To my husband: the love of my life, my best friend, and my biggest supporter
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This design case study provides an account of the design process a committee of ten librarians utilized to implement library makerspaces in a large school district of nearly 20,000 students to preserve and share the precedent knowledge gained (C. D. Howard, 2011). It describes the design process, resulting makerspace, successes and areas for improvement, and ways students experienced participation.

In keeping with the focus of design cases, this study asked, “What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district,” “What is the resulting school library makerspace implementation,” and “In what ways do students experience participation in the resulting school library makerspace?”

For research question one, I analyzed biographical data, meeting notes, and other documents. The resulting narrative includes committee member descriptions and presents processes and decisions involved in makerspace design organized around design components. It includes three sets of implementation guidelines the team developed: An Innovation Configuration Map establishing “optimal,” “acceptable,” and
“unacceptable” levels of initial implementation; Design and Facilitation Guidelines focusing on makerspace environment, activities, and facilitation; and Guidelines Based on the Educational Making Process Model (EMPM) which provide suggestions for facilitating the phases of the EMPM I developed and presented in Chapter Two.

For research questions two and three, I conducted observations of 5th grade students participating in a resulting makerspace, and interviewed the librarian, teacher, and eight students. Results for research question two showed the librarian was intentional in implementation, the makerspace aligned to many committee guidelines, and it was successful overall with areas for improvement. Results for research question three discuss adult facilitation of the space; student access, project participation and limitations, engagement in, and enjoyment of the space; alignment to EMPM, and student benefits.

The study discusses successes, areas for improvement, recommendations to others, and how results align to literature. Implications for my local context, other districts, the field of library science, and the study of makerspaces as learning environments as well as future research ideas are included. Finally, I reflect on what I learned about myself and additional progress made since the study was completed.
CHAPTER 1
INTRODUCTION

History of Makerspaces and Their Implementation in School Libraries

In his closing keynote address at the World Conference on Computers and Education in Sydney, Australia in July 1990, Seymour Papert (1991b) argued for the need for “megachange” in education, significant change that would affect the curriculum, the structure of school organization, and the view of learning or of knowledge itself. This educational and epistemological perestroika, a phrase Papert borrowed from the rapid and seemingly impossible changes that occurred in the Soviet Union and Eastern Europe during the 1980s due to Mikhail Gorbachev’s perestroika policy changes, would, Papert believed, result in a change from “curriculum-centered, teacher-driven forms of instruction” to “student-centered, developmental approaches to intellectual development” (1991b, p. 15).

Papert believed that the key to the type of megachange in education for which he argued was student participation in learning environments that were based on his theory of constructionism and that incorporated new technologies. Constructionism stems from constructivist learning theory and holds to the belief that learning happens through the active construction of knowledge by the individual through experiences. The defining difference between constructivism and constructionism is that constructivism views knowledge as the construction of mental models inside one's head, while constructionism posits that the construction of knowledge is improved when the learner constructs a “public entity” (Papert, 1991a, p. 1) or product “in the world” (Papert, 1993a, p. 142) as a representation of his evolving thinking and learning (Archwatemy,
In Papert’s (1991b) view, the activities, teaching and learning occurring in such an environment ought to be nearly unrecognizable to a teacher of 100 years ago, and a teacher from the past who might time travel to the present would be hard-pressed to take over the role of teacher in this new learning environment. Papert (1991b) described as follows for his conference audience what student learning would look like in such an environment.

In the LEGO/Logo environment workshop we see glimmers of what a different kind of learning environment would be like. Here the children are engaged in constructing things rather than (as Friere would say) “banking knowledge.” They are engaged in activity they experience as meaningful. And for this, they don’t need to be directed by a technician-policeman-teacher but rather to be advised by an empathic, helpful consultant-colleague-teacher. They are learning a great deal with a great deal of passion even though there is no technician to keep track of exactly what they are learning (p.19).

While computers are certainly more prevalent in K-12 schools today than when Papert spoke to the audience at the World Conference on Computers and Education in Sydney, Australia in July 1990, learning environments wherein students utilize the available technology to construct things in ways that are meaningful as Papert described above are still uncommon. The megachange in education he envisioned and hoped for has not, by and large, occurred. The introduction of technology into K-12 classrooms in and of itself has not led to the educational and epistemological perestroika of which Papert spoke. The time-traveling teacher from 100 years ago would, in many classrooms, still readily be able to step into the place of a modern day teacher and conduct business as usual. However, a relatively new type of learning environment that has made its way into K-12 education, makerspaces, offers schools
the opportunity to create a learning environment very much in line with what Papert (1991b) envisioned.

**Development of Community Makerspaces**

The simplest definition of a makerspace is that of a place where “makers” go to participate in “making” activities (Brahms & Werner, 2013; Britton, 2012; Range & Schmidt, 2014). Within this definition, however, are several terms that require further clarification in order to get a true sense of the concept of a makerspace.

Dale Dougherty released the first issue of MAKE magazine in February 2005, a magazine geared toward the tinkerers, hobbyists, and “do-it-yourselfers” whom Dougherty termed “makers” (2012), and the first Maker Faire, a gathering of makers and their creations, was held in 2006. Since that time, the maker movement has gained tremendous popularity (Colegrove, 2013; Gutwill, Hido, & Sindorf, 2015; Halverson & Sheridan, 2014; Martin, 2015). The maker movement is a resurgence of interest in tinkering and “doing it yourself” that has been propelled by recent developments of and easy access to technologies such as 3D printers, laser cutters, and digital editing software. (Blikstein, 2013; Dougherty, 2013; Halverson & Sheridan, 2014; Martin, 2015; Resnick & Rosenbaum, 2013). True to the term Dougherty used to describe them, it is a movement wherein people become empowered to be more than just consumers of things: they become makers (Dougherty, 2013).

When Dougherty determined to use the term “maker” to refer to the readers of his new do-it-yourself publication, MAKE magazine, it was with the purposeful intention of being inclusive of a wide variety of people and their interests (McCracken, 2015). Dougherty chose the term “maker” over other possible terms as he believed the term could be used to describe us all: that “we are all makers” (2012, p. 11). The term
“maker,” then, is intended as an umbrella term that includes any of a variety of other terms seen in the literature such as “tinkerer,” “hacker,” and “do-it-yourselfer” (Blikstein, 2013; Canino-Fluit, 2014; Martin, 2015; Resnick & Rosenbaum, 2013; Washor & Mojkowski, 2013). Though each of these terms has its own connotation, all of these types of individuals could be called makers. Defining “makers” in this more general sense helps when defining other terms associated with the maker movement.

The term “makers” conveys the sense of being more than just consumers of technology (McCracken, 2015). This same sense of empowerment is seen in Kalil’s (2013) description of makers as people who design and make things on their own time because they find it intrinsically rewarding to make, tinker, problem-solve, discover, and share what they have learned. “they put things together, they take things apart, they put things together in a new and different way. …Why? For the sheer pleasure of figuring out how things work and repurposing those things at will” (Kalil, 2013, p. 12).

