This paper establishes an argument for the beneficial roles makerspaces can provide in school library programs. It builds a bridge between formal and informal education by grounding it in current accepted educational theories and frameworks including constructivism, constructionism, inquiry-based learning, and Backward Design. The paper stresses the importance of understanding adolescents and how they learn in a school library makerspace. It also addresses the role of school librarians as collaborators and their responsibility to conduct evidence-based practice. The final product resulting from this work is a makerspace collaboration guide intended for use by school librarians. It provides tools for facilitating productive collaborations between the school librarian, teachers, students, and community members. A version of this collaboration guide is available for download and modification at jennythelibrarian.wordpress.com.

Headings:

Library media specialists

Librarian-teacher cooperation

Middle school libraries

School library makerspaces
LEARNING IN MIDDLE SCHOOL LIBRARY MAKERSPACES: A MAKERSPACE COLLABORATION GUIDE FOR SCHOOL LIBRARIANS

by
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______________________________
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INTRODUCTION

Makerspaces have enjoyed recent attention in popular library and education journals, websites, and blogs, where they are often presented as being a beneficial addition to a school library (Abram, 2013; Daley & Child, 2015; Hall, 2014; Kurti, Kurti, & Fleming, 2014b, c; Range & Schmidt, 2014; Smay & Walker, 2015). Most of these articles either document the experience of a librarian getting a makerspace started in their library, or give the reader instructions and tips for starting their own makerspace. The latter type of article tends to list helpful materials for the librarian to buy, or they might describe some one-shot project ideas to implement in the school library makerspace. These articles are a fantastic starting point for the librarian who is just hearing about makerspaces, but they do not allow librarians to tap into the true power of a makerspace and the significant impact it can have on student learning. They also provide little guidance or concrete advice for teaching required national and state standards and content in school makerspaces.

Because trends in current school librarian culture emphasize the importance of school librarians in various aspects of education, this paper argues that school librarians have an important role to play within the maker movement. With an ever-increasing emphasis on accountability and evidence-based practice, this paper asserts that a school library makerspace serves a fundamentally different purpose the fabrication labs (Fab Labs) and hackerspaces of the private, public library, or museum based makerspaces.
A false dichotomy seems to exist when it comes to views about education in the United States. One idea is that students must perform well *only* on standardized tests. This view often results in teaching to the test rather than developing deep understandings.

The other view is that imposing predetermined standards on students stifle real learning and creativity, so teachers should never interrupt student activity, nor should they attempt to measure the learning occurring because it is impossible. Curt Gabrielson (2013), a proponent of learning by tinkering and the founding director of the Watsonville Environmental Science Workshop, an informal science education center in California, for example, believes that children can teach themselves almost anything just by tinkering and reading on their own. This hands-off view often results in a negative perception of school and can ignore the benefits of standards and outcome-based learning, such as providing structure for students and opportunities for assessment. Laura Fleming, an educator and media specialist who wrote *Worlds of Making: Best Practices for Establishing a Makerspace in your School*, takes a more moderate stance between these two views by saying:

> It is more than possible to do both, to improve teaching and learning by aligning the practice and formative development of skills and ways of thinking to the standards, and by means of a wide variety of creative innovative pathways to learning (Fleming, 2015, 32).

As proposed by Fleming, there needs to be a middle ground between the world of rigid standardized testing and the chaotic, anything goes world of an adult makerspace. At the middle school level, students need a good coach to guide them toward productive learning outcomes and give them the tools they need to become independent learners. Formal learning and informal learning can work together to develop well-rounded students. Barbara Stripling, a key figure in the school library field, a professor at
Syracuse University, and the developer the Stripling model of inquiry discussed later in this paper, comments on how educators must teach for understanding:

For students to understand fully, they must have access to textual sources and formal learning, but they must also develop their understand through tapping into their informal learning from their own life experiences, communicate with others (including experts and practitioners in the field) and acting on the understanding) or applying and practicing it in multiple contexts) (Stripling, 2007, 43). Different students learn in a multitude of different ways, and providing many different points of entry to different topics ensures that each student gets the most out of their school education.

To begin building this bridge between formal and informal education, I have created a makerspace collaboration guide for use in my own future practice. I anticipate that other school librarians will use my guide to inform their collaborations with the teachers in their building and to teach their own students in a school library makerspace. I will make the guide available on the internet under a Creative Commons license. It provides templates for planning, delivering, and assessing units taught in a school library makerspace, and explanations of how to use them. The guide is grounded in both constructivist and constructionist theories, which are discussed in detail in the background section of the paper.

The makerspace collaboration guide also promotes the teaching of interdisciplinary STEAM (science, technology, engineering, arts, and math) lessons. In the world of education, we often talk of how we can no longer prepare our students for specific jobs in the twenty-first century. Our focus is now on cultivating dispositions that will allow students to think critically and solve problems, which are unforeseeable now, but will arise as the current generation matures. Carl Sagan gives a compelling reason for a scientifically literate society:
We’ve created a global civilization in which most crucial elements – transportation, communications, and all other industries; agriculture, medicine, education, entertainment, protecting the environment; and even the key democratic institution of voting – profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces (1996, 26).

The learning environment in a makerspace encourages the understanding and exploration of STEAM topics. Makerspaces are a valuable learning environment that can help prepare students for their futures in the areas of 1] Life and Career Skills, 2] Learning and Innovation Skills, 3] Information, Media, and Technology Skills, and 4] Key Subjects (Koh, 2015; P21, 2007).
Part 1: Background

The term “makerspace” is relatively new, so there is a limited amount of literature in the current body of work. However, the ideas the maker movement are founded upon align well with many ideas already deemed “best practice” in school libraries. This background section reviews what makerspace-specific publications are currently available. It also argues how existing theories—like constructivism and constructionism—and frameworks—like inquiry-based learning, Connected Learning, STEAM education, interdisciplinary education, and Backward Design—are relevant to makerspaces in school libraries. Finally, I discuss the place of collaborative experiences and evidence-based practice in the school library makerspace.

Section 1.1: Makerspaces

Current publications on makerspaces are a mix of opinion pieces, case studies of individual start-ups, and how-to guides for librarians and teachers who want to start their own makerspaces. Deeper examination of recent publications reveals that much of modern maker culture is embedded in older ideas, such as the 1) the learning theories of constructivism and constructionism, 2) inquiry-based learning, and 3) the engineering design process. Additionally, the term has been made more popular recently due to the publication of MAKE magazine launched in 2005, and the creation of the Maker Faire, a yearly conference for makers of all ages (YALSA, 2014, 2).
Section 1.1.1: What is a Makerspace?

Each article written about makerspaces gives is a slightly different definition of a makerspace. This is not an inconsistency since a makerspace is responsive to the community it serves and each one will look different from another. Despite these slight differences, many authors involved in the makerspace conversation agree on similar characteristics and themes that is required for a makerspace to be successful.

The overwhelming agreement among the maker community is that a makerspace is indeed a physical space where makers congregate to work on projects together (Bagley, 2014; Canino-Flint, 2014; Compton, Boese, Lewis, Teeri, & Yusko, 2014; Fleming, 2015; Graves, 2014; Loertscher, Preddy, & Derry, 2013; The Makerspace Team, 2013; Preddy, 2013; Range & Schmidt, 2014; Willingham & De Boer, 2015). In the school, the makerspace is a place where students can interact with other students, both across grade levels and within their own peer group, and with adult mentors, such as their teachers, parents, and experts in the community. When students work with physical materials in the makerspace, abstract concepts can begin to become more concrete. This is especially helpful at the middle school level, when adolescents are beginning to develop their abstract thinking skills.

Additionally, several of these writers argue that the virtual world of makers is also an important aspect of the makerspace (Fleming, 2015; Loertshcer, Preddy, & Derry, 2013; Sheridan, Halverson, Litts, Brahms, Jacobs-Priebe, & Owens, 2014). Internet message boards, how-to guides, and blogs are all in keeping with the spirit of the makerspace because makers share what they know with others, regardless of physical distance. The importance of communication via the internet makes the school library an ideal place for the makerspace because the librarian is available to teach students the
information and technology literacy skills they need to navigate the digital landscape.

Finally, students have the opportunity to contribute to the wider maker community by creating their own content by documenting their projects in the makerspace and reflecting on their learning in the form of blog posts, videos, and other formats.

Another key theme feature of makerspaces is the back and forth flow of learning between the less-experienced students and the more-experienced mentors in which “the line between learner and instructor becomes blurred” (Kurti, Kurti, & Fleming, 2014a). When students are allowed to guide the direction of their own learning, it is unlikely that the librarian or the core subject teacher is going to be an expert in every topic that interests each student. Rather than being a limitation, this facet of student-driven learning means that adults and adolescents can learn new things together. Furthermore, educators can focus more on teaching important skills that enable young people to take charge of their own learning, such as the ability to find and evaluate information independently and approaching issues from a problem-solving mindset. “More experienced” might not mean older in age because kids can become the experts on their topic of interest in this learning environment (Graves, 2014; Kurti, Kurti, & Fleming, 2014a; Loertscher, Preddy, & Derry, 2013).

The social aspect of the makerspace is even more important than the tools and technology provided there. Dale Dougherty, founder of the most popular publication of the maker movement online and in print Make magazine, states that “while technology has been the spark of the Maker Movement, it has also become a social movement that includes all kinds of making and all kinds of makers” (Dougherty, 2013, 7). It is not necessarily the available tools that make a space a makerspace, but the learning,
innovation, and collaboration that occur between the people who work there. In other words, a makerspace can be any gathering place that promotes a maker culture and mindset. Shared knowledge and a participatory culture is vital to developing a robust makerspace (Barniskis, 2014, 7).

This is not to say that tools are unimportant. The second most discussed characteristic of a makerspace is that it provides students with access to a variety of tools and resources that might not otherwise be available to the average person (Bagley, 2014; Canino-Fluit, 2014; Compton, et al., 2014; Fleming, 2015; The Makerspace Team, 2013). This means that school libraries committed to providing students with access to a vast collection of resources should consider developing a makerspace. Working with physical tools and materials allows students to experiment and “empower[s] them to think of themselves as something other than consumers” (Canino-Fluit, 2014, 22). Norton, Mochon, and Ariely, who all conduct research in the field of business, discuss a phenomena called the IKEA effect, which occurs when people value a piece of furniture they put together with their own hands—even if it is not technically perfect—more than they do a piece of furniture put together perfectly in a factory. Additional research suggests that participating in the creation of such projects contributes to feelings of competence and accomplishment in people who make things with their own hands (Mochon, Norton, & Ariely, 2012). An adage of the maker movement states “if you can’t open it, you don’t own it (The Makerspace Team, 2013, 22). This is evident in the IKEA movement, and in projects conducted in the makerspace, because “doing it yourself” is an empowering act that gives the maker some control over the world around them.
Finally, the importance of developing information literacy skills is often overlooked in current writings about educational makerspaces. Users of makerspaces need access to information which enables them to work on problems and projects of interest to them. While librarians can be a great resource in pointing students to helpful resources, we can also “provide [students] with strategies for finding the right materials, and help unlock the powerful search tools that readers can use to find what they want now and in the future” (The Makerspace Team, 2013, 17-18). The school librarian is in an excellent position to teach various information literacy skills. Using the American Association of School Librarians’ Standards for the 21st Century Learner as a guide, librarians can instill the skills, dispositions, responsibilities, and self-assessment strategies in the context of a makerspace. Since the makerspace inherently models real-world situations, transferring these skills to students’ everyday lives will be smoother than learning them out of context or in unauthentic learning experiences.

Section 1.1.2: Planning a Makerspace

Many articles and current publications inform the reader on how to plan and set up a school library makerspace. Laura Fleming, an experienced educator who has successfully developed a makerspace at her own school, suggests a simple, iterative framework for educators planning a school library makerspace:

- Understand your learners
- Assess existing curricula, programs, offerings within your school community
- Consider global trends and best practices
- Develop themes
- Order equipment and materials” (Fleming, 2015, 15).

No two makerspaces will look exactly the same because each community of makers offers different personalities, areas of expertise, and interests (Kurti, Kurti, & Fleming,
2014; Range & Schmidt, 2014). Fleming further comments on the importance of personalizing the space suggesting that “rather than buying prepackaged kits or a makerspace in a box, better favored is a custom approach in creating a dynamic makerspace” (Fleming, 2015, 13). When planning the makerspace, it is important to hear the voices of the main users of the space: the students. As students grow and graduate, the layout and focus of the space may change over time. Conducting a community assessment on a regular basis is an effective way for the librarian to determine “community needs, current resources, and general feasibility” (Range & Schmidt, 2014, 8) of makerspace activities and development. Describing the steps for conducting a community assessment fall outside the scope of this paper, however, the Compassion Capital Fund National Resource Center developed an excellent resource for this purpose available in the Strengthening Nonprofits resource library online.¹

There are long lists of possible materials to include in the makerspace available in numerous popular library news publications, on blogs dedicated to the maker movement, and from the creators of Make magazine. Materials and equipment are expensive, so doing the required work of getting to know the maker community is essential to stocking an engaging, cost-effective makerspace. One document developed by Make magazine gives an excellent overview of the different specializations a high school makerspace might focus on. Lists of suggested tool and material purchases, safety tips, special considerations regarding each specialization, and estimated pricing is included. The Table 1 below is a condensed version of the lengthy document (Hoefer, 2012):

---
¹ Conducting a community assessment: http://strengtheningnonprofits.org/resources/guidebooks/Community_Assessment.pdf
<table>
<thead>
<tr>
<th>Specialization</th>
<th>Description</th>
<th>Examples of materials and tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Workspace</td>
<td>The working environment of the space creating the foundation for a safe, comfortable and clean working environment.</td>
<td>Furniture, cleaning supplies, dry erase boards, fire extinguisher.</td>
</tr>
<tr>
<td>General</td>
<td>Tools and materials common among and across modules that are useful on a wide range of projects.</td>
<td>Basic hand tools like drills, wrenches, and saws; safety equipment like goggles and first aid kits; storage bins; various adhesives; fasteners, screws, and nails; paper.</td>
</tr>
<tr>
<td>Woodworking</td>
<td>Working primarily with wood.</td>
<td>Tools, equipment, lumber, hardware.</td>
</tr>
<tr>
<td>Metalworking</td>
<td>Working primarily with metal.</td>
<td>Wire tools, welding equipment, jewelry supplies, nuts and bolts.</td>
</tr>
<tr>
<td>Electronics</td>
<td>Using electricity from the basics of circuit design through more advanced microcontrollers, robotics, and other electromechanical creations.</td>
<td>Soldering equipment, measurement tools, various components, microcontrollers like Arduino, robotics.</td>
</tr>
<tr>
<td>Textiles</td>
<td>Working with flexible materials such as cloth, vinyl, leather, rope and string, including soft circuits and wearable electronics.</td>
<td>Sewing machines, cutting tools, hand sewing materials, knitting and crocheting materials, various fabrics, various fibers, wearable electronic components.</td>
</tr>
<tr>
<td>Computers</td>
<td>The hardware and software necessary for modern planning, design and fabrication.</td>
<td>Laptops, printers, external memory, paper and ink, digital cameras, software.</td>
</tr>
<tr>
<td>3D Printing</td>
<td>Additive manufacturing ability known as 3D printing which allows makers to create detailed, complex objects.</td>
<td>3D printer, plastic filament, software.</td>
</tr>
<tr>
<td>Laser Cutting</td>
<td>The requirements for a laser cutter, which would provide the ability to cut and etch materials quickly and with high precision.</td>
<td>Laser cutter, fire safety features like compressor and air filtration system, materials for cutting like acrylic, cardboard, or wood.</td>
</tr>
<tr>
<td>CNC Cutting</td>
<td>The requirements for Computer Numerical Controlled (CNC) machines, which accurately cut and sculpt various materials.</td>
<td>Desktop CNC, wet-dry vacuum, materials for cutting.</td>
</tr>
</tbody>
</table>

Table 1: Makerspace Materials Suggestions Adapted from Hoefer, 2012
While this list is a great jumping off point for a new makerspace, the librarian and other makerspace facilitators should consider the needs of their community. No makerspace is required, or even needs, to support all of these activities. If no students are interested in woodworking, there is no need to buy woodworking equipment. In contrast, combining specializations in different ways can lead to innovative creations, such as wearable electronics by combining electronics, programming, and textiles. Encouraging crossover between specializations should be encouraged because it further solidifies the idea that learning is interdisciplinary. The librarian should make sure there is a need for any expensive equipment, general tools should be purchased before project-specific tools, and maintenance costs must be factored into purchasing decisions (The Makerspace Team, 2013, 10-12).

