



GIRLS IN TECH

**Inspiring the next generation of creative,
entrepreneurial and digital women**

Written by Sylvia Libow Martinez for Intel® Australia



“The maker movement provides multiple entry points to engage and interest girls and other nontraditional users of computer science.”

– Intel report¹

“When our schools become more gender-fair, education will improve for all our students – boys as well as girls – because excellence in education cannot be achieved without equity in education.”

– How Schools Shortchange Girls²

MAKING FOR ALL

The Maker Movement has crept into the consciousness of schools, libraries, museums, and community centers around the world in the past few years. For some, it's a wake up call that over-tested, over-scheduled young people will not be the creative, enthusiastic learners we all hope to nurture. For others, it's a personal reconnection to collective, deeply felt human impulses to create, invent and shape the world.

Many teachers know that children learn best by doing. Teachers embracing the Maker Movement are creating rich learning opportunities with new tools and materials like robots, 3D printing, e-textiles, and more. Making in the classroom is more than technology, more than craft, and more than hands-on – it empowers students to connect classroom studies to real world passions, encouraging independence and self-directed, life-long learning. However in many instances, educational makerspaces find they are serving a narrow range of tech-savvy boys who are already adept with robots, programming, and drones.

It should come as no consolation or excuse for schools that gender disparity is a global problem in technology courses, majors, and careers. Although women now make up 60% of the general enrollment in many universities, women only comprise about a quarter of science, technology, engineering and mathematics (STEM) graduates.

Even in these STEM fields, there is a huge gap in specialties – women are the majority of university students in biology, psychology, and health related sciences, but are losing ground in fields such as engineering and computer science.

So in the face of all this, how can schools address issues that are challenging businesses, universities, governments, and families world-wide?

To provide more gender-inclusive maker-education programs, there are a number of key concepts that should be considered including gender differences, learning and problem-solving styles, culture and space considerations, and gender-differentiated interventions.

It should be noted that gender-related differences in learning styles and approaches are always generalisations, even when they are based on research. There are always young people who break through boundaries and defy expectations, much to the joy and delight of all.

Ensuring a maker experience is more inclusive is not about treating everyone the same. By understanding and taking differences into consideration, educators can create makerspaces that are better places for all students.

¹MakeHers: Engaging Girls and Women in Technology through Making, Creating, and Inventing, Intel Corporation, 2014 intel.com/content/www/us/en/technology-in-education/making-her-future-report.html ²aauw.org/files/2013/02/how-schools-shortchange-girls-executive-summary.pdf ³apa.org/research/action/stereotype.aspx ⁴apa.org/research/action/stereotype.aspx Generation STEM: What girls say about Science, Technology, Engineering, and Math - girlscouts.org/content/dam/girlscouts-gsusa/forms-and-documents/about-girl-scouts/research/generation_stem_full_report.pdf ⁵MakeHers: Engaging Girls and Women in Technology through Making, Creating, and Inventing (Intel infographic and research report) intel.com/content/dam/www/public/us/en/documents/reports/makers-report-girls-women.pdf



EMBRACE DIFFERENCES, DON'T ENSHRINE THEM

Conventional wisdom says that boys are better at technology than girls. However, this is often a difference of style, not skill or potential. Boys may tackle complex tools, programming, robotics, and other technology with eagerness, where girls hold back. Many boys are content with mastering technology for its own sake, where girls look for a reason to do so, such as designing a product that helps others or solves a problem. Offering a wide variety of opportunities to learn and make things is crucial for a gender-balanced approach.

TIPS

- Don't assume that speed always indicates interest. Allow time for girls to approach problems or challenges with deliberation.
- Be careful not to frame the desire to increase female participation as a need to change girls (i.e. "We need to raise their self-confidence.")
- Talk with young people honestly about stereotypes. Bringing the topic out into the open empowers people, even if the conversation is uncomfortable.
- People who believe that skills such as being good at maths are inborn are more prone to the effects of stereotype threat³. Help students understand that learning is a process of growth and change and that anyone can do it.

SUPPORTING THE MAKER MINDSET

There are some gender related tendencies that suggest that girls will handle maker-style learning better than boys. Girls often handle obstacles and challenges through negotiation. They tend to collaborate and communicate to solve problems⁴. They are generally more organized and better able to self-monitor. This deeply resonates with the iterative nature of the design process and self-directed "maker mindset" so often associated with making and project-based learning⁵.