Just as the term “maker” embodies a number of interests, the term “making” encompasses various activities ranging from crafting to building robots or from cooking to programming computer games (Abram, 2015; Halverson & Sheridan, 2014; Kafai, Fields, & Searle, 2014). Some writers provide precise definitions of such terms as making, tinkering, and engineering (Gutwill, et al., 2015; Resnick & Rosenbaum, 2013) to differentiate between “making” something by following a set of directions versus the more playful and experimental nature of “tinkering,” but “making” is the general term that is used often in the literature. Martin (2015) developed a working definition of making that reflects the melding together of the many activities that fall under the term. He defines making as
a class of activities focused on designing, building, modifying, and/or repurposing material objects for playful or useful ends, oriented toward making a “product” of some sort that can be used, interacted with, or demonstrated. Making often involves traditional craft and hobby techniques (e.g., sewing, woodworking, etc.), and it often involves the use of digital technologies, either for manufacture (e.g., laser cutters, CNC machines, 3D printers) or within the design (e.g., microcontrollers, LEDs).

Martin’s definition of making is quite similar to the definition of Papert’s theory of constructionism provided earlier and his description of a learning environment based upon it.

Another term closely associated with the maker movement is that of the “maker mindset.” Dougherty (2013) describes the maker mindset as a growth mindset based on the writings of Carol Dweck (2006) in which makers “believe they can learn to do anything” (Dougherty, 2013, p. 10). There are several elements of the maker mindset that have been identified in the literature as holding significance for education: its playful nature; its asset- and growth-orientation; its failure-positive nature; and its emphasis on collaboration between makers (Martin, 2015).

A makerspace, then, is a place where “makers” go to participate in “making” activities (Brahms & Werner, 2013; Britton, 2012; Range & Schmidt, 2014). As with several other terms associated with the maker movement, “makerspace” has become a more general term that describes several more specific types of spaces such as FabLabs, hackerspaces, and TechShops (Abram, 2015; Johnson, Adams, Estrada, & Freeman, 2015; Wong, 2013). Though each of these has its own unique characteristics (Cavalcanti, 2013), there are several underlying tenets that makerspaces of all kinds share. Makerspaces encourage play, personal interest, and exploration. They are communities of makers who share resources and support and learn from each other. They empower makers to be more than just consumers and users of technology: in fact,
many makers become entrepreneurs through their making activities. They invite makers to develop new skills or hone existing ones. They are failure-positive, encouraging makers to take risks, try something new, and challenge themselves (Barrett, 2014; Britton, 2012; Moorefield-Lang, 2015; Sheridan, et al., 2014). Though makerspaces were developed primarily outside of education as places for adult makers to come together, for a fee, to share resources and work collaboratively with like-minded individuals (Brahms & Werner, 2013; Martin, 2015; Resnick & Rosenbaum, 2013; Washor & Mojkowski, 2013), they soon found their way into K-12 education.

**Maker Movement Gains National Attention**

In June, 2009, President Obama (2009) announced the Educate to Innovate campaign to encourage innovative, hands-on teaching of science and math to American students. Describing some activities associated with the campaign, Obama stated that students would “have the chance to build and create -- and maybe destroy just a little bit -- (laughter) -- to see the promise of being the makers of things, and not just the consumers of things” (2009). Echoes of the previous definitions of makers and making can easily be heard in the President's words.

Dale Dougherty of MAKE magazine heard and heeded the President's call and started the Maker Education Initiative (Maker Ed) in 2012 with the vision of “every child a maker” and the goal of bringing the maker movement to education (“About Maker Ed: Who We Are,” 2015). The non-profit Maker Ed organization holds to the following values: making maker experiences accessible to all children; transforming education through maker experiences; creating a collaborative community of maker teachers; ensuring a variety of access points to making through a diversity of approaches; and developing deep and lasting engagement of students with learning through making.
Dougherty was named a White House Champion of Change in 2011 (A. Howard, 2011) for his work with MAKE magazine and Maker Faires, and as recently as June 18, 2014, the White House hosted the first ever White House Maker Faire, with President Obama (2014) declaring the day a National Day of Making.

### School Libraries as Makerspaces

School libraries are one place in K-12 education that makerspaces have become popular. Many trade journals in the field discuss school library makerspaces and provide advice about starting one (Canino-Fluit, 2014; Loertscher, Preddy, & Derry, 2013; Range & Schmidt, 2014). At first glance, makerspaces may seem an odd addition to school libraries, but there is a good match between elements of makerspaces and those of a school library.

**Access to all.** Just as the original makerspaces developed outside of education were intended to be a community resource accessible to all, the school library is one of few spaces in the school environment accessible to all students and staff, often throughout the entire school day. Placing a makerspace in the school library, then, means that it would be available for use by all students, regardless of factors such as grade-level, course schedule, or socio-economic status. Though many high schools offer courses that may incorporate some of the principles found in a makerspace such as robotics or computer programming, many students are unable or unwilling to enroll in them. Housing a makerspace in the school library allows these students to participate in making activities outside of their formal course schedule (Foote, 2013; Halverson & Sheridan, 2014; Houston, 2013; Martinez & Stager, 2013; Wong, 2013).
Role as facilitator. In a makerspace, the role of the “teacher” is to serve as facilitator to student learning, providing resources for students to “self-instruct,” assisting students in the pursuit of their own individual or group interests, and guiding and encouraging them through difficulties and frustrations they encounter along the way (Gutwill, et al., 2015; Houston, 2013; Martinez & Stager, 2013; Resnick & Rosenbaum, 2013). School librarians have long served such a role wherein they provide resources to meet the needs of the entire school, encourage the growth of students' individual interests, and work with students and teachers to support and facilitate their research and learning needs (Foote, 2013; Houston, 2013; Smay & Walker, 2015). With some training specific to the process of making, facilitating a makerspace in the school library should be a relatively easy transition for a school librarian.

AASL standards. For some time, school libraries have been working toward becoming places where students come to collaborate and create rather than simply to consume knowledge, which is quite in keeping with the idea of a makerspace. In 2007, the American Association of School Librarians published the *Standards for 21st-century Learners* (2007), a set of standards for school libraries with a strong focus on inquiry learning, creative thinking, collaboration, sharing new knowledge with others, and using technology in meaningful ways. Makerspaces provide a context in which students would be able to develop and master many of these standards (Canino-Fluit, 2014; Foote, 2013), another reason makerspaces may be a great fit for school libraries.