After identifying resources already available, the makerspace will still need significant funds to get running. Gaining support of the school community, local businesses, parent-teacher organizations, and local hackerspaces or tech clubs is an important first step, but if the money is not available in the yearly school budget, the librarian must get creative. While applying for grants can be time and labor intensive, they can provide significant funds for makerspace activities (Bagley, 2014; Willingham & De Boer, 2015). Donations are another possible source of funding (Bagley, 2014; The Makerspace Team, 2013; Martinez & Stager, 2013). Requests for donations may be made to directly to parent organizations present in the school. Looking into the wider community for donations or financial support is also effective, but one consideration to keep in mind are any “stipulations and requirements for how the money can be spent” (Bagley, 2014, 7-8). For example, the donor may want the makerspace use their donation
for computers when the makerspace needs sewing machines to meet student interests. Creating a specific list of what the space wants and needs can help ensure the donations are useful. Other suggestions for stocking the makerspace include holding a tool drive, where community members donate used tools for use in the makerspace (The Maker Team, 2013, 11), or using a crowdsourcing platform such as Donor’s Choose to raise funds for a specific project (Martinez & Stager, 2013).

Safety, while the last category in this list of makerspace planning recommendations, is one of the most critical pieces for the school library makerspace. Creating a “makerspace handbook” that can be shared with members and other stakeholders is an effective way to set rules and expectations for the makerspace. This document should outline various policies, such as hours of operation, safety training clearance levels for potentially dangerous equipment, safety rules, housekeeping, maintenance, and a code of conduct (Willingham & De Boer, 2015). Willingham and De Boer, who are both consultants for developing makerspaces in public libraries, have an excellent view on how safety concerns can be managed effectively while not limiting the work that takes place in the makerspace: “Develop reasonable safety practices, display rules clearly, supervise responsibly, and make commonsense decisions about equipment, training, and usage so you can manage risk intelligently” (2015, 122-123).

**Section 1.2: Learning in the Makerspace**

*Section 1.2.1: Constructivism Complements Constructionism*

A common criticism of any new educational movement is that it is a passing trend. This criticism of the maker movement has little weight because it is built upon the foundation of many accepted educational theories. Sylvia L. Martinez and Gary Stager,
both experts on using technology in education, cite precursors to the modern maker movement, such as Jean-Jacques Rousseau, Johann Pestalozzi, Friedrich Froebel, Maria Montessori, Jean Piaget, John Dewey, Seymour Papert, and Reggio Emilia for their influence on the natural abilities of children, how people learn, and how people create their own meaning (2013). Two theories stand out as the guiding views for makerspaces—constructivism and constructionism.

Jean Piaget’s theory of constructive posit that knowledge is constructed in a learner’s head based on their experiences. Knowledge is not delivered from the teacher to the student; rather students must work through issues themselves so that they may reach their own conclusions. Piaget’s work also focused on “what children are generally interested in and capable of at different ages” (Ackermann, 2001, 3) and how they often have logical reasons for not immediately believing an adult when they hear something that conflicts with their current way of thinking.

Edith Ackermann, a researcher of developmental psychology and how technology influences development, outlines three major implications for education following a constructivist line of thinking:

1] “Teaching is always indirect” [emphasis added] (Ackermann, 2001, 3). Kids are not empty sponges who soak up the knowledge given to them from an authority figure. They have their own experiences, knowledge, culture, and language through which they see the world. Viewing the makerspace through a constructivist lens means the librarian and the teachers relinquish some control and allow students to come to their own understandings through the pathways that work best for each student.
2] “The transmission model, or conduit metaphor, of human communication won’t do” [emphasis added] (Ackermann, 2001, 3). Information only truly has meaning when it is viewed through personal interactions with other people, natural phenomena, and things made by people. With this in mind, librarians and teachers can model good habits such as following safety procedures, citing sources, and documenting work done in the makerspace. By doing so, students can see their role models engaging in effective learning.

3]“A theory of learning that ignores resistances to learning misses the point” [emphasis added] (Ackermann, 2001, 3). Youth hold their own personal views of the world, and while these views may not always reflect reality, they often have their own logic that suits their needs and current experience. Ackerman concludes “for a child—or adult—to abandon a current working theory, or belie[f] system, requires more than being exposed to a better theory” (Ackermann, 2001, 3).

As shown above, Piaget’s theory aligns well with the maker movement in that it encourages a learning environment where the student engages in hands-on and minds-on learning experiences (Bonawitz, Shafto, Gweon, Goodman, Spelke, & Schulz, 2011; Hira, Joslyn, & Hynes, 2013; Kurti, Kurti, & Fleming, 2014; Martinez & Stager, 2013). Giving students a chance to see abstract concepts in action through activities in the makerspace will most likely have a more profound effect on their knowledge construction than just hearing about it from their teacher in an unauthentic experience.

Constructionism furthers the work of Piaget by being a more practical application of constructivism. Seymour Papert is a mathematician who worked directly under Piaget in Geneva from 1958-1963, helping Piaget to better understand how children construct
mathematical knowledge (Martinez & Stager, 2013). Papert was a proponent of using computers as a teaching tool for children, and wrote several books that developed the theory of constructionism. With Gary Stager, an education expert and researcher, Papert developed the Constructionist Learning Laboratory (CLL) at The Maine Youth Center in 1999. (Stager, 2005, 1). The goal of the Center was to develop a vision for what learning would like in the future. The CLL was an educational center for teens in prison, and the work done by Papert and Stager there was imperative to understanding what constructionist learning looks like.

Papert’s constructionism takes constructivist theory a step further towards action. Although the learning happens inside the learner’s head, this happens most reliably when the learner is engaged in **personally meaningful activity outside of their head** that makes the learning real and shareable (Martinez & Stager, 2013, 32).

Constructionists argue that whether the student is creating their own invention, making a digital video, or building a model, the learning begins in their head and is expressed in something outside of their head.

This theory of learning resonates strongly with learning in the makerspace (Bonawitz et al., 2011; Hira, Joslyn, & Hynes, 2014; Kurti Kurti, & Fleming, 2014; Martinez & Stager, 2013; Sheridan, Halverson, Litts, Brahms, Jacobs-Priebe, & Owens, 2014; Stager, 2005). When students are asked to make something, they have to express the knowledge inside their heads and build something that they can share with other people. Based in Piaget’s constructivism, Papert’s constructionism encourages students to take charge of their own learning and get their hands and minds busy with new ideas, understandings, and innovations. By using high-tech and low-tech materials together,
students can play around with ideas in a low-risk environment, where failure is not necessarily seen as a drawback and the things kids make are personally meaningful.

Section 1.2.2: Inquiry-Based Learning

Another application of Piaget’s constructivist learning theory is inquiry-based learning. In addition to learning by doing and integrating new information into past experiences, inquiry-based learning motivates and empowers students through two aspects: “engagement in authentic tasks and assessments and learning through social interaction” (Small, Arnone, Stripling, & Berger, 2012). In their Standards for the 21st Century Learner, the American Association of School Librarians advocates for inquiry-based approaches “to learning and the information search process (AASL, 2009, 25) in school library programs. Additionally, the learning outcomes outlined in the Next Generation Science Standards cannot be met by passive learning, rote memorization, and excessive standardized testing. Learning experiences must be:

- designed to elicit student thinking and include time for explication of thinking, argumentation, and reflection. Students must engage in a ‘minds-on’ as well as a ‘hands-on’ process to achieve the conceptual growth and development that these standards will demand. Every activity must have a clear connection to specific learning goals and expected student outcomes (Quinn & Bell, 2013, 25).

Inquiry-based learning aims to go beyond the mere comprehension of ideas and instead aims to instill deep understandings in students. It is a process that aims to connect student interests to learning, encourage students to ask probing questions, and motivate students to continue being curious (Small et al., 2004).

Barbara Stripling developed a process model of inquiry-based learning based on Piaget’s constructivist theory (Stripling, 2003). Her framework encourages open-ended exploration and aligns with constructivist theory by encouraging students to construct
“their own ideas through guided experiences” (Stripling, 2003, 4). Students have meaningful learning experiences and construct their own understandings from their work when they are allowed to approach new ideas through this lens. Inquiry-based learning accommodates a more “messy” learning environment that is student-centered. Student questions are at the center of inquiry rather than strict imposed tasks given to them by an authoritative instructor. Stripling’s model (see Figure 1), is an iterative process and students usually begin the inquiry process by “connecting” a problem that needs to be solved to their experiences and previous knowledge. They may also do some initial background reading to gain a more solid foundation of the topic(s) at hand. Then, they “wonder” about how they might go about solving the problem. In this stage, students ask questions and develop hypotheses. During “investigation,” students find, evaluate, and reflect on information that helps them solve their problem. They may realize they need to gain a practical skill to move forward. Once enough information is collected, they “construct” new understandings and draw conclusions about possible solutions to their
problem. They may talk with peers and mentors during this stage to further solidify their ideas. Students “express” their learning by applying their constructed knowledge to a problem they are trying to solve. They can share their final product with peers, mentors, and other members of the community to exhibit their hard work. Finally, students reflect on and self-evaluate what they learned. They may ask themselves what they did well, what they need to work on, and what new directions their learning might take next.

As represented in the diagram that this is not a linear process. It should also be noted that the diagram fails to show that students may jump from one stage to another, meaning the process is more of a web than a cycle. Students may go through any of the stages at various times. When they reflect on their work, students may realize that they need more knowledge; when they read something interesting, they might be pulled in a new direction that sparks a new sense of wonder.

Below, I analyze several studies that discuss the success of inquiry-based learning. Many of the reported results point to positive implications for library makerspaces to be centers of inquiry, which is a common claim in popular publications (cf. Barron & Darling-Hammond, 2008; Canino-Fluit, A., 2014; Kurti, Kurti, & Fleming, 2014).

Violet H. Harada, a teacher and researcher at the University of Hawai‘i and a former lower education librarian, and Joan M. Yoshina, a former elementary school librarian, drew from their graduate students experiences at their practicums in a local school (Harada & Yoshina, 2004). They interviewed a fourth grade teacher who had just completed a class project that required the students to research an animal and copy information they had found in encyclopedias. The teacher reported projects that were
“disappointing and mediocre” (22), because the information was simply located and regurgitated for the teacher with little or no synthesis on the part of the student. Harada and Yoshina work to reframe the animal assignment as a unit of inquiry, where the students visit a zoo, generate their own questions about the animals they saw, search for and synthesize information that relates to their question, and present their final products to their entire school. Students are expected to reflect on their thinking throughout the project (23). The study’s end result showed that rote learning activities are far inferior to inquiry-based learning when it comes to deeper understandings. In school library makerspaces, students are also encouraged to formulate their own questions, find relevant information, and make a final product that shares their learning with the wider maker community.

Chu, Tse, and Chow, a team of education researchers in China, studied how project-based inquiry learning could be used to teach information literacy and information technology skills. In their study, students, teachers, and parents of a primary school in Hong Kong completed self-reported questionnaires and a variety of interviews (Chu, Tse, & Chow, 2011, 135). After conducting an intervention where the librarian and the Information Technology teacher collaborated on a project-based learning lesson, the researchers concluded that the inquiry method was effective in promoting information and technology skills because it placed essential skills in a real-world context. The results support the idea that information and technology literacy skills “cannot be learned through one-time training such as tutorials or workshops” (139), instead, students have to be active, interested, and collaborative over a period of time in order to achieve deep understandings. This focus on information and technology literacy skills can also be met
by the school library makerspace, where the school librarian can mentor the students who use the space by helping them find and use information to support their projects.

Bevan, Gutwill, Petrich, & Wilkinson of the Exploratorium in San Francisco, a museum-based learning lab based in tinkering and constructionism, conducted a research project negotiated between researchers and practitioners in a museum makerspace. They focused on the concept of “making [emphasis added] as an educative inquiry-based practice” (2015, 98), and developed their Tinkering and Learning Dimensions Framework that described the kinds of learning and interactions that can occur in makerspaces. The four Learning Dimensions they identified are: Engagement, Initiative & Intentionality, Social Scaffolding, and Development of Understanding. As discussed earlier in the constructivism section of this paper, a common criticism of makerspaces is that they are a passing trend that, while they fun for students, do not offer a platform for deeper learning. The researchers directly addresses this concern by clearly “articulat[ing] and document[ing] what learning looks like in a museum-based tinkering program” (100). In an era of high-stakes testing and quantitative accountability, this framework is useful because it helps define what learning looks like in a more informal setting than a traditional classroom (118). It allows for students to be involved in their own assessment of their learning. The framework can also be useful for librarians when they must articulate the value their makerspace is adding to students’ education.

