The SAGE Encyclopedia of
Out-of-School Learning

Editorial Board

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Makerspaces

Maker culture is a worldwide, grassroots hobbyist movement involving hands-on, do-it-yourself or do-it-with-others building, creating, tinkering, hacking, and crafting. Maker culture employs a diversity of tools and materials—both high-tech and low-tech, digital and physical. Because of the different challenges involved in making with various tools and materials, its educational potential is vast and applicable to a great many disciplinary fields. Most makers meet with other makers in places called *makerspaces* that contain tools, materials, space to work, inspiration, and the company of others in a supportive community. Many youth-serving makerspaces exist as informal learning centers for youth to attend outside school hours, though many continue to spread into schools as well, and some out-of-school spaces have direct relationships with schools.

The maker movement is being hailed as "the next industrial revolution" and "shop class of the 21st century." It continues to grow and gain momentum, both among hobbyists and in educational spaces. The maker movement has inspired support from grassroots makers, educators both in school and out of school, academics, and even the White House. This entry discusses the origins of the maker movement, the educational value of making, the related practice of tinkering, and different types of out-of-school makerspaces. It concludes by discussing educational research on the maker movement and potential directions for future research.

Origins of the Maker Movement

The concept of making things is not new; people have always made and created. However, in recent decades, the Western economy has shifted from one of production to one dominated by consumption, with production largely kept out of sight in faraway factories. The maker movement has emerged as a critical response to this societal shift, in an attempt to revalue hands-on creation rather than consumption, personal fabrication rather than mass production. The movement grew from the grassroots, with hackers meeting in garages, crafting clubs in homes, or public spaces. With the emergence of the Internet, meeting fellow makers and sharing resources online have become easier than ever. In addition, recent innovations in personal fabrication have made it cheaper and easier to make whatever one wants with tools such as 3D printers and laser cutters.

In 2005, Maker Media first released *MAKE:*—a periodical containing instructions for DIY projects, as well as inspirational articles, profiles, and interviews. Maker Media followed up on the magazine a year later by sponsoring the first Maker Faire, a celebration of making in a convention or carnival-like setting, full of booths displaying impressive creations, hands-on activities for on-site making, and guest speakers and expert makers who share their skills and projects. Since then, Maker Media has largely become the public face of the maker movement. It has established an online store, the Maker Shed, selling products and kits appealing to makers. Other online retailers for makers have emerged, such as SparkFun and Adafruit, while other makers prefer conventional retailers that sell electronics, craft supplies, and construction tools and materials.

While the origins of the movement did not directly consider its educational implications, it was a natural leap, as makers recognized how much it was possible to learn from each project they created. This led to the establishment of youth-serving makerspaces with educational goals, both inside and outside schools.

The year 2012 saw the launch of Maker Ed, one of the most prominent nonprofits promoting the educational value of making, whose mission is "to create more opportunities for all young people to develop confidence, creativity, and interest in science, technology, engineering, math, art, and learning as a whole through making" (Maker Ed, n.d.). The organization runs maker programs for youth, sponsors work investigating the educational benefits of documenting the making process, and trains leaders to serve within youth-serving makerspaces, especially those in underprivileged areas.

The maker movement has sometimes faced criticism for being overly dominated by White, highly educated men and boys and for overprivileging high-tech tools and projects that may appeal more to this demographic. However, while technologies such as 3D printers and laser cutters are the "big-name" tools associated with the maker movement, there is growing awareness that the movement should include all types of making (whether high-tech, low-tech, traditional, or new) and all types of makers (whether men, women, children, crafters, hackers, engineers, artists, roboticists, or cooks). The movement itself also continues to grow and diversify, with increasing numbers of self-identified makers, makerspaces, Maker Faires in cities across the world, and participants in these Faires. Youth-serving makerspaces tend to serve more diverse audiences than adult makerspaces. Thus, educational spaces are often seen as the best hope for diversifying the movement and promoting greater equity and empowerment for all through making.

