, foundations, NGOs, museums, libraries and schools, as well as makers of all types and ages.

"Today, more and more Americans are gaining access to 21st century tools, from 3-D printers and scanners to design software and laser cutters. Thanks to the democratization of technology, it is easier than ever for inventors to create just about anything. Across our nation, entrepreneurs, students, and families are getting involved in the maker movement." President Obama, White House Maker Faire, June 18, 2014

Online opportunities for makers to connect and collaborate are also vast, and include sharing platforms and open source hardware. Children, as well as adults, connect online to discuss and share their maker experiences. Google and MAKE Magazine held their third annual online maker camp for kids in 2014, involving more than 2 million participants.

But making is not limited to the Internet, homes, clubs, and Maker Faires. Educational arenas like schools, libraries, and museums also offer spaces for making. Science centers enable visitors to interact with exhibits and make things linked to exhibit themes. Public libraries provide spaces for young people to play games and engage in digital production of animations, games, and electronic textiles. Even the Girl Scouts of America has added new merit badges for maker activities, including digital arts and entertainment technology.

Why is the Maker Movement important?

This technology-fueled revolution has important implications for individuals and for society at large. For individuals, the maker movement has the potential to improve engagement, learning, and skills, and to provide a practical understanding of technology. Developing electronic textile or e-textile design, for example, allows people to learn about traditional textile crafts like sewing, as well as technology, and engineering, when participants combine soft materials, such as fabrics and threads, with electronic components, including lights, speakers, and sensors. Makers learn to imbed the textiles with hardware and to design functional circuits to connect batteries, switches, and LEDs. They also learn how to program code to control the behavior of the LEDs.[11]

Making fosters learning through personally meaningful projects and collaborative, multidisciplinary, and playful learning approaches. It enables learners to pursue their own interests and work across different disciplines on

"The way we approach STEM or STEAM is with a focus on creativity. We always start with outcomes and cool projects. A student sees making as a tool in their creative kit, and then they realize it's not a heavy lift to learn how to work with electronics."

Louisa Campbell, Parsons Research Faculty

"Even though the denominator has grown with more women participating in college since the 1980s- the number of women participating in computer science has gone down. And while the denominator of computer science positions has grown, across our university system, the number of women participating in those programs has gone down. In early elementary school, girls at the same rate as boys say they are interested in careers like engineering, architects, and astronauts, But by time they get to high school those numbers have dropped dramatically. Partly because we lose girls in middle school in this country."

Chelsea Clinton,
Clinton Global Initiative
Annual Meeting,
Sept 24, 2014

projects that have a personal relevance for them, deepening their engagement. The 'tinkering' aspect of making is a playful way to learn through hands-on experience with technology. It encourages experimentation, exploration of new paths and new possibilities, and reassessment of goals and plans. Making strengthens critical 21st century skills, such as collaboration and problem-solving, as it allows makers to learn from and build on the ideas of others to develop solutions to real problems. It supports self-efficacy, experimentation, persistence and passion in science learning, all of which drive innovation.[12] The hands-on, DIY approach shifts people from passive consumers to active creators. Creation fosters a "growth mindset" which leading psychologists, such as Carol Dweck, argue is the new "psychology of success." They argue that capacities are not "fixed" but can grow.[13]

This type of learning and innovation are critical for the resilience of future economies. Such creative energy is the driving force of innovation that fuels economic progress and builds healthy economies. The excitement and interest generated by the maker movement is resulting in a wellspring of innovation that has the potential to transform our society, providing greater efficiency and opportunity. The potential outcomes of all this creative energy are vast, and the maker movement is being compared to the excitement generated by computer clubs and meetings in the late 1970s, which led to a new wave in software programming, semiconductor design, and technology products, and ultimately, to the world of technology as we know it today.[14]

"This maker movement puts power in the hands of the people to fund, design, prototype, produce, manufacture, distribute, market and sell their own goods.." Jeremiah Owyang, Web-Strategist.com[15]

The Powerful Benefits of the Maker Movement for Girls and Women

The maker movement holds tremendous potential. It can be used as a vehicle to strategically attract specific groups underrepresented in computer science and engineering fields, such as girls and women. Although women have made great progress overall in education and the workplace in the last few decades, they continue to be significantly underrepresented throughout the world in computer science and engineering fields. Fewer women than men graduate with computer science and engineering degrees, and fewer still choose technology careers. Educators recognize the movement as a way of engaging people in STEM. Making is a powerful vehicle for getting learners excited about science and technology, and improving STEM education.[16] Studies show that students are often bored with science and math classes that they see as having no connection to the real world.[17] But while STEM signifies "push" for learners, "make" signifies "pull." Learners' own interests draw them into making, and through making, they learn about technology and STEM without being forced to do so.[18] While design and making are not necessarily efficient ways to teach STEM, they are compelling ways

to stimulate the desire to learn STEM.[19]

"The cool thing about maker culture is that we don't have to sell it; kids/parents are pulling it into homes and schools... How we shape maker culture for learning is the real question." Kylie Peppler, Head of Make-to-Learn Initiative and Assistant Professor of Learning Sciences at Indiana University Bloomington

By engaging in making, girls and women can gain valuable skills and a familiarity with problem-solving related to computer science and engineering. Such skills and experience can attract them to a longer-term engagement in those fields and advance them economically through technology related education, new job opportunities, and improved livelihoods. Salaries in STEM fields are high and the growth in these sectors is considerably higher than average, providing greater economic gains and security. Women in STEM jobs earn a third more than their female peers in non-STEM jobs.[20] STEM occupations are projected to grow by 17 percent from 2010 to 2018, compared to 9.8 percent growth for non-STEM occupations.[21]

"The way we approach STEM or STEAM is with a focus on creativity. We always start with outcomes and cool projects. A student sees making as a tool in their creative kit, and then they realize it's not a heavy lift to learn how to work with electronics." Louisa Campbell, Parsons Research Faculty

Maker culture can also be an empowering experience for women on a more personal level, increasing their power. Their participation in making and STEM-related activities has the potential to increase their confidence and self-efficacy, their access to information and technology, and their use of media and technology.[22]

Women's and girls' engagement in making triggers a succession of important social and economic benefits. Broadening participation in the maker movement and computer science and engineering fields stimulates competition and innovation. This, in turn, leads to more efficient products and services, promoting economic resilience and progress. The fast growing maker movement has already boosted small business and produced a powerful and rapidly expanding market for technological equipment, products, and services. For example, the market for 3-D printing products and various maker services was estimated at $2.2 billion in 2012, and is forecast to increase to $6 billion by 2017 and $8.41 billion by 2020.[23] The maker spirit is vital to the growth of small business, which ensures job growth and a healthy global economy. In the U.S., small businesses create nearly two out of every three new jobs.[24]

In addition, as women and girls have better opportunities and livelihoods, and a greater sense of empowerment, society and the economy gain from greater gender equality. Research shows that technologies and innovation are key ingredients in the advancement of women and girls. A study by the International Center for Research on Women (ICRW)[25] indicates that improving women's access to and use of

"The cool thing about maker culture is that we don't have to sell it; kids/parents are pulling it into homes and schools... How we shape maker culture for learning is the real question."

- Kylie Peppler, Head of Make-to-Learn Initiative and Assistant Professor of Learning Sciences at Indiana University Bloomington

"We need to help girls explore new kinds of personal development experiences—programming at young age, speaking another language."
- Linda Lobato
CEO and Co-Founder of Machina

"My work blends technology with art and craft. What is so exciting about this approach is that this provides people with alternative cultures where they can have STEM experiences. You don't have to be a nerdy techie to write programs or build electronics. You can explore STEM content and ideas in a more comfortable context and culture—the context of fashion, art or biology for instance. I believe that the best way to increase diversity in STEM is to seed new subcultures where STEM can happen and a person can keep her own identity—as artsy, outdoorsy, a people-person, or feminine."

- Leah Buechley,
Developer of the LilyPad Arduino toolkit

"My interest in making is tied to the environment I grew up in."
Julliet Wanyiri, Founder & CEO of Foondi Workshops

"There are a lot of cultural challenges in getting girls to participate in STEM activities. In my Clubhouse, the girls are expected to come home and take care of the house after school. We have a Latino culture in our community, which means that until girls turn 15, they are more prone to be home afterschool and helping parents—for safety and because of culture."

Jannette Nelson,Computer Clubhouse Network,
Network Program Coordinator for Youth Programs

technology has the potential to spur their economic advancement and stimulate broader economic growth by:

- Improving women's productivity in current activities or allowing them to take advantage of other income-generating opportunities
- Creating access to income and other resources, as well as the skills and self-confidence to advocate for themselves
- Opening broad social benefits, such as better health and education for their children
- Improving the economic conditions of their families and communities

Economic empowerment and education are two key drivers of innovation, as well as girls' and women's advancement. Investments in supporting entrepreneurial and technical skills can lead to a range of positive benefits for women and girls by removing barriers in women's lives in diverse economies around the world. A report by ICRW[26] highlights how innovations can be leveraged to improve the lives of women and contribute to their empowerment. Both innovation and gender equality hold critical value by improving wellbeing. Both require a redefinition of pre-existing parameters and breaking the mold. The study notes, "Innovation and shifting gender roles are each catalytic processes that drive change." It goes on to identify three domains of innovations which are creative entry points for realizing women's empowerment: technology use, social norm change, and economic resilience. If women can flourish in any of these areas, there can be a demonstrable shift in gender relations.

Making and the STEM Gender Gap

The connection between making and STEM is made more important by the size of the gender gap in the STEM fields, particularly in computer science and engineering. While women receive over half of bachelor's degrees awarded in the biological sciences in the U.S., they receive far fewer in the computer sciences (18 percent), engineering (18 percent), and mathematics and statistics (43 percent).[27] Women make up a majority of the overall workforce in the U.S., but are much less represented in specific science and engineering occupations. For example, women comprise only 13 percent of civil engineers and only 6 percent of mechanical engineers.[28] This is the case despite the considerably greater earning and growth potential of these fields. Women's representation in computer science and engineering continues to drop at the graduate level and again in the workplace.[29]

"Even though the denominator has grown with more women participating in college since the 1980s- the number of women participating in computer science has gone down. And while the denominator of computer science positions has grown, across our university system, the number of women participating in those programs has gone down. In early elementary school, girls at the same rate as boys say they are interested in careers like engineering, architects, and astronauts, But by time they get to high school those numbers have dropped dramatically. Partly because we lose girls in middle school in this country."
Chelsea Clinton, Clinton Global Initiative, 2014

What explains these disparities?

Evidence from research has established that the

gender gap in STEM fields are due to socio-cultural, environmental and workplace issues.[30] During education, negative stereotypes about girls' abilities in math can indeed measurably lower girls' test performance and are believed to affect their aspirations. But such differences disappear when the environment is improved to ensure girls and boys are treated equally.[31] In the workplace, women leave computer science and engineering fields due to unsupportive workplace environments, bias, and family responsibilities. In the technology sector, women leave the computing workforce at twice the rate of their male peers.[32] Women's quit rate in technology exceeds that of other science and engineering fields.[33]

This loss of talent from computer science and engineering fields, in particular, affects the potential for creativity, innovation, and competitiveness. Scientists and engineers design the things we use every day—tablets, hybrid and electric cars, smart phones, GPS systems, hybrid and wireless headsets—and work to find solutions to the world's greatest problems, from cancer to global warming. A more diverse workforce could help to ensure the design of better technological products, services, and solutions that are more representative of all users.

Additionally, racial and ethnic equity in computer science and engineering fields continues to be a challenge. There is low participation of underrepresented minorities in the computing workforce and computer science and engineering graduate programs. African Americans, Hispanics, and Native Americans, combined, earned fewer than 8 percent of computer science and engineering degrees.[34] Research shows that many strategies can be used for increasing participation of both women and underrepresented minorities.

Well-crafted initiatives have the potential to transform this landscape. There are several efforts globally to engage, attract and retain women and underrepresented minorities in computer science and engineering fields. Groups like the National Center for Women in Technology[35], Girls Who Code[36], and WeTech[37] have many collaborations and programs focused on workshops, after-school programs, student mentoring, peer support, professional training, faculty mentoring, and other opportunities focused on elementary, middle school, high school, undergraduate, and graduate students. Another example includes Margolis' work at Carnegie Mellon University, where she implemented her research findings on institutional biases and barriers influencing women's decisions and progress (or lack thereof) in computer science. Based on her interventions, the percent of females in computer science went from 7 percent when the research began, to 40 percent after the research recommendations were implemented. Today, about 33 percent of the computer science graduates at Carnegie Mellon each year are women.[38]

"Technologies are enabling a global revolution around making that can potentially impact innovation and economic growth across sectors. From personal gadgets produced at low cost to rapid prototyping of life-saving devices; communities, machines, and spaces (virtual and physical) that make these activities possible are being created (and connected) around the world. Finding ways to link this global phenomenon to the education sector, and STEM careers in particular, is one of many areas where we are keen to work."

Arturo Muente-Kunigami,
Senior ICT Policy Specialist,
The World Bank

Making can be an effective pathway to attract underrepresented groups in computer science and engineering fields.

The playful and creative nature of making provides an avenue for people to engage in scientific and engineering problems that have personal meaning for them. Learners engage in activities that lead to understanding and

OVERVIEW: FEMALE MAKERS IN THE SURVEY

	FEMALE MAKERS	MALE MAKERS
MEDIAN AGE	**28**	**34**
Educational Background	Engineering (26%) Computer and information science (24%) Design (16%) Art (14%)	Engineering (47%) Computer and information science (30%) Design (13%) Physical Sciences & Science Technologies (11%)
What tools do they use?	Microcontrollers/ Development boards (62%) 3D printer (52%)	Microcontrollers/ Development boards (73%) 3D printer (36%)
What do they make?	Arts and crafts (52%) Smart devices (39%) Jewelry Making (35%)	Smart devices (55%) Robots (43%) Audio/musical devices (40%)
Frequency of Making (At least...)	2-3X per week (68%)	2-3X per week (68%)
Years as a Maker	1-2 years or less: 63%	3-4 years or more: 56%
Why do they make?	To help or give (41%) Knowledge (30%) I like to do things with my hands (29%)	Problem-solving (39%) Knowledge (39%) To Help or Give (31%)
Who do they make with?	With co-workers (35%) By myself (28%)	With coworkers (36%) By myself (35%)
Biggest challenges	Lack of tools and materials (35%) Lack of information when I get stuck (34%) **Lack of mentorship (33%)** Lack of money for membership or tools (30%)	**Lack of tools and materials(41%)** Lack of information when I get stuck (35%) Lack of money for membership or tools (32%) Lack of local like-minded people (26%)

mastery of concepts and tools needed to realize their projects, all within the social context of a supportive, creative community.[39] Because making is interdisciplinary, bringing together art and science, it enables students who excel at tech-oriented subjects to apply this work in an engaging, hands-on way. It can also be useful for those who might not initially be tech-oriented to pursue their interests, while also learning new content, practical uses of technologies, and computing to achieve their goals.[40]

Specifically, in this report, we examine the examples where the maker movement is stimulating girls' and women's interest and engagement in computer science and engineering, ranging from after-school programs integrating maker activities for girls, to informal programs and groups/associations of female makers. Since making is based on what is personally relevant to an individual, it allows people of all backgrounds to pursue their interests and to use technological tools to realize their own projects. People can develop a great variety of different projects, from building robots to developing mini drum kits using foil and Makey Makey. E-textile construction kits, such as LilyPad Arduino, have succeeded in helping to broaden female participation in the maker movement and have brought its users into the tech domain. The kits enable them to customize and personalize their work.[41] To build e-textiles, women use the components provided in the kit and conductive thread, learning engineering and construction skills, and they learn to program the microcontroller using a variant of the C programming language in the Arduino programming environment.[42] The kits enable them to create programmable garments, accessories, and costumes, such as a bike jacket that signals right and left turns through the touch of a button on the sleeve

of the rider. A study comparing the user base of Arduinos and LilyPad kits, showed that 65 percent of LilyPad projects were done by females, while 86 percent of the user base of the more traditional Arduinos was male.[43]

"My work blends technology with art and craft. What is so exciting about this approach is that this provides people with alternative cultures where they can have STEM experiences. You don't have to be a nerdy techie to write programs or build electronics. You can explore STEM content and ideas in a more comfortable context and culture—the context of fashion, art or biology for instance. I believe that the best way to increase diversity in STEM is to seed new subcultures where STEM can happen and a person can keep her own identity—as artsy, outdoorsy, a people-person, or feminine." Leah Buechley, Developer of the LilyPad Arduino toolkit

2 The Females Who Make

What do we know about the females who are makers? What are the key characteristics and trends that define them? This section of the paper examines results from women surveyed to identify patterns that emerge among women who are makers.