A final framework useful in facilitating inquiry-based learning in the school library makerspace is Connected Learning (Ito, et al., 2013), which illustrates how students can explore their own personal passions to learn what is dictated by the curriculum and other education standards. In a report on Connected Learning, several
case studies show how the framework supports student growth by allowing students to learn important academic concepts through avenues like creative writing (11) and hip-hop music (26). A Connected Learning approach emphasizes learning should be “socially embedded, interest-driven, and oriented toward education, economic, or political opportunit[ies]” (4) and an environment that fosters a sense of community, diverse ways of learning, and a shared purpose (8). The framework appears in a condensed version from the report in Table 2 below (12):

<table>
<thead>
<tr>
<th>Factor of Connected Learning</th>
<th>Characteristics of each Factor</th>
</tr>
</thead>
</table>
| **Learning contexts** crucial for Connected Learning to take place. | Peer Supported  
Interest-Powered  
Academically oriented |
| **Core properties** of Connected Learning experiences. | Production-centered  
Shared purpose  
Openly networked |
| **Design Principles** that inform the intentional connection of learning environments. | Everyone can participate  
Learning happens by doing  
Challenge is a constant  
Everything is interconnected |
| **How new media** amplifies opportunities for Connected Learning. | Fostering engagement and self-expression  
Increasing accessibility to knowledge and learning experiences  
Expanding social supports for interests  
Expanding diversity and building capacity |

Table 2: Summary of Connected Learning Framework

While Connected Learning is primarily focused on students’ interests, it is important to always connect their interests back to the curriculum. The school librarian is in a good position to do this in the makerspace. While facilitating hands-on learning related to topics that interest students in the makerspace, the librarian can also foster information literacy skills as students work on their own in-depth projects (Smay & Walker, 2015).
Section 1.2.3: STEAM and Interdisciplinary Education

STEAM (sometimes called STEM) stands for Science, Technology, Engineering, Art, and Mathematics education. The makerspace combines both high-tech and low-tech materials that can be very effective in teaching these concepts. STEAM falls under the umbrella term of interdisciplinary education. Breaking school down into subjects can have benefits, but doing so does not reflect how the real world works. The idea of interdisciplinary education, which views subject domains as interconnected rather than distinct disciplines, challenges students to see the interconnectedness of the world around them. The makerspace is a great place to foster this kind of learning because it encourages students to experiment with different subjects, share ideas, and see how most real-world experiences cannot be put into a subject box (Bevan et al., 2015; Sheridan Sheridan, Halverson, Litts, Brahms, Jacobs-Priebe, & Owens, 2014).

Hira, Joslyn, and Hynes, researchers at the Purdue University School of Engineering Education, identified several opportunities and challenges present in the classroom makerspace (Hira et al, 2014). One opportunity was that makerspaces can place scientific principles into real-world situations to help students solve problems. Doing so naturally integrates STEAM branches more effectively into the school culture (2-3). STEAM education can also present challenges, especially due to the lingering effects of the No Child Left Behind legislation of 2001, which favored high-stakes testing, strict accountability measures for teachers, and has been criticized for putting more weight on test scores rather than students gaining deep understandings. With the current focus on standardized testing over than more informal learning, STEAM education can be pushed aside. Many teachers also feel unprepared to teach STEAM concepts due to lack of training and resources (3-4). A thriving makerspace could help
meet these challenges head-on. When teachers come to the makerspace as learners as well, they can learn difficult STEAM concepts alongside their students in the true spirit of the makerspace.

A team of library science and education researchers wrote an article summarizing the different ways the school librarian can support STEAM education, especially for underserved populations such as youth of color, youth in poverty, and women (Subramaniam, Ahn, Fleischmann, & Druin, 2012). The authors make several suggestions for librarians to support STEAM education, such as recommending various media about STEAM topics during reader’s advisory (172), collaborating with classroom teacher to break down barriers between the core subjects (173), and integrating technology and digital tools into the library by fostering both learning through these tools and connecting with online communities that share their interests (175).

Shannon Barniskis, a doctoral student of library science, writes on her experiences of teaching art in the makerspace by integrating high-tech tools such as laser cutters and 3D printers (Barniskis, 2014, 6-7). A makerspace can cultivate artistic tendencies in students who do not consider themselves to be artists (9). She praises makerspaces for providing access to tools and resources that “encourage people to tinker, to fail, to experiment, to make things better” (9).

In addition to art, engineering principles are very compatible with the learning that occurs in makerspaces (Martinez and Stager, 2013) “The engineering design process is a series of steps that engineers follow to come up with a solution to a problem” (Science Buddies, 2016). While there are many variations on the engineering design process across the sub-disciplines of engineering, using the general framework is useful
for younger students (Hynes, 2010). Morgan Hynes of the Center for Engineering Education and Outreach of Tufts University, cites Nigel Cross, an engineering design educator. Cross “reviewed a number of design models and noted that they have the basic structure of ‘analysis—synthesis—evaluation’” (Hynes, 2010, 346). Figure 2 is a youth-friendly representation of the engineering design process, and closely resembles the process a student might follow when working on any project in the makerspace. This model of the engineering design process is compatible with Stripling’s inquiry model, which was discussed earlier in this literature review. It can be embedded into the inquiry model, especially during the “construct” and “express” phases of the overarching inquiry process.

Martinez and Stager argue that there are several dimensions to learning in the makerspace, saying that “engaging children as quickly as possible in real projects creates an authentic context for learning a specific science formula or math equation since
students realize they need that skill or information to continue their projects” (Martinez & Stage, 2013, 40). They discuss three important ways of knowing in the makerspace, the first two of which provide a solid foundation for student engagement in engineering projects:

- **Making** is about the active role construction plays in learning. The maker has a product in mind when working with tools and materials.
- **Tinkering** is a mindset – a playful way to approach and solve problems through direct experience, experimentation, and discovery.
- **Engineering** extracts principles from direct experience. It builds a bridge between intuition and the formal aspects of science by being able to better explain, measure, and predict the world around us.” (Martinez & Stager, 2013, 32).

Further, the authors argue that these types of learning provide students with a sense of “soft mastery” of STEAM skills and concepts. It is often common practice for teachers or textbooks to present students with the “hard facts” of science, which can be cause for the misconception that science is always a clean, easy process. In reality, scientists and engineers must work through problems by playing around, or tinkering, with new ideas (41). Of course, reading the work of fellow scientists is beneficial in that it can teach the reader about previous accomplishments and give a jumping off point for new work. However, kids are going to be much more engaged and motivated to engage with their textbooks if they have some firsthand experiences from the makerspace to bring context to the ideas being presented.

Multidisciplinary learning encompasses more than just the STEAM fields. It also incorporates English Language Arts, Social Studies, and numerous other “elective” subjects and disciplines. Makerspaces are excellent places for all of these disciplines to converge and build upon each other. Sheridan, Halverson, Litts, Brahms, Jacobs-Priebe,
and Owens provide an excellent summary of Brahms and Crowley’s (2014) work in analyzing the core practices of the maker community as described in *Make* magazine:

“Makerspaces support making in disciplines that are traditionally separate. Sewing occurs alongside electronics; computer programming occurs in the same space as woodworking, welding, electronic music, and bike repair. This blending of traditional and digital skills, art and engineering creates a learning environment in which there are multiple entry points to participation and leads to innovative combinations, juxtapositions, and uses of disciplinary knowledge and skill (Brahms & Crowley, 2014)” (Sheridan et al., 2014, 526).

These core practices in the makerspace clearly show how beneficial interdisciplinary is to the making and learning process.

The development of multiple literacies are a growing interest for learning in the twenty-first century. Both the Common Core State Standards and the Next Generation Science Standards call for schools to create a learning environment where students works together to solve problems, explain phenomenon, and argue nuanced viewpoints effectively (Quinn & Bell, 2013). Literacy in various technology and information skill is also an important consideration for education (Sheridan et al, 2014). Again, the school library is an ideal place for the makerspace because librarians can teach students about various technologies and copyright laws, including the Creative Commons (Hall, 2014). English Language Arts can be incorporated into the makerspace by encouraging students to document and reflect on their progress throughout the making process. Koh (2015) found that when students were engaged in a making program in a school library makerspace, they encountered challenges with finding information effectively and communicating successfully through writing. The researcher suggested that the school librarian can provide extra support for these skills. This idea is supported by the
Connected Learning Framework because students will more likely be personally invested in their projects and will learn such skills in an authentic environment.

**Section 1.2.4: The uTEC Maker Model**

Loertscher, Preddy, and Derry (2013) created the uTEC Maker Model (see Figure 3), which “visualizes the developmental stages of creativity from individuals and groups as they develop from passively using a system of process to the ultimate phase of creativity and invention” (49). This model helps foster certain dispositions in students working in a makerspace. As the students pass through each level, their personal expertise in a topic or skill grows and allows them to contribute more and more to their maker community (50). Cooperative group work is a lynchpin of the makerspace. An open floor space encourages the flow of thoughts, new ideas, opinions, and advice between individuals. In turn, Cooperation develops collaborative intelligence, where a group of students can collaboratively undertake finding a solution to a large problem. While guided learning experiences are important, the ultimate goals of the student in the makerspace should strive toward independent learning and inquiry (51).
**Section 1.2.5: Preparing Students for the Future**

The Partnership for 21st Century Learning lays out the Framework for 21st Century Learning as a set of guidelines “to define and illustrate the skills and knowledge students need to succeed in work, life and citizenship” (P21, 2015). The dispositions outlined in this document call for multiple literacies, the ability to be creative and innovative, the ability to think critically and solve problems, proficient communication skills, skillful collaboration, information, media, and technology skills, and various life and career skills (P21, 2015).

The results of one ethnographic case study conducted in a middle school yielded promising preliminary results for the effectiveness of supporting twenty-first century skills in school library makerspaces (Koh, 2015). Kyungwon Koh, a researcher of library and information studies at the University of Oklahoma, identified “three dominant styles of student learning in the Makerspace, including: 1] learning by doing, 2] learning by seeking information on their own, and 3] learning through and with others” (Koh, 2015, 2). Koh commented on how important information seeking skills are when learning in the makerspace. Since the teacher is not simply imparting all of the content knowledge students need to complete a project, the students must strike out on their own in the setting of the makerspace. Koh found that this resulted in significant improvement in the development of various facets of the Partnership for 21st Century Skills framework. One result especially important for school librarians is that students were given “access to a range of technologies that would otherwise have not been available” (Koh, 2015, 2). Additionally important is the assertion that school libraries are excellent place for makerspaces because students often need to seek, evaluate, and use information independently in order to solve their own problems. Students benefit greatly from having
information and technology specialists in the makerspace to help them work through any difficulties.

The job landscape of the present and future is uncertain due to frequent and rapid developments in digital technologies. This uncertainty makes it difficult to know how to prepare future generations for the workforce. The Institute for the Future (2011) released a report outlining six drivers of change that will influence the future job landscape: extreme longevity, the rise of smart machines and systems, a computational world, a new media ecology beyond text, superstructured organizations, and a globally connected world (4-5). In addition to these findings, the researchers identified vital work skills that our students will need to be successful in the workforce by 2020. In Table 3 below, I outline how each skill they identified can be fostered in a school library makerspace (Parks, 2015a).

<table>
<thead>
<tr>
<th>Skill</th>
<th>How a Makerspace Fosters this Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense-Making</td>
<td>Students work with high-tech machines and tools to make decisions and solve problems. The machine or tool might do the heavy lifting and rote manufacturing, but the students work together to identify problems to solve. They then use software and other technology as tools to plan a project and solve their problem.</td>
</tr>
<tr>
<td>Social Intelligence</td>
<td>Makerspaces are centers where like-minded people come together to share ideas, help each other, and socialize. Individual interests may be diverse, but the dispositions makers have are similar. A good makerspace allows for the flow of ideas, skills, and know-how between individual members.</td>
</tr>
<tr>
<td>Novel and Adaptive Thinking</td>
<td>The core philosophy of the makerspace is that if you can think it, you can make it. The makerspace allows for students to think big and abstractly. Then, the students can use skill-based techniques to physically, or virtually, create their idea.</td>
</tr>
<tr>
<td>Cross-Cultural Competency</td>
<td>The philosophy of the makerspace is inherently inclusive. Anyone and everyone is a maker, and having a diverse population in the makerspace community will allow for more ideas, perspectives, and productive problem solving.</td>
</tr>
</tbody>
</table>
### Table 3: How Makerspaces Foster Future Job Skills

<table>
<thead>
<tr>
<th>Skill</th>
<th>How a Makerspace Fosters this Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational Thinking</td>
<td>The makerspace is the perfect place for interacting with new technologies that require computational thinking. It gives students a place to learn coding and programming languages, and a space to make a physical object using their new thinking skills. This lays a foundation for students to then enter STEAM fields as they grow older.</td>
</tr>
<tr>
<td>New-Media Literacy</td>
<td>The makerspace community has a huge online presence, from blogs to intractables to forums. Allowing students to connect with other makers online is an appropriate context for teaching and practicing new media literacy skills, such as critical literacy (are the directions in this intractable safe?) and multimedia literacy (can students read an article, watch a video, then tweak what they learned to create their own project?)</td>
</tr>
<tr>
<td>Design Mindset</td>
<td>The makerspace is an open space designed to induce creativity in its members. Areas for collaboration and individual work are provided. Students have access to tools they could not afford on their own. The mere presence of other people working on creative projects can inspire students to be productive themselves.</td>
</tr>
<tr>
<td>Cognitive Load Management</td>
<td>The makerspace can allow so many options as to be overwhelming at first, but guiding students to first learn one skill or tool, then another, helps them break down the information into manageable pieces. Then, students can begin to hone their researching abilities to support their own learning through their own projects.</td>
</tr>
<tr>
<td>Virtual Collaboration</td>
<td>This is another inherent piece of the maker community. There are numerous stories of kickstarters where, once a prototype was made in the makerspace, a company was staffed and conducted business over the Internet. Students can also share their work and tweak others’ work on blogs and other online sharing forums to make something even better.</td>
</tr>
</tbody>
</table>

**Section 1.3: Adolescent Development**

**Section 1.3.1: Adolescent Development Overview**

Adolescents in middle school are typically in sixth, seventh, and eighth grade, and fall between the ages of ten and fifteen. Developmentally, these students go through a multitude of changes very quickly. Their bodies change as they enter puberty, their cognitive capabilities begin to develop and allow them to think more abstractly, and they

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2 Portions of section 1.3 were written by me (Parks 2015b) for a class assignment.
may be emotionally vulnerable as their hormones fluctuate. Social situations become more difficult as student begin working out their identities, which may change each week as they continue to explore who they are in terms of their gender, sexual orientation, political stances, and spirituality. In short, adolescence is often a stressful but exciting time for young people (McNeely & Blanchard, 2009).