The Educational Value of Making

Hands-on learning is proven to be very powerful. Many educational experts have observed that learning seems to proceed most productively when learners are engaged in the construction of a shareable, personally meaningful artifact. Making an artifact, whether physical or digital, represents the constructions one builds in one's own head. The maker spirit is especially suited for this type of learning, because it encourages an open-ended, creative approach driven by personal interests and/or community needs, as opposed to making something by following a step-by-step kit or top-down instructions. Many hands-on science projects in schools are seen as exemplifying this closed-ended approach, in which the goal is not to make a creative contribution but to reproduce the results demonstrated by the teacher or the textbook. In contrast, the maker movement celebrates creativity, variety, and personal expression.

While sharing final products at showcases such as Maker Faires is a centerpiece of the maker movement, makers also understand the importance of the process involved in making projects. Sometimes, that process proceeds according to a plan or goal that the maker brings in from the start. At other times, the goal emerges through tinkering. In almost all cases, though, makers run into frustrations or unexpected problems that they have to debug. Two colors of paint may not blend into the color the painter was expecting, and they have to explore color mixing until they get the intended shade. A coder may find that his or her computer program to drive a microcontroller-powered robot will not compile, and he or she will have to explore different possible solutions. The debugging process can be the most learning-intensive moment of making, as makers must reflect on their entire process so far that might have led to the problem they are trying to solve. The problem often reflects something they do not know yet. Once they solve it, they have learned something new.

An important part of the making process is sharing, of both the process and the final result. Whether this involves makers showing their friends and family what they have made, uploading a step-by-step guide online on how they made something and how others can do the same, or presenting it at a showcase event such as a Maker Faire or poetry slam, sharing allows engagement with the larger community of makers and often involves external articulation of what they learned from the making process. The artifact itself may represent what the maker has learned in a nonverbal manner. But makers who help someone else understand what they have made can come to understand it better themselves. Because the maker movement encourages personally meaningful projects that makers are proud of, sharing—and its educational benefits—tends to happen naturally.

Educators may wonder if particular valued disciplinary content, such as concepts from math, science, or language arts, can be engaged through making. The answer is only limited by one's imagination. Due to the vast variety of projects possible through making, nearly any disciplinary concept or standard can be involved. One can learn computer coding and computational thinking when programming a robot or a Flash animation. One can learn about physics and energy when building a circuit or trying to get a vehicle to move. One can learn about art and design when building and decorating a cardboard creature. One can engage with biology, conservation, urban planning, and civics when building an urban community garden with one's classmates. One can learn about literature and history when designing steampunk versions of common outfits or tools, since steampunk involves an alternate version of history. Recognizing patterns in code, art, or craft can be an important math-related skill. Even composing a story, poem, or song is considered making.

While making can involve any sort of disciplinary content, a lot of excitement around the maker movement's potential for learning has developed around its fun approach to STEM learning. It has been heralded as a great way for youth to learn engineering skills through the construction process, technology skills by programming microcontrollers or using high-tech tools such as 3D printers, and science skills as they use physics, biology, or chemistry to make things such as robots, gardens, or slime. However, it is important not to forget that the maker movement is about all forms of making, including those that fall more on the side of the arts and humanities rather than STEM. Making also values an interdisciplinary approach. Even if a group of youth together built the same wooden car, for instance, the decoration and customization process by which they make their car unique could be the moment the car becomes personally meaningful to them. Any physics they learned from the car's mechanisms becomes more likely to stick when they form a personal relationship to the project through artistic expression. And a youth who developed an idea for a project based on his or her own interests is not going to bother to maintain disciplinary boundaries when math, science, technology, art, and literature are all required to achieve that vision.

A final educationally relevant skill that the maker movement cultivates is a critical approach toward cultural narratives around production and consumption. This is applicable to everything from clothing to electronics. The maker spirit values making and repairing your own personalized projects over buying mass-produced products and throwing away broken items. Thus, it can teach makers to approach consumerism with a critical eye and can encourage sustainability. Critical, sustainable making requires a reflective mind-set and a commitment not to waste materials, however.