WOMEN: Who are the women who make?

The demographics of female makers

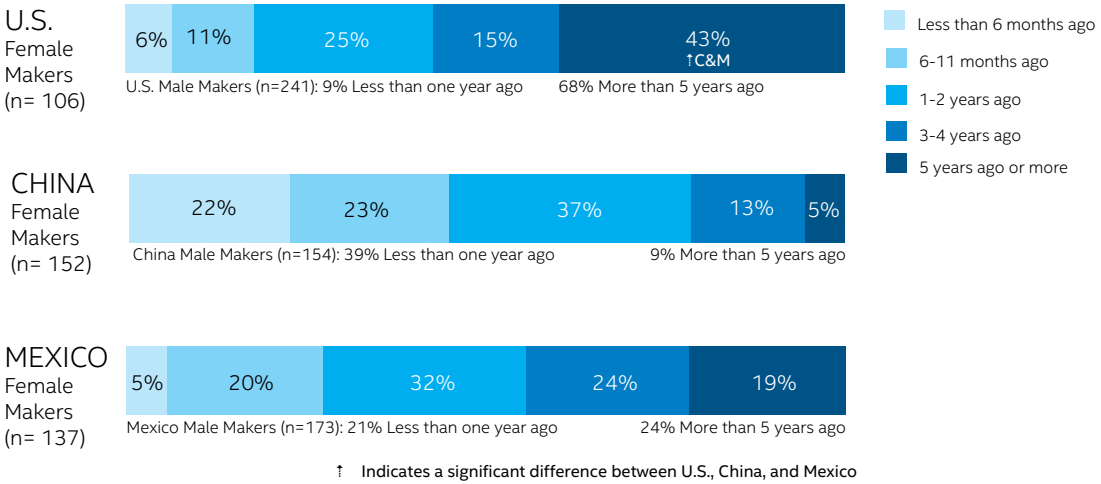
The makers surveyed online by Harris Poll on behalf of Intel in China, the U.S., and Mexico, range in age from 18 to over 65 years old. The median age of female makers from all three countries is 28 years of age, while the median age of adult male makers surveyed globally is 34 years old. In the U.S., female makers surveyed are considerably younger than males, with an average gap of nine years. While both females and males in the U.S. are significantly older than makers surveyed in Mexico and China, U.S. female makers are closer in age to the male and female makers outside the U.S. Male makers in the U.S. are the outlier. They are on average 15 or more years older than makers in Mexico and China, while female makers in the U.S. are 7 to 9 years older than makers elsewhere.

Defining Makers:

For the purposes of the survey, we defined makers as people who make physical objects with electronic tools for their own purposes or with their own designs. To be screened into our online survey, makers needed to have used one of these tools in the past year: microcontroller, laser cutter, computer development board, open source robotics, 3D manufacturing tools, or a 3D printer.

Partly as a result of their age, people who use maker technologies (as defined in the survey), including females, are relatively new to making. Across the countries surveyed, most females (63 percent) have been making for one to two years or less, while among males, 56 percent had been making four to five years or more. However, most of this gender difference comes from the U.S. In Mexico and China, all makers, both male and female, are relatively new to the game. In the U.S., although both male and female makers have been making longer than makers in the other countries, female makers have been

I started making things...



† Indicates a significant difference between U.S., China, and Mexico

making for less time on average than males. In the U.S. 68 percent of male makers and 43 percent of female makers have been making for five or more years.

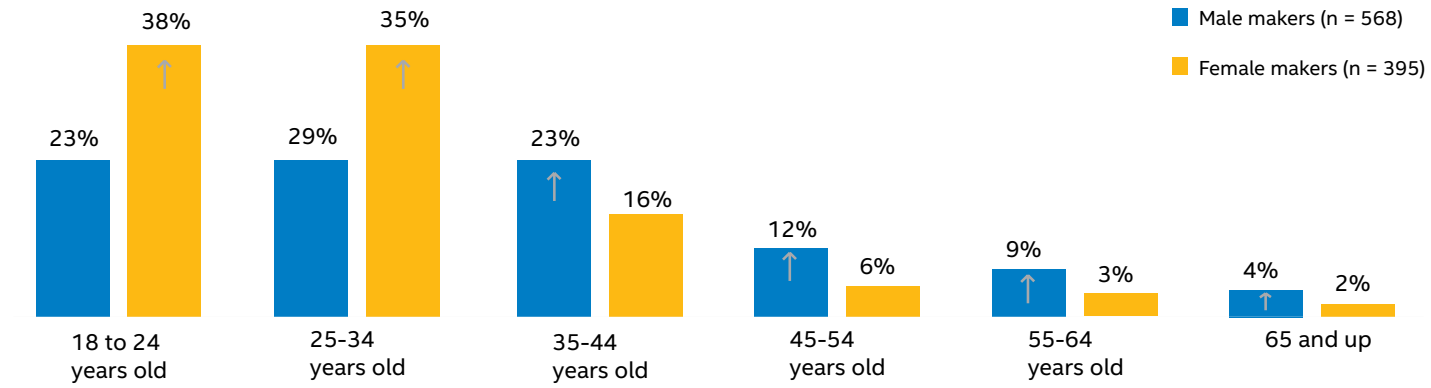
Female makers, like males, make things with electronic tools at least two to three times per week. Also, one in five female makers make at least every day, the same proportion as male makers.

Technology is the means, not the end

In the survey, female makers were more likely to have engineering or computer and information science degrees than any other credential. However, they were more likely to identify with arts and creation, and describe themselves as coming to making via arts. Technology is a means, not the end, for them.

The degrees most common among both female and male makers are engineering and computer and information science. Half of female makers surveyed

What is your age?

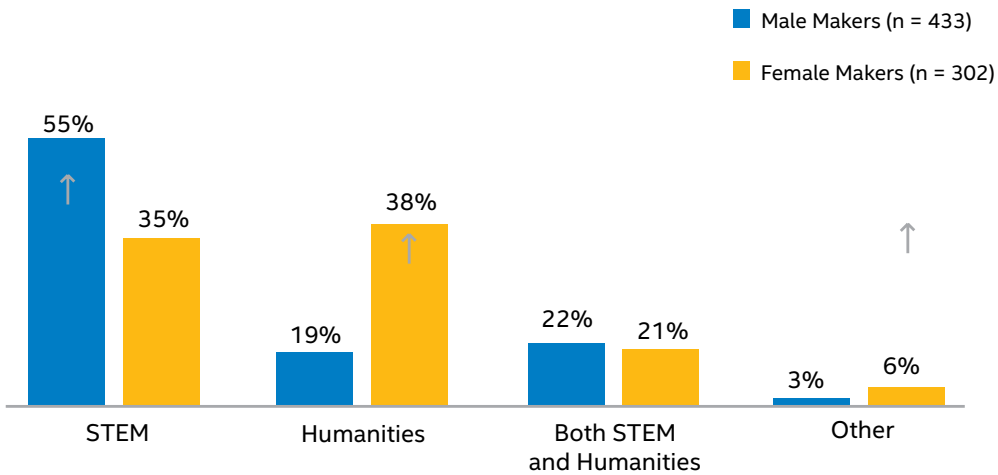


↑ *Indicates a significant difference between Male and Female*

have engineering (26 percent) or computer and information science (24 percent) degrees. Other degrees commonly held by female makers are design (16 percent) and art (14 percent). Female makers surveyed in the U.S. and China are significantly more likely than males to have degrees in art, particularly in the U.S., where 21 percent of female makers surveyed had degrees in art.

Overall, female makers are almost equally spread between the STEM fields and the Humanities, with 35 percent holding STEM degrees, 38 percent holding Humanities degrees and 21 percent holding both. This spread differs by country, with STEM degrees more common than Humanities among women in Mexico (49 percent vs. 27 percent), and Humanities more common than STEM among women in the U.S. (49 percent vs. 29 percent), while women in China are about equally spread between the two (32 percent STEM vs. 37 percent Humanities).

Educational backgrounds of survey respondents who completed a college degree



↑ *Indicates a significant difference between Male and Female*

DEGREES HELD BY MAKERS SURVEYED

DISCIPLINE	FEMALES n= 302	MALES n=433
Engineering & Engineering Technologies	26%	47%
Computer and Information Sciences	24%	30%
Design	16%	13%
Art	14%	6%
Physical Sciences & Science Technologies	11%	11%
Education	10%	5%
Business	8%	9%
Architecture	7%	5%
Economics	6%	4%
English & Literature	6%	3%
Psychology	6%	3%
Foreign Languages	5%	3%
Mathematics & Statistics	5%	7%
Biological and Biomedical Sciences	4%	4%
Social Sciences	4%	5%
Health professions and related programs	3%	3%
History	3%	2%
Legal/Pre-law	2%	2%
Nursing	2%	0
Philosophy/Religion	2%	3%
International Studies	1%	1%
Journalism	1%	2%
Performing Arts	1%	3%
Other	8%	5%

Green denotes a significant difference between males and females

Despite the fact that over half of female makers have STEM degrees, they don't always identify strongly with their science and technology backgrounds. In some cases, they identify with the arts. Female makers in all countries are significantly more likely than males to describe themselves as becoming makers via arts (45 percent versus 19 percent), while males are significantly more likely to describe themselves as becoming makers via a physical science and engineering background (61 percent versus 30 percent). In addition, arts, jewelry and textiles are prominent in the creations of female makers.

The identification with the arts is particularly evident among women makers in the U.S. and Mexico. In these countries, female makers identify more strongly than males with terms related to creation and art (creator, designer, artist, crafter, and inventor). However, in China, there was little difference in how male and female makers identified themselves.

A diverse array of making, with 3D printing prominent

3D printing, with its element of art and design, is a key tool in making among women. Women makers surveyed are significantly more likely to be using 3D printers than men (52 percent vs. 36 percent). In China, 3D printing is particularly popular among female makers surveyed, with 64 percent of women makers surveyed using it, second only to their use of imaging/design software (67 percent).

Women also use a variety other tools for making. The

In the U.S. and Mexico, female makers identify more strongly with terms related to art and creation (creator, designer, artist, crafter, inventor); gender in China plays a limited role.

This is "Exactly Who I Am"	U.S.	CHINA	MEXICO
	Creator Maker Crafter Artist Designer Tinkerer DIY-er	DIY-er Hobbyist Upcycler Maker Innovator	Creator Designer Innovator Inventor Artist Entrepreneur
	Tinkerer Maker Hobbyist DIY-er Engineer Builder	DIY-er Hobbyist Maker Developer Upcycler	Creator Engineer Innovator Programmer Entrepreneur

Golden text indicates term showed up in top 5

most popular technology tools used among women makers are development boards and/or microcontrollers (62 percent), imaging/design software (59 percent), and sewing machines (52 percent).

Female makers surveyed are most likely to be making things related to smart devices (39 percent) or in the category of arts (52 percent). Many women are also making jewelry (35 percent), audio devices (34 percent), e-textiles (34 percent), prints/books (34 percent), and kids projects (33 percent). Among women makers, those in China and Mexico are more likely to be making smart devices than women in the U.S.

Motivated by social service

Female makers are particularly motivated by the social service aspects of making. Among those surveyed, female makers in the U.S. and Mexico are more likely than males to be motivated to make because they want "to help or to give." For example, they like to teach others or make a difference, or they want to create gifts for friends and family. Among Chinese female makers, this was the second top reason for making after "to feel a sense of accomplishment." Other important reasons for women, overall, were to increase knowledge and the love of making things.

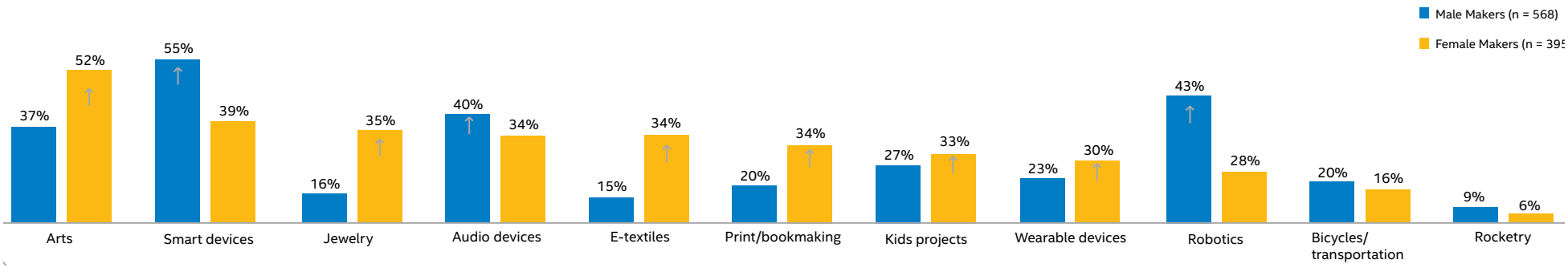
Female makers, like the male makers, surveyed are entrepreneurially-inclined, and have mixed feelings about the consequences if the funding "dream" came true.

Female makers are connectors

Interacting and connecting with others is important to women makers. In general, they enjoy collaborating with others and are more likely than males to take part in maker events and clubs, as well as to connect via the Internet.

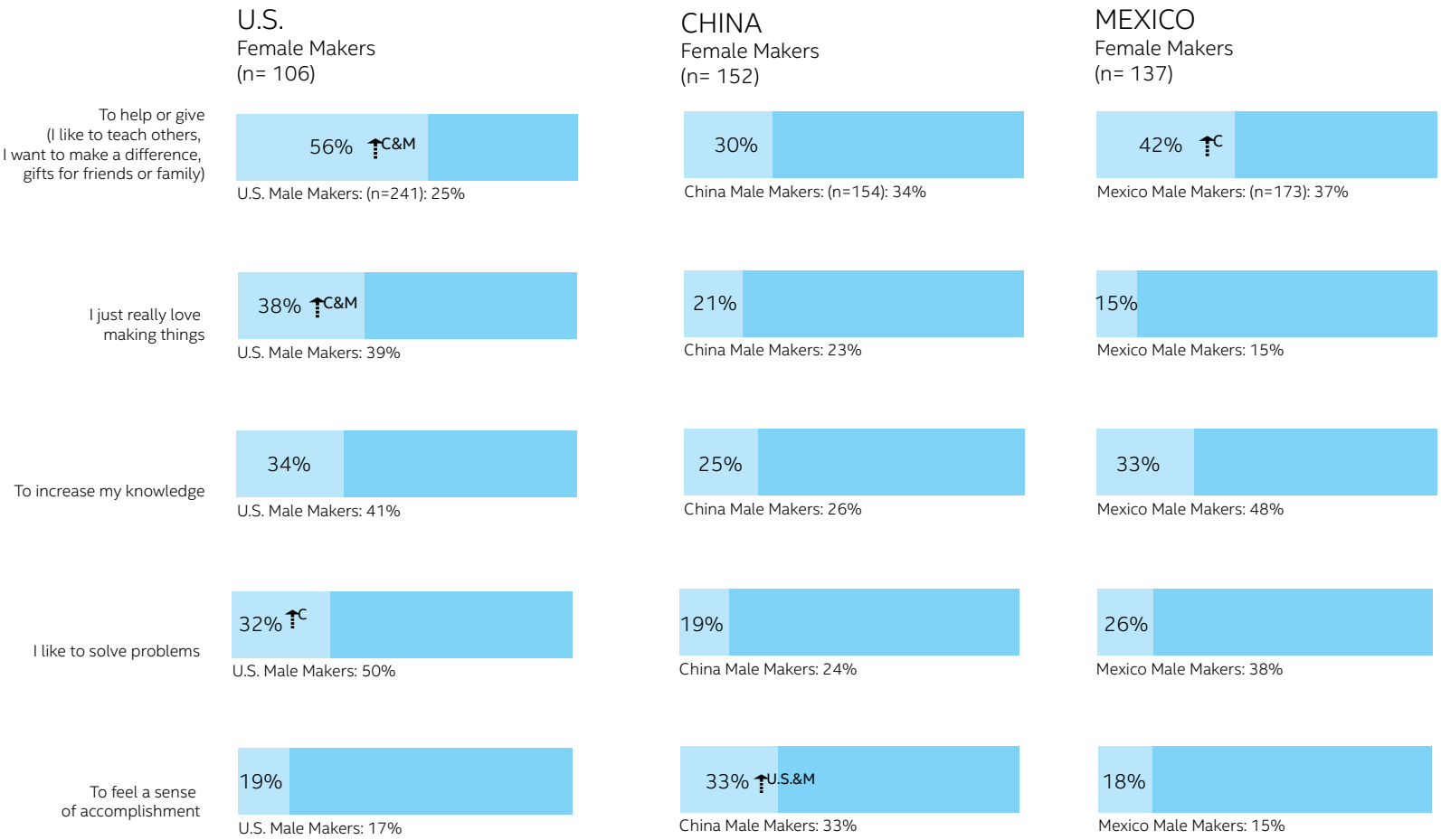
The majority of female makers create with others, whether it be co-workers, their children, or with educators. In the U.S., female makers surveyed are significantly less likely than males to create alone.

