National Inventors Hall of Fame®

HOW TO CULTIVATE A MAKER MINDSET IN YOUR MAKERSPACE

THE BIRTH OF THE MAKERSPACE

All of us are makers. From artists painting a landscape, to architects designing a new house, to computer programmers developing the next revolutionary application, the need to create and improve the world around us is a part of being human.

In the early 2000s, this inborn desire, paired with advances that made additive and subtractive technologies like 3D printers and laser cutters more affordable, initiated the "Maker Movement."[1] According to Dale Dougherty, founder of both Make: Magazine and Maker Faire – the world's largest and most influential maker festival – one of the reasons this movement occurred was that people were growing tired of interacting with the world as consumers. Simply put, there was a desire for agency.

"The maker movement has come about in part because of people's need to engage passionately with objects in ways that make them more than just consumers," Dougherty said. "Whether it's arts and science or crafts and engineering, they seem to belong together, connected by enthusiasm and a common passion."2

It did not take long for educators to see the potential benefits of developing curricula that promoted a hands-on approach to learning. They saw that creating designated spaces for children to explore and work together could naturally create a strong sense of community and collaboration in their students.

While the capabilities of this new technology are incredible, the effectiveness of embracing play and using tools to learn and build have long been promoted.[3] The work of renowned educator and mathematician Seymour Papert's educational theory, constructionism, strongly supports the effectiveness of learning by doing. In his famous grant application to the National Science Foundation in 1987, he explains this learning technique in simple terms:

> From constructivist theories of psychology, we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences is constructing a meaningful product.[4]

Papert was concerned with the act of learning itself, and how making something creates a powerful cycle of self-directed learning.[5] Central to the effectiveness of this method is its ability to empower students and encourage them to discover their own answers. Instead of waiting for an instructor to tell them what to do, students are given permission to take ownership of what they're learning. This type of meaningful education not only has incredible effects on classroom engagement but also has the ability to fundamentally change what a child believes they can accomplish.[6]

Three STEM Maker Lab® participants work together on their invention

DEVELOPING A GROWTH AND MAKER MINDSET

Due to the impressive capabilities of today's modern makerspaces, it is sometimes easy to forget that the most important learning outcome in these spaces is the development of a growth mindset. **In other words, a collection of tools does not define a makerspace. Instead, a makerspace is defined by what it enables.[7] A student can have access to the newest equipment and highest quality materials, but true innovative thinking**

1. Martin, L. (2015). The Promise of the Maker Movement for Education. Journal of Pre-College Engineering Education Research (J-PEER), 5(1), 30-39. doi:10.7771/2157-9288.1099
2. Dougherty, D. (2012). The Maker Movement. Innovations, 7(3), 11-14. Retrieved from https://www.mitpressjournals.org/doi/pdf/10.1162/INOV_a_00135
3. Montessori, M (1912) The Montessori method, New York, NY: Frederick Stokes Co.)
4. Papert, S. (1987). Constructionism: A New Opportunity for Elementary Science Education. Retrieved from https://nsf.gov/awardsearch/showAward?AWD_ID=8751190
5. Ackermann, E. (n.d.). Piaget's Constructivism, Papert's Constructivism: What's the difference? Retrieved from https://learning.media.mit.edu/content/publications/EA.Piaget_Papert.pdf
6. Martinez, S. (2014, October 1). The Maker Movement: Standing on the Shoulders of Giants to Own the Future. Retrieved from https://edutopia.org/blog/maker-movement-shoulders-of-giants-sylvia-martinez
7. Graves, C., Graves, A., & Rendina, D. L. (2017). Challenge-based learning in the school library makerspace. Santa Barbara, CA: Libraries Unlimited, an imprint of ABC-CLIO, LLC.

won't occur unless educators are able to foster a maker mindset within their classes.

In 2006, Stanford University psychology professor Carol Dweck wrote her bestselling book "Mindset," which popularized the difference between fixed and growth mindsets. Those who have a fixed mindset believe their abilities are concrete and will not improve. Individuals who have a growth mindset, on the other hand, believe their capabilities can develop and improve over time.[8] Because our world continues to change at an ever-increasing rate, those who can grow and adapt their abilities will have a clear advantage over those who are reluctant to change.

According to Dweck, fixed mindsets are problematic because they place too much emphasis on outcomes: "In the fixed mindset, everything is about the outcome. If you fail – or if you're not the best – it's all been wasted. The growth mindset allows people to value what they're doing regardless of the outcome. They're tackling problems, charting new courses, working on important issues."[9]

Those who have a growth mindset believe success is not solely dependent on positive outcomes. Instead, what's most important are the skills and habits formed while executing a process. For those who have cultivated this way of thinking, success is defined by the act of continuous improvement.

Makerspaces are the ideal places to nurture this style of thinking and give students the freedom to explore on their own terms. In a makerspace, the act of problem solving transforms from an arbitrary exercise into a tangible obstacle children feel compelled to solve in order to advance their own project. Here, the only limits are the ones students place on themselves.[10]

A STEM Maker Lab participant works with a 3D printer

USING A MAKERSPACE TO EMPOWER STUDENTS

One of the most powerful aspects of makerspaces is their ability to develop students into confident creators. Researchers from the Harvard Graduate School of Education describe this unique characteristic as "maker empowerment: a sensitivity to the designed dimension of objects and systems, along with the inclination and capacity to shape one's world through building, tinkering, re/designing, or hacking."[11]

Fundamental to this definition is the idea that ability does not assure action. Instead, in order to commit to an action and solve a problem, an individual must feel motivated to act and have the sensitivity to know when to act. For example, someone who has world-class computer coding skills will not suddenly decide to create a new helpful piece of software just for the sake of it. Instead, they must first be sensitive to the problem their software will address and be motivated (or inclined) to work toward finding a better solution.[12]

This distinction from the Harvard Graduate School of Education researchers makes it clear that learning technical skills is only one component of developing maker empowerment. It is equally important for educators to show their students how they can use these newfound abilities to solve real-world problems and give them the courage to take risks to do so.

