
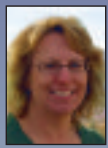
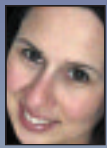

"Even though the map to educational makerspace success remains vague, pioneers in the field are pushing forward and reporting their findings."

Practical Implementation of an Educational Makerspace

Part 3 of Making an Educational Makerspace

R. STEVEN KURTI, DEBORAH KURTI, AND LAURA FLEMING

A culture of innovation in an educational makerspace arises from student ownership rather than from the presence of high-tech tools.

Figure 1. The old NMHS library—a typical high school library space that was slowly becoming a "barren wasteland."

Owning the learning experience opens unexplored horizons to students because independent thinkers have the uncanny ability to strike out into uncharted territory. Educational makerspaces are the ideal environment to foster such independent exploration, but the map for creating engaging educational makerspaces remains relatively sparse.

Even though the map to educational makerspace success remains vague, pioneers in the field are pushing forward and reporting their findings. The first installment of this three-part series discussed the philosophy of educational makerspaces.[1] The second installment explored the look and feel of the physical space and the selection of tools to inspire tinkering, creating, and inventing.[2] This final part of the series exposes a real-life case study of a makerspace in an average school in an average district, with results that are anything but average.

STARTING AN EDUCATIONAL MAKERSPACE: A SHORT CASE STUDY

By most standards, New Milford High School (NMHS) in Bergen County, New Jersey, is a normal high school. It has a normal amount of per capita funding, and the students come from a normal cross-section of the population. Being a public high school, all the state and national standards, as well as the required test metrics, must be met. Yet there a few aspects in which NMHS is not quite ordinary. The principal, Eric Sheninger, is a nationally recognized author for his educational leadership ideals and strategies.[3] Sheninger has adapted some of the most progressive strategies in business management and marketing to catapult NMHS into the national spotlight, and a little over a year ago, he recruited a new librarian to revolutionize their library into a full-scale learning resource center. This change at the library was instigated by Sheninger's desire for the NMHS library to be more than a "barren wasteland."[4]

The renaissance of learning and creativity in the library at NMHS had humble beginnings: a simple makerspace where students could learn from one another and from unscripted tinkering. The process to create such dramatic results at NMHS has progressed through several phases: observations and planning, initial student engagement, development of student ownership, and leveling up to intermediate tools. In this article, each phase will be unpacked and the central elements and actionable steps extracted. However, what follows is not the story of a cookie-cutter recipe for starting a makerspace—there is no such recipe. Nevertheless, important principles have emerged from the first year's experience.

Curiously, the development of the NMHS makerspace followed the stages of a good maker project: begin with an idea, observe and plan, jump straight into trying things, and tinker with it until it works well.[5] This symmetry in ideals and action appears to be a deeper principle but beyond the scope of the present work. The NMHS case study encourages educators to try their own ideas without overthinking the process or even biasing personal observations with research that may or may not be relevant.

Figure 2. Glimpses into the makerspace at NMHS, a "thriving learning metropolis."

The new librarian took the challenge to transform the library into a vibrant learning environment, and the principal extended immense professional freedom to adjust the space in any manner necessary to inspire students at NMHS to learn, create, and innovate. To an outside observer, the initial stages of the transformation would have appeared quite subtle or even nonexistent, but within a few months, the once-barren library earned the new label of "thriving learning metropolis."[6] Such a complete change in a few months seems beyond optimistic, but the story that follows illustrates the steps any school can take to achieve a similar metamorphosis.

OBSERVATIONS AND PLANNING

The NMHS makerspace grew from the notion that every student has the ability to invent, tinker, create, and innovate. Building on the school culture already being developed, the NMHS makerspace began with a foundation of full student ownership of both the tools and the learning experiences. The environment allowed learning and collaboration to transcend academic potential, social and language barriers, and developmental strata. As with many great movements in history, the NMHS makerspace began in the mind as a dream and slowly solidified into action.