I make these types of projects with electronic tools...



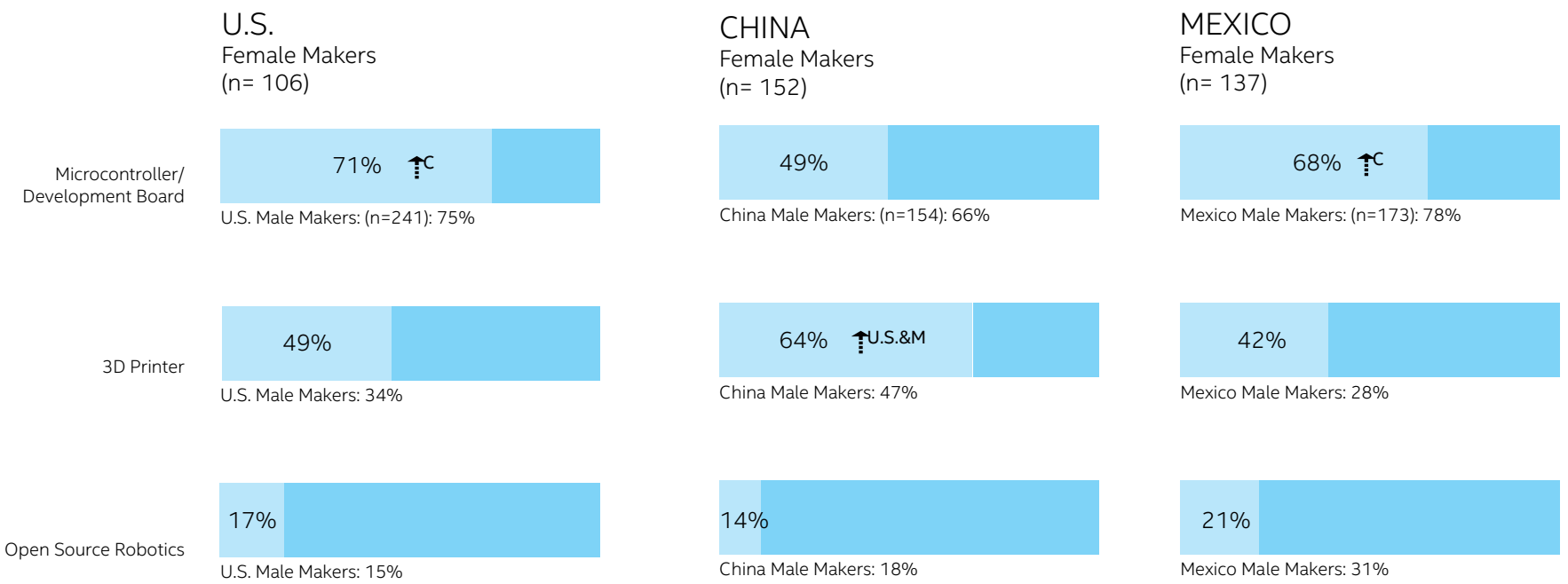
Indicates a significant difference between Male and Female

I make or create things because...



↑ *Indicates a significant difference between U.S., China, and Mexico*

I create physical things using...



Female makers are more likely than males to connect with others through maker events and clubs. Among those surveyed, female makers in all countries were more likely than men to go to Maker events and fairs and participate in a club or social group related to making. Like men, women makers are also likely to be part of online maker communities. Female makers in all countries take part in maker events and online communities. In China, clubs are a particularly important means of interaction for female makers. Just over half of women makers surveyed in China reported that they participate in a club or social group.

GIRLS: Who are the female makers of the future?

Girls and boys equally likely to be "Tech Makers"

Our survey of American youth showed that making is a popular and sizable trend among both girls and boys in the U.S., and girls and boys are equally likely to be "techmakers."[44] Girls and boys participate in making activities in similar places and have similar reasons for making with technology. One-quarter of tweens and teens have made a physical object with technology during the past year. Girls who were makers were most likely to have made an object that has parts that can move, light up or make a sound (53 percent), made clothing or jewelry that lights up (48 percent), and used a 3D printer to make something (23 percent).

Making at school and home

Over half of boys and girls make at home (57 percent) and in class at school (56 percent). Some girls and boys also make in clubs out of school. Girls are significantly more likely than boys (20 percent versus 12 percent) to make in clubs and in groups at school, while both boys and girls are about equally likely to make in a club or

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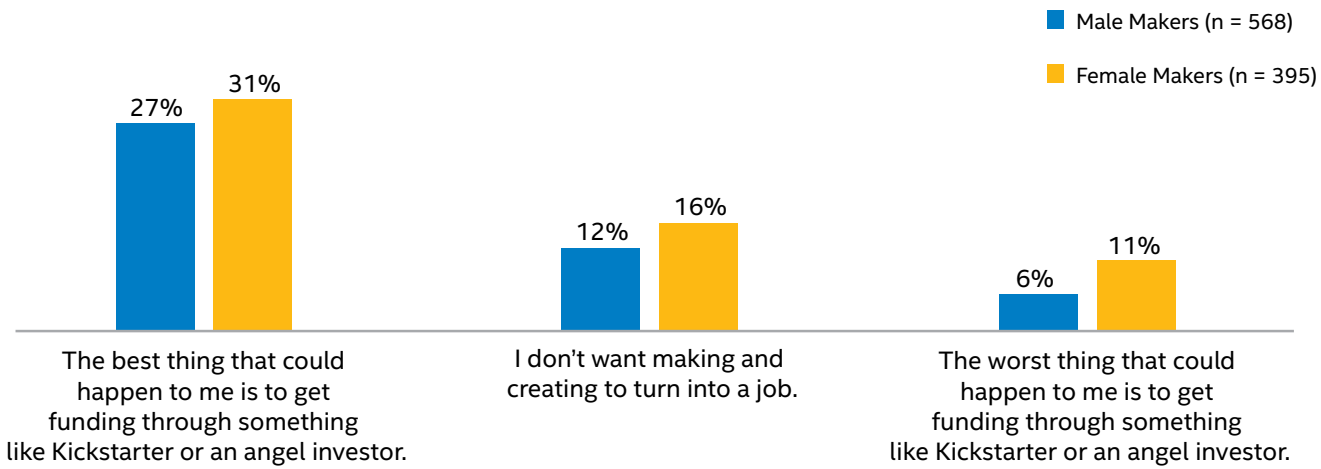


group outside school (10 percent -11 percent).

Girls and boys have similar patterns in their making partners. Youth makers, both male and female, typically make with teachers, friends, and parents. They also make with a club or group leader.

"I have been coming to this Computer Clubhouse since 2009. Here you can let yourself be free from judging. You won't be judged for what you have created. People are always supportive of what you are doing no matter what it is. It's different than school. If you come here with a problem or something you want to make, people will help you with it. In school, people will just tell you if you should do it or not." Adriana, age 13, Computer Clubhouse attendee and participant in Start Making! camp.[45]

Joy of making and learning

Girls and boys have similar reasons to make things with technology. The top two reasons for both boys and girls to use technology to make things were related to the pleasure of learning and the joy of making—that is, "I like to learn new things," and "I really love to do it." Other reasons both boys and girls commonly cited included "for a class assignment," "I like to solve problems and figure out how things work," "I like to make things with my hands," and "It makes me feel proud."

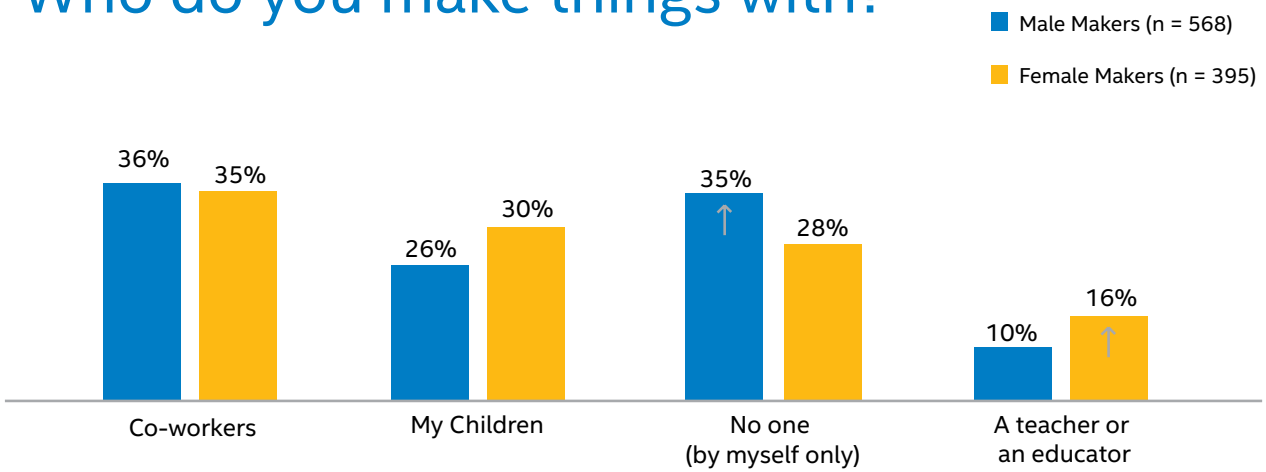
Persistent and socially engaged

All youth makers, both female and male, are more likely than other young people to describe themselves as independent, hardworking, solution-oriented, and social. They were equally likely to reply positively to the following statements:

"We must demonstrate relevance to the lives of girls and the worlds they inhabit... and have rewards associated with it. Some rewards are that life is better; or someone else' life is better; positive feedback and recognition; inclusion in a community that reinforces positive behavior. Girls often make because they like to or have problem they solve. It doesn't take a lot to in-centivize young women to start solving things when they can."

Ruthe Farmer
National Center for Women Information Technology (NCWIT),
Chief Strategy & Growth Officer

Who do you make things with?



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"There is a need to focus on how programs can help young people create an identity that maps to the kinds of STEM-area skills and maker/tinkerer dispositions we hope they'll carry forward into their lives. Here, it's not about a domain-first approach, but about drawing out the learner's identity as a means of engaging these domains more deeply."

Marc Lesser,
Senior Director of Learning Design,
MOUSE

- I follow my own ideas or interests, even if other people don't agree with me.
- I know that if I work hard enough, I can solve almost any problem that I have.
- I have a lot of friends.

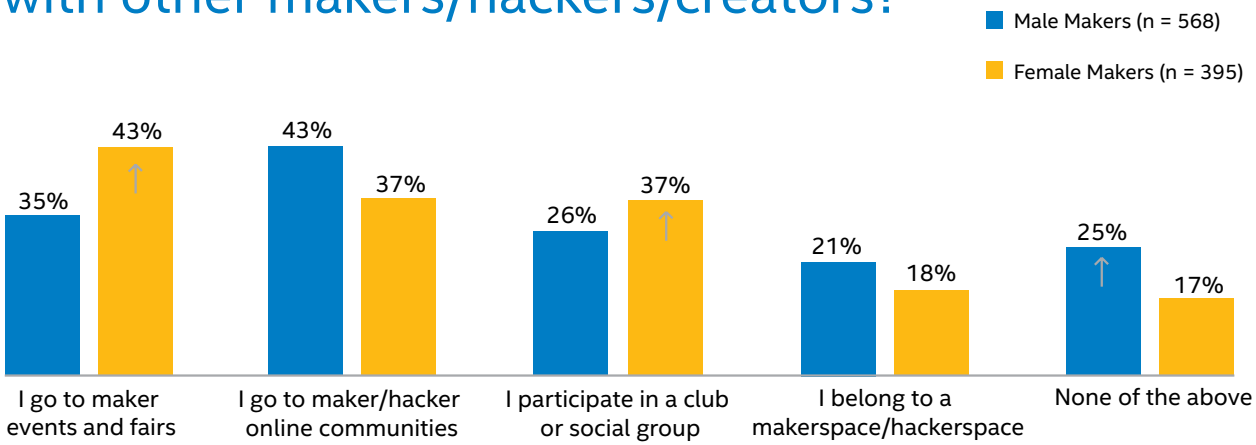
Girl tech Makers are more likely than boys to describe themselves as persistent; they are more likely than boys to report that the statement "If something doesn't work the first time, I usually give up" is not at all like them. Girl tech Makers also are significantly more likely to report that the statement, "I know that if I work hard enough I can solve almost any problem that I have" is "a lot" like them. In addition, girl makers are also more likely than boys to describe themselves as creative, artistic and caring.

Girl makers were significantly more likely than boy makers to report that they like making art projects to show to friends and family. Youth tech makers, both female and male, are more likely than other young people to have access to people and places that foster the creation of things with technology. They were more likely to be in schools with spaces for making and with access to electronic tools (such as 3D printers, microcontrollers, and robotics), know adults who like to do computer programming or create things using technology, and know other people their age who like to do computer programming or create things using technology. They are also more likely to have parents who are interested in their math and science schoolwork and projects.

Youthful appeal of making

Maker activities hold appeal for the majority of youth, both girls and boys. Seven in ten of the youth would like to learn to do "tech maker" activities. Girls and boys are both very interested in learning to make a variety of things with electronics. Tweens, particularly between the ages of 10 to 12, show the greatest interest in tech activities.

Which of the following do you do to interact with other makers/hackers/creators?



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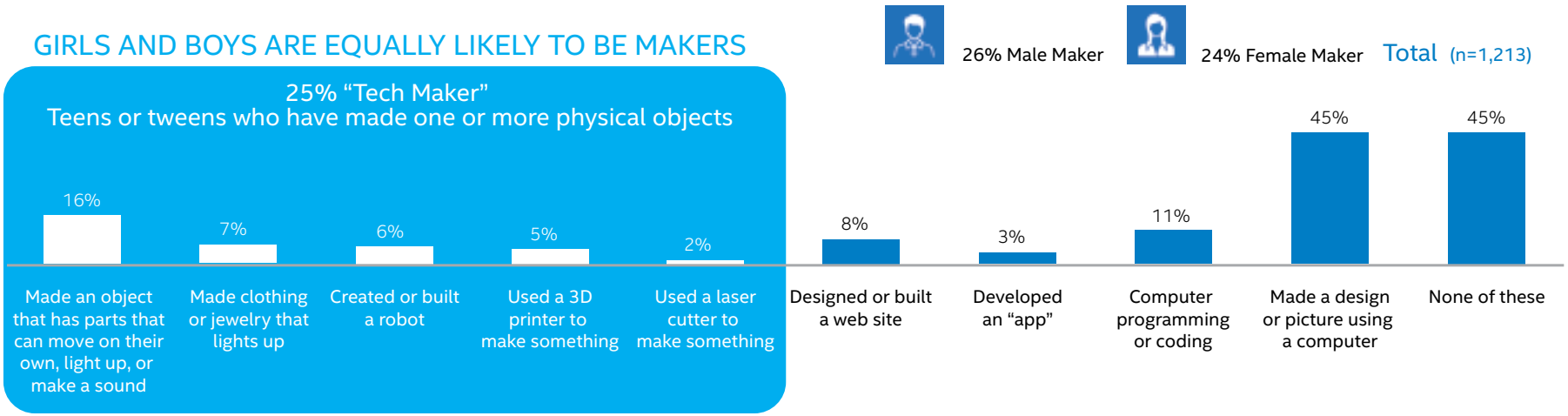
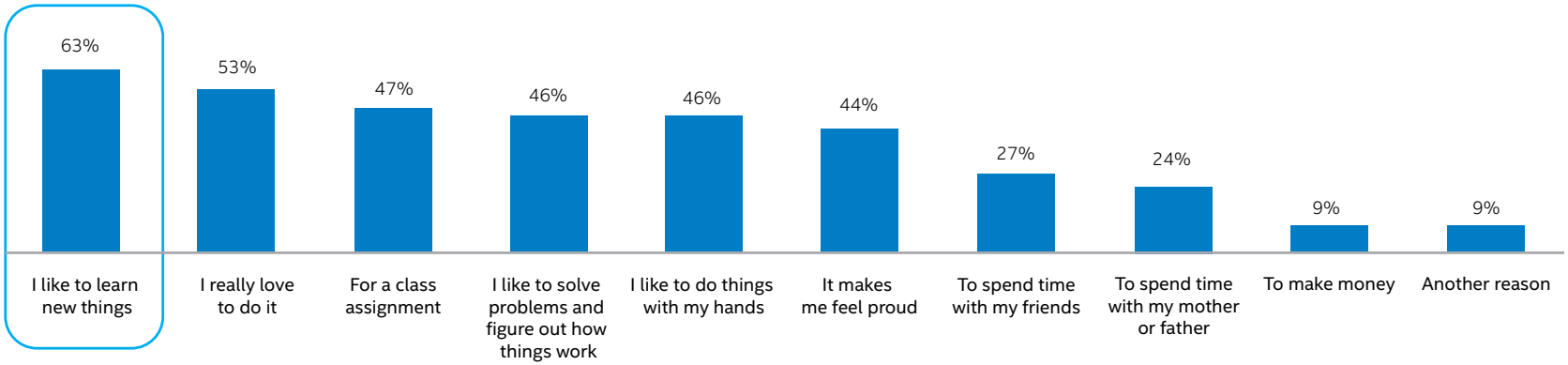
I've done the following the past year...

