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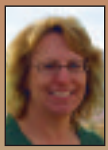
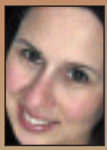

“No makerspace survives and thrives without a supportive environment.”

# The Philosophy of Educational Makerspaces

## Part 1 of Making an Educational Makerspace

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Educational makerspaces (EM) and maker education (ME) have the potential to revolutionize the way we approach teaching and learning. The maker movement in education is built upon the foundation of constructionism, which is the philosophy of hands-on learning through building things. Constructionism, in turn, is the application of constructivist learning principles to a hands-on learning environment. Thus maker education is a branch of constructivist philosophy that views learning as a highly personal endeavor requiring the student, rather than the teacher, to initiate the learning process. In this philosophy of learning, teachers act as guides for inquiry-based approaches to the development of knowledge and thinking processes. Upon reflection, it is natural to believe that the learner should initiate learning, as it is physically impossible for any teacher to mechanically rearrange and reinforce the physical neuronal pathways developed in the brain during the learning process.

In practical terms, educational makerspaces are the ideal environment for maker education. Thus it is necessary to explore maker education to properly understand educational makerspaces. In an ideal constructivist environment, the line between learner and instructor becomes blurred. For instance, consider a student experiencing a roadblock in designing a gear reducer. As the first student struggles in the design, another shares a solution he or she has used or is currently using. Then together the students work to overcome the obstacle; in this case one student is the classical “learner,” while the other is the classical “teacher.” Yet as the students collaborate to meet the challenge, they are both actively engaged in learning and teaching new concepts to each other. All the while the adult teacher observes from the outside, remaining out of the picture unless further rigor becomes necessary. The primary objective of the teacher in this case is to facilitate the acquisition of concepts by building a specific project. This is the ideal learning environment of an educational makerspace.

Makerspaces outside of the educational environment are adult playgrounds for thinking and whimsical construction. Learning may occur, but it is not the primary objective. Educational makerspaces, on the other hand, harness the same intellectual playground concept for the purpose of inspiring deeper learning through deep questioning. However, to preserve the true aspect of maker education, it is imperative that the process remain learner driven rather than teacher driven. In this case, teachers are master strategists considering the army of tools at their disposal—notice that the students are *not* the army; rather the tools are the army. The teacher then commands and arranges the tools in such a way that the enemy—ignorance and small thinking—is effectively banished and replaced with intense questioning, playful curiosity, and deeper thinking. In this approach the learners are being gently guided by the army of tools—the educational makerspace—to create their own learning for their own reasons. At any random moment, the makerspace may appear to be simply a chaotic melee of students, tools, and strange creations. However, in reality, it is a well-planned design to allow students discover the concepts the teacher intended them to learn all along.

The maker education approach to learning is highly individuals yet lives within certain boundaries. It recognizes that no two students will learn the same concepts at the same rate. It even recognizes that some peripheral concepts may not be learned by all students. Yet students faced with a common challenge to design their own unique solutions will naturally come to some common understanding. This occurs because there are laws in the universe that we have found to be quite consistent: gravity, the speed of light, vector math, material science, and a host of others. These rigid boundaries do not bend, even for the most stubborn of students. No matter how hard a student wants the pen to float in mid-air, with the rules of physics, it is doomed to crash to the earth. However, the curious and innovative student may decide that the pen simply needs a little encouragement from a helium balloon or a catapult or quad copter. This type of innovation naturally arises from students being challenged to find a solution to a particular problem.

The individuality within such an environment comes from the solutions that students create. While the laws of nature preclude certain solutions, there are thousands—if not millions—of workarounds in which the laws can be harnessed by innovative thinking. Thus one of the overriding themes in maker education is individuality. At some level, maker education is a grassroots reaction against one-size-fits-all education designed for mass warehouse-style instruction. Deep inside we know that we are each very unique, and we strain at the ropes of conformity that have been imposed by many aspects of modern education. The effective use of educational makerspaces form the basis for a new paradigm in education which is actually a remaking of former systems, such as the artisan system, in which a master or mentor took an understudy. In our technicolor society, we desperately need to move from the gray hues of our recent educational past to a panoply of vibrant colors and a desire for our students to experience the ecstasy of creating their own stunning masterpieces.

## THE EDUCATIONAL MAKERSPACE ENVIRONMENT

Curiously, the tools that are ushering in the maker education renaissance are so modern that many have still not heard of a 3D printer, used 3D design software, or programmed a mobile application to control their refrigerator. Yet these are the very possibilities educational makerspaces are bringing to the average school. It is precisely here that many institutions are balking, because there is a feeling that bringing in such technology requires experts in order to teach it. However, this is not strictly true. Some expertise may be needed to use certain tools common in makerspaces, but in general, educational makerspaces do not need to be overly complicated or formidable.