Potential Benefits of School Library Makerspaces

STEM and other content knowledge. There are several potential benefits to students of participation in makerspaces that can be found in the literature. There is broad agreement in the literature that makerspaces could have a potential positive
impact on student learning in the areas of science, technology, engineering, and math (STEM) as well as the arts (STEAM) (Britton, 2012; Houston, 2013; Peppler & Bender, 2013; Quinn & Bell, 2013; Vossoughi & Bevan, 2014; Worsley & Blikstein, 2014) and that they support the Framework for K-12 Science Education (Martin, 2015; Petrich, Wilkinson, & Bevan, 2013; Quinn & Bell, 2013). Because making encompasses such a wide variety of interests and activities, makerspaces are interdisciplinary by nature (Blikstein, 2013; Sheridan, et al., 2014), and they can support learning across other content areas such as history and music (Blikstein, 2013).

**Student interest in STEM areas and STEM careers.** There is also the potential that makerspaces help build student interest in STEM content areas and in STEM careers. While activities or projects that incorporate STEM are a natural fit for makerspaces, they are primarily places of invention and creation, not primarily STEM labs (Blikstein, 2013). Students often encounter and learn STEM concepts through the making process while pursuing their own personal interests (Blikstein, 2013), but in a context that is immediately applicable to the students' needs and is, therefore, more accessible to the student (Houston, 2013). For these reasons, it is believed that makerspaces provide an entry point for a wider variety of students to develop an interest in STEM and STEM-related careers, including girls and minorities that are underrepresented in these areas (Blikstein, 2013; Britton, 2012; Houston, 2013; Kalil, 2013).

**21st century skills.** Students are also purported to develop “soft-skills” or 21st century skills through participation in makerspaces, another potential benefit discussed in the literature. However, there is not a well-defined list in the literature of these skills.
Rather, there is a broad listing of such skills across much of the literature. Table 1-1 shows a sampling of these skills discussed across the literature.

Table 1-1. “Soft-skills” or 21st century skills encouraged through making activities.

<table>
<thead>
<tr>
<th>Adaptability</th>
<th>Focus</th>
<th>Innovation</th>
<th>Problem-solving</th>
<th>Computational thinking</th>
<th>Collaboration</th>
<th>Growth mindset</th>
<th>Intentionality</th>
<th>Self-expression</th>
<th>Critical thinking</th>
<th>Creativity</th>
<th>Ideation</th>
<th>Invention</th>
<th>Learning from failure</th>
<th>Social responsibility</th>
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<th>Persuasion</th>
<th>Persistence</th>
<th>Teamwork</th>
<th>Visual literacy</th>
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<tr>
<td>Focus</td>
<td>Innovation</td>
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<td>Teamwork</td>
<td>Visual literacy</td>
</tr>
</tbody>
</table>


**Student engagement.** Sustained student engagement is another purported benefit of makerspaces in schools consistently seen in the literature (Peppler & Bender, 2013). There is mention of students becoming “passionate about who they are as learners” (Thompson, 2014, p. 35) when given the opportunity to participate in making activities. In their study conducted of making activities in the Tinkering Studio, Gutwill, et al. (2015), identified Engagement as the first of the four dimensions of learning observed in those taking part in making activities. One indicator of engagement they observed was “displaying motivation” in making activities (Gutwill, et al., 2015), a concept reiterated elsewhere in the literature which claims that making activities are motivating and engaging (Martin, 2015) and that makers are “intrinsically motivated” (Makerspace Playbook, 2013).

**Challenges of Bringing Makerspaces to Education**

Though the literature points to several potential benefits of makerspaces in schools, there are certainly challenges in doing so. Some challenges relate to the makerspace itself, such as funding for the space and liability issues if certain potentially dangerous tools are included in the space (Houston, 2013; Plemmons, 2014). These
types of issues are to be expected when starting any new project in a school setting, but those wanting to start a makerspace are advised to get started regardless of these types of obstacles (Kurti, Kurti, & Fleming, 2014a). Other challenges are more global in nature and deal with issues of school curriculum as well as issues of learning and assessment. These challenges may be more difficult to overcome, but it is important for anyone hoping to implement a school makerspace to be aware of them.

**Curriculum & organization issues.** Washor and Mojkowski (2013) identify lack of room in the elementary and secondary curriculum for creativity and exploration as one of three major barriers standing in the way of bringing making activities into schools. They compare today's typical school curriculum to the modern day Mr. Potato Head, which, when it was first invented was a kit of “body parts” that could be attached in a multitude of ways to a variety of real vegetables. Today's Mr. Potato Head consists of a plastic toy potato and body parts that can only be attached “correctly” due to matching shapes on the body part and slots on the potato. Like the modern Mr. Potato Head, Washor and Mojkowski contend (2013), the school curriculum has become a tightly scripted exercise with the goal of ensuring students are proficient in reading and mathematics so they do well on high-stakes tests. According to Washor and Mojkowski (2013) this is not sufficiently preparing students to do the creative and inventive thinking required in the real world. In order for the maker movement to be implemented in schools, the curriculum needs to allow students room to explore, discover, and tinker with concepts as real scientists and mathematicians do (Washor & Mojkowski, 2013). In addition, schools need to adopt teaching methods that are student-centered, allowing students to work together to investigate and solve meaningful problems and to exhibit
their learning through a variety of authentic assessment methods rather than through paper-and-pencil tests (Quinn & Bell, 2013; Washor & Mojkowski, 2013).

**Learning & assessment issues.** A major difference between makerspaces outside of schools and makerspaces in schools is that learning *may* occur in a makerspace out of school, but it is a primary goal of makerspaces in schools (Kurti, Kurti, & Fleming, 2014b). As such, the issue of how to assess student learning in a makerspace environment is a challenge that needs to be addressed.

Oftentimes when students are asked to create a project, as is the case in a makerspace, a rubric is used to assess the quality of the project. They are intended as a guide for the student so he knows the expectations for the project and as an objective way for the teacher to grade the student's work. The use of a rubric in a makerspace environment, however, runs counter to many of the principles of making, such as stymying a student’s creativity, hampering his opportunity for learning through discovery, and “penalizing” the student for mistakes rather than embracing failure as a learning opportunity (Martinez & Stager, 2013). In his study of assessment in ill-structured, complex problem-solving contexts, Kim (2012) found that the use of a series of mental models or concept maps constructed by the student was a viable way to assess the learning progress of the student. This may be a way to assess student content learning in a makerspace environment without interfering with the principles of making.

Student portfolios are another tool often used to assess student progress. An experimental school in Thailand that operates entirely according to a constructionist approach to learning implemented the use of student portfolios along with a rubric.
(Archwateym, et al., 2005). They utilized the portfolios to assess both content knowledge objectives of the unit (math skills and Thai language skills) and “soft” skills they hoped students would acquire (personal mastery, mental model, shared vision, team learning, and systems thinking). The study showed gains in both academic and soft skills, though gains were higher in the academic skills. If they are founded on constructionist principles, student portfolios may be an option to assess learning in makerspaces.