GIRLS AND BOYS ARE EQUALLY LIKELY TO BE MAKERS



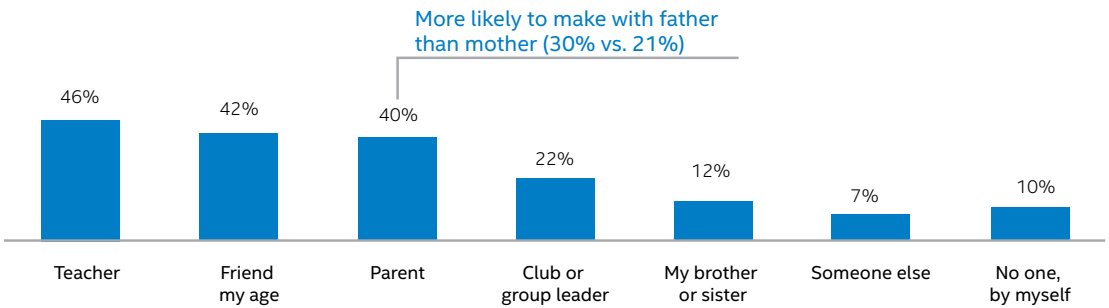
U.S. Youth, girls and boys

I use technology to make things because...



"Tech Maker" (n=284) U.S. Youth, girls and boys

Whom I make with...



"Tech Maker" (n=284) U.S. Youth, girls and boys

Where the making happens...

56% at school

55% at home

18% at a club at school

13% at a club outside of school

Who are the guardians of the makers of the future?

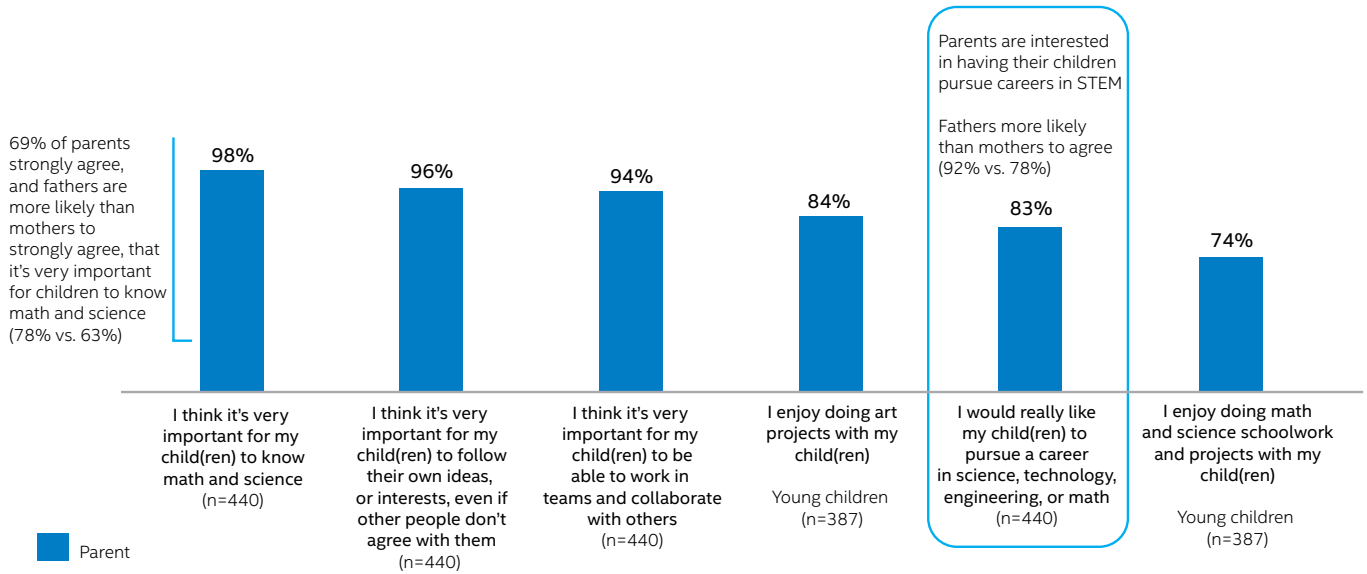
Parents recognize the benefits of making. The survey of U.S. adults included 440 parents of children under 18 living in their household. Nearly all parents surveyed believe that getting both girls and boys involved with making and creating things with electronic tools is a great way to build interest and skills in STEM, essential for their future career.

Parents support children's interest in math and science and would like their children to pursue a STEM profession. Most (69 percent) strongly agree that it's very important for children to know math and science. Fathers are more likely than mothers to strongly agree (78 percent vs. 63 percent). Parents agree it is important for children to be able to work in teams and collaborate with others, as well as to follow their own ideas or interests, even if other people don't agree with them. Parents enjoy engaging with their children in both art projects, and in science and math projects, with their children. The majority of parents indicate interest in having their children pursue careers in STEM.

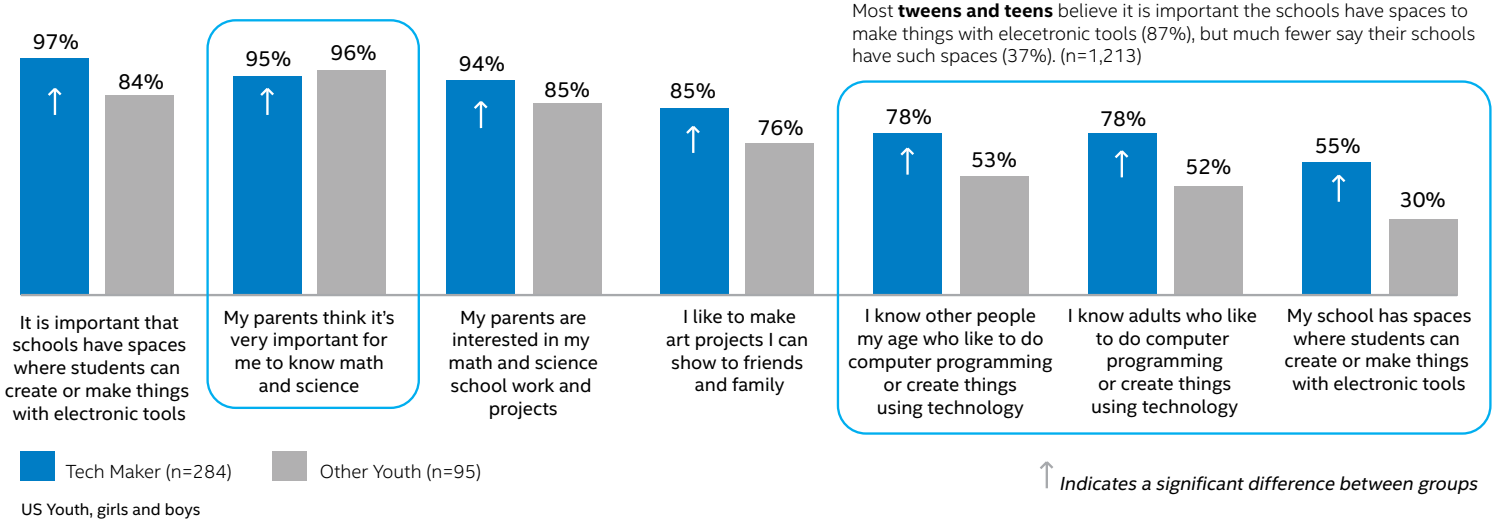
Nearly all parents (97 percent) agree that it is essential that children today have strong math and science skills in order to be prepared for college and a career. Most parents (94 percent) also agree that getting kids involved with making and creating things with electronic tools is a great way to get them interested in the fields of STEM. Most parents (84 percent) think schools and libraries should provide spaces where kids can create or make things with electronic tools (such as 3D printers, microcontrollers, and robotics). Two thirds of parents agree that kids don't have enough opportunities to be creative.

A majority of parents of both boys and girls think it is important for their children to learn to make things with technology. They are particularly supportive of activities that teach their children to make objects that have parts that can move on their own, light up, or make a sound; to create or build a robot; to use a 3-D printer to create something; and to make clothing or jewelry that lights up.

I somewhat or strongly agree that...



I somewhat or strongly agree that...



US Youth, girls and boys

Most **tweens and teens** believe it is important the schools have spaces to make things with elecetronic tools (87%), but much fewer say their schools have such spaces (37%). (n=1,213)

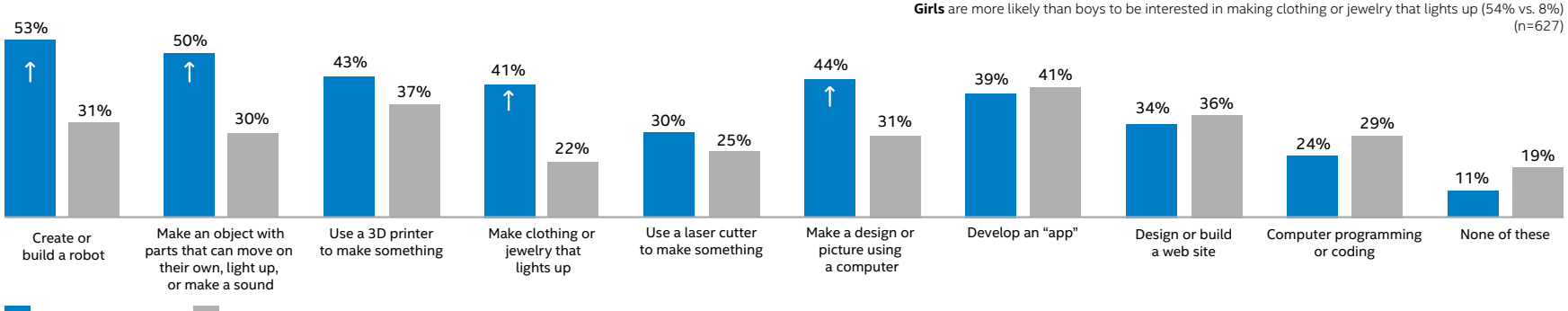
↑ *Indicates a significant difference between groups*

I would like to learn to...

71% of tweens or teens are interested in tech maker activities, with the greatest interest from tweens

Boys are more likely than girls to be interested in creating or building a robot (50% vs. 31%) or using a laser cutter to make something (30% vs. 24%) (n=586)

Girls are more likely than boys to be interested in making clothing or jewelry that lights up (54% vs. 8%) (n=627)



US Youth, girls and boys

↑ *Indicates a significant difference between groups*

3 Factors influencing engagement in Making

This section of the paper examines the factors that influence the engagement of girls and women in making. By recognizing and addressing these factors, we can develop informed initiatives and policies to support their participation in making. Based on more than 20 interviews with experts in the maker space and literature review, these factors emerged as key influencers of engagement for girls and women.

Factors that influence women's and girls' engagement in making

The chart at right describes the factors that affect the engagement of women and girls in making at both the individual and environmental levels. These factors are both negative and positive, some typically acting as barriers to women and girls, and others as factors that enable the ongoing involvement of women and girls in making.

In general, the survey showed that male and female makers surveyed face similar challenges to making, such as lack of money, lack of information, and lack of money. Additionally, women cited lack of mentorship, cultural biases about the appropriateness of women in making, and safety as challenges they faced. Among those surveyed:

- One in six (or 17 percent) has been excluded for being a woman.
- One in six (17 percent) said she lives in a culture where making is viewed as inappropriate for girls and women.

Factors Influencing Women's and Girls' Engagement in Making

Mentorship	• Presence of role models and mentors for female makers
Gender Norms	• Availability of female-only and female-friendly maker spaces, with safe, access
Interest and Personal Relevance	• Understanding why making is interesting, relevant, and useful and how it can be tied to personal interests
Community and Collaboration	• Availability of a supportive community of makers and opportunities to collaborate in making
Early Encouragement	• Parental encouragement and engagement in girls' making • Availability of initiatives and approaches to support children's engagement
Learning Approaches **- Multi-disciplinary** **- Learning through Play**	• Multi-disciplinary educational approaches and initiatives to support learning through the integration of different disciplines • Educational approaches and initiatives to support learning through play

- One in 14 (7 percent) doesn't feel safe going to maker activities.

Mentorship

Among all female makers surveyed, lack of mentorship was their third top challenge. A third of women found lack of mentors as a challenge, while only a quarter of men found it was a challenge. Lack of mentorship is particularly a problem for female makers in the U.S., as well as for both males and females in China.

Evidence from other research also supports the importance of mentorship to females. Role models and mentors play a key role in girls' personal and professional development, as well as in their leisure activities.[46] Relationships with mentors benefit girls in many ways, such as fostering their creativity and entrepreneurialism. Research on innovative young people revealed a "stunning pattern" of a significant relationship with a teacher or mentor in every case.[47] Women pursuing professional lives gain a great deal from personal relationships and mentors. This is particularly true in the male-dominated IT field, where people influence women's image of the field and who can work in it, as well as their own perceptions of their abilities, skills and experiences. Role models and mentors play a key role in helping to support women's entry into and persistence in the IT profession. Research shows that women working in IT identify a number of people who encourage them in their career path.[48] Such relationships enable them to get information from others with similar interests, problem-solve through difficulties, and find

Challenges and barriers I have faced...

	U.S. Female Makers n=106	China Female Makers n=152	Mexico Female Makers n=137
Top challenges	1. Lack of money 2. Lack of mentorship 3. Lack of information 4. Lack of access to tools and materials	1. Lack of information 2. Lack of mentorship 3. Lack of access to tools and materials	1. Lack of money 2. Lack of access to tools and materials 3. Lack of information 4. Lack of local, like-minded people
Challenges related to being female	**17%** have been excluded for being a woman **11%** face cultural views of inappropriateness **12%** don't feel safe going to Maker actvities	**13%** have been excluded for being a woman **16%** face cultural views of inappropriateness **5%** don't feel safe going to Maker activities	**20%** have been excluded for being a woman **22%** face cultural views of inappropriateness **5%** don't feel safe going to Maker activities

networking opportunities. However, females find it hard to get access to role models and mentors in computing, particularly female ones. Evidence from the field of computer science shows that female students lack the personal relationships and mentors to which men have access.[49] This dearth of personal support creates additional challenges for females, making it harder for them to pursue a professional life in the field.

Gender norms

Female makers also experience gender norms, bias and stereotypes that negatively affect their involvement in making and their access to maker spaces. As described earlier in this section, negative gender norms such as exclusion for being a woman and living in a culture where making is considered inappropriate for girls and women are experienced by a considerable number (17 percent) of women surveyed, making it harder for them to freely engage in making as they might do otherwise. Some women surveyed (7 percent) also are concerned about their safety when taking part in making activities.