Of all the aspects required in a makerspace, environment is at the very top of the list. No makerspace survives and thrives without a supportive environment. There is no amount of bright, shiny new technology that can take the place of inspiration, and inspiration is a direct result of the environment created by the space. A simple and relatively unadorned makerspace with an electric atmosphere of learning will invariably succeed where a fully instrumented, equipment-rich space lacking that same spirit is doomed to fail. Thus when considering the installation of a makerspace in school, it is crucial to first consider the environment necessary for success. The aspects of the environment can be broken down into three areas: the feel, the guiding principles, and the spacemakers.

## THE FEEL OF AN EDUCATIONAL MAKERSPACE

The feeling students perceive in the makerspace is of the utmost importance. For inquiry-based learning to occur, students must be attracted to the space and be inspired to use it. Attracting students to the space is the first big challenge. A makerspace without makers is just a workshop full of lonely tools. How does one attract students hungry to learn? Create an en-



## JUNIOR NONFICTION

### $ FOR KIDS

Bullard, Lisa. **Ella Earns Her Own Money** (Cloverleaf Books: Money Basics). Lerner: Millbrook Press, 2014. 24p. LB $17.95. 978-1-4667-0761-9. Grades K-3. Colorful cartoon-type characters take the reader from wanting a soccer ball, to working for money, and then buying the ball. Instructions on making a money-chart round out the title, along with a glossary, further reading, and a short index. Other topics in the series include borrowing money, making a deal, keeping track, saving, and knowing the difference between wanting and needing.

Randolph, Ryan. **How to Earn Money** (A Smart Kid's Guide to Personal Finance). Rosen Power Kids, 2014. 24p. LB $20.34. 978-1-4777-0741-8. Grades 2-5. Learning the importance of money and how it works is an important skill. Here are simple suggestions to begin getting paid for things like pet care and making crafts. There are sections on money-earning tips, a glossary, a brief index, and websites.

Reynolds, Mattie. **Kids Making Money: An Introduction to Financial Literacy** (Start Smart: Money). Red Chair, 2013. 24p. LB $21.63. 978-1-937529-37-6. Grades K-2. Bright color photos enhance this easy-to-read text that begins with why people need money and ends with suggestions for making and using money.

Yomtov, Nel. **Starting Your Own Business** (A True Book). Scholastic, 2014. 48p. LB $25.25. 978-0-531-24779-2. Grades 3-6. Mid-range readers will find interesting facts about accomplished business leaders as well as fact boxes and colorful photos. This would also serve as a high-low reader for older students. Back matter includes resources, glossary, and index.

vironment that inspires students with the principles highlighted below.

***Invite curiosity.*** Students are naturally drawn to things that pique their curiosity. If you have ever watched young children, it is obvious that the power of curiosity is a deep motivator. Curiosity has the ability to reach deep into the soul and draw out the best and most engaging aspects of our personalities. A gentleman by the name of Sugata Mitra has done some fascinating studies in which he introduces a computer with Internet access to rural Indian villages for the purpose of studying the power of curiosity to motivate independent learning. His results are some of the most compelling evidence for the dynamic effects of curiosity on knowledge acquisition.

[1] Thus one of the most important considerations in the educational makerspace environment is how to invite curiosity.

***Inspire wonder.*** Closely linked to curiosity, wonder is a fast-fading ethic in our culture, yet the awe that comes from the unexplained is a very necessary component in connecting to curiosity. To illustrate this point, consider the last time you were truly awed by some technology or experience. It has likely been days, if not weeks, since a deep sense of transcendence has washed over us. We have been trained by our society to respond with, "Been there, done that," rather than, "Wow!! How did that happen?!" As a researcher, there is no more powerful ally in the search for truth than the wonder that gives rise to the deeply probing question, "Why does it work *that* way, as opposed to all the other possibilities?" A deep sense of wonder is poignantly missing in many learning environments, and finding ways to create it in an educational makerspace is a crucial ingredient for success.

***Encourage playfulness.*** As educators of teenagers, we rarely consider learning in the very young. Yet in the space of time from birth to three years old, humans develop a complex sensory-motor feedback loop known as "balance," enabling them to walk and run. They develop an auditory library of phonemes and cadences that can be recognized in milliseconds and repeated back with variances to communicate intricate meaning, such as, "More juice please," which results in another human engaging the previously mentioned complex motor-sensory feedback loop to walk to the fridge, grab a bottle of juice, and pour the liquid into a cup without spilling any of it. They also learn to identify regularly appearing optical disturbances, focus them onto the retina of the eye, and interpret them using edge-recognition algorithms, color analysis, and pattern recognition. This level of feedback control loop complexity is currently not even found in the most sophisticated artificial intelligence developed by the military. Thousands, if not tens of thousands, of scientists have worked on these challenges for over fifty years and still cannot learn as much as a two-year-old who is learning by playing! Playfulness is an extremely important tool in the engagement of learning. Students who play will learn without even knowing it has happened. We may not yet thoroughly understand the power of play, but an effective educational makerspace will engage students through the medium of playfulness because it works.[2]

***Celebrate unique solutions.*** We are all familiar with the power of praise. Not all individuals are highly motivated by affirmation, but to the significant fraction who are, being recognized for a talent or creation is a powerful motivator. Even the individual who is not as highly motivated by being recognized typically appreciates that someone has noticed. Thus a makerspace will be much more likely to thrive in an environment where unique solutions and one-of-a-kind devices are noticed and put on display for all to see. To keep the excitement and confidence of students high, successful educational makerspaces will regularly recognize student contributions and achievements by displaying them, having show-and-tell sessions, or simply by saying, "I think you should go see Shauna. She has a couple of fantastic examples of how to do that!"