In their efforts to define learning taking place in the Tinkering Studio of San Francisco’s Exploratorium, Gutwill, et al. (2015) examined audio- and video-recordings of fifty visitors participating in making activities and developed the Learning Dimension Framework. The framework identifies four “dimensions” of learning: Engagement; Initiative and Intentionality; Social Scaffolding; and Development of Understanding. It also provides indicators and descriptions of learners’ interactions for each dimension to help observers recognize learning in a making activity. Though this framework was developed in a public museum makerspace, there is potential to utilize it as a basis for assessment in a school makerspace environment.

Within the field of Library Science, David Loertscher has long championed student-centered school libraries as places of collaboration and creation, and he has embraced the incorporation of makerspaces into school libraries. As a way to help teachers and others recognize behaviors in makerspaces that may be considered negative in a school environment but that are actually desirable in a makerspace (Loertscher, 2014), he and colleagues Bill Derry and Leslie Preddy developed the uTEC Maker Model (Loertscher, et al., 2013). The uTEC Maker Model identifies four
developmental stages or levels of expertise of creativity that makers progress through as they become more proficient makers: Using, Tinkering, Experimenting, and Creating. The model provides an elaboration and examples for each stage. Additionally, the model identifies dispositions that develop in the budding maker in the categories of “Roles” (e.g., presenter, communicator, leader), “Actions” (e.g., imagine, design, collaborate), and “Strategies” (e.g., organization, teamwork, persistence) (Loertscher, et al., 2013). Though not an assessment tool, per se, the uTEC Maker Model may be useful as a basis for the types of behaviors and dispositions a school might anticipate resulting from incorporating a makerspace.

**Challenges of Bringing Makerspaces to School Libraries**

**Space issues.** There are also several challenges specific to implementing makerspaces into school libraries. Carving out a space in the school library for a permanent makerspace is not possible in all school libraries. As a result, some school libraries utilize mobile makerspace carts to offer making experiences to students which may limit student choice in what they are able to make.

**Budget issues.** Though some makerspace supplies such as cardboard or scrap material may be obtained through donations, other supplies and resources such as LED lightbulbs and 3D printers have an ongoing cost associated with them. Finding a consistent source of funding to support the school library makerspace is another challenge to implementation.

**Scheduling issues.** Scheduling issues can also be a challenge faced by librarians who are attempting to bring meaningful making experiences to their students. Though the school library is open and accessible to all students, the time students may have to spend in the library, and, therefore, in the makerspace, is limited. In my district,
elementary students attend library lessons bi-weekly as part of the encore rotation of classes along with music, art, and PE. This time could be used to give students consistent time in the makerspace. At the middle and high school levels, however, students may have a consistent time during which they visit the library with their class to check out books, but there is not a consistent time they visit which could be used for time in the makerspace.

Safety issues. There are also safety issues that must be considered as librarians implement makerspaces in their libraries. Not all librarians are aware, for instance, that certain electronics hold electricity in a capacitor within the component and are dangerous to include in a “take apart” station in which students deconstruct items. All of these challenges need to be addressed in order for school library makerspace implementation to be successful.

Researcher Background and Interest in Makerspaces

Multiple factors in my professional context have influenced who I am as a professional and why I developed an interest in designing and implementing school library makerspaces in my school district.

Education. My educational pursuits have been primarily in the areas of Library Science and Educational Technology. These two fields overlap quite a bit, especially in their focus on the process of student learning rather than on students' learning a specific set content curriculum.

Professional influences. Early in my career, I had the opportunity to see two speakers at professional conferences who greatly impacted my thinking about student learning. One was Ian Jukes, who coined the term "infowhelm" (Jukes, Dosaj, & Macdonald, 2000), referring to the overwhelming amount of information available to us
via technology. Jukes emphasizes the importance of students mastering information literacy skills to better navigate the extensive amount of information they will encounter. The person who influenced me most, however, was Jamie McKenzie. One of his catch phrases is that students should make answers, not find them (McKenzie, 1998), meaning that research projects should be designed so that students have to make a choice, make a decision, or develop a solution rather than just finding and reporting back information. Another of his catch phrases is that "toolishness is foolishness" (McKenzie, 2001, cartoon at beginning), meaning, in part, that if students do research wherein they find information and report it back, but they present it as a PowerPoint instead of a poster, the technology did nothing to transform that student's learning and it was a foolish use of technology. McKenzie's words resonated with me, and, henceforth, I have designed research units with these ideas in mind.

Professional experience. I started my career as a school librarian in 1997, and I have focused primarily on the teaching of information and technology literacy skills in the context of "make answers" research projects. The three sets of standards on which I base the skills I integrate into student research projects are the AASL Standards for the 21st Century Learner (Standards for the 21st-century learner, 2007), ISTE's Standards for Students ("ISTE Standards", 2016), and "21st century skills," such as creative or inventive thinking, collaboration, and communication (Framework for 21st century learning, 2009). In 2012, I became the Library Coordinator for my district. Though this position requires me to be more of a generalist, I still focus my efforts on the teaching of information, technology, and 21st century skills in context.
**Professional challenges.** There are many challenges librarians in my district face which we are addressing through the development and implementation of a 5-year strategic plan. The plan consists of five goals which address challenges in the areas of instruction, creating a culture of literacy, resources, facilities, and professional development. The two of most import to this discussion are the instruction goal and the facilities goal, as these two feed into our interest in school library makerspaces. Our goal for instruction is to find a way to ensure all students master the information, technology, and 21st century skills they need and to find a way to assess and track student mastery of these skills. Our facilities goal is to transform our libraries from places where students consume information to places where students create and innovate.

**Recent developments.** A few recent developments have also impacted my interest in school library makerspaces. First, there is the STEM movement in education, which my district has partially implemented through Project Lead the Way (PLTW) course offerings at the middle school and high school level. My district is looking for ways to encourage more girls into these course offerings and, hopefully, into future STEM-related careers. Second, there is the fact that school library makerspaces have become quite popular recently, and the topic has been prevalent for the past several years in school librarian trade journals, at school librarian conferences, and in webinars geared toward school librarians. Many makerspaces include STEM activities such as computer programming, 3D modeling, engineering, electronic circuitry, etc. Currently, several media specialists in my district want to start or have recently started makerspaces and have the support of their principals to do so.
Interest in makerspaces. All of this has led me to my interest in designing and implementing school library makerspaces in my district, as it seems they are in sync with Jamie McKenzie’s idea that students should “make answers” (McKenzie, 1998). Too, it seems they would be a natural place to meaningfully incorporate many information, technology, and 21st century skills. I also feel they could help us reach our goal of transforming our libraries into spaces where students create and innovate. Finally, makerspaces might be a way to support my district's efforts to encourage more girls to discover an interest in STEM courses and STEM-related careers.