Ultimately, regardless of what you make or the disciplinary content used in it, making is a mind-set of creativity, curiosity, expressiveness, problem solving, and personal interest and agency. It is about actively making one's own stuff and experiences rather than passively accepting what is given or what is readily available. Developing this mind-set is often more important to maker educators than is particular disciplinary content.

Tinkering: A Maker Habit of Mind

One of the most educationally powerful practices common among makers is tinkering. Tinkering involves playfully exploring processes and materials in an open-ended, iterative manner—for instance, hacking an electronic toy to explore how it works and how to change its sound and light effects in unexpected ways. Tinkerers often start out with no goal or only a vague goal, which they continually refine over time as new ideas emerge from the materials. This allows them to approach challenges creatively, without fixating on the first plan that occurs to them. This sort of flexibility is seen by many as crucial in a rapidly-changing world.

While school seems to privilege an orientation toward planning, tinkering is also an important and educationally relevant skill that learners should have the chance to practice. This is especially true since professionals in STEM careers often approach their work with a playful tinkerer's attitude as they encounter unexpected developments. This contrasts with the stereotype, especially prevalent in schools, that STEM fields are straightforward and planning oriented. This misconception can serve to exacerbate trends of underrepresentation in STEM fields, by shutting out natural tinkerers from the start, even though their approach is actually valued in these fields. However, it is important not to lose sight of the fact that tinkering—like making itself—is valuable in any capacity, and not just for STEM.

Types of Out-of-School Makerspaces

Out-of-school makerspaces run the full range of diversity of people, projects, materials, and locations. They can be in museums, warehouses, garages, church basements, libraries, and so on. And they could have anything from computers to 3D printers, to sewing machines, to welding stations. The types of makerspaces profiled in this section are only an overview and are not an exhaustive list.

Makerspaces in museums tend to cater to younger audiences. Thus, their emphasis is sometimes on the more "crafty" aspects of making, such as building with cardboard and other recyclables, painting, sewing, or weaving. Some bring in early experiences with technology, such as through circuits made of blocks that snap together or made out of conductive modeling compound. Others feature "real" construction tools, such as hammers and saws, modified and closely monitored for safety, while still respecting that children do not always need plasticized, "dumbed-down" introductions to adult tools. Still, other museums have high-tech tools such as 3D printers that extrude plastic layer by layer to create a 3D form or laser cutters that can cut plastic, wood, cardboard, or fabric into any shape a visitor programs. These tools are often geared more toward older youth visitors, and because they take a long time to produce completed projects, they may be used only in special workshops. Unless leading specific workshops, adult mentors in museum makerspaces tend to try to facilitate rather than overly script youth's engagement with the hands-on projects.

Many libraries have embraced the maker movement as compatible with their mission of sharing resources. While libraries have provided access to tools such as computers in addition to books for a long time, many are now taking that a step further by providing high-end design software on computers for digital making, access to production tools such as audio and video studios, and opportunities to check out high-tech items such as laptops, iPads, and drawing tablets. Some have invested in 3D printers and laser cutters, while others focus on low-tech making. Many have set aside a special location in the library for a makerspace, and often, this space is directed toward youth, with age restrictions on entry and/or programs. Library makerspaces tend to expand the roles of librarians, but some public libraries specifically bring in "maker educators" with special skills relevant to making. A few public libraries have opened "tool libraries," allowing patrons to check out hand tools, power tools, yard tools, electronics, how-to instructions, and so on for DIY projects, just as they would check out books. This allows the community to share these tools, without everyone needing to buy their own. Sometimes, tool libraries are run by organizations other than public libraries.

Makerspaces that serve youth outside school but are unattached to larger organizations such as museums and libraries vary greatly. Some are permanent spaces with their own rooms or buildings that are open to anyone after school hours. Some are clubs that only meet once a week, borrowing a space such as a classroom. Some allow any project anywhere, while others have stations that are dedicated to specific types of projects (e.g., a 3D printing station, a sewing/fashion station, a digital making station, a cooking station). Some may focus on individual interest-driven projects, while others do collaborative and/or community-driven projects. Tools and materials can be any of the ones mentioned so far, but these types of spaces are more likely than institutional spaces to purchase items requested by individuals or groups for specific projects. An adult may take an explicitly educational role as the leader of a class, may act as more of a supervisor, and/or may learn right along with the youth if working on a project with which he or she is unfamiliar. Peer mentoring by youth is also common, as they share skills with one another, whether formally in how-to sessions or informally when they seek help from a peer who is a greater expert in some skill than they are.