"There are a lot of cultural challenges in getting to girls to participate in the STEM activities. In my clubhouse, the girls are expected to come home and take care of the house after school. We have a Latino culture in our community, which means that until girls turn 15, they are more prone to be home afterschool and helping parents—for safety and because of culture." Jannette Nelson—Computer Clubhouse network program coordinator for youth programs

Gender norms and stereotypes can likewise discourage women's participation in computer science and engineering. Evidence shows that the perception of computer science as a male field is a factor in discouraging girls from participating in computing classes. Such stereotypes also reinforce expectation of success in computing in favor of men, which can motivate them to engage further in that domain, while also discouraging girls from entering computing.[50]

Gender norms also affect the maker spaces available to women. Among those surveyed, women tend to make in mixed company, while men surveyed are more likely to interact with a maker community of the same gender. Typical spaces for makers tend to be male dominated. In a survey of 250 hackerspace members around the world, 90 percent of respondents were male.[51] As a result, girls and women may be intimidated at times to participate freely in such spaces. For example, unbalanced gender participation in computer classes in high school has been found to be a discouraging factor for female students who may be hesitant to enroll in these classes.[52] In extreme cases, harassment and an unfriendly atmosphere in maker spaces may discourage women from participating. Women may face pressure from male peers to prove that they belong. Such difficulties discourage women from participation.

The range of maker spaces available to women-only is limited. The spaces that do exist for female makers can

"A great learning model for maker activities is connecting what young people are doing that is interesting and looking at opportunity spaces to engage them. The cultural resonances are important. Because kids are different, we need to reach them in different ways. We have to give kids cover in able to legitimatize who they are right now and provide them with entry into different worlds"

Mimi Ito, Professor in Residence at the Humanities Research Institute at the University of California, Irvine

"We have a number of strategies to get more girls to participate at the Clubhouse. We are trying to add activities that are attractive to girls, like editing and film club. We make crafts by sewing. The girls in our club are interested in more than crafts, but we see that as a way to get girls into the maker activities."

Alejandro Jiménez Espinosa, Computer Clubhouse Coordinator, Mexico City, Mexico

be limited in number and may offer a narrow range of tools, kits, and types of activities. This lack of female-only maker spaces can make it hard for women to gain access to a community of female makers. As a result, while men are able to get together to make, women who want to work with others have to be more resourceful, working in mixed groups and opposite gender groups.

"Our geek cred is constantly challenged or belittled. You might be there coding, and you want to stop for a while and draw in your notebook and think, but if you're not staring at a black and green screen or, like, melding your brain with an Arduino every second, some dude is going to come up to you and act like you need his expert lessons in how to hack." – Liz Henry, Co-Founder, Double Union[53]

Female-friendly maker spaces, in-person and online, can connect women to other women in the field, providing them with a community and potential role models and mentors for inspiration and assistance. An analysis of the community website of LilyPond, a music engraving program, indicates that two of the primary ways members use the site are to find information and inspiration and make community connections.[54] Access to such communities is particularly helpful for girls when most users are female. While toolboxes are typical toys for boys, girls are not usually encouraged to work with tools and workbenches. Seeing female peers actively participating in making activities helps offset such gender stereotypes that can negatively affect girls' identity and performance.[55]

Interest and personal relevance

Interest, self-identity and personal relevance are closely tied and each has a potentially important influence on women's and girls' engagement in making.

Interest and self-identification

Our interests and sense of identity help define our choices and actions. Understanding the interests and identities of female makers is important for strengthening female engagement in maker activities. There is a tension between acknowledging female interests and stereotyping them. While we recognize existing patterns in women and girls' engagement in making, we have to be careful to ensure these do not limit the range of options available to each individual female. The female makers surveyed and interviewed reflected a wide range of backgrounds and disciplines that did not box them into one identity. They came from a diversity of backgrounds such as engineering, computer science, design and arts, to name a few. They were also interested in making a wide variety of things, similar to the diversity of interests of male makers. That is the essence of making: that one can make virtually anything based on available materials, interests, and passion.

The patterns among women makers surveyed indicate some conflicts between background, interests, and identity. As shown in results from surveys, although female makers are more likely to have engineering or computer and information science degrees than any other credential, they do not always identify

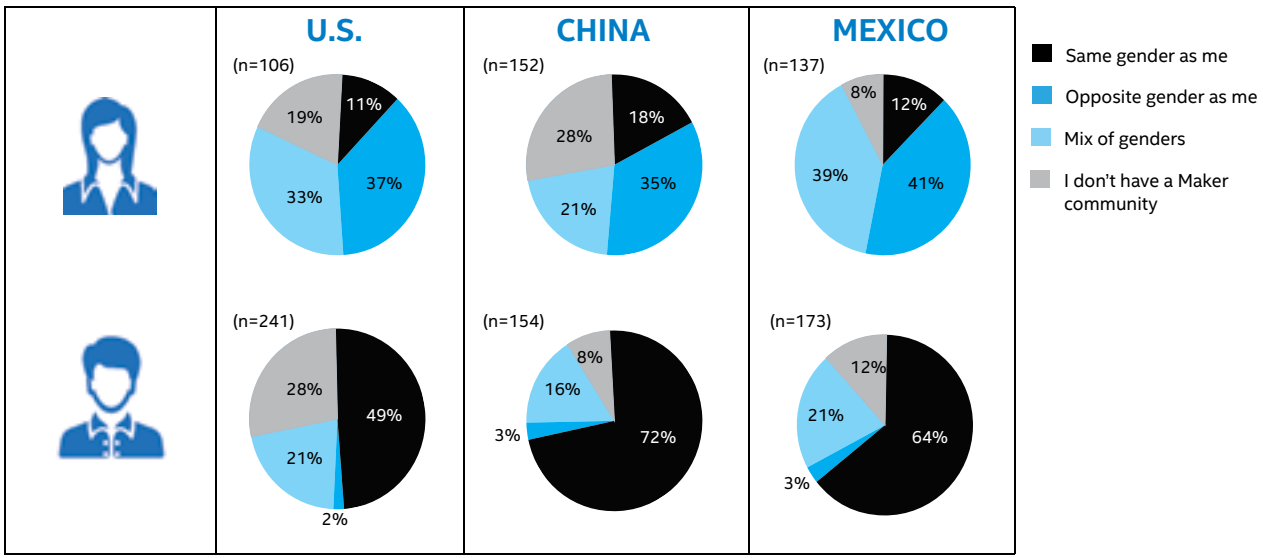
strongly with engineering and science. Despite the fact half of female makers have backgrounds in engineering or computer and information sciences, many female makers describe themselves as coming to making via different paths, such as the arts.

Women may be underrepresented in making computer science and engineering communities and fields because of a lack of interest in these disciplines due to the way they are currently established or advertised.[56] For example, females are underrepresented in robotics and computer programming, yet these are often the types of activities emphasized by formal and informal education programs in relation to making. Designers of the LilyPad Arduino kit argue that one of the underlying reasons for this lack of interest may be narrow traditional disciplinary boundaries and limited breadth in computing fields, both intellectually and culturally.[57]

"Lack of participation in STEM is partially a matter of perception. Women ask, 'Is this something that feels like me? Do I see people like myself?' It does not feel accessible. But if you start to layer things on top, like the LilyPad, [which] resonates with people's interests, it makes it easier. Design work can help to bridge some of the lack of experience and make STEM more accessible." Yasmin Kafai, Professor of Learning Sciences, University of Pennsylvania Graduate School of Education

A lack of identification may be a barrier to women's interest and engagement in some of the more tech-oriented aspects of making, at least initially. Once women engage in making, a lack of self-identification with science does not prevent them from engaging in using

The Maker community I interact with is...



technologies, such as smart devices and 3D printing. Both are common aspects of making among the females surveyed. But the bigger issue may be getting girls and women involved in making in the first place.

Based on the survey results and multiple paths people take to come to making, the arts may be one starting point to facilitate entry into making. A broader multi-disciplinary approach incorporating individual interests might draw more females into making. These can be used as a "hook" to stimulate their initial engagement in making.

"There is a need to focus on how programs can help young people create an identity that maps to the kinds of STEM-area skills and maker/tinkerer dispositions we hope they'll carry forward into their lives. Here, it's not about a domain-first approach, but about drawing out the learner's identity as a means of engaging these domains more deeply." —Marc Lesser, Senior Director of Learning Design, MOUSE

Personal relevance

People are attracted to projects they find personally relevant and meaningful. Research by psychologists Chris S. Hulleman and Judith Harackiewicz University of Wisconsin suggests that for most people, whether one finds something interesting is largely a matter of whether you think it is personally valuable. For many students, "science is boring because they don't think it's relevant to their lives."[58] Involvement in the design of maker projects can strengthen a learners' engagement by enabling them to tie their work to their personal interests, experiences and strengths. Evidence shows that effective strategies for engaging girls include hands-on, authentic science

Female Makers (n=395)

Male Makers (n=568)

	Female Makers (n=395)	Male Makers (n=568)
Uses what they make	**48% family members** **41% friends**	**42% family members** **37% friends**
Inspires their making	**34% (my family)** **24% (in-person community of Makers)**	**27% (my family)** **20% (in-person community of Makers)**
Provides information about making	**40% (friends or family)**	**28% (friends or family)**
Helps solve problems during making	**37% (friends or family)**	**29% (friends or family)**

Green text denotes a significant difference between males and females.

explorations tied to personal experiences[59] and allowing them to co-create curriculum based on their interests and strengths.[60]

Evidence shows that girls are motivated by projects that allow them to problem-solve, particularly those that enable them to help people and make a positive community impact.[61] Among women makers surveyed, the top reason for making is to help or give. Women's attraction to real world issues is supported by studies of gender differences in men and women's interests in computing. Women are often drawn to broad applications of computing, such as the application of computing for solving real world problems—"computing with a purpose." [62]

"We must demonstrate relevance to the lives of girls and the worlds they inhabit... and have rewards associated with it. Some rewards are that life is better; or someone else' life is better; positive feedback and recognition; inclusion in a community that reinforces positive behavior. Girls often make because they like to or have problem they solve. It doesn't take a lot to incentivize young women to start solving things when they can." Ruthe Farmer National Center for Women Information Technology (NCWIT), Chief Strategy & Growth Officer

The maker movement highlights the importance of personally meaningful projects,[63] enabling girls and women to pursue and cultivate their interests, whether related to joy, aesthetics, or helping others. Makerspaces and formal and informal making initiatives provide women and girls with the opportunity to work on projects they value the most in which the purpose, buildstructure and design of the objects they make, all can reflect personal significance.

"A great learning model for maker activities is connecting what young people are doing that is interesting and looking at opportunity spaces to engage them. The cultural resonances are important. Because kids are different, we need to reach them in different ways. We have to give kids cover in able to legitimatize who they are right now and provide them with entry into different worlds" Mimi Ito, Professor in Residence at the Humanities Research Institute at the University of California, Irvine

Children often become engaged with new technologies, and learn through playing with these technologies, when they work on projects growing out of their own personal interests. When children care deeply about the projects they are working on, they are not only more motivated but they also develop deeper understandings and richer connections to knowledge.[64]

"The way to get young people interested in technology is to study what they do—not with intent of accepting it or changing it, but to look at patterns of activities of childhood and think about those as foundations for new design and maker activities." Mike Eisenberg, Professor, Department of Computer Science, Institute of Cognitive Science, Center for Lifelong Learning and Design, University of Colorado, Boulder.

"There was an immediate impact for parents. It made them aware of what making entailed, and they indicated that they would have sent their kids to the Clubhouse sooner if they had understood the true benefits."

Suha, Director, ICT for Development Program and Former Computer Clubhouse Coordinator, Jordan

"In our work in after-school centers and museums, my colleagues and I have seen how important it is to provide multiple entry points into new learning experiences. An approach we have found effective is to offer workshops focused on creative themes that support a diverse range of project ideas. For example, rather offering a workshop focusing on the technology, such as, "Introduction to Robotics," we will choose a creative theme, such as "Design a Park," "Make an Interactive Animal," or "Create a Celebration." We can introduce the same concepts and skills, but in a way that attracts youth and families with more diverse interests and backgrounds—and results in a broader array of projects, extending beyond the typical robotic car to include ideas such as sensor-activated owls, merry-go-rounds, soccer scoreboards, and music-making machines.

The design of the workshop environment and interactions also can support broader engagement. We typically start workshop sessions with group members facing each other (rather than the technology) and engaging in a warm-up activity that relates to the theme. We share a couple of example projects that are inviting for beginners and suggest a playful range of possibilities. We provide familiar objects and materials for designing—along with new tools and technologies—to expand the range of potential projects and to enable people to build on their existing skills. Throughout the workshop, we make time to encourage sharing of process with other participants. Our workshops often culminate in an exhibition where participants share their creations with friends, family, and other community members. We see the potential of the maker movement to expand these approaches to other settings in order to engage more young people in learning through creating projects that build on their interests and experiences."excited about making, reaching out to girls and minorities who are underrepresented in STEM careers, and just having a great time letting creativity reign."

Natalie Rusk, Research Specialist in the Lifelong Kindergarten Group at the MIT Media Laboratory developing creative learning technologies; Lead developer of Scratch; started a model after-school program called the Computer Clubhouse.

Community and collaboration

Social interactions and motivations and a sense of community are deeply tied to women's and girls' engagement in making. Results from surveys show that, in addition to being connectors and being motivated by wanting "to help or give" to their community, women makers depend on personal and community connections to support their making more than men. They are more likely to rely on personal connections as resources throughout the course of a making project, from inspiration to troubleshooting when they get stuck. Female makers surveyed are significantly more likely than males to rely on friends and family to get information and support to help resolve problems related to making. Family is also significantly more likely to be an important source of inspiration for their making.

A supportive community and the opportunity to share their work with others are important for the progress of female makers. When asked what helped "a lot" to get them where they are today, female makers surveyed cited the importance of supportive teachers, supportive parents and supportive peers, as well as the opportunity to celebrate their creations.

Female makers, like male makers, believe that collaboration and social interactions are an important aspect of making. Among those surveyed, both women and men agreed that collaboration is a key part of making/creating a thing and that making and creating things is an important part of their social life.

Evidence indicates that girls generally prefer more collaborative relationships to competition.[65, 66] Participants in technical programs prefer working

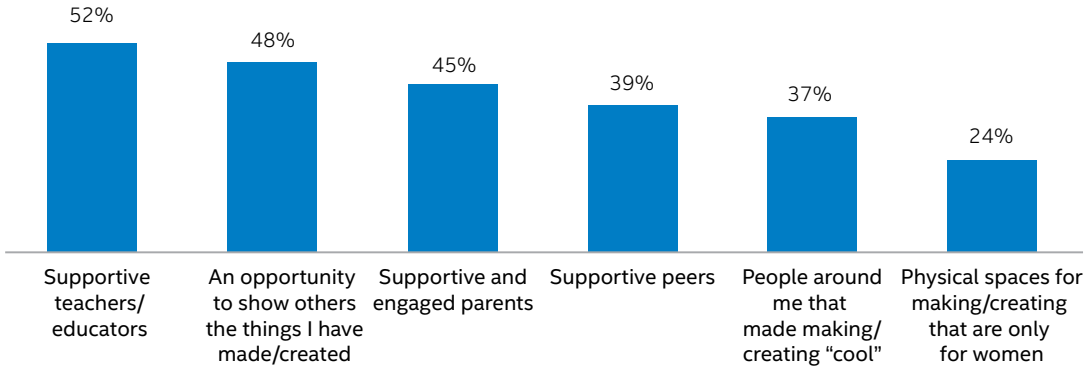
with others to working on their own and gain many benefits through collaboration. By working together in the Techbridge program, for example, girls learn from other's questions, offer support to those who are struggling with a step, and jointly discover that mistakes are part of the scientific process and can lead to more effective problem solving.[67] Rather than competing against each other, girls help each other improve their outcomes. When such approaches provide girls with specific, positive feedback on things they can control—such as effort, strategies, and behaviors—their confidence, as well as performance improves.[68]

"For kids in general, it is really important that their work is real and out there in the world. Things like getting kids to show work at maker faire and getting them to write instructables—is hugely motivating for them. Being part of maker culture—when it is mixed with adults and kids can be really great..." Ann Eisenberg, CU Boulder

However, competitions are common in the STEM fields. Science fairs and robotics championships provide forums to highlight the skills and achievements and attract new participants. One study indicates that, while many robotics activities are structured as competitions, these can be motivating for many students, but alienating for others.