In encouraging the maker mindset, these characteristics are helpful, yet in excess, will sabotage the learner. Building consensus through collaboration is a good skill to master, but not being able to make a decision is a bad habit. Being a good team player can be beneficial to the team, but might result in a girl not getting the credit she deserves. To promote a maker mindset, the teacher's crucial role is that of a helpful, but non-judgmental mentor and guide.

TIPS

- Girls' relationships with adult leaders are very important to them. This may mean that they will avoid a path not suggested or anticipated by the teacher.
- Offer neutral, yet encouraging support for students to think outside the box. Saying, "I don't know, but we can figure it out" models this attitude for all students.



UNCONSCIOUS BIAS

A number of research studies have shown that teachers pay more attention to boys, give higher maths grades to boys than their actual work warrants, and listen to boys while girls are told to wait their turn^{6,7}.

And it's not just teachers – parents talk more to boys about science⁸ and buy them more computers and scientific toys⁹. Unconscious bias, reinforced by tradition and culture, is not an easy subject to tackle, because the hardest thing to see is your own bias.

TIPS

- Be mindful of your own behavior and make an effort to reach out to students (not just girls) who don't "fit the mould" of your typical makerspace inhabitants.
- Create options in your makerspace that contrast with your current offerings.
- Try not to only offer experiences that are "popular" – you may be unconsciously responding to the needs of a narrow but limited audience of students.

THERE ARE NO GIRLS HERE BECAUSE THERE ARE NO GIRLS HERE

If you have a program that is overwhelmingly male, it will deter girls from joining which reinforces the perception that making is only for boys. You may need to specifically recruit girls, even reaching out to incoming students. The rugby and netball teams recruit promising students, why not you?

TIPS

- Current participants (especially girls) should be part of your recruitment team.
- Start a "girls only" club to nurture talent for the future, but don't completely depend on gender-segregated experiences to keep girls interested.
- In school situations, talk to learning support staff, counsellors, careers advisors and librarians and ask for ideas about who might be overlooked candidates for participation. Be explicit that you want girls!
- Partner with other school activities to increase awareness. Use design to solve problems and make things for music, drama, and science classes.

ROLE MODELS AND MENTORS

One of the most common activities to support girls in makerspaces is to provide role models of women in technology careers. However to be successful, mentoring programs need to ensure the experience is active, not passive. Girls shouldn't just "see" women in technology, but have a chance to interact with them.



TIPS

- Teach students to be peer mentors and leaders. Girls often find that helping others is a driver for their own learning, and value these relationships and collaborations.
- Placing students in positions of leadership and authority models student-led, inclusive learning where the teacher is not the guru who has all the answers. This is not just for show – creating student expertise in ever-evolving maker technology frees the teacher to focus on the bigger picture.

TOOLS AND TECHNOLOGY

The new technology of the maker movement provides experiences unlike any other. The miracle of 3D printing, the beauty of electronic clothes, the thrill of building a machine that flies, the satisfaction of making things that solve age-old problems are attracting people to learn new things in new ways. While the tools and technology are not the main reason to create a maker program, consideration should be given to constantly curating the most flexible and open-ended tools for young people to use.



TIPS

- Don't segregate tools or materials into "craft" vs. "tech" categories, especially for activities traditionally associated with women.
- As your space allows, combine traditional workshop, visual arts, cooking, and other hands-on activities with newer technologies.
- Girls will not compete for scarce resources; tools and technology should be plentiful and easy to access.
- The current vision of making relies heavily on electronics and fabrication, but this is changing. Give students the opportunity to research and explore new outposts of the Maker Movement such as wearable devices, the Internet of Things, and bio-hacking.

⁶How Schools Shortchange Girls - aaup.org/files/2013/02/how-schools-shortchange-girls-executive-summary.pdf ⁷Recognizing (Almost) Invisible Gender Bias in Teacher-Student Interactions alicechristie.org/pubs/Christie-Gender.pdf ⁸Parents explain more often to boys than to girls during shared scientific thinking. ncbi.nlm.nih.gov/pubmed/11437311 ⁹Can, But I Don't Want To: The Impact of Parents, Interests, and Activities on Gender Differences in Math, rcgd.isr.umich.edu/garp/articles/jacobs05.pdf

SPACES AND CULTURE

Every learning space should be open to all people: children and adults, all genders, all backgrounds, and those who are interested in the arts, engineering, or both. However, in many technology-based learning spaces, there is an implicit message about who is welcome – and who is not.