As students navigate these changes, they need support from their peers adults, and the community. The Search Institute (2007) developed a framework called the 40 Developmental Assets for Adolescents (ages 12-18) which they call the “building blocks of healthy development…that help young people grow up to be healthy, caring, and responsible.” Below Table 4 shows some of the assets that makerspaces can support:

<table>
<thead>
<tr>
<th><strong>External Assets</strong></th>
<th><strong>Internal Assets</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Support</td>
<td>Commitment to learning</td>
</tr>
<tr>
<td>Caring school climate</td>
<td>Achievement motivation</td>
</tr>
<tr>
<td>Parent involvement in schooling</td>
<td>School engagement</td>
</tr>
<tr>
<td>Other adult relationships</td>
<td>Bonding to school</td>
</tr>
<tr>
<td>Empowerment</td>
<td>Reading for pleasure</td>
</tr>
<tr>
<td>Youth as resources</td>
<td>Positive values</td>
</tr>
<tr>
<td>Service to others</td>
<td>Caring</td>
</tr>
<tr>
<td>Safety</td>
<td>Equality and social justice</td>
</tr>
<tr>
<td>Boundaries and expectations</td>
<td>Honesty</td>
</tr>
<tr>
<td>School boundaries</td>
<td>Responsibility</td>
</tr>
<tr>
<td>Adult role models</td>
<td>Social competencies</td>
</tr>
<tr>
<td>Positive peer influence</td>
<td>Planning and decision making</td>
</tr>
<tr>
<td>High expectations</td>
<td>Interpersonal competence</td>
</tr>
<tr>
<td>Constructive use of time</td>
<td>Cultural Competence</td>
</tr>
<tr>
<td>Creative activities</td>
<td>Peaceful conflict resolution</td>
</tr>
<tr>
<td>Youth Programs</td>
<td>Positive identity</td>
</tr>
<tr>
<td></td>
<td>Personal power</td>
</tr>
<tr>
<td></td>
<td>Self-esteem</td>
</tr>
<tr>
<td></td>
<td>Sense of purpose</td>
</tr>
<tr>
<td></td>
<td>Positive view of personal future</td>
</tr>
</tbody>
</table>

Table 4: Selected Developmental Assets

A school library makerspace is a place that encourages collaboration and exploration, and can provide students with access to several external assets. Adolescents
can interact with peers and adults who are interested in their work in the makerspace. Adolescents can also be the experts in their area of interest and teach less experienced newcomers or provide input on their peers’ projects. Additionally, teachers and other adults in the community can volunteer to mentor young adolescents. With all of this external support, adolescents can work on developing their internal assets. A successful makerspace is one that foster the growth of the entire student, academically and emotionally.

Section 1.3.2: Adolescent Information Needs

The information needs of adolescents are as diverse as adolescents themselves. Agosto (2011) and Hernandez (2010) reported similar generalized information needs of adolescents. From these two reports, I have identified six major themes in the information needs of adolescents shown in Table 5:

<table>
<thead>
<tr>
<th>Theme</th>
<th>Specific Information Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationships</td>
<td>With peers, family, authority figures.</td>
</tr>
<tr>
<td>Everyday information</td>
<td>Popular culture, leisure activities, social media, local information.</td>
</tr>
<tr>
<td>needs</td>
<td></td>
</tr>
<tr>
<td>Academics</td>
<td>Information for school assignments, future academic planning, college and career information.</td>
</tr>
<tr>
<td>Health</td>
<td>Physical health and safety, mental health, drugs, emerging sexuality, sexual intercourse.</td>
</tr>
<tr>
<td>Money</td>
<td>Financial responsibilities, consumer needs.</td>
</tr>
</tbody>
</table>

Table 5: Adolescent Information Needs

One study that examined the reading habits of rural teenagers also asked participants what they wanted to do after high school. In response to that question, the students who wanted to pursue a specific career listed “truck driver/mechanic, electrical engineer, teacher, game designer/tester, and traveling nurse” (Moeller & Becnel, 2015, 12). Students need to be provided with information literacy skills to access information in
the topics they mentioned above. Additionally, gaining first-hand experience with the skills they need to pursue their career goals could easily happen in the context of the school library makerspace.

Like adults, adolescents encounter different types of information needs. One study found that students “had no trouble identifying the true information need” (Bilal, 2002, 112) when searching for entirely self-generated information tasks. In comparison, about half of the students were successful on the fact-based task while 69% were at least partially successful when researching a topic imposed by the teacher (112). While students should have practice in successfully completing imposed task, this finding should be kept in mind when teaching new technological and information literacy skills. Student may be more invested in learning a skill if they have a personal interest in the topic, and once learned, those skills can be transferred to “less interesting” imposed tasks.

The school library also serves as a community center for adolescents and the space should be made to accommodate their needs. Adolescents are very focused on social groups, and creating spaces where students can converse with each other allows for the information exchange of information (Cesari, 2014). To meet students’ emotional needs, the school library makerspace program should exude a culture of safety and trust in the library. The librarian should also provide students with “safe ways for them to experiment with their identity and opportunities for them to build emotional intelligence and self-esteem” (46-47). In addition to the general information needs discussed above, the librarian can support and encourage students to explore topics that are important to them and encourage individual exploration in the makerspace. The school library can also be a hub of information for events or clubs taking place both in the school and in the
wider community. Since adolescents can often be risk-takers, offering them “avenues for safe risk-taking” (48) in the form of trying a new sport, going out for a talent show, or trying a new project in the makerspace can meet this aspect of adolescents’ behavioral development needs. Part of meeting adolescents’ information needs is creating an environment in which they are comfortable to explore and deeply engage with the information.

Section 1.3.3: Adolescent Information Seeking Behaviors

It is very important to help adolescents define information tasks. One study reported that when searching for information on the internet, most students seemed more concerned with getting “finished” rather than truly engaging with the content (Wallance, 2000). Students may struggle with representing their information need in searchable terms (Shenton & Dixon, 2004). The engineering design process could be a scaffold taught by the school librarian and science teacher to support students as they articulate their information need. Also, the study observed that students “skipped the exploration phase of information seeking and immediately tried to generate queries to answer their questions” (Wallace, Kupperman, Krajcik, & Soloway, 2000, 89). Students spent very little time on one webpage before moving on to the next, meaning they did not have time to read the information presented there thoroughly (91). Part of this problem might result in students struggling to find materials that are suitable for their current reading or cognitive level (Shenton & Dixon, 2004). Since the amount of time and effort spent reading was low, students often conflated web pages pulled by the search with actual evidence that supported their assignment (Allen, 2007; Wallace et al., 2000). Students
often want to find one perfect source, but in reality it is required to find and read several sources in order to form their own understanding.

The type of search task (whether it is self-imposed or imposed) also affects how successful adolescents are in information seeking tasks. Depending on the type of resource students are used to using, finding current information such as news or local events can be difficult. While students may not have as much trouble finding information about topics they are personally invested in, they still need to be supported in finding information they need for school assignments or other everyday activities (Shenton & Dixon, 2004). When students have to find information that will allow them to make their makerspace project work, they are more likely to successfully develop and transfer essential information seeking skills.

Another study found that students were more likely to search results rather than the content of individual web pages, and students often make judgements based solely on titles or summaries of web pages (Walraven, Brand-Gruwel, & Boshuizen, 2009). It is often cited in the information seeking literature that adolescents have a difficult time evaluating information found on the internet. Few students name “accuracy” or “authority” as criteria for evaluating information (Hirsh, 1999). From most cited to least, students said that they used the following criteria to evaluate information: topicality, novelty, peer interest, quality, convenience, recency, interest, authority, language (1275). Additionally, when gathering information, students rarely keep a record of useful URLs or other searching pathways, which in turn led to difficulties in re-finding information (Allen, 2007; Hirsh, 1999, Wallace, 2000). Encouraging young people to consistently document their work and learning in a “Maker Notebook” could support the development
of information evaluation skills because students would have a record of what information had a positive or negative impact on their project.

**Section 1.3.4: Adolescent Use of Information**

In their book *Hanging Out Messing Around, and Geeking Out*, a team of researchers present the “synthesis of three years of collaborative, ethnographic work” that focused on a multitude of case studies (Ito, et al., 2010, xvii). The authors delved deep into how youth use new media in both socially driven interactions and interest driven interactions, and how “media and technology are meaningful to people in the context of their everyday lives” (Ito et al., 2008, 4). “New media” is defined as an “ecology where more traditional media, such as books television, and radio are ‘converging’ with digital media, specifically interactive media and media for social communication” (Ito et al., 2010, 10). The learning that takes place in these environments is usually very informal. Adolescents using new media have the freedom to pursue various topics of interest, connect with like-minded people over the internet, and create their own content.

In a different report that focuses on the role of new media, Ito and her team recommend that educators do three things to facilitate learning in this environment. First, teachers must challenge the view that social media and other recreational uses of new media are a waste of time. “Erecting barriers to participation deprives teens of access” (Ito et al., 2008, 2) to informal learning, which can slow digital literacy attainment and social development. Second, while teens might not welcome adults in more socially driven new media activities such as Facebook, teens are more receptive to an adult presence when it comes to “more ‘geeky’ forms of learning (Ito et al., 2008, 2) such as learning how to write computer programs or practicing creative writing skills. Finally,
peer-based learning should be encouraged. Youth are often experts when it comes to using new media, and allowing them to teach each other as well as adults in the room can be empowering (Ito et al., 2008, 2). With these recommendations in mind, it is clear that adolescents need access to new media, online and in-person peer groups, and information related to their interests. This need can be met by encouraging students to engage with new media in the makerspace, both through technological projects and using digital tools to document their work over time.

Jessica Pater, Andrew Miller, and Elizabeth Mynatt, researchers in the field of technology, studied how adolescents live rich online lives. They reported that “28% of participants reported that they viewed their online identities as separate or different from their offline identities” (Pater et al., 2015, 2319). Hiding from parents was a common concern for adolescents. This could potentially be problematic if youth are using anonymity on the internet to bully others or participate in other harmful behaviors. However, while privacy is an issue, using the internet as a legitimate form of academic communication at school can allow students to participate in engaging learning activities.

Students often spend a great deal of time searching for information and “only a small amount of time on processing and organizing information” (Walraven, Brand-Gruwel, & Boshuizen, 2009, 245). Walraven et al. of the Educational Technology Expertise Centre in the Netherlands, contemplate that student might not have been given enough time to fully interact with the information they found, and as explained in the previous section, students tend not to have a critical attitude about information on the internet, indicating that a focus on information literacy is just as or more important than technological literacy. These skills must be taught, and students need to use them in
authentic contexts. Susan M. Allen, the Director of Libraries and Academic Technology Coordinator at Nichols School in New York, researched this issue in her school library. She quantitatively evaluated how well her middle school and high school were supporting the development of their students’ information literacy skills (Allen, 2007). When mapping information literacy skills to the fifth through eighth grade curriculums, she found that support for information literacy skills was well covered in lower grades, but drops off as students progress through school (18). This could happen because of a common misconception that young people are naturally competent and comfortable with technology. Helsper and Eynon (2010) concluded that age has little to do with how comfortable people are with using technology. Finally, Allen concludes that “to succeed in college, career, and twenty-first century life, students need to be information savvy, not tech-savvy” (Allen, 2007, 24).

Helping students become more information savvy could be supported by allowing them to work collaboratively, especially when two students are already friends. Werner, Denner, Campe, Ortiz, DeLay, Hartl, and Laursen (2013) conducted a study that explored the way friendship affected student outcomes in computer science skills. The researchers concluded that “since the benefit of working with more knowledgeable peers is greater when students are confident, it is important for teachers to focus on increasing confidence as well as knowledge” (425). The results of this study could be applicable to other information literacy activities taking place in the library, such as using search engines and evaluating information. Adolescents are social beings, and having extra peer support could go a long way in improving their evaluation and synthesis skills. Allowing this kind of interaction is natural in the context of the makerspace, where all of the users are
encouraged to work together and get feedback. Makerspaces might even allow new friendships to flourish between people who might not have otherwise interacted due to perceived differences in interests.

Section 1.4: Librarians in the Middle School Library Makerspace

Section 1.4.1: Role of the Librarian

School librarians are required to take on many roles to support students and teachers in a twenty-first century learning environment. The American Association of

![Diagram of Roles of school librarians](image)

Figure 4: Roles of school librarians (Subramaniam et al., 2013, 2)

School Librarians (AASL) gives five key roles school librarians: Leader, Instructional Partner, Information Specialist, Teacher, and Program Administrator (AASL, 2009).

Subramaniam, Ahn, Waugh, Taylor, Druin, Fleischmann, & Walsh (2013) an information science research team from the University of Maryland, gives an excellent summary of the responsibilities each of these roles as they pertain to school librarians in Figure 4.

Librarians are leaders in their school community because they facilitate a major social and academic hub for the entire school. The AASL standards call for a shift to a
more student-centered library, where the learner is at the center rather than the materials.

Harada and Yoshina (2010) summarize the main shifts in their book on teachers and librarians as assessment, seen in the table below:

<table>
<thead>
<tr>
<th>Focus on providing resources</th>
<th>Focus on student learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teach skills that involve location and retrieval of library resources.</td>
<td>Teach skills that involve evaluation, synthesis, and interpretation of information.</td>
</tr>
<tr>
<td>Emphasize product.</td>
<td>Emphasize process as well as product.</td>
</tr>
<tr>
<td>Measure effectiveness through data on library’s collection size, circulation, etc.</td>
<td>Measure effectiveness through how well students meet learning objectives.</td>
</tr>
<tr>
<td>View assessment as evaluating products, giving final grades.</td>
<td>View assessment as an ongoing examination of learning.</td>
</tr>
<tr>
<td>Believe that assessment is solely the responsibility of the teacher.</td>
<td>Believe that assessment is a shared responsibility with the teacher.</td>
</tr>
</tbody>
</table>

Table 6: Shifts to Student-Centered Learning (Harada & Yoshina, 2010, 16)

This shift from providing resources to focusing on student learning makes each role of the school librarian more important than ever.

The Association for Middle Level Education calls for leaders who collaborate with their school community to advocate for young adolescents and “change practices that do not serve students’ best interests” (AMLE, 2010, 29). Middle school librarians can lead the way to more authentic interdisciplinary education by 1] advocating for a makerspace in their library and 2] collaborating with every teacher in the school to show how beneficial making can be in deepening student understandings. Additionally, the school librarian is responsible for integrating twenty-first century skills throughout units, lessons, and learning throughout the school.