It shows that an alternative approach is to offer the opportunity for young people to display their work through exhibitions rather than competitions. This is a strategy to engage young people with diverse interests and learning styles.[69] Making offers both girls and boys a more collaborative way to learn computer science and engineering skills within a community of makers. Maker events, such as Maker Faires and maker spaces, are designed to promote connection and collaboration

These helped me a lot to get where I am today...



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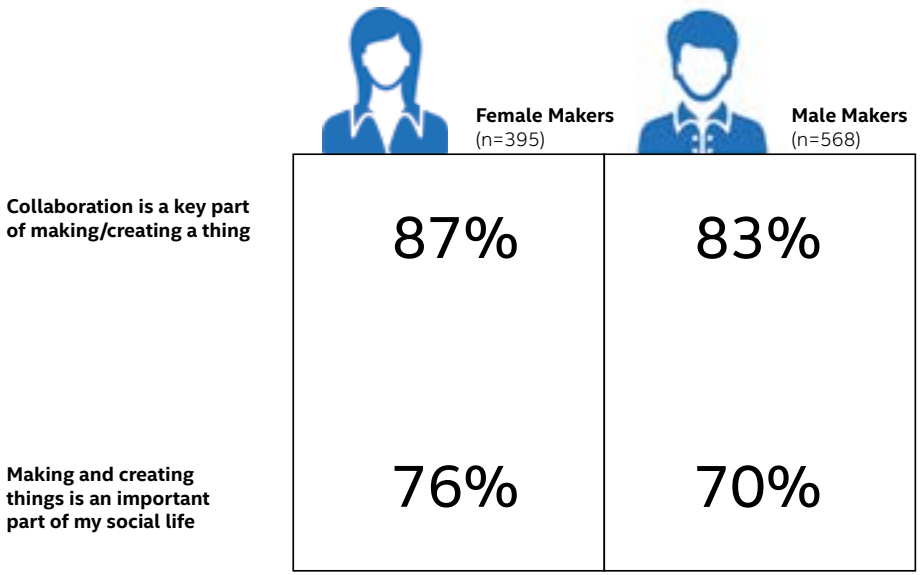


"I feel like what I'm doing is art and technology. The technology is a tool to make my art better."

Sammy, Age 12
Attendee at Computer Clubhouse and Maker Camp

among makers. Maker spaces, both in-person and online, provide a social platform for makers to meet and interact. They enable people to find others with similar interests and issues, motivating their ongoing engagement in making. For example, a qualitative study of three maker spaces in rural public libraries found that members of these spaces describe them as spaces of social engagement, which enabled them to share the discovery process and support each other. A collaborative process of building knowledge in these spaces is a key factor in motivating ongoing participation, perhaps even more important than the availability of high tech tools.[70]

Similar findings are reported in research on virtual communities related to making. A study on the adoption of construction kits found that social interaction—whether among small groups or across communities of thousands of members—is critical in the use of technology.[71] The Scratch community provides a good example of the importance of collaboration and community support for its membership, as well as for innovation. The development of the Scratch programming language grew in parallel with the development of its users' website. Users collaborated, supported, and critiqued each other, spurring creativity and building on each other's designs.[72]

"Culture privileges competitive male ways of engaging. One prominent example can be found in robotics competitions, which undermine women's participation. But if you have a showing of robots in a gallery setting—something non-competitive—everyone wins. Galleries allow for more divergent and aesthetically compelling design possibilities. Maker Faires are similar in this respect and excel at providing opportunities to showcase your work." Kylie Peppler, Head of Make to Learn Initiative and Assistant Professor of Learning Sciences, Indiana University Bloomington.

Early engagement

Early engaging projects can help children gain skills and experience at an early age. Evidence indicates that girls can be disadvantaged by a delay in their interest in and attachment to computers. Early attraction to computing can lead to longer-term advantages, yet studies on patterns of computer engagement show that more boys experience an early passionate attachment to computers than girls.[73]

Parental support and engagement is critical to ensuring girls' early exposure to computing. By engaging in maker activities with their children at an early age, parents can encourage girls' attachment to computers and enable them to gain experience that can help them succeed throughout their education. Our survey results show that parents recognize the benefits of making for their children's futures and support their children's involvement in making. Educational programs and initiatives can help translate this support into action by engaging parents in making with their children through parent-child activities designed to attract parents. Making initiatives also can help to address the gap in early

exposure and attachment by using methods and tools that appeal to girls and young women. They can engage girls in making through tapping into their interests and facilitating playful learning experiences. For example, Robot Diaries enables young people to develop their own robots from craft materials and instill them with emotional expressions that they can share with their friends. It has been successful in appealing to middle school girls and improving their technical competency.

One recommendation for getting girls engaged in making in the Computer Clubhouse in Jordan is inviting families. On the International Day of the Girl, we invited parents to participate in a maker activity at the clubhouse and opened it to the community. The girls were engaged and took a lead role in planning everything. There was an immediate impact for parents. It made them aware of what making entailed, and they indicated that they would have sent their kids to the Clubhouse sooner if they had understood the true benefits." Suha, Director, ICT for Development Program and Former Computer Clubhouse Coordinator, Jordan.

Each of these factors can have a positive influence on encouraging girls to take part in making activities and to become makers. Appropriately designed initiatives and policies do a great deal to determine just how powerful this positive influence is.

Learning approaches

Two learning approaches have a particularly strong potential to strengthen women's and girls' engagement in making: a multidisciplinary approach and "learning through play."

Multidisciplinary approach

There are multiple pathways to making, whether via engineering, computing, science, arts, design, or another discipline. Combining different entryways can be a way to engage more people in making. The arts, for example, can create an entry point for broader engagement in science, math, and computing. The computing and craft mix can be especially useful for youth who are alienated by abstract traditional science and math educational approaches. They thrive on the opportunity to engage in learning by doing via design and experimentation.[74] E-textiles and other "computational craft" kits allow students to combine traditional arts with computing and electronics. Students may be more comfortable exploring and experimenting if they are working with familiar materials—mixing the "unfamiliar with the familiar"—and they may also be more intrigued when unexpected things happen.[75]

Studies of maker spaces show that female participants become more engaged in learning new technology-based skills when they are integrated with arts.[76] The success of the LilyPad Arduino, a microcontroller board designed for wearables and e-textiles, with women also supports this finding. A study comparing the user-base of Arduinos and LilyPad kits, showed that 65 percent of LilyPad projects were done by females, while 86 percent of the user base of the more traditional Arduinos was male.[77] Storytelling is another way to use creativity to make computing more attractive to females, particularly girls.[78]

"We have a number of strategies to get more girls to participate at the Clubhouse. We are trying to add activities that are attractive to girls, like editing and film

The Culture of Innovation

There are five elements of innovation that help develop imagination persistence and entrepreneurialism in youth. These elements reinforce the importance of several of the enabling factors discussed earlier and help explain how the maker movement stimulates innovation. are five elements of innovation that help develop imagination persistence and entrepreneurialism in youth. These elements reinforce the importance of several of the enabling factors discussed earlier and help explain how the maker movement stimulates innovation.

1. **Individual achievement versus collaboration**
   It's a complete myth that innovators work alone.

2. **Specialization versus multi-disciplinary learning**
   We compartmentalize learning by discipline. The innovative process crosses boundaries.

3. **Risk avoidance versus trial and error**
   Schools are highly risk averse. When you make a mistake in school, you fail. Not so in the culture of innovators who are encouraged to take risks. Fail early, fail often, or as Olin College of Engineering puts it: "It's about iteration."

4. **Consuming versus creating**
   Learning can be an overwhelmingly passive experience. In the best classrooms that produce innovators, students are creators, not consumers.

5. **Extrinsic versus intrinsic motivation**
   How do we motivate learning in our schools? In the children who are innovators, parents have deep confidence in their children's ability to find their passion. As one of the teacher/mentors puts it: "Make sure there is whimsy in everything,"

Source: "Design-Make-Play: Growing the Next Generation of Science Innovators," Report of Conference held at New York Hall of Science in May 2012. Queens, NT: New York Hall of Science.

club. We make crafts by sewing. The girls in our club are interested in more than crafts, but we see that as a way to get girls into the maker activities." Alejandro Jiménez Espinosa, Computer Clubhouse Coordinator, Mexico City, Mexico

Multidisciplinary approaches can also enrich formal education. The goal of STEAM, with the A for arts, is to integrate the arts and humanities in STEM in order to promote creativity and versatility for the evolving workplace. The STEAM curriculum encourages learning by doing and "engaging learners in team-based multidisciplinary problem-solving through mentoring, learning communities, research projects, and partnerships with outside agencies."[79] Traditional STEM degrees focus on convergent thinking, which builds skills in understanding and solving complex problems. However, skillful innovation also requires the divergent skills that are the focus of arts and humanities fields, which help to apply solutions to the problems in the real world.[80] Through promotion of creativity and opportunities for self-expression and personal interest, STEAM has the potential to revitalize the STEM field.

"I love art. You can express yourself in art. What you draw describes how you feel. You can do that with this maker stuff, as well. You take the stuff sitting around you and make what you want instead of going to the store. I feel like what I'm doing is art and technology. The technology is a tool to make my art better." Sammy, Age 12, Attendee at Computer Clubhouse and Maker Camp.

Learning through Play

Many people are drawn to learning through exploration and play. Play can be effective and can lead to rich learning experiences. Research indicates that girls may enjoy hands-on, open-ended projects and investigations, and play as a way to learn.[81] For example, in a Girl Scout/NCWIT study, women reported that the hands-on activities in informal IT programs were the best aspect of the program, enabling them to manipulate technology, program, design, and create.[82]

"Tinkering" is a playful, experimental, iterative style of engagement that encourages makers to explore new paths, imagine new possibilities, and reassess goals. Tinkering strengthens innovation and resiliency, and helps prepare youth for our rapidly changing world.[83] "Design-Make-Play" is a motivational methodology aimed at improving engagement and learning through a collaborative process through which designers and makers learn from and build on others' ideas, often adapting codes and techniques. These methodologies build self-efficacy, drive, persistence, and passion into science learning."[84] Making lends itself to playfulness and allows children and adults to secure the learning benefits of playing. Enabling children to play with construction toys, take things apart and put them back together again, and work with their hands, develops their spatial skills, which promotes student interest in mathematics, physics,

engineering, and computer science. Strong spatial skills also enable girls and boys to be more confident about their abilities and express greater interest in pursuing STEM-related subjects.[85]

"I did the maker camp. I learned a lot of stuff there. It was cool that you got to create something and learn how to do it. While you are creating something, you get to use some of the tools. So it's like learning something else while you are learning about what you are creating." Adriana, Age 13, Computer Clubhouse Attendee and Participant at Maker Camp, Colorado

Maker spaces encourage playful learning through open-ended projects, interaction, and collaboration, and mixing technology with arts and design. Even designers can be surprised by the playful interactions their creations provoke.[86] Making toolkits foster creativity and play. Makey Makey and Robot Diaries, for example, offer a variety of learning opportunities in regard to thinking imaginatively and creating. Programming environments, such as Scratch, Storytelling Alice, and MOOSE Crossing, provide diverse options for content creation, enabling users to innovate according to their interests and passions, without limiting their imaginations. Online interactions further facilitate the playful nature of making, spurring learning, innovation, and production. New and old designers and makers find inspiration and virtual audiences by exploring making sites and sharing their creations using digital images and commentary.

But careful facilitation may be needed to ensure playful learning experiences. Technologies, even when designed for creative play, can be used in ways that do little to stimulate invention. For example, LEGO Mindstorms, although specifically designed to encourage people to develop their own robotic inventions, are also used in projects in which students are assigned and graded on their ability to build a particular robot according to pre-designed plans.[87]

"I have observed this through public outreach—that parents have forgotten what tinkering is. Playing and entertainment—even with cardboard boxes and scissors—have been forgotten. Making is reintroducing this as an activity and game play to people's lives. Too often, these are activities we do alone. There is a great opportunity to bring kids together, friends together and even within families." Dale Dougherty, President & CEO of Maker Media

4 Taking Action

The maker movement is gaining interest and excitement. Action is needed to take advantage of this momentum to increase participation and diversity in making. This means inspiring not only girls and women, but also underrepresented minorities and others (including boys and men) who may not be "enamored with technology for technology's sake."[88] We recognize that there is great diversity of views, priorities, learning styles, and interests within and among each of these groups, and by no means do girls and women represent the perspective of all underrepresented groups. Our goal is

"I have observed this through public outreach—that parents have forgotten what tinkering is. Playing and entertainment—even with cardboard boxes and scissors—have been forgotten. Making is reintroducing this as an activity and game play to people's lives. Too often, these are activities we do alone. There is a great opportunity to bring kids together, friends together and even within families."

Dale Dougherty, President & CEO of Maker Media

to emphasize that broadening participation in the maker movement is critical, particularly for groups historically underrepresented in computer science and engineering fields.

Making provides multiple entry points to engage and interest girls and other nontraditional users of computer science. It creates alternate pathways into the fields of computer science and engineering by simply building on individual interests. Our goal is to stimulate broader participation and on-going engagement in making. We face the fundamental challenge that many people do not often relate to the "identities" associated with computer science and engineering fields. Thus we need to leverage maker activities based on personal interests, to create and affirm identities that do resonate, whether based on engineering, arts, creativity, sports, or what is personally relevant. These different arenas can provide cultural alternatives where students explore STEM content and ideas, and do not feel encumbered by the dominant culture associated with computer science and engineering. Leah Buechley stated in an interview, "I believe that the best way to increase diversity in STEM is to seed new subcultures where STEM can happen, and a person can keep her own identity as artsy, outdoorsy, a people-person, or feminine."

Our recommendations for action involve key stakeholders, including educators, policymakers, parents, and the private sector. The goal is to:

- Interest more participation in STEM, particularly in computer science and engineering fields for girls and women and other underrepresented minorities.
- Increase the size of the "well" of people for the STEM pipeline by engaging these underrepresented groups in maker activities.

Call to action

To broaden diversity and participation in the maker movement requires commitment to action across the private, public, and civil society sectors.

> **Activate 25,000 aspiring makers from underrepresented groups over the next two years by introducing maker activities into existing STEM programs (informal after school, clubs, groups focused on girls, and underrepresented minorities).**

To support this, stakeholders must collaborate and coordinate efforts to encourage making and ensure links between home and school, and informal and formal learning environments. The following recommendations focus on the factors that influence engagement in making that emerged from the research findings and interviews with experts in STEM, making, and learning sciences, as well as from existing literature. They are based on existing strategies from STEM programs that work to encourage participation, combined with the unique characteristics of maker activities. Success in achieving the call to action requires the recommendations be tailored to particular groups being targeted and each country context in their implementation. Success is also contingent on coordinated and collaborative action across the public and private sectors.

Recommendations to Address Key Factors Influencing Women's and Girls' Engagement in Making

Factor	Recommendation	Parents	Educators	Policy Makers	Private Sector
Interest and Self-identification	• **Support and customize making projects based on the interests and identities of participants, whether aesthetic, joyful or related to helping others.** • **Identify current trends and fads among different age groups and integrate them in making activities.**	X	X	X	X
Personal Relevance	• **Develop and support making activities that are solution-oriented, focused on real-world and community challenges and individual end goals.** • **Identify problem spaces that allow individuals to identify their own making activities and promote a sense of agency and ownership.**	X	X X		X
Gender Norms	• **Embed safety into the design of a maker space or program to make participants feel safe and welcome.** • **Address cultural norms that act as barriers in maker spaces and initiatives.** • **Support spaces for open-ended project investigation, allowing underrepresented minorities to pursue personally relevant and meaningful projects in a safe, un-stereotyped environment.**		X X	X	X
Community & Collaboration	• **Provide facilitation in maker initiatives and spaces to ensure intellectual safety, creativity, and genuine interest in supporting learner's ideas.** • **Develop more inclusive maker spaces for public access points (like libraries and schools) to enable participants to connect with others with similar interests and issues.**		X	X	X
Mentorship	• **Create special initiatives to get more participants and mentors into making, clubs, and exhibitions to ensure underrepresented groups have more access to advisors, role models and people their own age who are making.** • **Create links to mentors who can support their interests and professional lives**			X	
Learning Approaches	• **Support multidisciplinary maker projects in formal and informal education, integrating areas such as art and music with computing, science and engineering.** • **Adopt performance-based, assessment methods to capture the process of making; measure enjoyment, engagement and motivation in the making process;**		X	X X	X
Early Encouragement	• **Encourage parent engagement in making with their children—with a focus on both girls and boys to promote gender equality.** • **Develop and support parent-child and community initiatives to engage children in making at an early age and strengthen their attachment to making and computing.**	X X	X	X	X

Select interventions

For Immediate Action

- **Educators:** Connect to others who are promoting making in classrooms or in after school programs.
- **Policymakers:** Address access to technologies and maker spaces and enhance teacher professional development to help teachers to become makers themselves.
- **Parents:** Meet other parents who are making with kids. Find out about making programs in your area.
- **NGOs:** Connect underrepresented groups through maker initiatives. Create inclusive maker spaces.
- **Private Sector:** Share innovation by underrepresented groups. Promote role models in making and STEAM.
- **Library/Museums:** Hold informal maker 'hangouts' for underrepresented groups. These can be in-person or virtual.