From a practical perspective, the general cycle of action at the NMHS makerspace is reflected by the following process:

The initial seeds of observation grew as the students performed daily activities. One of the most important lessons gleaned from the experience at NMHS is that the space was designed around the interests, capabilities, and aspirations of the students. Much of the later success in student engagement can be attributed to the early observations. Over the course of a month or two, the librarian gathered her notes while considering the first tools to introduce into the "maker corner." The lesson here is to study the future users of the space prior to any investment into resources or space.

The NMHS librarian also took time to assess and evaluate existing curricula, offerings, and programs at the school. Being a connected educator, she was able to consider global trends and best practices. With all the foregoing considerations, themes were developed as a framework for the activities within the small makerspace corner of the library. Then, with the most persistent themes as a guide, the NMHS makerspace acquired the following short list of tools: Legos, Little Bits, some old computers, a few hand tools, MaKey MaKey

WORLD WAR I = 100 YEARS

Anderson, Richard. **Ernest Hemingway and World War I.** (Writers and Their Times.) Cavendish Square, 2015. 112p. LB $29.95. 9781627128094. Grades 9-12. This biographical look at Hemingway presents world events of fine arts, political and economic trends. Information for research includes photos, timelines and fact boxes with a more-to-read section, index and glossary.

Hyde, Natalie. **World War I: the Cause of the War.** (World War I: Remembering the Great War). Crabtree, 2014. 48p. LB $$23.49. 9780778703877. Grades 6-9. As the first of a six book series, the world's political and social cultures are explained. Documents, photos, sidebars and timelines carry the reader through to the end of the war.

Pratt, Mary K. **World War I.** (Essential Library of American Wars). ABDO, 2014. 112p. LB $23.95. 9781617838811. Grades 6-12. Causes and the personal impact of the war are described with primary source materials, photographs, fact boxes, timeline, and extensive source notes. Other titles in the series cover the Civil War, Korean War, Revolutionary War, Vietnam War, and World War II.

World War I (1914-1919). (Defining Documents in American History). Michael Shally-Jensen, ed. Salem Press, 2014. 308p. LB $175. 9781619254916. Grades 9-12. This academic title provides an in-depth examination into the causes, issues and long-term effects of the war through the writings of experts in the field. Included are primary sources of journals, legislation, and speeches of the time. Each section includes a bibliography and additional reading. A chronological list, Internet resources, general bibliography, and detailed timeline complete the volume.

Figure 3. The NMHS process for planning the makerspace.

kits, molecular gastronomy kits, and a 3D printer. The initial investment—aside from the 3D printer—was less than $1,500, and some of the tools were free, such as the old computer take-apart station, still a favorite among the students.

Just as a room with tools does not imply a makerspace, a big educational budget does not create a learning utopia. This is not indictment of high-tech tools. They are a natural step in growing an academic makerspace, but the lack of a technology budget should not be an excuse to delay the creation of a makerspace. To be fair, the 3D printer NMHS purchased was more than the $1,500 price tag mentioned above, but it was not absolutely crucial in the startup phase. The 3D printer has indeed become a main attraction for NMHS, and there are several high-quality student-accessible 3D printers now that can be acquired for under $1,500. Nevertheless, if the 3D printer is a cost barrier, don't wait for more money before starting a "maker corner."

From the NMHS experience, a month or two should allow plenty of time to observe the students, organize the data, and identify themes and patterns. The NMHS analysis indicated investment of tools for STEM projects, but other schools may choose to focus their makerspace more toward art, career technical education, or entrepreneurship. However, no amount of data collection can predict the perfect time or the perfect set of tools, so make some reasonably intelligent decisions and move forward.