Problem of Practice: School Library Makerspace Project Overview

Due to the various purported benefits of makerspaces, and because they seem a fit with school libraries, several school librarians in my district over the past several years began to incorporate makerspaces into their libraries. However, these makerspaces were being incorporated haphazardly based on what each individual librarian had read about makerspaces or had heard at conferences, on social media, through other librarians, or through other informal means. As library coordinator for the district, I recognized the need to ensure that we were purposeful in our design and implementation of these spaces so that they remained in keeping with the underlying principles of constructionist learning theory and helped meet the goals of the district library program. To that end, I formed and led a committee of librarians in my district who were interested in makerspaces to serve as a design team to develop makerspace implementation guidelines for the district library program. In order to retain an understanding of knowledge gained and design decisions made during the process as a resource to be used for future work, there was a further need to formally document the
work of the makerspace design team. Utilizing a design case approach for this study was well-suited to meeting this need for documenting the process.

**Purpose Statement**

The purpose of this design case dissertation is to provide a detailed and thorough account of the design process the makerspace committee of librarians went through to bring makerspaces to the library program in my school district in order to preserve and share the precedent knowledge gained through the process (C. D. Howard, 2011). While this dissertation represents only a snapshot of an ongoing design process, this account will include detailed information both about the design process itself as well as the resulting implementation of makerspaces based on the design and will speak to both the successes of the design as well as any areas of needed improvement.

**Research Questions**

According to C. D. Howard (2011), design cases have an overall singular focus in asking the question, “How did the design come to be as it is?” (p. 53). He further states that design cases seek to answer the question “What design resulted from the process?” (p. 49), and he stresses the importance of including a description of the user experience of the design to help readers better understand the design. In keeping with these foci, this design case dissertation seeks to answer similar questions.

- Research Question 1: What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district?

- Research Question 2: What is the resulting school library makerspace implementation?

- Research Question 3: In what ways do students experience participation in the resulting school library makerspace?
Significance of Study

This design case is significant to those attempting to implement makerspaces in their school library facilities because it provides a detailed description of the process used, design decisions made, and the resulting implementation of makerspaces in my school district. This design case will discuss the work of the makerspace design committee leading up to the initial implementation of school library makerspaces as well as additional design decisions made by the committee after the initial implementation and the changes that resulted.

The guidelines for the design and implementation of school library makerspaces could assist others in their own makerspace design and implementation. Such guidelines could be used, then, in order to better support students as they work through the process of making in an educational setting so as to provide the best opportunity for students to realize the many potential benefits of participation in these learning environments.

This is relevant to me in my professional practice and the librarians in my district who are beginning to implement school library makerspaces. It also has relevance to the field of library science, as makerspaces have become quite popular in the field. Many are implementing makerspaces in the hopes that they will have positive benefits to students, and the precedent knowledge documented through this design case could be helpful. The thorough description of the design process used to implement makerspaces in the school libraries in my district and the thorough description of the resulting makerspaces would also be helpful to the field of study of makerspaces as learning environments.
Definition of Terms

Educational makerspace. A makerspace located in a K-12 school setting that is facilitated by educators who guide students as they learn what they need to learn to pursue their personal making interests. In addition to providing opportunities for students to pursue their own interests and creativity, educational makerspaces often have the additional goal of documenting student learning of conceptual knowledge and skills through participation in the makerspace.

Educational Making Process Model. A process model developed by the researcher based on a synthesis of the literature surrounding makerspaces and their underlying theories. The Educational Making Process Model graphically represents and verbally describes non-linear and recursive processes involved in making in an educational makerspace. It was developed as a tool to help others’ understanding of educational making as a process and to serve as a tool for use in the design and implementation of educational makerspaces.

Maker. Someone who has the desire, through personal need or inspiration, to make something and who works towards their making goal by learning what they need to learn along the way to make what they want to make. Makers believe they can learn new things in order to meet their making goals, and they willingly work through multiple unsuccessful attempts in order to find ultimate making success.

Makerspace. A physical location available to the public, sometimes for a minimum membership fee, that houses tools, technologies, and various resources that individuals can use for their personal or collaborative making projects. In addition to these physical resources, the knowledge and expertise of the individuals who use the makerspace serves as another valuable resource to others using the space.
**Making.** The process of determining the personal desire to make something either for playful or practical reasons, learning what one needs to know to make it, actually making the item, and, oftentimes, sharing the item itself and the knowledge developed through the making process with others. Making often involves an element of tinkering and exploration. Making is more than simply the assembling of parts to put-together a pre-designed item.

**School library makerspace.** An educational makerspace that is housed in a school library. Ideally, there would be dedicated space in the library for the makerspace, though a school library makerspace is sometimes housed on a series of mobile carts that are stored in a closet or workroom and brought out for making activities.

**Student maker.** A K-12 student who, through participation in an educational makerspace, experiences the opportunity to pursue his own personal making projects. Through the educational making process, the student maker is developing conceptual knowledge and skills particular to his making pursuits as well as developing the learning practices and mindset of an expert maker.

**Chapter Summary and Organization of Remaining Chapters**

This dissertation is divided into six chapters. Chapter One provides an introduction to and history of makerspaces, how and why they have made their way into school libraries, and the potential benefits and challenges of implementing makerspaces into school libraries as well as their potential benefits to students. It also discusses my background and my interest in school library makerspaces, and describes the makerspace design project. Chapter Two provides a review of the literature pertaining to makerspaces, including the literature specific to makerspaces as learning
environments. It also discusses the major theories underlying educational makerspaces and how these led to my development of the Educational Making Process Model. Chapter Three of this dissertation will establish the design case framework that will be used for this study. It will also reiterate the study’s purpose and research questions, present the study’s conceptual framework, discuss the methods used for data collection and analysis, provide information as to the trustworthiness of the study, and discuss ethical considerations and limitations. Chapter Four will speak to research question one and will present the professional context of the study and the processes used and decisions made during the school library makerspace design process in my district. Chapter Five will speak to research questions two and three, presenting and discussing the results of school library makerspace observations and interviews of students, a librarian, and a teacher I conducted as part of the study. Finally, Chapter Six will discuss both successes of school library makerspace implementation in my district as well as areas for improvement.
CHAPTER 2
LITERATURE REVIEW

Makerspaces as Potential Megachange in Education

When Seymour Papert (1991b) spoke to the audience attending his closing keynote address at the World Conference on Computers and Education in Sydney, Australia in July 1990 about the need for “megachange” in education, significant change that would affect the curriculum, the structure of school organization, and the view of learning or of knowledge itself, he envisioned this change would occur through student participation in constructionist learning environments that integrated technology in meaningful ways. He further described such learning environments as places where children are engaged in constructing things rather than (as Friere would say) ‘banking knowledge.’ They are engaged in activity they experience as meaningful. And for this, they don't need to be directed by a technician-policeman-teacher but rather to be advised by an empathic, helpful consultant-colleague-teacher. They are learning a great deal with a great deal of passion even though there is no technician to keep track of exactly what they are learning (Papert, 1991b, p.19).