## THE GUIDING PRINCIPLES OF AN EDUCATIONAL MAKERSPACE

While we should encourage students to explore their unique interests and pursuits, there are still some basic principles that are important to articulate by posting them and talking about them often.

***It's OK to fail.*** In fact, we encourage what most of society calls "failure," because in reality, it is simply the first or second or third step toward success. No amazing innovation is created on the first try. Truly paradigm-shifting technologies and devices are the outgrowth of many iterations. Thus the path to success is paved with failures. There is a famous concept in business that to reach success more quickly, one must find ways to double their failure rate.[3] Educational makerspaces must be failure tolerant, and it would be even better if exploration and productive failure were explicitly encouraged by signs, words, and responses to failure. Big ideas are built on the lessons learned from smaller failures!

***Breaking things is not a cardinal sin.*** In light of the previous paragraph, a truly vibrant makerspace is likely to have the carcasses of broken things lying around. While it is a good idea to discourage indiscriminate destruction, sometimes the advancement of a truly brilliant idea may result in unintended damage. This is normally not fatal. Good training is important for expensive machinery, but consider the power of saying, "Oops! I suppose that was a bad idea. How do you think we can get this running again?" This type of proactive statement empowers a budding engineer or scientist to solve a bigger problem—the broken device—while garnering the confidence of a trusted adult. Contrast this with the words, "I can't believe you did that. You aren't allowed to use this anymore!" One statement encourages learning and growing, while the other has the capability of permanently shutting off a student's willingness to experiment, tinker, and make things.[4] This single topic is much too large to cover in detail in the present article, but suffice it to say, mistake tolerance is critical. Educational makerspaces must be able to tolerate the occasional broken instrument by communicating that mistakes happen, but we fix them and move forward.

***Collaborate, collaborate, collaborate!*** The best companies, engineers, and researchers in the world know the power of teams—today's science is not a solo sport. The challenges are simply too complex for any single individual to create the solution. Thus the only practical way forward is to collaborate with others. Then each member of the team works within their strengths to move the project forward.[5] The same principles hold true in a makerspace. To encourage growth and collaboration, challenges beyond the natural ability of any single individual can be given. Then students can band together in groups to come up with creative solutions that they would never have invented individually. Thus within the framework of a makerspace, the typical mantra of, "Don't cheat from your neighbor," simply becomes irrelevant. Students are encouraged to share knowledge, help each other, and work in teams. The challenges presented should simply be too large for any single individual to solve on their own. Great educational makerspaces embrace the power of collaboration.

## THE SPACEMAKERS

Every successful makerspace has individuals that start and manage the space. We are going to call them "spacemakers." Spacemakers, like every leader, will be likely to face challenges and obstacles. They must be resourceful, failure tolerant, collaborative, and always learning themselves. In short, they need to be able to live out the principles and ethics of the makerspace in front of the students. It is particularly important that questions be answered with another question—good old-fashioned Socratic wisdom. If spacemakers spout off answers too often, they become "experts," and students will not surpass their knowledge. In contrast, a spacemaker who asks questions need not feel threatened by not knowing the answer because unanswered questions are a sure sign that the makerspace is still serving its purpose. In fact, as students gain confidence, they will begin to be the experts, and the spacemaker can then help them become mentors. This recursive process will ensure lasting success and inquiry by even the most timid of newbies.

In effect, the spacemaker becomes what Liz Wiseman calls a "multiplier." Multipliers bring together groups and are able to extract the fullest potential of individuals. They do this by recognizing talent, liberating potential, challenging others to grow, encouraging productive debates, and investing resources into the space and the makers.[6] These individuals do not feel the need to be the experts but stand on the side to alternately cheer and challenge the makers. Make no mistake, individuals who aspire to start or manage an educational makerspace must be leaders who practice the philosophy of the multiplier, but if followed, this philosophy will help to create a thriving educational makerspace.

## CONCLUSION

Many concepts of maker education and educational makerspaces have been briefly touched on in this article, but there are three main take-away lessons: (1) maker education inspires deeper learning, (2) educational makerspaces are based on student ownership of their learning, and (3) it is not necessary to be a technical expert to start a makerspace in your school or library. We could review those concepts here, but instead let's summarize some of the benefits of maker education spaces. Maker education fosters curiosity, tinkering, and iterative learning, which in turn leads to better thinking through better questioning. This learning environment fosters enthusiasm for learning, student confidence, and natural collaboration. Ultimately, the outcome of maker education and educational makerspaces leads to determination, independent and creative problem solving, and an authentic preparation for the real world by simulating real-world challenges. In short, an educational makerspace is less of a classroom and more of a motivational speech without words.

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(Endnotes)

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