As an instructional partner, the middle school librarian “has the advantage of serving the entire school community—all grades, all subjects” (Donham, 2013, 129). This allows librarians to gain a perspective of the entire school and aide teachers in implementing the Common Core State Standards, the Next Generation Science
Standards, and any other state-mandated standards, such as the North Carolina Essential Standards. Using this knowledge, the librarian can partner with classroom teachers to create and co-teach interdisciplinary units. A school makerspace already promotes thinking across various disciplines, and bringing classroom teachers into such a space can show students that classroom learning can have an authentic application. “It should be clear to students that the teacher and the school library media specialist are full and equal partners in designing, implementing, and evaluating the lesson” (Doll, 2005, 41). The combination of a big-picture view of the school and collaborating with teachers allows school librarians to provide continuity and structure for students throughout the school year and over the course of their school career.

As an information specialist, the school librarian has a responsibility to “integrate information literacy by collaborating with teachers, teaching students directly, and serving on curriculum committees” (Doll, 2005, 77). School librarians work on several levels to make sure students know how to identify information needs, how to search for information, and how to synthesize information. Collaborating with teachers to integrate information literacy into classroom work is essential. Additionally, school librarians have an opportunity to engage teachers in professional development by introducing them to emerging technologies that make their lessons more meaningful for students. School librarians can teach students directly in the makerspace by facilitating an environment where students are motivated to learn information and technology literacy skills in order to complete their own projects. Finally, the school librarian must draw on their role as a leader in the school community to ensure information and technology literacy is integrated throughout the school curriculum.
The school librarian as a teacher is concerned with reading, multiple literacies, the ethical use of information, and the facilitation of inquiry-based learning throughout the school. The first common belief stated in the AASL *Standards for the 21st-Century Learner* is that “reading is a window to the world (AASL, 2009, 12). Donham provides a summary of what supporting reading looks like in the school library:

“The school library curriculum, while certainly concerned about students learning to access, use, and evaluate information, also needs to consider helping young people become competent and engaged readers. Creating a library curriculum that introduces young people to the best of literature for their respective ages and promotes discussion of that literature with questions that challenge them to draw inferences and make predictions and judgements affords a significant opportunity for creating excitement about literature and the experiences it provides” (Donham, 2013, 193).

The school library should create an environment where students are self-motivated to read for pleasure, work toward a project in which they are personally invested in, and enable them to learn about news topics and concepts because they are interested in them. The Common Core focuses on reading places great weight on students continuously increasing the complexity of the texts they read (Donham, 2013), but reading serves a more personal purpose for adolescents. In her article on building resiliency in adolescents through the school library program, high school media specialist Jami L. Jones offers practical protective factors in the form of the “Library Ladder of Resiliency” model. Grounded in a large body of research, one protective measure that encourages the development of resiliency is reading in general, and fiction in particular. “[Teens] want to read about characters who successfully develop their own identity, which is an important developmental task for this age group. Reading helps teens formulate their identity” (Jones, 2003, 96). In relation to the school library makerspace, school librarians can direct students to relevant reading materials such as informational books, popular science,
science fiction, science and engineering magazines, and non-print media (Subramaniam, Ahn, Fleischmann, & Druin, 2012). If students can see themselves in characters who are good at STEAM disciplines, they might begin to see these strengths in themselves as well.

Last but not least, the librarian is the program administrator. “School librarians typically ensure that resources and technology are available to all students and meet the variety of their needs and interests” (Subramaniam, Ahn, Waugh, Taylor, Druin, Fleischmann, & Walsh, 2013, 10). As a facilitator of the school library makerspace, the school librarian must develop budgets, write policy, collaborate with students, teachers, and the wider community, and manage the physical and digital resources that make up the makerspace. Additionally, the librarian must be aware of any accommodations students with disabilities might need as laid out in an Individual Education Plan (IEP), such as access to assistive technology, physical accommodations, multiple formats, and differentiated instruction. Collaborating with the special education teachers is important when planning the library program as a whole, and especially when planning access to the school makerspace.

Section 1.4.2: Collaboration

All of the roles a school librarian must take as discussed in the previous section of this paper rely on a core factor: collaboration. School librarians work together with classroom teachers to enrich instruction. However, it goes further than just identifying problems in the school. Collaboration is an active process that, while time consuming, yields great results for student achievement (Lance, 2000). Carol Doll writes:

Collaboration is a partnership, and each individual brings important elements to the table. Teachers bring their knowledge of students in the classroom, expertise
in their subject areas, and background in education and instructional design. The school library media specialist brings knowledge of the students in the media center setting (perhaps over a number of years), expertise in information literacy, and background in education and instructional design. Also, if fully involved in the school, the school library media specialist knows the curriculum and what is taught at each grade level. Everyone has something to contribute, and the students benefit. (Doll, 2005, 4).

Collaboration is essential to the success of the school library makerspace. A makerspace has the potential to bring every discipline across the school together into one place.

Working with the experts available in the school community is the best way to make the interdisciplinary learning meaningful. “An effective library program cannot function in isolation” (Donham, 2013, 115). Collaboration with teachers, students, and community members gives direction and purpose to the school library by including key stakeholder voices in decision making.

The process of collaboration must be a deliberate, conscious action for all parties involved. Patricia Montiel-Overall created a model, shown in Figure 5, of the collaboration process between teachers and school librarians based on a case study of a collaborative effort. A school culture of teamwork is essential to the beginning phase of this model. It involves garnering interest in collaboration among teachers and administrators, and requires the school librarian to articulate the benefits of collaborative experiences on student learning. This takes preparation on the part of the school librarian, who…

[should take time to] understand the culture of the school, learn about its curriculum, figure out the administrator’s preferred management style, connect with individual teachers in the school, and generally become acquainted with the setting in which everyone will be working (Doll, 2005, 31).

The school librarian should be sensitive to classroom teachers’ feelings and respect their method of teaching in the classroom. While there is a place for challenging traditional
ways of doing things and advocating for best practices, school librarians should take care not to shut a potential door to collaboration due to disagreements with teachers. Taking on a helpful role, such as offering suggestions for helpful resources to use in a current unit, can lay the foundation for deeper collaborations in the future. When first beginning a collaborative effort, especially for a school librarian new to the school or trying a new program such as a makerspace, Carol Doll suggests choosing a teacher who is an enthusiastic volunteer or mentor, a teacher who is starting a new unit, an innovator who is interested and willing to try new things (Doll, 2005, 37).

![Diagram of the Collaboration Process](image)

**Figure 5: The Collaboration Process (Montiel-Overall, 2010, 47)**

Once the librarian has a teacher partner, they must begin the lengthy process of getting to know one another and building a solid professional relationship (Montiel-Overall, 2010). The physical environment is one place to begin making everyone more open and comfortable. The participants in Patricia Montiel-Overall’s study identified “appropriate room size, adequate seating, temperature, and food” (Montiel-Overall, 2010, 47) as important factors to facilitating the growth of good relationships during the
Relationship Phase. When people’s basic needs are met, they can focus less on discomfort and more on the work at hand. It is important to cultivate a safe environment where all of the collaborators feel comfortable and confident sharing ideas and thinking deeply about possible solutions to problems. This environment leads into the Productive Phase of the model.

“The productive phase identifies a higher level of collaboration in which deep thinking is evident” (Montiel-Overall, 2010, 48). Without trust and respect, collaborations will not be effective and people will not feel comfortable working together. The idea of building an ambiance of participatory culture is useful when establishing collaborative relationships with educators. While originally used in the context of describing how young people participate in content creation online, but it has applications for educators who are collaborating (Donham, 2013; Hamilton, 2011). Henry Jenkins, the professor of Communication, Journalism, and Cinematic Arts at the University of Southern California, defines a participatory culture as on with:

1. Relatively low barriers to artistic expression and civic engagement
2. Strong support for creating and sharing creations with others
3. Some type of informal mentorship whereby what is known by the most experienced is passed along to novices
4. Members who believe that their contributions matter, and
5. Members who feel some degree of social connection with one another (Jenkins, Purushotma, Weigel, Clinton, & Robison, 2009, 5-6).

These characteristics perfectly describe the maker culture as well a collaborative experience between teachers and librarians. Low barriers to engagement mean that the librarian is flexible and accommodating to teachers’ busy schedules. “The school librarian must take the initiative to determine what might be interfering with teacher-librarian collaboration and adjust accordingly” (Donham, 2013, 114). Support for sharing
is both a philosophical and pragmatic characteristic. Collaborators should feel comfortable enough to share their ideas, thoughts, and products with the group. When there is a culture of openness, trust, and respect, it allows all participants to share their knowledge so that other members of the group can build upon it and integrate their ideas into future teaching (Montiel-Overall, 2010). In a pragmatic sense, sharing ideas both face-to-face and digitally can be facilitated by the school librarian. Interpersonal skills are essential when working with a team, especially in a professional setting. Collaborative tools like Google Documents and task delegation software like Trello can facilitate such sharing in a way that saves time and energy. Other skills include simply listening to the ideas of others, understanding different points of view, and knowing how to effectively resolve conflicts (Doll, 2005). This allows collaborators to accommodate for differences in opinion and to reach a consensus that results in several minor outcomes (which include tasks like scheduling meeting times, drafting plans, and delegating responsibilities) that work toward the ultimate outcome (such as a successfully administered unit of study on information communication technology) of the collaborative experience. Finally, by working together, all members of the collaborative group can establish positive social connections among each other, and know that they have a system of support for future collaborative experiences.

It is important to realize that not all collaborative experiences are the same. Numerous models of school librarian-teacher collaboration are available, and I argue that the model most relevant to the school library makerspace is Betty Marcoux’s Pyramid of Collaboration model (see Figure 6). It is applicable to both educators and to students working in the makerspace. I summarize her model of the five levels of collaboration:
- **Consumption:** Students use library resources.
- **Connection:** The librarian knows if a teacher is scheduled to use the library, but is not directly involved.
- **Cooperation:** The librarian knows general details, such as learning outcomes. The librarian might give a short workshop on information literacy skills.
- **Coordination:** The librarian knows specific details of the unit. The librarian shows students resources and how to use them, and has helped students in developing the focus of their work.
- **Collaboration (Ultimate):** “The library staff and the classroom teacher have jointly planned and implemented the entire lesson. Teaching is shared on all aspects of the lesson, and student assessment/evaluation is done jointly. There is evaluation of both content mastery and also resource use. Students are also assessed on their information literacy process” (Marcoux, 2007, 22).

![Figure 6: Pyramid of Collaboration (Marcoux, 2007, 23)](image)

One useful observation from a different collaboration model, Loertscher’s *Taxonomies of the School Library Media Program*, is worth keeping in mind. Donham writes

“Loertscher designed a more detailed model of collaboration that acknowledged, importantly, that sometimes no collaborative involvement is appropriate; school librarians connote and do not need to collaborate with teachers on every unit taught” (Donham, 2013, 120). Each level of collaboration has its place in both the school library makerspace and the wider school library program. Students and teachers should feel that they have enough ownership of the makerspace to be comfortably consume resources.
They should also feel that they can approach the librarian when they want to collaborate, and be open when the librarian approaches them with suggestions.

**Section 1.4.3: Evidence Based Practice and Assessment**

Many proponents of the maker movement have a negative view of assessment, which, perhaps unintentionally, means they are not supporters of evidence-based practice. Martinez and Stager (2013) are especially adamant in their argument that “assessment always interrupts the learning process” (81), rubrics are stifling (82), and that the concept of Backward Design is problematic because it assumes that “maximum educational value is achieved when every student gets to a goal preordained by the teacher” (52). I do not agree with these views because I have a different understanding of what assessment looks like. Students should learn to self-assess their own work (Louis & Harada, 2012), and mentors who have more experience can add value through constructive feedback. Encouraging students to reflect on their work is valuable, and gives them the tools they need to develop dispositions that will aid them in their future learning and career. In this section, I discuss evidence-based practice and assessment to further support this argument.

Ross J. Todd, a professor of library and information science at Rutgers University and a specialist in evidence-based librarianship, argues that school librarians need to focus on knowledge construction and human understanding, implemented through constructivist, inquiry-based frameworks” (Todd, 2007, 62). Focusing on these factors aligns with the views of the makerspace, which strives to develop students’ understandings in authentic contexts of problem solving and following personal interests. By engaging in evidence-based practices in the makerspace, school librarian can improve
their instruction, be certain that their program is truly impacting student learning, and gain the support of key stakeholders.

Todd (2007) describes evidence-based practice in a framework of “three interrelated and integrated phases: evidence for practice, evidence in practice, and evidence of practice. Further, he identifies seven key guiding principles of evidence based practice, listed below:

1. Know the research, and know the research intimately;
2. Make visible the research foundations of your practice in you school;
3. Make student learning outcomes the center of your evidence;
4. Integrate evidence-generating strategies in your practice that focus on learning outcomes;
5. Mesh results of local evidence of learning outcomes with other evidence in the school, as well as with existing research to establish evidence-based claims, and to build a continuous improvement plan;

Each paragraph of the following paragraphs discuss how each of these principles is important for librarians in the school library makerspace.

All educators should engage in current research on education, librarianship, psychology, and other relevant research to identify best practices. Additionally, school librarians should diversify their reading sources to various disciplines, fields, and formats (Todd, 2007). Reading widely is especially important for a school librarian who runs a school library makerspace due to the great focus on interdisciplinary learning, especially in the STEAM fields. Being aware of the current advances in STEAM education is vital to supporting both teachers and students.

Effective communication is essential to identifying how relevant research foundations support the impacts of the school library program. Librarians…
have to judiciously and carefully shape that communication to show how it is situated in and responsive to school goals, initiatives, and improvement agendas, and to provide ideas as to how the whole school community might begin to take action on the findings (Todd, 2007, 66).

As an information specialist, the librarian is in an excellent position to distribute current research findings to teachers and administrators throughout the building and collaborate with them to act on these findings in a way that will positively impact learning. Keeping an updated, user friendly library website is one way to communicate research findings at the national, state, and local levels (Todd, 2007). Keeping a current professional collection of publications for each discipline is also effective. As leaders, librarians can help shape the vision, mission, and goals of the entire school community by bring in relevant research to school board meetings, teams of teachers, and other meetings conducted by key figures in the school community. In relation to the makerspace, the librarian can explain how the maker movement is rooted in accepted learning theories like Piaget’s constructivism, and utilizes an inquiry-based approach as required in the AASL standards.