While there are certainly more computers and other technological devices in schools than when Papert delivered this speech, and while it has become more acceptable in the realm of K-12 education to consider a more student-centered approach to learning (Blikstein & Worsley, 2016) thanks to the work of Papert and other progressive educational researchers, the educational and epistemological perestroika for which Papert hoped has not come to fruition. Rather, there is a strong emphasis in education today on students learning and being tested on a specific set of standards (Dougherty, 2016; Peppler, Halverson, & Kafai, 2016; “Practices,” 2013, p. 22) as evidenced in the wide-spread adoption by states of the Common Core State Standards and the standardized tests that accompany them.
The state in which this study was conducted had originally adopted the Common Core State Standards, but has since moved away from them. The new state learning standards, however, are largely based on the Common Core Standards, and still prescribe what students are to learn in various subject areas in each grade level. Though the state no longer uses the specific standardized tests that accompanied the Common Core State Standards, students in the state are still held accountable to standardized state testing developed by the state itself. This focus in schools on prescribed standards and standardized testing for which districts are held accountable through accreditation reviews by the state makes the implementation of constructionist learning environments such as the ones of which Papert discussed difficult as, according to Paulo Blikstein, “constructionism has, at its heart, a desire not to revise, but to invert the world of curriculum-driven instruction” (Blikstein, 2015, p. xv).

Makerspaces, however, and the student learning that takes place within them through the process of making, are noted by some as having the potential to disrupt current school structures through their implementation into K-12 education. This is in part because the underlying philosophies and practices of making are not necessarily congruent with current school practices nor with the current state and federal accountability requirements to which school districts are held and because of the current widespread popularity and acceptance of educational making (Blikstein & Worsley 2016; Halverson & Sheridan, 2014; Litts, 2015; Martin & Dixon, 2016; Peppler, et al., 2016; “Practices,” 2013, p. 22; Sheridan, et al., 2014).

Not all who want to bring making to education believe it need be disruptive to current school structures. In their article wherein they develop a framework to help K-12
teachers bring certain components of the maker movement to their classrooms, Cohen, Jones, Smith, and Calandra (2016) encourage the “makification” of formal education. The authors acknowledge “the rigid structure of the current formal education curricula and assessment” (p. 131), and further state that “pure constructionism needs freedom and minimal restrictions (standardized regulations), which is difficult to come by in today’s climate of crowded curricula and high-stakes testing” (p. 131). However, rather than hoping for “megachange” in school structures to allow for educational makerspaces based on “pure constructionism,” the authors argue for the integration of making activities into current school structures. The authors (Cohen, et al., 2016) identify four principles of makification based on a review of the literature that they believe are essential to making in educational contexts: creation, iteration, sharing, and autonomy. They stress that the “makification” of classroom activities must be based on these core elements in order for the underlying principles of the maker movement to be upheld.

While I appreciate the identification of several core elements that are considered essential to making in an educational context, adapting making to fit the current school structures of a rigid curriculum and high stakes testing is unlikely to lead to a change from “curriculum-centered, teacher-driven forms of instruction” to “student-centered, developmental approaches to intellectual development” (Papert, 1991b, p. 15) that makerspaces may have the potential to bring about and for which many who study makerspaces as learning environments hope (Blikstein & Worsley, 2016; Dougherty, 2013; Martin & Dixon, 2016; Resnick & Rosenbaum, 2013; Washor & Mojkowski, 2013). Rather, purposefully designing educational makerspaces based on an understanding of
their underlying theories, the principles of makerspaces and making in general, and related research can better ensure students gain from the many benefits of educational makerspaces (Brahms, 2014; Litts, 2015) and encourage megachange in education.

The purpose of this design case dissertation is to provide a detailed and thorough account of the design process the makerspace design committee of librarians went through to bring makerspaces to the library program in my school district so as to preserve and share the precedent knowledge gained through the process (C. D. Howard, 2011). According to C. D. Howard (2011), the review of relevant literature and theory in a design case serves the purpose of helping readers understand the background influences that impacted the designers and, therefore, the specific perspective of the design case. In keeping with the design case approach used for this study, the following literature review aims to outline the theories, principles, and research instrumental to my understanding of educational makerspaces and that were influential in the design decisions made for the implementation of school library makerspaces in my school district.

Constructionism as the Theoretical Foundation of Educational Makerspaces

Though the maker movement in education has gained much popularity recently and appears to be a new phenomenon, the development of the learning theory underlying the maker movement, research of learning environments based upon this learning theory, and the development of technologies based on this learning theory have been ongoing by leading educational researchers in this area for decades.

Seymour Papert of Massachusetts Institute of Technology (MIT) began thinking about ideas of learning that led to his theory of constructionism, the learning theory upon which the maker movement was built (Archwatemy, et al., 2005; Kurti, et al.,
2014b) as early as the late 1960s (Falbel, 1993). Papert worked closely with Jean Piaget for several years in the late 1950s and early 1960s, and he was greatly influenced by Piaget’s beliefs about student learning. In particular, Papert’s theory of constructionism stems from Piaget’s constructivism and holds to the belief that learning happens through the active construction of knowledge by the individual through experiences. The defining difference between constructivism and constructionism is that constructivism views knowledge as the construction of mental models inside one’s head, while constructionism posits that the construction of knowledge happens better when the learner constructs a “public entity” (Papert, 1991a, p. 1) or product “in the world” (Papert, 1993a, p. 142) as a representation of his evolving thinking and learning (Archwateyny, et al., 2005; Blikstein, 2013; Papert, 1991a; Papert, 1993a; Sheridan, et al., 2014). Papert refers to these artifacts as “objects to think with” (Papert, 1993b), which both represent the individual’s learning and recursively influence it (Ackermann, 2004; Falbel, 1993; Litts, 2015).

Papert (1993a) explained that the product created through constructionism can be “shown, discussed, examined, probed, and admired,” (p. 142) alluding to a social aspect to constructionism. This social aspect of constructionism is further exemplified in Papert’s seminal book, Mindstorms (1993b), wherein Papert provides a hypothetical conversation between two children as they work together and learn from each other while attempting to use LOGO to program their computer to draw flowers and flying birds on the screen. He also draws similarities between a LOGO learning environment and a Samba dance school on the basis of both being communities of learners wherein the members learn with and from each other rather than simply receiving instruction.
from the teacher (Kafai & Resnick, 1996). Such references to a social and collaborative nature of constructionism have led some to argue that students also learn social skills in a constructionist learning environment (Archwatemy, et al., 2005).

Papert further stressed the importance of developing learning environments that support students’ pursuits of personally meaningful projects that are facilitated by the availability of technology and supportive adults (Papert, 1991b; Papert, 1993a; Papert, 1993b). According to Blikstein (2013), Papert argued for the use of technology in schools as a way to empower students to construct their own knowledge through the creation of physical or digital artifacts. It is, then, easy to see the similarities between constructionist learning environments and makerspaces and to understand why Papert has come to be known as “the father of the maker movement” (Martinez & Stager, 2013, p. 17).