INITIAL STUDENT ENGAGEMENT

With the initial planning done, tools were ordered before too much overthinking occurred, and a 150–200 square foot corner of the library was designated as the makerspace. Soon after, the students began to notice new items in one corner of the library, but it became clear that they weren't interacting much and needed a little prompting to investigate the space on their own. After a few tests, the makerspace began relying on "digital breadcrumbs" to lead unsuspecting students into the makerspace. These subtle suggestions appeared every day by means of a large flat-screen TV placed in the maker corner. Some days the display would ask a simple question. Other days it showed a quote, link, or video designed to inspire curiosity. The students were not strong-armed into using the space. Rather, they were coaxed by means of strategically placed tools—breadcrumbs—or projects growing on the 3D printer. Always, the librarian stood off to the side, just outside the space, pretending to ignore the goings-on but tuned in to see what could be adjusted for more student engagement.

The makerspace at NMHS was designed to run itself. This was possible because it consisted of fixed stations as well as flexible stations. The fixed stations included a Lego table, a Makey Makey station, a littleBits bar, 3D printing and design station, and a take-apart tech station. These stations were out in the space at all times and never changed. All the activities at these stations were quick and had a low barrier of entry, allowing for students of all abilities to participate. The flexible stations in the makerspace changed on a rotating basis. These included activities or projects that required a bit more teacher facilitation or even extended student work time, such as stop-motion animation, computer programming/hacking, and engineering inventions.

STUDENT OWNERSHIP

The "hands-off" approach at NMHS has caused students to take ownership. In fact, the librarian now confesses students often know more than she does, but as all good educators know, this is a definite sign that student ownership is occurring. She is quite convinced now that students will never be held back by what she does not know. We must stop here to underscore this point: Spacemakers acting as experts on a subject will generally limit the users in the space. To remove this limitation and give the students ownership of their learning, it is crucial to stand slightly to the side and allow the students to make their own mistakes and find their own solutions.[7] In this way, students will begin to find the joy of learning and will not need a formal teacher other than to accelerate learning. Students who learn how to learn will find few limits and a deep sense of confidence. With this philosophy, the NMHS makerspace has become a thriving environment where students stop over after quickly wolfing down their lunch just to have a little more time to create. Students from different social groups who never interact outside the makerspace find common ground to work together and help one another build projects. The space has truly become a hub of informal learning within the NMHS ecosystem.

The initial newness of the space has begun to fade, and the students are becoming more comfortable dropping in to try things. Students have emerged as experts and have taken it upon themselves to share their knowledge with their peers. Two students in particular have become the 3D printer experts, and other students are coming to them for advice. One of these students is more of an engineering type, while the other is more of an artist. Their approach to making things is quite different, but in the makerspace their strengths complement each other, and they regularly help each other on projects.

The advantage of empowering student experts is that there are always more students than librarians, and thus the learning is not limited by the time commitments of the librarian or other teachers. Any time someone needs to learn a new skill in the space, a student can be found to help. With student experts, makerspaces create scalable mentoring, relevant experiences, and authentic learning—a significant shift from traditional instruction.

TRANSITION TO INTERMEDIATE MAKER TOOLS

With the first year in the makerspace drawing to a close, NMHS is looking to the future. The next phase appears to be growing technically to accommodate the students who are ready for bigger challenges. Many of the students have now tried most of the simple tools from the makerspace's startup days and are ready to level up in their learning. With an interest in robotics, students are ready to move onto intermediate challenges involving sensors and programming. A couple of Arduino robot kits now adorn the makerspace, and more Arduino tools are on the way. Another 3D printer or two are planned to increase the capacity for students to design and print their projects.

The reaction of the students to the new tools is not yet known, but the philosophy of maker education urges the ideas to be tried, data taken and analyzed, and the process adjusted, all while keeping the makerspace machinery running—similar to an action research project.[8] Curiously, tinkering is one of the procedures used by the best scientists and engineers for rapid innovation.[9] As mentioned in Part 1 of this series, improving faster simply requires one to double the failure rate for success to happen more quickly! The NMHS makerspace is very much a work in progress, but as a constructionist/constructivist experiment, it is a wild success.