TIPS

- Take a hard look at your space. Research shows that girls react to surroundings that reflect stereotypical geek culture by denying that they are interested in science and engineering¹⁰. Girls won't be fooled by putting up a few Hello Kitty posters. If you aren't sure what vibe your classroom or makerspace is communicating, ask some girls!
- Lower barriers to entry. Take any opportunity to open up the doors both literally and figuratively, so anyone with even a slight curiosity can see something that might attract them. Add shorter experiences, different times and days, and see what happens.
- Create a participatory culture that speedily responds to feedback and ideas, but do not allow initiatives that privilege one group over others.
- Do not rely on once a year assemblies about bullying to create a welcoming culture. Immediately address bullying behavior, "jokes" that target any group, condescension, or exclusionary behavior.
- Reduce competition. Both overt contests and more subtle competition, like a lack of adequate materials and tools, can reduce participation of girls. It can also be a barrier for beginners and students who don't see themselves as "technical." Competition raises the stakes to a level that is too risky for students to jump in and try something they may actually enjoy.
- Don't depend on "girls only" clubs, segregated hours, or other single-gender offerings as your only solution. While these experiences can be powerful and validating for girls, the research is unclear about the ultimate outcomes of gender segregation.

IS IT SCHOOL? OR SOMETHING DIFFERENT?

Girls tend to be more tolerant of a wide variety of situations – meaning that they “get along” better in traditional school settings. So you may assume that girls don't need maker-style open-ended learning or time to tinker because they have mastered coping in the traditional classroom.

Yet tinkering is often how real science happens as opposed to the more linear, step-by-step method favored in the classroom. Real scientists make mistakes, ponder, have a cup of tea, argue with each other, and sometimes have happy accidents. Tinkering is the real process of design, and a natural progression from the play of childhood to a more reasoned and directed approach, but still a non-linear and iterative way to solve problems.

TIPS

- Make your makerspace as unlike the typical classroom as possible. If you have the luxury of an ungraded, informal maker program, avoid creating school-like structures simply out of habit.
- Allow personal expression, style, identity, and artistic expression to flourish.
- Don't impose pre-requisite school courses for maker experiences or require that projects fit into standard school subject areas.
- Create space and time for conversation and collaboration.
- Don't force the design process through rigid steps. Allow for serendipity and new insights to change project directions.
- Honour all problem-solving styles. The right solution to a problem is the one that works.

¹⁰Cheryan, Sapna, Plaut, Victoria C, Davies, Paul G, & Steele, Claude M. (2009). Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science. *Journal of Personality and Social Psychology*, 97(6), 1045. sciencewithart.ijss.si/pdf/How%20stereotypical%20cues%20impact%20gender%20participation%20in%20computer%20science.pdf ¹¹MakeHers: Engaging Girls and Women in Technology Through Making, Creating, and Inventing. intel.com/content/dam/www/public/us/en/documents/reports/makers-report-girls-women.pdf ¹²Chicago Public Library: Making To Learn. chicago.bibliocms.com/wp-content/uploads/sites/3/2015/04/cpl-maker-lab-making-to-learn.pdf

STEM FOR THE REAL WORLD

One of the top reasons to create maker programs is to bring life to STEM subjects. Girls say that science is interesting because it helps people and makes the world a better place. Feed that passion by creating opportunities to do science that matters. Real-world topics, real research, real projects, real tools, and tangible technologies attract not just girls but all students who are disinterested in dry textbook science.

According to Intel research, “Girls who make, design, and create things with electronic tools develop stronger interest and skills in computer science and engineering.”¹¹ Informal learning spaces can take advantage of this as well. The Chicago Public Library’s research on their makerspace initiative found that, “The Maker Lab engages female patrons to participate in STEAM learning.”¹²

TIPS

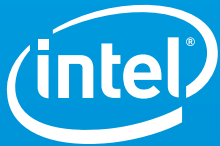
- Find ways to use STEM to solve real problems that young people care about.
- Don’t advantage one kind of building over another. Robots are cool, but the same technologies of micro controllers, programming sensors, motors, and lights can make smart clothes, a useful invention for an elderly aunt, or better still, something no one has thought of before. Provide incentives, multiple access points, praise, and glory for all kinds of making.
- Allow students to approach problems from different disciplines. In school subjects, girls are typically better at a wider range of things than boys. Girls who may seem initially disinterested in STEM may simply have more options.
- Create introductory experiences that do not assume prior knowledge about the technology or skill. This does not mean “dumbing down” activities, but providing interesting challenges that will need a variety of skills to accomplish.