Research of Constructionist Learning Environments

Research in the area of constructionist learning environments is plentiful. This section will discuss research that illustrates that learning does indeed happen in these student-centered, technology-rich environments, that students learn conceptual or content knowledge as well as various other skills, such as technological skills associated with the overarching project, and that collaboration between and among learners seems to be a natural and frequent occurrence in these learning environments.

In an article based on her dissertation, Idit Harel (Harel & Papert, 1991) describes a constructionist learning environment wherein students were given the umbrella task of designing a piece of instructional software that explained something about fractions to an intended audience. The students kept a design notebook in which they wrote at the beginning and end of each session, and there were short, focused
lessons during some of the sessions led by the researcher on various aspects of instructional design and the use of Logo software. The 15-week Instructional Software Design Project showed that students involved “achieved greater mastery of both Logo and fractions as well as improved metacognitive skills than did either control class” (Harel & Papert, 1991, p. 79). Harel attributes these results to multiple factors. The physical space itself afforded movement around the room and around the computers. The situatedness of the learning was also a contributing factor, as students were learning the concept of fractions within the context of their development of instructional design software about fractions. Finally, the affordances of the Logo software allowed students to see representations of fractions, become personally engaged with knowledge of fractions, and to share that knowledge with other students (Harel & Papert, 1991).

In a related article focusing on the social aspects of the Instructional Software Design Project discussed above, Kafai & Harel (1991) describe the interaction and collaboration between learners that takes place in a constructionist learning environment in order to better define this aspect of the theory of constructionism. They identified the following several collaboration styles within this project. Optional collaboration is defined by Kafai & Harel as students having the choice to work on their own software design project or to work with others on a shared project. Flexible partnerships is defined by the researchers as students moving in and out of collaborative partnerships during the project, deciding with whom, when, and for what purposes they collaborate with others. Collaboration through the air is defined as the concept of a student coming to a new idea he believes to be his own but that was
influenced by the talk in and across the learning environment, the work of other students that is visible on the computer screens, and various other ideas that are floating in the air in this type of learning environment. These various styles of collaboration were found to be an important aspect to student idea generation in the project, especially as students were in the early, or "incubation phase" (p. 87) of the project.

Resnick and Ocko (1991) discovered in their research of LEGO/Logo learning environments that students developed a deeper understanding of various concepts such as the mathematical concept of even and odd numbers and the scientific concept of friction. In addition, students learned about the process of design through the act of designing. The researchers stress the importance of organizing the LEGO/Logo activities around student freedom to create something personally meaningful rather than students being provided "building instructions" or following a "recipe-based" (p. 144) approach to building in order to reap the benefits of such deeper learning. Resnick and Ocko (1991) also list three guiding principles of the design of such learning environments for children summarized as follows: 1) Put children in control – students determine their own projects, designs, and experiments; 2) Offer multiple paths to learning – students are allowed to start their design project from the direction or perspective of their choosing, be it mechanics, programming, or aesthetics; 3) Encourage a sense of community – students are encouraged to share their designs and ideas and to provide feedback to each other.

Another study was conducted at an experimental school in Thailand that operates entirely according to a constructionist approach to learning (Archwatemey, et al., 2005). Student portfolios were implemented as a way to assess both content
knowledge objectives of a unit of learning (math skills and Thai language skills) and “soft” skills that researchers hoped students would acquire (personal mastery, mental model, shared vision, team learning, and systems thinking). The study showed gains in both academic and soft skills, though gains were higher in the academic skills.

Kafai, Peppler, and Chapman (2009) discuss Computer Clubhouses wherein youth engage with technology in ways that allow them to design and create a variety of projects. Reported benefits of youth participation in these afterschool constructionist learning environments include gains in content knowledge, technological skills, and soft skills such as collaboration and problem-solving. These Computer Clubhouses are specifically designed based on four guiding principles: 1) Support learning through design experiences; 2) Help members build on their own interests; 3) Cultivate an emergent community of learners; and 4) Create an environment of respect and trust (Rusk, Resnick, & Cooke, 2009).

**Leading Constructionist Researchers and Technologies Developed Related to Makerspaces**

As early as 1968, Papert and some colleagues at MIT developed the Logo programming language (Martinez & Stager, 2013), a computer programming language designed for children to make things on computers. In 1985, Papert and others at MIT created the MIT Media Lab whose “playful spirit of learning by doing made it the birthplace of many of the ideas and materials embraced by the modern maker movement” (Martinez & Stager, 2013, p. 23).

Mitchel Resnick, a researcher at the Lifelong Kindergarten research group at the MIT Media Lab, was instrumental in developing the Scratch programming language for children and, in collaboration with the LEGO group, the Lego Mindstorm and WeDo

According to Resnick, Scratch and other technologies developed based on constructionist learning philosophy are intentionally designed so that users can tinker with them (Resnick & Rosenbaum, 2013), allowing users to play and experiment and try new things with the technology rather than the technology prescribing or limiting the users’ actions. Resnick (1996) also coined the phrase “constructional design,” which he describes as the intentional design of constructionist learning environments wherein students have “emergent learning experiences” (p.173). Though these environments may be designed around a particular concept, in such experiences, there is not a specific or imposed set of learning expectations for all students, and students do not all learn the same things at the same time. Rather, each student learns what, when, and how he needs to within the designed learning environment.

Yasmin Kafai is another researcher who, along with Mitchel Resnick, was instrumental in developing the Scratch programming language. Kafai was, and still is, instrumental in conducting research that looks at gender issues in constructionist learning environments. Her recent research on e-textiles as a “disruptive design” for a making activity (Kafai, et al., 2014) shows that they may serve to allow an entry point into computer programming for students, especially young women, who may otherwise be hesitant to participate due to gender notions towards computer programming.

Another concept that came out of MIT is the idea of digital fabrication labs (FabLab), developed by Neil Gershenfeld (Martinez & Stager, 2013). Gershenfeld
envisioned a “technological revolution” wherein people would have inexpensive access to technology that would enable them to make the tools and inventions they created on a computer in a “mini high-tech factory” he deemed a FabLab (Martinez & Stager, 2013, p. 24). Gershenfeld and colleagues at MIT designed a “pre-packaged” FabLab with all of the equipment and technology needed, and began to market them around the world (Blikstein & Krannich, 2013).

In 2008, Paulo Blikstein of Stanford University began the FabLab@School project with the goal of bringing FabLabs to K-12 schools (Blikstein, 2013; Martinez & Stager, 2013). In 2011, he hosted the first ever FabLearn conference at Stanford for educators and others desiring to “present, discuss, and learn about digital fabrication in education, the 'makers' culture, and hands-on learning” (“About the Conference,” 2015; Martinez & Stager, 2013).