For longer-term

SEED. Develop creative initiatives that encourage parental involvement. Exposure and learning in physical and digital environments depends on the involvement of parents. Tap the innovative potential of young people by thoughtfully designing maker initiatives to stimulate family participation in making. Create environments that welcome children and their parents to explore a range of materials and tools, and to develop shared areas of interest and experience.

Actors: Parents, NGOs, Museums, Private Sector, Educators.

Examples: Tinkering Studio at Exploratorium, the Children's Museum of Pittsburgh

Books: The Art of Tinkering by Karen Wilkinson and Mike Petrich

Community: https://communities.intel.com/community/makers

E-textiles: https://www.kitronik.co.uk

CREATE. Design maker spaces for diverse learners in community contexts not ordinarily served by maker initiatives. Create spaces where young people from low-resource communities have the opportunity to access the tools, materials and facilitation to help them get started in making. Such spaces should focus on nurturing and growing student interests by fostering stimulating interactions and experimentation using interdisciplinary high-tech and low-tech strategies. Developing a network of such spaces will enable these initiatives to learn from and build on others' experience and ideas. The spaces can also tap into existing resources such as museums and other community initiatives.

Actors: Museums, NGOs, Policymakers, Private Sector,

Examples: Science museums that serve as "hubs" for making include: the New York Hall of Science, Pittsburgh Children's Museum, San Francisco Exploratorium, and Intel Computer Clubhouse Network (http://www.computerclubhouse.org/).

LINK. Build partnerships between informal and formal educational organizations. Museums and science centers create spaces for making within their environments. Create synergies between the making

activities of museums, communities, and schools by linking the design activities of museums to community maker spaces and school programs. Such links will enable different types of institutions to leverage existing initiatives, and encourage adoption by schools of effective museum and community-based activities. Partnerships between informal and formal learning organizations can involve service-oriented maker activities, workshops and clubs tailored to the different interests and needs of young people in urban, suburban and rural environments.

Actors: Museums, NGOs, Educators, Policymakers, Private Sector

Examples: Cooper Hewitt Museum's Design In Education programs, the Salvadori Center, National Lab Day (www.nationallabday.org).

EXPAND. Develop a network of volunteers to create maker groups in communities and schools. Broaden the diversity and base of makers by developing a corps of volunteer master makers to bring making to new communities and schools. Select a diverse group of skilled, passionate volunteers to ensure that learners in a range of different schools and communities can have peers and mentors to whom they can connect easily. Lessons from the experiences of these mentors can be used to inform maker spaces and initiatives in schools and communities.

Actors: NGOs, Educators, Private Sector

Examples: Maker corps (http://makered.org/makercorps/about-maker-corps/)

MEASURE. Strengthen evaluation of existing maker initiatives and develop experimental initiatives to evaluate and measure the efficacy of learning through making. Many effective maker initiatives lose the opportunity to establish and document their results due to lack of monitoring and evaluation of their efforts. Providing public or private funding and expertise to enable such initiatives to measure the efficacy of their work enables other initiatives to gain from their experience, spurring further innovation. Development of new maker initiatives with randomized, experimental and longitudinal research designs built-in allows for measurement of motivation and learning and better understanding of the impact of making on job retention and STEM careers. Disseminate findings from these efforts to ensure their lessons inform key stakeholders (actors, policymakers, private sector, NGOs).

There is much to be done, but even more to be gained. These actions can ensure that the creative energy of making enriches the lives and futures of girls and women of the world. But the moment is now. The maker movement is in full swing. If tapped now, this wellspring of innovation can determine the wellbeing and progress of our societies and economies. Ensuring that girls, women, and all underrepresented groups can take part will give the movement even greater power.

Appendix

Methodology

The findings in this report draw from a number of secondary and primary sources:

- A survey of makers in the U.S., China, and Mexico conducted on behalf of Intel by Harris Poll;
- Two general population surveys of youth and adults in the U.S., also conducted on behalf of Intel by Harris Poll;
- Interviews with experts in the field;
- Ethnographic research on girls and women engaged in the maker movement; and
- Literature reviews on the maker movement and the gender gap in STEM.

The Meet the Makers Survey conducted by Harris Poll on behalf of Intel drew participation from a broad swath of makers in the U.S., China and Mexico. It was conducted online between April 10 and May 5, 2014, with a total of 963 respondents. Respondents qualified for participation based on the following criteria:

- Adults, 18+
- Residents of U.S., China, or Mexico
- Make physical objects with electronic tools for their own purposes or with their own designs

Meet the Makers Survey Participants			
	Male	Female	TOTAL
United States	241	106	347
China	154	152	306
Mexico	173	137	310

Due to the known low-incidence of makers in the eneral population, the Harris Poll used a variety of sample sources including: the Harris Poll Online Panel, banner ads on websites frequented by those who use electronic tools to create things, referrals from leaders of various Maker online communities and forums, and subscribers to MAKE Magazine. Furthermore, Intel requested an oversampling of women, knowing that the incidence would be low. Survey data are unweighted and therefore representative only of the individuals surveyed. This online survey was not based on a probability sample and therefore no estimate of theoretical sampling error can be calculated.

The survey results are not generalizable due to the way the study was recruited. The survey was not based on a probability sample and therefore no estimate of theoretical sampling error can be calculated.

The surveys of U.S. Youth and Adults were conducted as part of their Youth and Adult Omnibus surveys that they field weekly in the U.S., using the Harris Poll panel. Qualified youth respondents were residents of U.S., aged 8 to 18. Youth participants included 284 Tech Makers, defined as those who have done one or more of the following within the past year: made an object that has parts that can move on their own, light up or make a sound; made clothing or jewelry that lights up, created or built a robot, or used a 3D printer or laser cutter to make something. Qualified adult respondents were residents of U.S., aged 18 and above.

U.S. Survey Participants		
Youth		
Males	**Females**	**Total**
586	**627**	**1,213**
Adults		
Parents*	**Non-parents**	**Total**
440	**1,611**	**2,051**
***Defined as parents of children under 18 living in their household.**		

For both of these studies the data have been weighted to reflect the composition of the U.S. population as needed for age, sex, race/ethnicity, parental education (youth survey only), education, urban, city, and region. Propensity score weighting was also used to adjust for respondents' propensity to be online. All respondents for these surveys were selected from among those who have agreed to participate in Harris Poll surveys. Because the sample is based on those who agreed to be invited to participate in the online panel, no estimates of theoretical sampling error can be calculated.

The literature review focused on the literature on girls and STEM and gender gaps in STEM in the pipeline and workforce. It also looked at literature focused on making, STEM, gender, educational outcomes.

Twenty interviews were conducted with experts, practitioners and academics focused on the topic of making, STEM, gender and other topics. This was conducted through a snowball sampling, identifying key experts to interview as the research unfolded.

The ethnographic research included interviews and participant observation in maker spaces including Double Union, TechGyrls, Double Union Female Hacker Space, Mothership Hackers. Respondents included women participating in maker spaces or self-identified makers. Interviews (in person or phone) were also conducted with female makers in in Mexico, the U.S., China, Ireland, and Kenya to create maker profiles.

Maker Profiles

Camille and Genevieve Beatty, Ages 14 & 12

Middle & High School Students and Co-Founders of Beatty Robotics

Asheville, North Carolina, USA

Maker Profile:

Teen and Tween Makers with the Imagination to Dream and Do

"Who needs a paper route when you can start a robotics company?"

At ages 14 and 12, Camille and Genevieve Beatty, of Asheville, North Carolina, are accomplished makers and cofounders of Beatty Robotics. There, Genevieve does the wiring, while Camille machines the metal. To date, they have designed and built a variety of robots, including a 16-legged, walking robot, as well as a Mars rover for the New York Hall of Science (NYSCI). Other projects include a wireless XBee telegraph system and steampunk jewelry. The Beatty sisters and their father, Robert, were recently honored at the 2014 White House Maker Faire, where President Obama mentioned them in his address for the event. The Beattys say one of the main things they've learned over the last few years isn't about power tools or engineering or electronics. They've learned; "If you can imagine it, then you can do it, whatever it is."

Source: Terranova, A., Makezine.com "Camille and Genevieve Beatty: Teen and Tween and Already Accomplished Engineers," June 25, 2014.

Maker Profile:

Giving young girls the chance they never had

"Seeing young girls becoming passionate about STEAM makes me passionate about helping them."

As a young child, Amaris Benavidez's favorite subjects were math and science. "I was always at the top of my class and loved every minute of these subjects," says Amaris. "Once I started high school, however, I realized that, although I was intelligent, there was so much that I was not exposed to in middle school. The world was full of information that was never available to me. I learned about Girls Have IT Day and was truly inspired. I realized that my calling in life was to spread this knowledge to anyone willing to listen."

Amaris is now the student co-chair of Girls Have IT Day and Girls Have IT Camp. These two annual events are designed to promote science, technology, engineering, art, and math (STEAM) to middle school girls. Amaris says, "I love being able to inspire young women to dream big in STEAM. The girls are being exposed to such fascinating topics at a young age, which enables them to continue their aspirations in STEAM. The more I become involved, the more I understand the importance of engaging young girls in STEAM-related education and activities."

On Girls Have IT Day, the clubs on campus create booths with a wide variety of activities, ranging from origami to flight simulators to robotics. Amaris says, "All of these activities receive great feedback, and the smiles on the girls' faces show that they are all having a great time." Last summer at Girls Have IT Camp, Amaris helped girls learn about computer science and other aspects of technology. Amaris explains, "The girls learned how to make 'bugbots,' which are miniature battery-powered circuit robots. This also incorporated the use of 3-D printing. We showed the girls how to design wheels (and other objects) and how the printer prints them. Another exciting activity was the use of Makey Makeys. With these input devices, the girls could do things such as play Flappy Birds, take pictures, and play the piano. We also incorporated several other STEAM activities throughout the week that everybody loved. We recently received Sphero, an awesome device-powered ball, from AspireIT that we hope to share with the girls next summer. You can play interactive games and code missions for the ball."

The camp is an important experience for both campers and counselors. Amaris says, "We try to instill in the counselors that they are role models for these girls and that it's important to always be a caring, inspiring helping hand. We teach the campers that anything is possible if you are passionate and work hard to achieve your goals."

Amaris received the NCWIT Aspirations in Computing award in 2014. In addition to taking several AP courses at school, Amaris is also active in sports and other extracurricular activities. She is the captain of the Varsity Basketball team, co-president of Blue Crew, her school's spirit squad, and secretary of the Calculus Club.

Amaris Benavidez, Age 17

High School Student

Phoenix, Arizona, USA

Kun Jia

Graduate Student, Age 25

Beijing, China

Maker Profile:

Creating Playful and Functional Solutions

"No matter what you have learned, you can make good things if you have the enthusiasm for making."

The first time Kun found out about making was when she took part in Designow, a two-day workshop held at the Institute of Service Design at Tsinghua University in 2013. There, Kun created a simple toy bear capable of interacting with people. "It was amazing," says Kun. "I fell in love with making. I joined a lot of workshops and competitions after that, and made many interesting things." Since then, Kun has taken part in workshops and competitions in China and abroad. Her team, Happy Tree Friend, won first prize in the China-US Young Maker Competition in July, 2014. The team project, Communitree, sought to reconnect nature and communities in urban environments faced with the detrimental effects of climate change. Playful and functional, Communitree is a robotic planter that uses sensors to gather data, which in turn triggers a range of actions.

Making has been a collaborative process for Kun. She says, "I have a good sense of design and I can do the programming, which is my advantage. But still, I can't do all of the work by myself. I need others to help me. I have been a team leader several times. It was a challenge to make the plan and distribute **the** work to team members. You have to be patient and organized." Mentorship and guidance from her professor has been an important support for Kun's making. She says, "He encouraged me to be involved more making activities, and gave me tons of brilliant advice. Even though most makers are male, he still believes that I can make better things than them."

Kun is currently studying at the Department of Information Art & Design, Academy of Art & Design at Tsinghua University. She did her undergrad studies in Computer Science.

Maker Profile:

Creating magical stories with light and shadow

"I've always done stuff with my hands. I've always made crafts. I think I just got to a point where it wasn't interesting enough because it didn't do anything. I'm really into interactive stuff. What does this object do, and can it tell a story?"

Becca Rose considers herself an artist, maker, and educator. In college, she first majored in architecture, then literature and the history of art, all the while making things in her spare time. From weaving and knitting, she expanded her skill set to create puppets that were interactive and animatronic. She then began creating paper shadow boxes, complete with lights and circuits, and wove all of these elements together to present stories through puppetry, light, and shadow. "It was a way of making a small world that people could kind of experience, and touch and feel, she says. "And I realized the only way that I could do it was I had to solder, and I had to make the circuits myself."

In San Francisco, Becca became one of the first members of Double Union (DU), a feminist makerspace. There, she co-runs electronics night and teaches paper circuitry.

"When I first started hanging out at Double Union, I would think that I wasn't the right person for learning new tech, but the women in the space would shrug and say, 'Why wouldn't you be?' It wasn't a response I'd experienced before, as previously people had said, 'Oh, that's really cute that you want to get into tech.' So I found DU really encouraging. Since, I've started learning programming as well as adding more electronics to my work."

A multi-layered, lighted forest by Becca Rose.

Additionally, Becca now teaches making and technical arts in Bay Area high schools through Maker Corps. She plans to go back to school for a degree combining illustration, craft, and circuitry, and hopes to work part-time as a teacher and part-time as a maker.

Becca Rose, Age 31

Teacher

San Francisco, California, USA

Julliet Wanyiri, Age 24

Founder & CEO of
Foondi Workshops

Engineer, Designer,
Workshop Leader

Nairobi, Kenya

Maker Profile:

Leveraging engineering and design to develop local solutions

"Making speaks to my core values and what I am most passionate about, specifically, making things that solve local problems."

Juliet Wanyiri is the founder & CEO of Foondi Workshops, which creates access to affordable, high tech solutions for Africa through collaborative design workshops. She is part of the first cohort of the Stanford FabLearn Fellows Program, which brings together tech educators from all over the world to develop an open source curriculum for makerspaces and FabLabs around the world. Prior to this, Juliet was the lead instigator of Gearbox, Kenya's first open space for rapid prototyping, small scale fabrication, and design. She is also one of the founding members of the Fab Lab Robotics Outreach Program, which she has led collaboratively for the last five years.

Juliet is a natural problem solver. In her last year in college, she developed a traffic light management system for Nairobi. She has worked on sanitation projects in Brazil, where she and her team developed an evapotranspiration system to prevent rivers being polluted by human waste. Additionally, because bicycles are plentiful in Africa and she and a team of artists and designers wanted to create pedal-powered technology, she designed a bicycle blender.

Juliet is passionate about leveraging her background in both engineering and design to collaboratively build solutions for emerging markets. Juliet studied electrical engineering in university, but comes from family of designers. She says, "My interest in making is tied to the environment I grew up in. My mom made a lot of things, baking, stitching, [working on] generally creative projects. I learned I could do things with my hands and learn from people around me. I grew up knowing I could make anything. My dad was always fixing things and explained how they worked. From a young age, I had an idea of what women could do, and I was never held back."