SUMMARY AND REFLECTIONS

In this final part of the series, we covered the practical steps used by one high school to create a successful makerspace:

1. Observe the students to determine their interests.
2. Review curriculum and school programs to find compatibilities and possible augmentations to offer in the makerspace.
3. Consider national and global trends in technology and culture.
4. Identify themes in steps 1–3 to use in the makerspace.
5. Set aside space and bring in tools and parts.
6. Create an environment promoting student ownership of the makerspace.
7. Continue assessing, redesigning, and adding new tools every semester to ensure a relevant, growing experience.

The seven steps above provide a practical and actionable guide for starting an educational makerspace, and we could spend much more time unpacking each of them. However, overthinking the process is not recommended, and we will wrap up with two important considerations from this short case study:

If at all possible, a makerspace should be a school project—not in a death-by-committee sort of way—carried forward by one or two dedicated educators with the full support of the administration. NMHS's efforts to create a thriving makerspace matured rapidly because the principal trusted the librarian to lead the project to success.

And finally, any dedicated educator can create a makerspace. The absence of large budgets and technical wizardry need not be a hurdle to undertaking such an endeavor. A great educational makerspace is within the reach of any educator possessing a powerful vision and a willingness to try new things.

In the NMHS study, the librarian had the full support of her administration and other teachers. Unfortunately, many potential educators desiring a makerspace do not have such support. As mentioned earlier while discussing a lack of budgetary resources, we shouldn't make a lack of administrative support an excuse to delay the creation of a makerspace. A full treatment of this challenge cannot be made here, but we offer a couple of possible approaches. First, if you are outgoing and motivated, approach the PTA, the district leadership, or anyone else necessary to get sufficient support. Sometimes the answer is to create the needed support.

Alternatively, a low-key personality may try starting with a "maker table." This small addition to the space is likely to go unnoticed if it is not overtly publicized. Make it inviting for students and somewhat unobtrusive. In this way, there is a good chance it can fly under the radar, and in time it can slowly become a "maker corner" and eventually a makerspace. By progressing in small increments, the de facto existence of a creeping makerspace can be its own evidence, and the key factor in garnering administrative support along the way will be good data. Watching the students, making observations, and organizing the data will lead to a compelling case for a makerspace, and when it is time to get official buy-in, the data can be used to recruit more supporters. Every school and student population will have differences, so specific advice is unwarranted. However, thoughtful action even by a single dedicated educator has the inexorable power to inspire change.

Maker education ideals have sparked a learning revolution where students can learn through rigorous exploration, and the makerspace success at NMHS shines a light on the path ahead. As we mentioned previously, the makerspace environment fosters enthusiasm for learning, student confidence, and natural habits of collaboration. So whether you are part of a powerful collaboration or a lone trailblazer, choose action, move forward, and create an educational makerspace. A new world of learning possibilities awaits!

(ENDNOTES)

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Makerspaces are environments where individuals use technologies to make physical artifacts within a community of fellow Makers. There has been growing interest in the educational potential of Making activities which has resulted in many schools procuring tools and technologies to set up their Makerspaces. However, there is scant research investigating the efficacy of Making these newly emerging Makerspaces intended for learning. In our work, we narrow this gap in knowledge between the claimed educational potential of Making and its attainment.Â The purpose of a space could be people-focused, means-focused, or activities-focused, or some variable combination. All aspects of the framework always exist but sit at tension with the variable focus of the space.

The introduction of the curriculum was a significant development in primary education and was the culmination of an extensive process of collaborative curriculum planning and design by the education partners, under the auspices of the National Council for Curriculum and Assessment (NCCA). Previously, the last revision of the curriculum for primary schools was Curaclam na Bunscoile (1971). 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.Â 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. Makerspaces have spread to libraries in recent years, to promote equitable access to technologies, expand services, and encourage participation and learning. In this paper, scaffolding of learning is studied from the perspective of library makerspace practitioners. On the basis of interviews in six Danish libraries, we analyze formal, non-formal, and informal activities and identify seven ways of scaffolding. Three challenges are discussed: (a) fostering community while ensuring inclusion in informal activities, (b) avoiding to stifle creativity in short-term activities, and (c) finding the ro