CONCLUSION

In any maker education program, there should be many strategies at work, with a resultant synergy. As programs mature, there should also be constant reflection and renewal about what is working and what could be improved.

There are many, many examples of makerspaces, both community and school-based, that work to empower a wide range of people. Creating these experiences means that everyone can benefit from the learning that happens when hands-on is combined with heads-in. Makerspaces should be about empowering people, all people, to experiment with ways to make sense of the world, to make meaning in their lives, and to make the world a better place.





About Sylvia Martinez

Sylvia Martinez is a maker, mom, engineer, and the co-author of the book, *Invent To Learn: Making, Tinkering, and Engineering in the Classroom*, called "the bible of the maker movement for schools". Sylvia speaks to and works with schools around the world evangelizing authentic, inclusive use of technology across the curriculum. She is president of Constructing Modern Knowledge Press, creating books and professional development advocating using modern technology for learning. Sylvia is also the principle advisor to the FabLearn Fellows program at Stanford University. Prior to that, Sylvia ran the educational non-profit Generation YES, designed and programmed educational software and video games, and was an aerospace engineer specializing in GPS navigation and high frequency receiver systems. Find Sylvia online at sylviamartinez.com, on Twitter @smartinez or by email at Sylvia@inventtolearn.com

Invent To Learn: Making, Tinkering, and Education in the Classroom inventtolearn.com - This website is the home of a groundbreaking book by Sylvia Libow Martinez and Gary Stager. *Invent To Learn: Making, Tinkering, and Engineering in the Classroom* gives educators a practical guide to bringing 21st century tools, technology, and pedagogy to any classroom. The website also includes recommended books and hundreds of links to resources and professional development for making, tinkering, and engineering in the K-12 classroom.

Resources

Tech Girls Movement – This Australian based non-profit offers resources such as a book, *Tech Girls Are Superheroes* that raise awareness of technology career options for girls through positive female role models to encourage and raise awareness of technology careers options for girls. techgirlsmovement.org

I Choose Technology (ICT) – Offers a vibrant look at the many careers that use ICT including profiles of both men and women and personalized pathways. ichoosetechnology.com.au

National Computer Science School Girls' Programming Network – Run by girls for girls, this Australian group runs workshops and offering tutoring for girls interested in computer science. ncss.edu.au/girls-programming-network

Robogals – Robogals is an international, not-for-profit, student-run organisation that aims to increase female participation in Engineering, Science and Technology through fun and educational initiatives aimed at girls in primary and secondary school. sydney.robogals.org.au/

Power of Engineering – Power of Engineering work to inspire young people to consider a diverse and creative career in the profession of engineering, with a particular focus on females, regional and indigenous students. powerofengineering.org/

Girl Geek Academy – Girl Geek Academy is a global movement encouraging women to learn technology, create startups and build more of the internet. girlgeekacademy.com

MacICT – MacICT is a collaboration between the NSW Department of Education and Macquarie University, providing professional learning services to schools and conducting research with partners to provide significant insights into the capacity of new technologies to enhance teaching and learning. macict.edu.au/

Young ICT Explorers – With a high female participation rate, Young ICT Explorers is a non-profit annual competition run by SAP and supported by industry partners, that encourages Years 3-12 students to create their own technology. From fantastic apps and games that solve social problems to amazing new sensor-based technologies that once upon a time were the stuff of science fiction, this is a fantastic competition for girls and boys to dip their toes into using technology to create something meaningful. youngictexplorers.net.au/

Digital Careers – Digital Careers aims to increase the number and quality of ICT graduates in Australia while building a robust and sustainable ICT capability for the future digital economy. digitalcareers.edu.au/

Research

Intel: Girls and Women in STEM – intel.com/content/www/us/en/technology-in-education/girls-and-stem.html

MakeHers: Engaging Girls and Women in Technology through Making, Creating, and Inventing – Intel infographic and research report. intel.com/girlsintech

Securing Australia's Future STEM: Country Comparisons – Australian Council of Learned Academies. bit.ly/STEMSecuringAustFuture