Having access to a fab lab while she was in college cemented Juliet's interest in making. She was in an environment where she could make just about anything. She says, "Being in that environment and learning engineering, I saw that there are a lot of amazing things technology can help solve in terms of challenges that people have here in Kenya. Both high-tech and low-tech solutions can help solve these problems. I applied the knowledge I learned in university and used the opportunity of being in a fab lab to create things to address these challenges."

"Fab labs and incubation spaces help to get more people interested and comfortable with making," says Juliet. They provide a lot of mentorship, which was important for Juliet. She says studying engineering prepared her for industry, not for exploration or making. She explains, "Mentors help to guide you on a path to question things, think outside the box. This gives you the confidence to make and come up with something amazing."

On why she developed her company, Juliet says, "I want to create an environment where people can make,

create, collaborate and build solutions for Africa. I have been facilitating hackathons for people interested in electronics, robotics. I get people excited about technology and provide capacity building."

One of biggest challenges Juliet faced in her making projects was getting access to electronics in Kenya, despite the fact that she was working in a fab lab or ihub context. She says, "It is harder to get electronics here, and these things slow down the process of working. I feel that people who are making in a local context should have access to the resources they need—local materials and tools—so that making should be about taking it to next level." Regarding gender barriers she has faced, Juliet explains, "There are few women making, even with hackathons. It can be really disheartening that you are kind of in it alone." She feels strongly that there is a need for more women makers and that making should be accessible to anyone.

Maker Profile:

Energized by making with others

"When you're on the computer you work by yourself. When you make stuff you work with people."

Carla is a member of the Computer Clubhouse in Beaverton, Oregon, an after-school learning environment for kids to explore their own interests and learn about technology. The Clubhouse director describes Carla as a "major maker."

Carla likes science and math, and wants to be a veterinarian when she grows up. She and her friends like working with each other to make things. Recently, she and a few of her Club mates made a little village using Makey Makey, an invention kid that turns everyday objects into conductive touchpads.

When asked about the difference between making things in the Computer Clubhouse program or in science class at school, Carla's energy level drops. She says that, in school, the girls do the writing, and the boys do the experiment. "The boys grab stuff and do it, and the girls write the description."

Carla,** Age 13

Middle School Student and Computer Clubhouse Member

Beaverton, Oregon, USA

**A pseudonym and stock photo have been used to protect the research particpant's privacy

Alicia Browning, Age 26

Director, Computer Clubhouse

Albuquerque, New Mexico, USA

Maker Profile:

A Mentor to Encourage, Support, and Inspire

"The girls saw what making is and now they can teach others. They have such an interest in circuitry, and they showed the boys what they have learned."

Alicia became a member of the Computer Clubhouse in Albuquerque, NM, in 2005, when she was still in high school. After graduation, in tandem with pursuing further education, she became one of youngest coordinators for the Computer Clubhouse Network.

"I was part of the push to get more girls involved," says Alicia, whose early Clubhouse experience was dominated by guys, with 90 percent of members being male. "We had only three to four girls on a regular basis," she explains. "I come from the same background. I am Hispanic and a Mexican minority. What you see in this neighborhood is that the job of a Hispanic Mexican woman is to raise children and be at home, while the male figure is out providing for family. I knew I had to do an extra push to educate girls. I took it personally because I grew up in exactly the same type of neighborhood."

Alicia's Clubhouse was selected to be part of Intel's "Start Making!" pilot program, which included five-day camps for girls 10 to14 years old. Alicia recruited six female volunteers from the local Intel site in Albuquerque to help.

To market the program, she walked through the community and talked to people. She got 17 girls to join and show up on regular basis. "The first few days were intimidating for them," she says. "They said, 'We can't do this. We don't know how to do it. That is something a boy can do.'"

Every day when the girls arrived, Alicia gave them a worksheet with a list of things they would do that day. She says, "They would say things like, 'What's a circuit? That sounds weird.' Or 'How will we sew LED lights?'

But when Alicia introduced the girls to the sewing part of the curriculum, where they had the opportunity to use technology to make stuff light up, they were hooked.

"They got to connect things together using LilyPad, make clothes and pillows, and make them light up. They used Makey Makey, which is a switchboard that you hook up to computer and doesn't require installation. It acts like keyboard and connects via electronic waves to complete the circuit using every-day stuff. We hooked it up to food, graphite drawings, and playdough. They figured out what's conductive and what's not. They learned about how we open and close circuits."

Once the girls got the hang of it, Alicia reports, they were genuinely excited about coming every day to make more. "A lot of girls became more interested in Computer Clubhouse. They got in touch with Intel and worked with Maker Faire. We did a graduation ceremony. We opened it up to rest of computer clubhouses and inspired them to take initiative to do more. We can do animation, and incorporate physical things into art based activity. One girl can take apart a computer and put it back together, with no guidance. Some girls were really creative and some were focused

on changing the world. They wanted to share skills with each other so they have something that helps others. One girl was working on a robot that encourages people by saying, 'Oh you're beautiful!" to help girls with their self-esteem."

Maker Profile:

A love of making and biology

"I wanted to show that we can connect art and biology, and that it can be fun to do a science project."

Suhyeon Yoon dreamed of becoming a car mechanic as a kid because she loved making and fixing machines with her hands. She chose biology as an alternative because her parents did not allow her to be in the male-dominant engineering world. Suhyeon studied biology at a women's college in Korea and received her PhD, while spending her free time making things. In her lab, she was always assembling lab equipment and fixed computers.

"I was almost a tech support for my department," she says. "I was so much happier dealing with the hardware and machines that were needed for my experiments than running actual experiments. It was pretty sad. That was part of the reason I picked bioinformatics. It is more engineering-like than traditional biology."

Through one of her graduate school friends, who later became a co-founder for Hacker Space Seoul, she met some makers who were thinking of setting up a hacker space. With those makers, she secured government funding for the initial set-up. One of her interests was using biology to create art. In 2012, she and some makers from Hacker Space Seoul did a bacteria silkscreen project. She designed and created the bacterial incubator needed for the project using computer power supplies, cooling fans, Arduino-driven temperature regulators, and UV lights. The results were beautiful petri dishes made with E-coli patterns.

Today, Suhyeon lives in the DC metro area and works as a post-doctoral researcher at the National Institutes of Health. She is a member of HackDC and is working to assemble a group of NIH biologists to create a mobile DIY-BIO lab to teach children about science, biology, and making.

E-coli Silkscreen project

Suhyeon Yoon, Age 34

Biologist

Washington, DC, USA

Linda Lobato

CEO and Co-Founder of Machina

Fashion Design and Production

Mexico City, Mexico

Maker Profile:

Wearables and Creation

"There are mostly men in the maker space. I constantly promote including women in making and related events. I have been to different kinds of hackathons where they are all men. It is important to have females on these teams of people making products."

When Linda Lobato was in college, her collaboration on a social service project led to her co-founding a company for the rehabilitation of prisoners through art. For six years, Linda and her business partner worked inside a prison in Mexico City, where they conducted design, fashion, and photography workshops for prisoners.

There, they created a fashion brand based on the premise that creativity is everywhere, and they set out to test this idea. The prisoners had limited access to materials and information. But they did have time and the opportunity for creativity to bloom.

Linda worked closely with the prisoners to test different materials and to build a brand with them. They then set up a runway inside of the prison and invited families of the prisoners, retailers, and media to showcase the work they had created. It was Linda's first marketing project, as well as her first experience with making and building things.

Three years ago, Linda co-founded a new company, Machina, with a partner/fashion designer who integrates electronic components into fabrics. Though "wearables" have been around for a while, they have traditionally been created by engineers. Linda saw an opportunity to add fashion design to the mix and take her wares to market. Today, Machina is well-known for its line of high tech clothing, including a jacket that makes music when the wearer moves.

Additionally, because Linda has learned how to program, sew, and participate in the design process, while managing the marketing of the business, she now conducts wearable technology workshops in San Francisco and Mexico City.

Though Linda doesn't consider herself a true maker, she is in the business of creating new products and admits she has picked up some maker skills along the way—skills that have been quite useful as she weighs in on technical issues and fields questions from others.

As a pioneer in the techmaker field, and as a female CEO hoping to pave the way for others, she says, "Women are kind of scared to test new skills. This may be because in an early stage in life they were told not to do it. They were told these are only guys' programs. They ask, 'Why would girls code?' That is slowly changing, but there is still a long way to go." She elaborates, "Parents should not limit children at a young age by their gender. There needs to be an exploration of other things, other than the princess kind of dream. We need to help girls explore new kinds of personal development experiences, programming at young age, speaking another language."

Maker Profile:

Wearing her creations to start a discussion

"I could make something that sits on my table or that I bring out to show a friend —a cool robot car—but if I wear it, it's already there to start the discussion."

Actor and dancer Tenaya Hurst performs in musicals, including the San Francisco Follies, when she's not making. She started out sewing, knitting, cross-stitching, and making projects out of soda-can tabs, rubber bands, and anything else she could get her hands on.

"I've always been a maker," she says. "I just didn't call myself that."

In 2013, Tenaya went to Maker Faire. There, she discovered Arduino, the popular open-source electronics platform, and has since been creating jewelry and clothing with embedded electronics.

Using, LilyPad, she makes T-shirts, hats, stuffed animals, fairy wings, headbands and more. She makes Blipace "blippy" necklaces that make ambient sounds react with a flicker and shimmer of LEDs, and recently presented a full collection of wearables at Bay Area Fashion week. "For me," she says, "being excited about electricity and electronics goes directly to 'I want to wear it,' because I am sort of a showy, actress-y person."

And today, she says she makes something else: "Makers."

That's because she now teachers others how to make, running workshops for adults and camps for kids, teaching programming, soldering, and how to sew circuits.

A Bliplace "blippy" necklace made of Atmel© microcontrollers, designed by Tenaya Hurst and developed by Austin Appleby and Mark Atwood.

Tenaya Hurst, Age 30

Actor and Dancer

San Francisco, California, USA

Kate O'Donovan, Age 16

Secondary School Student

Clonakilty, Ireland

Maker Profile:

An enthusiastic and powerful advocate for math and technology

"I've no idea at all what I'll do after college. Some days I think pyrotechnician, some days, NASA. I'll almost certainly find a way to incorporate robotics into whatever I do. After talking to people at Dublin Maker, I realize that very few people follow a straight path to their chosen career."

Kate O'Donovan has been interested in math, technology and building things since she was a child. She recently took part in Dublin Maker. "My original plan was to make an LED light cube that displayed different color lights depending on your choice of music, relayed via a smart phone," she says. "In the end, my project was much simpler and consists of a black box that plays sequences of lights. I still plan to complete my original idea. It's just going to take longer than expected."

Kate got involved in Coderdojo when she heard about it though family friends. She says, "My mum's friend mentioned some people I knew from school had attended, so I decided to give it a go. I had used an Arduino board for a project in second year, and when I was given the chance to experiment with the Galileo board, I jumped at it. The Coderdojo mentor was a great help to me, as well as other members that received a Galileo. A volunteer from Emutex Labs volunteered to help answer any weird and unusual questions we had and provided information and inspiration on what could be done with the board."

Kate's favorite STEM subjects are math and technology. "I enjoy subjects that involve solving a whole problem, such as how to combine art and technology. I created a found object metal sculpture for art, and I built a mock-up of an animated concert stage for technology for my junior level exams. My point? With minimal modifications, I could have handed either one up in the other class. I think it is as important to allow kids to develop problem-solving skills, as it is to teach the basics of engineering, math, and physics."

Regarding the strong male presence in her field, she says, "I do find it a bit strange and sometimes daunting. But I love electronics, and I really want to be at events like Dublin Maker, so I don't let it bother me too much."

Kate has several recommendations about what needs to be done to get more girls involved in STEM:

- Girls need good mentors and enthusiastic female teachers in STEM subjects. "My first mentor was a woman who thought me how to solder," she says.
- There should be more women in visible roles. "At Dublin Maker, she says, "there were a lot of men and maybe three women in our tent. If you are a small, blond, ponytailed girl, aged eight, it is very daunting to walk over to a group of men to ask your questions."
- Teacher need to find ways to incorporate practical tasks that use engineering skills (e.g., kinetic sculpture in art, origami in math).

- Peer-to-peer mentoring among girls would help demonstrate how great and interesting these subjects can be."

Maker Profile:

Making by Life Stages.

Life stages can influence the different types of things women and girls make. Maker spaces and programs support these varied interests.

A space that hacks life more than technology

At Mothership Hackermom in Berkeley, California, the emphasis is on life transitions, also known as life hacking. After having children, women come here to reinvent their lives. They find ways to balance making or entrepreneurial ventures with parenting. Their leader, Sho Sho Smith, says, "To be a maker you don't need an engineering degree; you need childcare." Thus, the organization provides both childcare and children's workshops, so that moms can create. Members knit, sew, and write PhD theses. One member is even designing a car. Additionally, Mothership Hackermom offers women the opportunity to participate in Failure Club, where they can pilot ideas and support mistakes. Members invent products, change careers, and start businesses in a safe space that encourages and celebrates failing, since risk and failing are essential to healthy creation.

A safe space for making and feminist activism

At Double Union, a feminist hacker space in San Francisco, the makers are young and hip. Most do not have kids. It is a community workshop where women can work on projects in a comfortable, welcoming environment. Projects include programming, electronics, wood working, fiber arts of all kinds, sewing, and zine making. The space includes tools, such as a vinyl cutter, which are hard to come by. Some members are highly technical coders, while some are more craft oriented. The space is dedicated to providing a harassment-free experience for everyone.

Girls Who Make

TechGyrls is a successful nationwide YWCA after-school empowerment program that provides girls with opportunities to increase their skills and confidence in the use of technology and engineering. At a TechGyrls after-school session in San Jose, the girls were given the freedom to come up with a concept for what they wanted to make. One team made a stuffed unicorn with built-in intelligence. When two unicorn horns "hook up" they light up to show the unicorns are happy. Another team built a rainbow iPhone case that lights up. When provided with an open-ended, girls-only experience uncommon in the formal education system, these kids chose to make colorful projects for the sheer fun of it. They were more motivated and delved deeper into the technology than they would have in a traditional school classroom.

Sho Sho Smith

Founder of Mothership HackerMoms, a hackerspace for creative mothers

Berkeley, California, USA

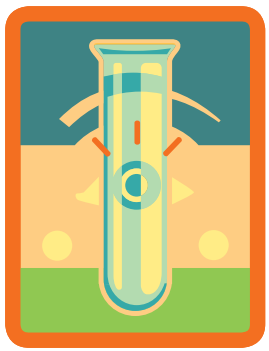
Girl Scouts®
Where Girls Grow Strong℠

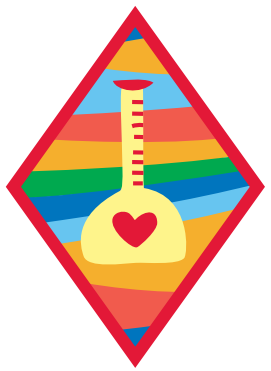
Maker Profile:

Girls push boundaries, test limits, and look at the world around them with inquisitive eyes. They're natural scientists!

Every girl needs a chance to explore the fascinating world of STEM.

Girl Scouts introduces girls of every age to science, technology, engineering, and math (STEM) experiences relevant to their everyday lives. Whether they're discovering how a car's engine runs, how to manage finances, or exploring careers in STEM fields, girls are fast-forwarding into the future. Every girl needs a chance to explore the fascinating world of STEM. Girl Scouts encourages girls of all ages by offering "fun with purpose" through its K–12 national program. National Leadership Journeys lead girls to discover what they care about, help them connect with others and change the world in positive ways. Girls explore a variety of interests along a Journey, everything from the arts to the outdoors and, of course, STEM. The Get Making With Get Moving! Journey adds a special focus on "making" and how it can engage girls in exciting hands-on activities related to energy. In Girl Scouts, girls earn badges when they develop new skills on specific topics they choose. Many badges include fun and age-appropriate STEM activities, including Naturalist badges, Digital Art badges, Science and Technology badges, Innovation badges, and Financial Literacy badges. To learn more, check out www.girlscouts.org.





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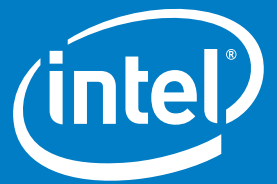

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