Section 1.4.4 Evidence-Based Practice and Student Outcomes

Student outcomes should be at the center of evidence-based practice. The school library program must show that reaching the Common Core, information literacy, and other relevant standards adopted by the school “has an impact beyond the school library” (Todd, 2007, 67). This feeds into the idea that the goal of the school library is to instill deep understandings in students that have a lasting benefit on their lives, not just the ability to regurgitate facts learned on a standardized test. This is where Backward Design is an effective approach to use in the school library makerspace and the wider school community (Pappas, 2008). Developed by veteran educators Grant Wiggins and Jay
McTighe, Backward Design is the approach to designing effective instruction that most closely aligns with the principles of evidence-based practice. The model challenges teachers to begin with the end, or outcomes, in mind when planning learning experiences.

The three stages of Backward Design are:

1. Identify desired results.
2. Determine acceptable evidence.

Backward Design requires educators to articulate what lasting understandings their students will develop rather than simply covering a list of topics through direct instruction. The authors summarize the difference between knowledge and understanding in Table 7 below.

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>The facts</td>
<td>The meaning of the facts</td>
</tr>
<tr>
<td>A body of coherent facts</td>
<td>The “theory” that provides coherence and meaning to those facts</td>
</tr>
<tr>
<td>Verifiable claims</td>
<td>Fallible, in-process theories</td>
</tr>
<tr>
<td>Right or wrong</td>
<td>A matter of degree of sophistication</td>
</tr>
<tr>
<td>I know something to be true</td>
<td>I understand why it is, what makes it knowledge</td>
</tr>
<tr>
<td>I respond on cue with what I know</td>
<td>I judge when to and when not to use what I know</td>
</tr>
</tbody>
</table>

Table 7: Knowledge versus Understanding (Wiggins & Grant, 2005, 38)

Viewing understanding in this way allows for students, teachers, and librarians to conduct more authentic assessment, identify direct outcomes of learning, and gather better quality evidence for analysis. I believe backward design is compatible with the school library makerspace. Educators in schools are responsible for aligning instruction to the various standards, I agree with Laura Fleming in her argument that “rather than embodying any one learning goal, makerspaces offer an environment that allows students to develop many of the skills outlined in the standards” (Fleming, 2015, 32). Teachers may begin
with an enduring understanding in mind when they begin a unit of study in the makerspace, but students should not be left out of this equation. Students should given a general framework to work within when teachers use Backward Design to identify an overarching concept, but students might reach understandings that teacher did not consider. An example of articulating a deep understanding is given below:

- The Next Generation Science Standards for Middle School Engineering Design state the following standard: “**MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**”

- From this standard, the educator can identify a big idea, or lasting understanding, that provides a focus their instructional planning: **Multiple design models need to be evaluated before pursuing the most promising solution.**

- The educators can then identify a topic that is of interest to students in order to provide a domain to work within and content for engagement, such as information communication technology or bioengineering. With guidance from the librarian and classroom teachers, students can identify a problem in which they are personally invested, brainstorm several solutions, and then pursue one of their ideas.

Students may even identify and articulate understandings not planned by the educator, which is an excellent outcome and can inform future instruction. Far from being stifling to the learning process, I assert that Backward Design provides a useful framework for work in the makerspace.
In order to collect evidence, the librarian must focus on the desired learning outcomes. While usage statistics and number of collaborations per month are valuable data to collect as well, these are indirect measures that do not elucidate specific learning outcomes, and are not enough to provide a full picture of the impact of the school library program (Todd, 2007). Authentic student assessment is a direct measure of student learning and becomes evidence that communicates the impact of the school library makerspace. Violet Harada suggests using the evidence collected by the library to meet several different goals and communicate findings to multiple audiences, including: “empowering student learning; informing instructional effectiveness; communicating evidence of learning to parents; winning support from administrators” (Harada, 2005, 9).

In their book Assessing for Learning: Librarians and Teachers as Partners, Harada and Yoshina (2010) discuss many different tools for assessment in great detail; rubrics, checklists, conferences, exit passes, graphic organizers, and portfolios are just a few examples of assessment that can be used in evidence-based practice. All of these tools can be used by educators to assess student work, and by students as an aid in self-assessment. The results of analysis can in turn inform future instruction, communicate the activities of the school library makerspace to parents, and secure the support of administration. Generating this kind of evidence is a natural part of the school library makerspace, which encourages the documentation of projects on blogs, the creation of portfolios, and the use of the internet to share new knowledge.

Meshing the results of evidence generated in the school building with standardized test scores and existing research on the local, state, and national levels
allows educators to make evidence-based claims about their school library program and school library makerspace. Todd (2007) states that evidence should be cumulative. The evidence from a single instructional intervention or service initiative is not likely to result in dramatic change. Evidence-based practice is an ongoing, constructive, and integrative process that requires a broad range of quantitative and qualitative data and its analysis. The goal is to provide as full a picture as possible of every impact the school library makerspace has on student learning.

Finally, disseminating the evidence and the conclusions drawn from it to the wider school community is a cause for celebration at student achievement, progress, and learning. Collaborating with teachers and students to analyze the evidence is an effective way to involve the entire school in the success of the school library program. Evidence should be displayed in multiple formats, including on bulletin boards, on the school website, on the librarian’s blog, in paper newsletters distributed to parents and teachers, and in reports to administration. Evidence-based practice has a place in the school library makerspace because it educators and students to make informed decisions, be aware of their own thinking, and track their progress over time, all in the context of the learning theories and frameworks discussed in this background section.
Part 2: Project Design

The focus of this project has changed considerably since I first proposed it. Initially, I planned to create an interdisciplinary unit to be taught in a school library makerspace. As I began attempting to plan this unit, I realized that I would need the input and advice of other classroom teachers in order to make sure I was identifying valuable understandings in each content area. It is difficult to collaborate with teachers I have no access to, but I was able to engage in deep thinking and prepare for future collaborations. While I knew I could find useful resources to help teach STEAM centered lessons, I have little experience in teaching that content. I then decided that creating a makerspace collaboration guide to use in my future practice would be more useful than a single unit plan. This guide can be used to plan a multitude of units with the teachers in my school.

In order to create this makerspace collaboration guide, I drew on Backward Design principles. I knew that my desired result was to create a comprehensive guide to planning teaching and learning in a middle school library makerspace. The evidence for the validity of the collaboration guide is discussed in great detail in Part 1 of this paper. I identified multiple education theories, summarized the parts of each theory, and explained how each of these theories is relevant to learning in the school library makerspace. The result is an argument that strongly advocates for the presence of makerspaces in school libraries. My final product is a makerspace collaboration guide that will allow school librarians to think deeply about planning for instruction in a
makerspace. The nature of learning in a makerspace puts students at the center of all learning. To accommodate this, I encourage school librarians to engage with all of their users and allow students to direct their own learning.

The first step in creating this resource guide was gaining a firm understanding of makerspaces, what kinds of learning takes place in them, and identifying other relevant theories that I have engaged with during my studies in my master’s program. The first book I read was Sylvia Martinez and Gary Stager’s *Invent to Learn: Making, Tinkering, and Engineering in the Classroom*. This book gave an excellent overview of makerspaces in schools, and influenced my thinking about how learning in the makerspace is rooted in constructivist and constructionist theories. When I finished that book, I began to search citation indexes for terms like “makerspaces,” “school library makerspaces,” “maker culture,” “constructivism,” “constructionism,” “STEM and STEAM education,” and “interdisciplinary learning.” These lead me to many relevant articles that deepened my conceptualization of learning and teaching in the makerspace. I also drew on my previous knowledge of the Connected Learning framework, which is relevant to makerspaces because it encourages teaching students in the context of a topic that already interests them. Finally, I consulted *Empowering Learners: Guidelines for School Library Program* published by the American Association of School Librarians. These guidelines helped me identify the role of the school librarian in the makerspace because they stress the importance of collaborating with key stakeholders in the school, supporting multiple literacies, encouraging inquiry-based learning, and assessing student learning outcomes. Once I had completed reading about these topics in depth, I was able to start writing the makerspace collaboration guide.
The guide is divided into three parts: 1] Preparing for Collaborations,
2] Collaborative Planning for Makerspaces: Engaging with Teachers and Students, and 3] Assessing Learning in the Makerspace. Each part is described briefly below:

1. **Part 1** focuses on what the school librarian should do in order to facilitate productive collaborations. It guides the school librarian through writing a policy for the library makerspace. I advise school librarians to plan their makerspace program through the lens of Backward Design, which encourages them to determine the learning outcomes students should obtain as a result of working in the makerspace. Next is a section on identifying existing community assets that might result in valuable partnership opportunities. Finally, I provide an inventory template so the librarian can inform potential collaborators what resources they have access to through the school library makerspace.

2. **Part 2** provides tools that will facilitate communication between all collaborators. It includes a template for curriculum maps cross several months, a survey for to identify student interests, and a guide identifying topics and issues that cross multiple disciplines. These tools intended to help teachers and librarians organize big understandings and content to be taught in the makerspace. The last section provides students and teachers with a project planning worksheet, which is inspired by Backward Design principles.

3. **Part 3** focuses on evidence-based practice. It provides suggestions for collecting, analyzing, and disseminating evidence produced in the school library makerspace.
Even though my final product is different from my initial idea, I think my change in focus was beneficial. I have done deep analysis and thinking about planning for learning in the school library makerspace, which by nature is a messier learning environment than the traditional classroom. However, this guide provides school librarians with a framework that is based in relevant education theories and aligns with the standards expected of school librarians.
Part 3: Future Practice and Implications

The next step for this makerspace collaboration guide will be to use it in my future school library program. By using my guide in a real collaboration with practicing teachers, I can identify areas of possible improvement that will only reveal themselves in the field. I will assess how well the guide works and make continuous improvements to each tool I created. I will also encourage the modifications of other school librarians and consider any insights they have about my guide.

The creation of this guide has several implications. First, the connections I made with existing educational theories to how they can be used in the makerspace gives more credibility to the maker movement and its place in school libraries. While makerspaces can and should still function as an informal learning environment, it can also be used in more formal education. Librarians can approach learning in the makerspace from various lenses (constructivism, constructionism, inquiry-based learning, connected learning, backward design, etc.) in order to meet the standards mandated in the Common Core, the Next Generation Science Standards, state standards, and school goals.

A second implication is that this makerspace collaboration guide will empower young people to take charge of their own learning. It encourages them to articulate their thinking in the context of a project or problem they personally want to solve. The makerspace then provides an opportunity for the student to work towards solving a problem by making something tangible that they can share with the world. Finally,
creating more focused learning experiences in the school library makerspace implies that our students will be ready for the uncertain landscape of the twenty-first century. By focusing on STEAM education, students will be more prepared to interact with our technology and information-driven society. They will work toward the mastery of multiple literacies, and perhaps get closer to becoming the scientifically literate society Carl Sagan envisioned when he wrote *The Demon-Haunted World* nearly twenty years ago.
Part 4: Makerspace Collaboration Guide

This makerspace collaboration guide will be available for download as a Google document on my own professional website, jennythelibrarian.wordpress.com. Other librarians can save a copy and make their own revisions to fit the needs of their school library makerspace. The guide appears in full below:

Collaboration Guide for a School Library Makerspace

The purpose of this collaboration guide is to guide school librarians in planning effective learning experiences in the school library makerspace. While the primary audience is middle school librarians, it can be used at any educational level. This guide will assist you, the middle school librarian, in preparing for collaborative experiences with teachers, community members, and students; in initiating communication with these groups; in planning learning experiences appropriate for a makerspace; and in assessing and documenting the activities occurring in your makerspace.

Part 1: Preparing for Collaborations

Writing a Policy for Your Makerspace

A policy specific to your makerspace will ensure that all users know the expectations, rules, and procedures. To give adolescents a feeling of ownership of their school library makerspace, involve them in the development of the policy. You might revisit the policy each year to see if new students want to make any changes to the current policy.

Involving collaborating teachers is also beneficial. Taking their preferences into consideration will lay a good foundation for future collaborations. Everyone who uses the makerspace should have a voice in how it is run.

Step 1: Align with your Library Mission

The school library makerspace is a piece of the bigger school library program, so it should fall under the same mission and goals. You can keep a Backward Design approach in mind when designing the library makerspace: first, identify desired results. Second, determine acceptable evidence. Third, plan learning experiences and instruction (Wiggins & McTighe, 2005, 18). Articulate what your mission and goals are in particular, keeping an outcome-based approach to planning and running the makerspace. Later, you can work
toward meeting these goals with planned learning experiences, and by allowing students free time to explore independently.

The worksheet below will help you in articulating the mission for the library makerspace at your school. I have modified Grant Wiggins and Jay McTighe’s Backward Design template for use in planning a library makerspace program.

<table>
<thead>
<tr>
<th>Stage 1 - Desired Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Established Goals</strong></td>
</tr>
<tr>
<td>• What aspects of your overall library program will your makerspace meet?</td>
</tr>
<tr>
<td>• Consider the AASL <em>Standards for the 21st Century Learner</em></td>
</tr>
<tr>
<td>• Inquire and think critically.</td>
</tr>
<tr>
<td>• Draw conclusions, make informed decisions, apply knowledge to new situations, and create new knowledge.</td>
</tr>
<tr>
<td>• Share knowledge and participate ethically and productively as members of our democratic society.</td>
</tr>
<tr>
<td>• Pursue personal and aesthetic growth (AASL, 2009, 7).</td>
</tr>
<tr>
<td>• What goals are other teachers and administrators in your school working toward?</td>
</tr>
<tr>
<td><strong>Understandings</strong></td>
</tr>
<tr>
<td>• What big ideas do you want your makerspace as a whole to communicate?</td>
</tr>
<tr>
<td>• What dispositions do you want to instill in your users?</td>
</tr>
<tr>
<td>• What misunderstandings or misconceptions are likely? How will you address them?</td>
</tr>
<tr>
<td><strong>Essential Questions:</strong></td>
</tr>
<tr>
<td>• Collaborate with students and teachers to determine essential questions that encourage a maker mindset.</td>
</tr>
<tr>
<td>• What provocative questions will encourage inquiry, understanding, and transfer of learning?</td>
</tr>
<tr>
<td><strong>Students will know...</strong></td>
</tr>
<tr>
<td>• Consider the resources available to you. What key content areas can you cover with what you have?</td>
</tr>
<tr>
<td>• What opportunities do you have to foster interdisciplinary learning?</td>
</tr>
<tr>
<td><strong>Students will be able to do...</strong></td>
</tr>
<tr>
<td>• What skills specific to the makerspace will students need to be able to do?</td>
</tr>
<tr>
<td>• What skills will transfer to other contexts and future learning experiences?</td>
</tr>
</tbody>
</table>

| Stage 2 - Assessment Evidence |
### Performance Tasks
- Through what authentic performance tasks will students demonstrate the desired understandings?
- By what criteria will performances of understanding be judged? How will you involve students in criteria selection?
- What kinds of evidence will you collect to show the impact the makerspace is having on student learning?