Makerspaces that cater to a mostly adult audience tend to have a paid membership structure and may provide access to tools typically not considered "safe" for youth, such as power tools, strong chemicals, and welding stations. Unlike most youth-serving spaces, adult spaces tend not to have an overt educational focus, though of course learning occurs wherever making occurs, and sometimes, these spaces provide classes. Other than classes, mentorship tends to proceed in a largely informal manner. Locations vary greatly, though wide-open spaces such as warehouses are favored.

Educational Research on Maker Movement

Educational research on the maker movement has focused heavily on STEM-related aspects, such as learning engineering dispositions, computer programming, and self-efficacy with regard to technology after engaging in maker activities. Other work has investigated making as personal expressiveness, families learning together in museum makerspaces, and critical and community activism through making. An entire subgenre of this literature investigates digital making in particular, such as digital art making, video creation and editing, computerized music composition, and video game design. Further work remains to be done in studying non-STEM-related learning, in looking for changes in the amount learned over time, and in comparing different pedagogical approaches to making (e.g., a workshop model vs. an open, free-choice studio model).

Sophia Bender and Kylie Peppler

See also Children's Museums; Constructionist Learning; Crafting; Design and Out-of-School Learning; DIY Media; Fab Lab; Grassroots Organizing; Hackerspaces; Hobbies; Libraries and Library Services; Museum Learning; Science-Technology Centers and Science Museums; Tinkering Studio, The

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Martial Arts

A scholastic definition of martial arts considers them as systems that blend fighting techniques, strategy, philosophy, and tradition. That is why contemporary scholars include other martial traditions—such as Western medieval swordfight—under the umbrella of martial arts. Nonetheless, a layperson's understanding of martial art is still attached to Asian bare-handed fighting techniques involving some degree of spiritual development. This entry discusses the development of martial arts based on Asian traditions, research on the effects of martial arts on participants, theories on how involvement in martial arts leads to change, and the characteristics of successful educative programs and interventions based on martial arts.

Martial art was originally a Western term applied to Asian martial traditions. The term is foreign to those Asian traditions that use myriad cognate terms instead. As an example, three related but different Japanese terms are (1) *bugei* (martial methods), (2) *bujutsu* (martial techniques), and (3) *budo* (martial ways). Also, we can differentiate traditional martial arts (*koryū*) as opposed to sportified martial arts (*kakutogi*). These traditions involve more than fighting efficiency. Following the example of Japanese *budo*, the premodern concept of *bunbu ryodo* referred to the ideal of a double path of development regarding the literary (*bun*) and martial (*bu*) skills of the samurai. This conception was pivotal in the development of modern martial arts and has remained at the set core of values of true martial artists.

The modern understanding of martial arts as involving educative means for character building was to a great extent due to Jigoro Kano (1860–1938) and his conception of judo as a way to develop harmonic citizens. Kano considered that the practice of judo would help people acquire two basic principles: (1) maximum efficiency with minimum effort and (2) *mutual* welfare and *benefit*. Kano was aiming further than the practice hall—he talked of "big judo" as the transference of the principles learned on the mats toward society and even humanity as a whole.

Kano's project raises the question of how training in fighting techniques can deliver desirable character building. There is no easy answer. Ideally, the development of respect, control of aggressiveness, and a calm and gentle disposition are achieved when we defeat our most fearsome enemy—ourselves. Only when we have built enough confidence in our own skills and understand that conflict avoidance—not the beating of one's enemy—is the goal to attain, do we start to see that there is no need to hurt, to be vengeful, or to be full of anger; we can become the calm person we always think of as an advanced martial artist. This is the promise of the so-called "mundane enlightenment" bound to these martial practices.