A newly instilled maker mindset enables "students' discovery of their own passions, their capacity to pursue them, and the confidence and resourcefulness developed as they learn with and from others."[13]

LEARNING BY DOING

Makerspaces provide students with the opportunity to learn through the act of creating. An abstract problem that might not resonate in a classroom setting suddenly begins to make sense when a child is confronted with a challenge firsthand. When it comes to teaching STEM (science, technology, engineering and mathematics), there simply is no better way to show the relevance of these subjects than for students to apply these technical concepts to their own projects.

By developing a maker mindset, students will begin to understand that the world around them needs their ideas and solutions. To solve society's greatest challenges, it will take the collective efforts of those who embrace challenges and persist in the face of setbacks. In this way, we at the National Inventors Hall of Fame® are committed to inspiring the next generation of innovators not only to dream big, but also to take the necessary steps to turn that dream into reality.

The more opportunities students have to grow their maker mindsets, the greater chance they will have to apply the skill set of a maker in the future. It's for this reason that Dougherty advises teachers

8. Dweck, C. S. (2017). Mindset. London: Robinson.
9. Ibid., 48
10. Ibid., 56
11. H., & P. (2015). Maker-Centered Learning and the Development of Self: Preliminary Findings of AbD. Retrieved from http://pz.harvard.edu/resources/maker-centered-learning-and-the-development-of-self-preliminary-findings-of-abd
12. Ibid
13. Ibid., 4

who understand the importance of this educational philosophy to identify as "makers" themselves, and to serve as mentors for children in as many ways as possible.

The future will be decided by those who have the courage to see their ideas through to completion. Because makerspaces instill a problem-solving mindset and give students the freedom to work together and pursue projects and activities that excite them, these spaces provide the ideal conditions to grow a maker mindset and set students up for future success.

"Getting these makers involved in summer camps and after school programs at science museums and community centers is one good way to reach kids, but going where the kids are during the day — at school — is even better."

- Dale Dougherty, Founder of Make: Magazine

FIVE WAYS TO MAKE THE MOST OF YOUR MAKERSPACE

1 DEEMPHASIZE THE IMPORTANCE OF TECHNOLOGY

While laser cutters, 3D printers and circuit boards are incredible in their capacity to produce nearly anything students can imagine, successful makerspaces don't need the latest and greatest technology. Instead, a maker mindset can be cultivated using found and donated materials such as cardboard, duct tape, fabric and plastic bottles. By focusing on the creative process rather than the tools, educators can help students practice skills they can take with them the rest of their lives.

2 PROMOTE COMMUNITY AND COLLABORATION

Just as the desire to create is a human desire, so too is the need to connect with others. Makerspaces enable these connections by creating a centralized place that promotes the importance of working together.[14] Here, group work occurs naturally and often without the prompting of an educator. To nurture this cooperative environment in your school's makerspace, when possible, have students troubleshoot problems that their friends might have when working on their projects. Through these interactions, ideas often combine to form even better and more creative solutions.

3 EMBRACE THE ACT OF GUIDED PLAY

According to Alison Gopnik, psychology professor at the University of California, playing teaches us how to deal with the unexpected.[15] Makerspaces provide environments where children are encouraged to discover on their own terms, giving them the agency to solve problems in unique and interesting ways by augmenting classroom learning. By allowing students to explore through the act of play, they will naturally develop a passion for what they're learning.

4 INTRODUCE ROLE MODELS INTO YOUR CURRICULUM

According to Opportunity Insights, children who are exposed to innovation at an early age are more likely to become inventors when they grow up.[16] When students are introduced to relatable, innovative role models, such as National Inventors Hall of Fame Inductees, they are better able to realize that they too can invent. By working alongside students and providing them with support when they need it, educators also have the opportunity to be an inspiring presence and model the behavior of a problem solver.

5 DON'T BE AFRAID OF LARGER PROJECTS

Kimberlee Burris, a second-grade teacher at Barbara Morgan STEM Academy in Idaho, believes in the importance of instilling a maker mindset in children. As a facilitator of National Inventor Hall of Fame education programs, she has been impressed with her students' ability to develop unique solutions. For educators looking for ways to best make use of their makerspaces, she suggests that teachers not shy away from promoting long-term projects. "It is better to do less and go deeper with the process than try and do a lot of quick things," Burris said. Because time in makerspaces is often limited, she also suggests that educators "have a system to store materials and have clear expectations about kids being involved in the cleanup and management of

Kimberlee Burris, second-grade teacher at Barbara Morgan STEM Academy

14. Stager, G. (2014). What's the Maker Movement and Why Should I Care? Retrieved from http://www.scholastic.com/browse/article.jsp?id=3758336&eml=

15. Gopnik, A. (2016, August 12). Playing Is More Than Fun-It's Smart. Retrieved from https://www.theatlantic.com/education/archive/2016/08/in-defense-of-play/495545/

16. Bell, A., Chetty, R., Jaravel, X., Petkova, N., & Reenen, J. (2018). Who Becomes an Inventor in America? The Importance of Exposure to Innovation. Retrieved from http://www.equality-of-opportunity.org/assets/documents/inventors_summary.pdf