### Other Evidence
- Through what other evidence will students demonstrate achievement of the desired results?
- How will you ensure students reflect and self-assess their work?
- What statistics will you use to show your progress?
- How will you include the voices of your students, teachers, community mentors, and parents in your assessment?

### Stage 3 - Learning Plan

#### Learning Activities
What learning experiences and instruction will enable students to achieve the desired results? Speaking with teachers and cultivating collaborations is the only way to truly answer this question. Use the collaboration form in the “Planning” section of this collaboration guide.

- How will you allow students the freedom to pursue their own projects?
- What kind of structure will you provide for students to work within?
- How will the design...
  - **W** = Help the student know Where the makerspace program is going and What is expected? Help the teacher know Where the students are coming from (prior knowledge, interests)?
  - **H** = Hook all students and Hold their interests?
  - **E** = Equip students, help them Experience the key ideas and Explore the issues?
  - **R** = Provide opportunities to Rethink and Revise their understandings and work?
  - **E** = Allow students to Evaluate their work and its implications?
  - **T** = Be Tailored (personalized) to the different needs, interests, and abilities of learners?
  - **O** = Be Organized to maximize initial and sustained engagement as well as effective learning?

### Step 2: Hear from your Users
Rather than imposing a policy as the authoritative figure in the school library makerspace, listen to your users and potential users. Everyone in the school should have an opportunity to use the makerspace because it belongs to the entire community. Some suggestions for hearing from your users are:

1. Conduct short surveys of important user groups: students, teachers, volunteers, mentors, etc. Ask them what times are best for the makerspace to be open for free use, preferred scheduling procedures, what they think of maintenance of the makerspace, and more.
2. Develop a focus group to gather detailed data to guide your policy.
3. When introducing each class to the makerspace, have a discussion with the students about different aspects of the policy, and allow them to vote on any changes to policy.

See Step 3 for more focused questions to help you structure your policy discussions with various user groups.

**Step 3: Write the Policy**

Willingham & De Boer (2015) provide an useful outline of what should go into a policy for a makerspace. I have used their list as a starting point, then developed more pointed questions to aid in the creation of a school library makerspace policy. Involving adolescents in the writing of the policy is an excellent learning experience and gets students involved with the regulation of the makerspace right away.

<table>
<thead>
<tr>
<th>Policy Section</th>
<th>Probing Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hours of operation</strong></td>
<td>When is the makerspace open for free use?</td>
</tr>
<tr>
<td></td>
<td>When is the makerspace reserved for classes or workshops?</td>
</tr>
<tr>
<td></td>
<td>Is the makerspace open on weekends? Before/After school? During lunch?</td>
</tr>
<tr>
<td></td>
<td>How can you ensure that all students have at least some time in the makerspace for free use?</td>
</tr>
<tr>
<td><strong>Code of conduct</strong></td>
<td>Is there an existing code of conduct that the entire school has adopted that should be enforced?</td>
</tr>
<tr>
<td></td>
<td>What are the expectations for social interactions in the makerspace?</td>
</tr>
<tr>
<td></td>
<td>How will you ensure that all users are responsible for being safe around potentially dangerous equipment?</td>
</tr>
<tr>
<td></td>
<td>How will you foster a culture of teaching and learning?</td>
</tr>
<tr>
<td><strong>Scheduling</strong></td>
<td>What is the procedure teachers should use to reserve the makerspace?</td>
</tr>
<tr>
<td></td>
<td>Is there a limit to how often teachers can use the makerspace for class?</td>
</tr>
<tr>
<td></td>
<td>When will you collaborate with teachers?</td>
</tr>
<tr>
<td></td>
<td>How will you accommodate for community members’ schedules?</td>
</tr>
<tr>
<td><strong>Safety rules</strong></td>
<td>What kind of safety gear is required? Under what circumstances?</td>
</tr>
<tr>
<td></td>
<td>Will you require users to sign a liability waiver? What will the waiver say?</td>
</tr>
<tr>
<td></td>
<td>What kind of orientation will users need to complete in order to use different levels of equipment?</td>
</tr>
</tbody>
</table>
| **Housekeeping and maintenance** | • Who is responsible for cleaning and maintenance?  
• Where will users keep in-progress projects?  
• Who keeps the inventory updated? How does the librarian know when it is time to order more supplies? |
| **Community access** | • Are community members allowed access to the space? Under what circumstances?  
• How will you keep track of community volunteers? Who is allowed in the makerspace during regular school hours?  
• Can groups outside the school use the makerspace if they ask to reserve it? |
| **Documentation** | • How will you encourage your users to document the work done in the makerspace?  
• What online platforms will you promote? How will you teach users to use it effectively?  
• Do you need to get permission to take photos, videos, or recordings?  
• What will be posted publicly and what will be posted just for your community of users?  
• How will you get students involved in the documentation process? |
| **Collection Development** | • What criteria will you use to make purchasing decisions?  
• Will you have a print collection? Will you have a digital collection?  
• Where will makerspace materials (like books) be housed? |
| **Budget** | • Will funds come out of the entire library budget?  
• How will you allocate funds between equipment, technology, consumable materials, and information resources?  
• Will you apply for grants?  
• Will you ask for donations? |

**Conclusion**
Involve your users as much as possible when writing the policy for the school library makerspace. The policy should be a living document that changes as your community grows. Priorities, logistics, and interests may change over time. The librarian must communicate with the user group to make sure that the makerspace policy meets user needs and wants.

**Works Cited**
Developing Community Partnerships

In order to develop partnerships with the community, you need to know what is available to you. It is important to identify community assets. The goal of the makerspace is to bring together various disciplines so that students (and adults) can see how things in the real world are closely interconnected. Expand your thinking to include businesses and institutions that might not traditionally work with the school.

Remember, “businesses [emphasis added] enter into partnerships with schools for two reasons: to contribute to the public good by improving the quality of the school and to increase their own standing in the marketplace. Likewise, schools [emphasis added] seek business partnerships for two purposes: to increase their resources and to improve the community understanding and respect for their programs” (Donham, 2013, 97).

Partnering with the community can benefit everyone involved. It also gives students a chance to feel like a more important part of their community and exposes them to supportive adults who are working in jobs adolescents might have one day.

Step 1: Brainstorm Possible Partnerships

Use the following chart to brainstorm possible partnerships in your community. Think of businesses, institutions, and organizations that fall under specific domains. Universities, museums, and public libraries can help with a wide variety of topics, while a business that focuses on electrical engineering can provide interested students with deep, specialized knowledge and experience.

It might be helpful to collaborate with a group to identify as many possibilities as possible. Parents, students, teachers, administration, and friends outside of your school might lead you to businesses or organizations you were unaware of.

Once you generate a list of possible partnerships, move on to step two to conduct a deeper analysis of each partner possibility.

Community Partner Possibilities

<table>
<thead>
<tr>
<th>✔ Partner</th>
<th>Examples in the community (e.g. local business, public library)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If possible, include a possible contact who is willing to work with your makerspace.</td>
</tr>
<tr>
<td>Ex. ✔ Communications</td>
<td>Time Warner Cable</td>
</tr>
<tr>
<td></td>
<td>Jane Doe</td>
</tr>
</tbody>
</table>
## General and Specialized Education

<table>
<thead>
<tr>
<th>Universities, various departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Colleges</td>
</tr>
<tr>
<td>Museums</td>
</tr>
<tr>
<td>Public Libraries</td>
</tr>
</tbody>
</table>

## STEAM Focused Partners

<table>
<thead>
<tr>
<th>Mechanical Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>Civil Engineering</td>
</tr>
<tr>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Medical</td>
</tr>
<tr>
<td>Information Communications Technologies</td>
</tr>
<tr>
<td>Transportation</td>
</tr>
<tr>
<td>Computer Science</td>
</tr>
<tr>
<td>Sustainability</td>
</tr>
<tr>
<td>Local Artists</td>
</tr>
</tbody>
</table>

## Vocational Focused Partners

<table>
<thead>
<tr>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plumbing</td>
</tr>
<tr>
<td>Electrical</td>
</tr>
</tbody>
</table>
Step 2: Background Research

After identifying possible partnerships, you will want to engage in some background research on each business or organization before reaching out to them. The following questions will guide you decide whether or not to pursue a collaboration with each possible partnership option you generated above.

<table>
<thead>
<tr>
<th>Community Partner Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does this potential partner do?</td>
</tr>
<tr>
<td>Who do they serve? What is their mission?</td>
</tr>
<tr>
<td>Who works there?</td>
</tr>
<tr>
<td>Does this potential partner have any history of collaborating with schools before?</td>
</tr>
</tbody>
</table>
Is there any indication of a willingness to work with schools or similar institutions on their website?

Does this potential partner have any history of working with young adolescents?

What kinds of skills/topics/expertise could this partnership offer your makerspace?

Do they specialize in any particularly interesting technology?

Do any parents affiliated with the school work with this potential partner?

Do you already know someone who works with the potential partner that could be a beneficial contact?

Informally ask some trusted colleagues about their impression of the potential partner.

**Step 3: Initiate Communication**

After completing some initial research, decide which potential partnerships you think could be successful. You can use the worksheet below to guide a conversation with your contact in the business or other institution to see whether a partnership would benefit both parties. Additionally, you should articulate the mission, goals, and vision of your makerspace and what you are looking for from this partnership. You also might provide a condensed version of your makerspace policies and some general information about who uses the makerspace, some general information about your student population, and the kind of work you have already done with students there.

**Initial Communication Form**

<table>
<thead>
<tr>
<th>(Partner Name) Important Goals</th>
<th>School Makerspace Goals</th>
</tr>
</thead>
</table>

What can (partner name) offer the school library makerspace?

- Presentations
- Workshops
- Volunteers
- Mentors
- Job shadowing
Internship opportunities for students
- Professional development for school faculty
- Other: _______________________________

What can the school library makerspace offer (partner name)?
- Promotion of (partner name)’s contribution to the school library makerspace
- Advertisement
- Payment

Who else at (partner name) is interested in collaborating with the school library makerspace?

---

**Step 4: Mentor Matching**

If your partner has indicated they can provide specialized mentors for your students, it is important to get an idea what assets each person can offer. Use this form along with the student version to help match students with mentors. Make any changes to the form to fit your own school library makerspace. (This form was inspired by The Makerspace Team’s form in *Makerspace Playbook: School Edition* (2013, 65).

<table>
<thead>
<tr>
<th>Name:</th>
<th><strong>Contact Information</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preferred Phone #: ________</td>
</tr>
<tr>
<td></td>
<td>Email Address: _______________</td>
</tr>
<tr>
<td></td>
<td>Best time to talk outside the makerspace:</td>
</tr>
</tbody>
</table>

| Name of Company/Institution | **Have you ever attended a Maker Faire?** |

| What skills and expertise can you offer the makerspace? (Use the list below to help you brainstorm) | **What are you interested in learning more about?** |

Circle any content areas you have expertise in.
Check any content areas you are interested in learning more about.

<table>
<thead>
<tr>
<th>Alternative energy</th>
<th>Gaming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animation</td>
<td>Gardening</td>
</tr>
<tr>
<td>Architecture</td>
<td>GPS</td>
</tr>
<tr>
<td>Arts</td>
<td>Graphic Design</td>
</tr>
<tr>
<td>Astronomy / Space</td>
<td>Hacking</td>
</tr>
<tr>
<td>Bicycles</td>
<td>Knitting</td>
</tr>
<tr>
<td>Biology</td>
<td>Lights</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Mathematics</td>
</tr>
<tr>
<td>Circuit Boards</td>
<td>Mechanics</td>
</tr>
<tr>
<td>Recycling</td>
<td>Robots</td>
</tr>
<tr>
<td>Robots</td>
<td>Rockets</td>
</tr>
<tr>
<td>Sewing</td>
<td>Social Media</td>
</tr>
<tr>
<td>Spy / Surveillance</td>
<td>Sustainable Living</td>
</tr>
<tr>
<td>Sustainable Living</td>
<td>Technology</td>
</tr>
<tr>
<td>Technology</td>
<td>Toys</td>
</tr>
</tbody>
</table>
Conclusion
By identifying possible partners and communicating with them to see what you have to offer each other, you are using your position as a leader in the school to connect students with people who can spark their passions and insight their curiosity. Tweak these forms in any way to better fit the needs of your school library makerspace.

Further Reading
A more in-depth guide to mapping the assets in your community was published by the UCLA Center for Health Policy and Research. It can be accessed here: http://healthpolicy.ucla.edu/programs/health-data/trainings/Documents/tw_cba20.pdf

Works Cited


**Makerspace Inventory**
Keep an up-to-date inventory of everything you have in your makerspace so that teachers and students can see what is available for them to use. This inventory list adapts the “High School Makerspace Tools & Materials” document published by makerspace.com (see works cited for this section).

Use a spreadsheet to keep the inventory organized and easy to read. The figure 7 is a preview of such a spreadsheet.
The top row lists each domain of the makerspace in a column. Customize this row to reflect the domains your makerspace supports.

The left column divides your inventory into six categories: equipment, tools, materials/parts, consumables, safety, and accessories. The definitions of each are below.

**Equipment:** “Heavy duty” machines that most likely require adult supervision to use. Examples include a 3-D printer, a laser cutter, sewing machines, or a variety of woodworking saws.

**Tools:** Hand tools that require minimal adult supervision. Examples include hammers, hot glue guns, soldering irons, or knitting needles.
**Materials/Parts:** Common and useful materials on which students use the equipment or tools available. Examples include lumber, electronic components, cloth, or hardware. **Consumables:** Items that need regular replacing. Examples include hot glue sticks, replacement blades, solder, or pens. **Safety:** Items that lessen the risk of injury when using equipment and tools. Examples include safety goggles, ear protection, or fire extinguishers. **Accessories:** Items that support the use of tools. Examples include storage, workspace, or power strips.

Consider allowing your students to assist you in keeping this inventory updated. Again, feel free to change this spreadsheet to fit your own needs.

**Work Cited**

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**Part 2: Collaborative Planning for Makerspaces: Engaging with Teachers and Students**

Once you have a clear idea of the missions and goals for the school library makerspace, it is time to begin planning with classroom teachers. The makerspace might be housed in the library, but you will need the expertise of the teachers in your building in order to create authentic and comprehensive units for your students. You should also carefully consider your students’ input, consider opportunities to develop multiple forms of literacy, and strive to connect the learning done in the makerspace to their own interests. An interdisciplinary lens with help you with making connections across the school curriculum and allow students to connect their learning to the real world.

**Step 1: Know What Your Teachers are Already Doing**

If you are just starting your school library makerspace, it might be difficult to ask teachers to change their entire teaching method in a short period of time. You can start slow by getting a big picture of what the school-wide curriculum looks like by reading an
existing or creating a new curriculum map with the teachers in your building. A
curriculum map “paints a portrait of who is teaching what, with which students in each
grade level, and at what time of the calendar year” (APPLE Corps, 2001, 65). This allows
you to see what topics, learning activities, and projects teachers are already using in their
instruction. See where you can fit within their frameworks, and begin encouraging maker
education in your school by working to enhance their existing units of study.

Core Curriculum Map

<table>
<thead>
<tr>
<th></th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language Arts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information and Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For more information on how to create a curriculum map, see Heidi Hayes Jacobs’s
*Mapping the big picture: Integrating curriculum and assessment K-12*. You can read the
first two chapters for free here: [http://www.ascd.org/publications/books/197135.aspx](http://www.ascd.org/publications/books/197135.aspx)

**Step 2: Identify Student Interests**

Next, you should communicate with your students so that they have a voice in the
direction of their own learning. A strength of the Common Core State Standards is their
flexibility and focus on big ideas and dispositions. You might not teach the same content
from year to year, but you can still meet the standards while engaging students with
topics and issues they care about.

You can survey your students, hold group discussions, and talk with students one-on-one
to help determine the topics the makerspace should focus on, what skills they interested
in acquiring, and problems they are interested in solving.

**Possible Student Survey**

<table>
<thead>
<tr>
<th>Question</th>
<th>Student Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>What problems and challenges to you see in the world today? (social, environmental, etc.)</td>
<td></td>
</tr>
</tbody>
</table>
Have you thought of any possible solutions to these problems and challenges? If so, what are they?

What skills would you like to learn how to do?

What do you want to do when you “grow up?”

If you could make anything, what would it be?

What else should the librarian know about you, your plans, and your interests?

**Step 3: Think about Themes**

Look for content possibilities that can support a unit of interdisciplinary study. Be sure to keep relevant standards in mind. Starting with a theme in mind can be useful, especially when these themes appear in various disciplines. You can make a content web to identify important concepts, ideas, keywords, and more about a real-world topic. Organizing content is another opportunity to involve students in planning their own learning. They might not think of everything an expert content teacher would, but it will give them a tool to use in their own future learning.

Here is a short list of possible interdisciplinary themes to get you started:

- Change
- Interconnectedness
- Responsibility
- Diversity
- Risk
- Equality
- Communication

Here is a short list of possible interdisciplinary content areas to get you started:

- Evolution
- Environmental issues/sustainability
- Nutrition
- Information Communication Technology infrastructure
- Invention/innovation

**Step 4: Organize Specific Content**

By yourself, with collaborating teachers, and with students, brainstorm important skills, ideas, and resources for a particular topic area. Stretch your thinking to identify concepts across the disciplines.
Do not worry too much yet about what information is most important. Instead, just get as much down as you can. The classroom teachers are the experts in the specific content, so be sure to get their input. Below is an example of an interdisciplinary map for Information Communication Technology.

<table>
<thead>
<tr>
<th>Science</th>
<th>Technology</th>
<th>Engineering</th>
<th>Art</th>
<th>Math</th>
<th>Language Arts</th>
<th>Social Studies</th>
<th>Information Literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-Waves</td>
<td>Binary code</td>
<td>Infrastructure</td>
<td>Graphic design</td>
<td>Mathematical models of waves</td>
<td>Communication skills: Speaking, writing, listening</td>
<td>Key innovators and historical figures</td>
<td>Intellectual property</td>
</tr>
<tr>
<td>Electromagnetic spectrum</td>
<td>Other programming languages</td>
<td>Engineering design process</td>
<td>How music is recorded</td>
<td>Linear relationships</td>
<td>Multiple viewpoints</td>
<td>Social issues regarding ICTs</td>
<td>Patents</td>
</tr>
<tr>
<td>Frequency</td>
<td>Electrical components that make electronics work</td>
<td>Measurement of waves</td>
<td></td>
<td></td>
<td>Bias</td>
<td>Globalization</td>
<td>Creative Commons</td>
</tr>
<tr>
<td>Amplitude</td>
<td>Fiber optic cables</td>
<td></td>
<td></td>
<td></td>
<td>Rhetoric</td>
<td>Influence on society</td>
<td>Information search strategies</td>
</tr>
<tr>
<td>Amplitude</td>
<td>WiFi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Research strategies</td>
</tr>
<tr>
<td>Digital signals</td>
<td>Using radio signals for communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital signals</td>
<td>Receivers and transmitters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After you develop a comprehensive list of possible study, it is time to prioritize the content. Grant Wiggins and Jay McTighe suggest starting with a broad view of a topic, then focusing on the most “important knowledge, skills, and concepts that have connective and transfer power, within this unit and with other units of study on related
topics (Wiggins & McTigue, 2005, 72). This idea is illustrated by the Figure 8, which shows three nested ovals that represent the priority of the content knowledge:

![Figure 8: Prioritizing Content Knowledge (Wiggins & McTigue, 2005)](image)

Step 5: Backward Design

Once you have a topic mapped out in detail, it is time to plan the actual unit of study. Remember that Wiggins and McTigue’s model has three key stages:

1. Identify desired results
2. Determine acceptable evidence

You can use the official Backward Design template in your planning. It is available on Jay McTigue’s website for free, or you can acquire the book Learning by Design to gain a deeper understanding of how to plan, teach, and assess a Backward Design unit.

While Backward Design is an open-ended approach to teaching and learning, learning in the makerspace can be even more open-ended. Below are some suggestions to encourage students to take charge of their own learning.

1. Give students the freedom to explore, inquire, and learn independently, and intervene when necessary. While you should do your best to guide students
toward the desired outcomes of a unit, remember not to discourage them from reaching understandings that you had not considered yet. Use their understandings to inform your future practice.

2. Involve your students in the development of desired results. Listen to your students for misunderstandings, and use those misunderstandings as an opportunity to allow students to discover something new. This is part of constructivism: students need a good reason to change a deeply-held belief or understanding. Just telling them from your place of authority as a teacher will probably not have a profound effect until your students experience the phenomenon on their own.

3. Allow students to pursue their own projects. While they can work under your guidance, allow them to choose problems they are interested in. As the librarian, you can direct them toward useful resources and enable them to find their own resources.

**Step 6: Project Facilitation**

The school library makerspace should support both projects being done for core classes and projects pursued by individuals users outside of class. You might consider running specific skill workshops, having open hours for users to have free reign, and allowing teachers to schedule class time during the school day. Teaching users good habits when developing a project is an important job for the school librarian. The sections below will help you collaborate with teachers and students when planning and facilitating a specific project.

**Deciding on a Project**

In your formal collaborations with classroom teachers, you should have some big understandings in mind that will inform the kinds of projects done in the makerspace. Additionally, you will need to help students choose and develop their own projects. This tool will focus your thinking.

**Tool 1: Maker Notebook**

You can encourage your students to develop good mental habits by modeling best practices, such as keeping a Maker Notebook. This tool allows users to see their thinking over time, record their progress and pitfalls, and communicate their work with other people. While each Maker Notebook can be totally unique to a specific user, there are some general guidelines that make keeping such a record more efficient.

- A physical composition notebook could be useful in a messy makerspace, but do not limit students to a particular medium. A private blog might work just as well, and permits users to take videos, photos, and recordings of their project in progress.
- Help students develop an organizational system. They might keep a table of contents, color code their entry type (blue for events, red for pitfalls, green for data entry), or create subject tags in a digital Maker Notebook.
- Encourage your students to make entries in chronological order without skipping pages. This allows them to see the true trajectory of their projects.
**Tool 2: Project Planning Worksheet**
The following worksheet is loosely based on the engineering design process (Science Buddies, 2016). It poses the user of the makerspace to think through their project and record their progress, even if it is only in short entries. This tool can be used by students and teachers.

**Project Planning Worksheet**

<table>
<thead>
<tr>
<th>Choose a Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you want to learn how to do/ what do you want to know?</td>
</tr>
<tr>
<td>Define your problem/issue. What are you trying to improve?</td>
</tr>
<tr>
<td>Who is your audience?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you need to know in order to work on your solution?</td>
</tr>
<tr>
<td>Brainstorm some keywords that relate to your topic.</td>
</tr>
<tr>
<td>Search online.</td>
</tr>
<tr>
<td>- Makerspace blogs</td>
</tr>
<tr>
<td>- Instructables</td>
</tr>
<tr>
<td>- Past Maker Faires</td>
</tr>
<tr>
<td>- Other sources?</td>
</tr>
<tr>
<td>Search your library.</td>
</tr>
<tr>
<td>- Books</td>
</tr>
<tr>
<td>- Internet databases</td>
</tr>
<tr>
<td>- Periodicals/Magazines</td>
</tr>
<tr>
<td>- Other sources?</td>
</tr>
<tr>
<td>Ask a friend, teacher, or mentor what they know about your topic.</td>
</tr>
<tr>
<td>See what others have done in response to the problem you have identified. How might you improve on their work?</td>
</tr>
<tr>
<td>What is your plan for safety?</td>
</tr>
<tr>
<td>Specify your Intended Results</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>What does your successful project look like? How will you evaluate your product? Define evaluation criteria.</td>
</tr>
<tr>
<td>Break your project down into smaller steps.</td>
</tr>
<tr>
<td>• Do I need to do more research?</td>
</tr>
<tr>
<td>• What parts will make up the whole project?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Try it Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinker with materials, equipment, and other resources. What are your thoughts?</td>
</tr>
<tr>
<td>Prototype a solution and test it. Did it meet your evaluation criteria? Why or why not?</td>
</tr>
<tr>
<td>If you are not happy with your product, what are your next steps for improvement?</td>
</tr>
<tr>
<td>• More background research?</td>
</tr>
<tr>
<td>• Try a new skill/medium/approach?</td>
</tr>
<tr>
<td>• Talk with a mentor?</td>
</tr>
<tr>
<td>• Something else?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assess your Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflect on your learning throughout your project.</td>
</tr>
<tr>
<td>• What are you doing well?</td>
</tr>
<tr>
<td>• What do you need to improve?</td>
</tr>
<tr>
<td>• How are you feeling about your work?</td>
</tr>
<tr>
<td>• Do you need to ask for help?</td>
</tr>
<tr>
<td>• What do your experiences with this project mean for your future learning? What will you be able to do at the end of your project?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communicate your Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will you post updates periodically or publish an analysis of your product when you are done? Either way, make sure to keep good records in your Maker Notebook.</td>
</tr>
</tbody>
</table>
How will you communicate your results?

Check all that apply:
- Publish online
- Create a project portfolio
- Make a presentation
- Teach a workshop
- Something else?

Conclusion
In order for a librarian to facilitate effective learning in the school library makerspace, they need to collaborate with students and their teachers to figure out the best way to meet learning outcomes. Learning outcomes can be met in the context of almost any topic that interests students. It is the job of the teacher and the librarian to push student learning in a way that guides them to the desired learning outcomes and beyond.

Further Reading
See an overview of how to use the Backward Design template here: http://www.grantwiggins.org/documents/UbDQuikvue1005.pdf

For more resources on Backward Design, visit Jay McTighe’s website here: http://jaymctighe.com/resources/downloads/

For more on the engineering design process, visit Science Buddies here: http://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml#theengineeringdesignprocess

Works Cited


Part 3: Assessing Learning in the Makerspace

Assessing Learning in the Makerspace
An essential piece of facilitating a successful school library makerspace is to evaluate the impact it is having on students, teachers, and the school community as a whole. Evidence-based practice can help you make decisions about future practice, communicate your impact with key stakeholders, and allow students to see their progress over an extended period of time. Todd (2007) stresses the importance of student learning outcomes in evidence-based practice. By collaborating with classroom teachers, community volunteers, and students, the librarian can lead the way in assessing the impact of the school library makerspace.
Step 1: Gather Acceptable Evidence
When you collaborated with the classroom teachers and students, you agreed on what the desired learning outcomes for the unit were and what would qualify as acceptable evidence for meeting these outcomes. This list of evidence sources is a starting point for your own collection.

Qualitative Data
- Samples of student products
- Samples of student Maker Notebooks
- A Makerspace Community blog that allows anyone to make posts
- Individual student blogs
- Samples of lesson plans or workshops taught in the makerspace
- Records of collaborative planning and teaching activities
- Student surveys, commentary, and feedback
- Teacher surveys, commentary, and feedback
- Mentor surveys, commentary, and feedback
- Checklists of observed behaviors in the makerspace
- Rubrics created in collaboration with students
- Others?

Quantitative Data
- Standardized tests scores over several years
  - School, district, state, and national levels
- Number of users per month
- Number of collaborations per month
- Circulation statistics of makerspace-related materials
- Others?

Step 2: Analyze the Evidence
Evidence by itself is not enough to make a strong case in support of your library makerspace. Give meaning to the evidence by analyzing it, making inferences about your program, and providing suggestions for future improvement. The questions below can guide your evidence analysis.
- Compared to a previous piece of evidence, does this piece of evidence indicate an improvement or a decline in performance?
- What does the general attitude toward the makerspace seem to be based on reflections, feedback, and observations of students, teachers, and mentors?
- How have standardized test scores changed since the implementation of the makerspace?
- Other implications?

Step 3: Disseminate your Findings
Once you have analyzed the data, you need to get it into the hands of key stakeholders. There are many ways to do this. Below are a few suggestions for sharing the impact of the school library makerspace.
• Update a blog about the activities of your makerspace regularly. Include commentary about student learning throughout the year. Include student voices on the blog by helping them craft good posts to share their work.
• Post information on the school website.
• Create graphics such as infographics to display information in a visually pleasing format.
• Write regular reports and newsletters for various audiences, including your principal and other administration, parents, and the general community.
• Spread news through word of mouth and through casual conversations, but have something thoughtful put together to distribute should someone ask for more information.
• Display student work prominently in the library.
• Hold a community-wide Maker Faire. Allow students to plan, run, and assess the success of their Maker Faire. You can include project presentations and short workshops or stations for teaching simple making skills to the general community. Have students write a report of the event to post on the blog.

Work Cited
Part 5: Bibliography


AMLE. (2010). *This we believe: Keys to educating young adolescents*. Westerville, OH: Association for Middle Level Education.


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