To keep in perspective what was happening in the maker movement outside of education at this time, it is worth repeating that it was in 2009 that Obama announced the Educate to Innovate campaign (Obama, 2009) and 2012 when Dougherty started the Maker Education Initiative to bring the maker movement to schools (“About Maker Ed: Who We Are,” 2015).

A more recent development to come from the Lifelong Kindergarten research group and to be widely incorporated into educational makerspaces is the MaKey MaKey kit, which allows one to use any object that conducts electricity, including such things as fruit or human beings, to create an interface with a computer (Martinez & Stager, 2013; Resnick & Rosenbaum, 2013).
The Lilypad Arduino kit (Buechley & Eisenberg, 2008) was developed by Leah Buechley, a researcher who was a professor at MIT’s Media Lab. This e-textile kit allows those with no computer programming experience an entry point to sew and program their own “wearable computers.” As with the previously mentioned technologies, the Lilypad Arduino has become a popular item in school library makerspaces.

AnnMarie Thomas, a professor at the University of St. Thomas and founder of its Playful Learning Lab (“AnnMarie Thomas, Ph.D,” n.d.), led a group of students in the development of another popular school library makerspace item, Squishy Circuits. This hands-on kit engages students in the building of electronic circuits using conductive dough and LED lightbulbs. Pilot testing using a pre- and post-test design showed that students with little to no prior knowledge of circuits or electricity show an increase in such knowledge by interacting with Squishy Circuits (Johnson & Thomas, 2010).

Research on Makerspaces

Makerspaces are places where individuals with the shared interest of making come together as a community to share tools, technologies, and knowledge. It is this sense of community that is often identified in the literature as a foundational or core component of a makerspace and which is considered to be very important to the process of making (Brahms, 2014; Litts, 2015). In fact, Litts (2015, p. 53) points out that “not every classroom can become a makerspace, since makerspaces require a community element that transcends the systemic limitations of a traditional classroom.” Several researchers of makerspaces have utilized Wenger’s (1998) Communities of Practice framework as a lens with which to view the interactions of those individuals within a makerspace (Brahms, 2014: Sheridan, et al., 2014), as makerspaces are
centered around the shared use of space, tools, and materials as well as on the collaboration between and support of members of various levels of expertise during the process and practices of making (Washor & Mojkowski, 2013).

A member of a makerspace can take advantage of knowledge that can be found not only within themselves, but also in the variety of other resources available in the makerspace community including print and digital resources (Brahms & Crowley, 2016) as well as the knowledge and skills of other individuals within the space, showing that knowledge and learning in a makerspace is distributed in nature (Brahms, 2014; Cohen, et al., 2016; Litts, 2015; Oxman Ryan, Clapp, Ross, & Tishman, 2016). This hearkens back to the theory of distributed cognition (Perkins, 1993; Salomon, 1993) which contends that knowledge is distributed among the people and artifacts in an environment and that knowledge is socially constructed through collaboration between the persons and artifacts in that environment.

It is not just this sense of community that is essential to a makerspace, but the context within which the making takes place (Litts, 2015). Makerspaces provide an authentic workshop-style context wherein various tools, materials, and resources are available and where members learn the skills they need while working on personally meaningful projects. This is reminiscent of Lave and Wenger’s (1991) ideas of learning skills in the context wherein they would be used and of being a co-participant in the processes of and often with the guidance of an expert.

Also in keeping with the idea of situated learning, members of the makerspace can work side-by-side with more knowledgeable members to learn new skills through collaboration and co-participation (Bevan, Gutwill, Petrich, & Wilkinson, 2015;
Gabrielson, 2013; Halverson & Sheridan, 2014; Litts, 2015; Martin, 2015; Vossoughi & Bevan, 2014). This element of makerspaces is also consistent with Vygotsky’s theory of social constructivism and the Zone of Proximal Development (Berland, 2016; Bevan, et al., 2015; Martin, 2015; Vossoughi & Bevan, 2014) wherein a student can achieve a higher level of problem-solving with assistance from an adult or more experienced peer than his developmental level might otherwise allow (Vygotsky, 1978).

It is important to note that, while makerspaces can and do support an interdisciplinary or multidisciplinary approach to creation and problem-solving that aligns with the STEM movement (Brahms & Crowley, 2016; Oxman Ryan, et al., 2016), makerspaces are not equivalent to STEM labs. Rather, makerspaces are primarily places of individual creation, whether that be in the fields of science and technology, arts and crafts, cooking, music, or any other area of interest to the individual maker. When considering makerspaces, it is important to be inclusive of a wide variety of interests rather than to focus primarily on STEM areas (Blikstein & Worsley, 2016; Peppler & Hall, 2016).

**Makerspace Design Principles**

When considering the design of a school makerspace, it is undesirable to develop a prescribed list of what should be included, as each makerspace should be a reflection of the needs and interests of the individual school community, and, therefore, unique (Canino-Fluit, 2014; Kurti, et al., 2014a; Range & Schmidt, 2014). However, through an examination of the literature, a set of general considerations has emerged for the design of school library makerspaces. These general considerations have been organized around the three aspects of makerspace design that Petrich et al. (2013) recommend taking into account when designing a makerspace to ensure that learning
happens: environment, activities, and facilitation. The list is not exhaustive; rather it reflects design principles that were discussed in the literature with some frequency. They apply to a school makerspace that is a permanent space rather than a mobile makerspace or makerspace events that are set up and taken down as needed.

**Considerations for Design of Makerspace Environment**

**Space/storage.** A school library makerspace should be designed with enough space for individuals and groups to simultaneously work on self-directed projects with room to walk around the space. Consideration should be made regarding storage of various resources and materials the makerspace will house as well as storage of ongoing projects. Other space design considerations include ensuring adequate lighting and ample electrical outlets to accommodate a wide variety of projects (Houston, 2013; Martinez & Stager, 2013; Petrich, et al., 2013; Range & Schmidt, 2014).

**Flexible use.** Makerspaces are spaces where makers share resources, learn from each other, and collaborate on projects of shared interests. Therefore, school makerspaces should be designed so that collaboration can happen easily and naturally. Furniture in the makerspace should be flexible, mobile, and encourage collaboration. At the same time, however, the makerspace should readily accommodate those who desire or need to work on a project independently. The needs of both individuals working alone and groups working collaboratively should be met through the flexible use design of the space (Gutwill, et al., 2015; Houston, 2013; Kurti, et al., 2014b; Petrich, et al., 2013; Resnick & Rosenbaum, 2013).

**Decor/feel of makerspace.** When choosing the decor for a school makerspace, it is important to choose paint colors, posters, signs, etc. that are “gender-friendly” or “gender-neutral” in order to encourage both boys and girls to explore and learn in the
space (Blikstein, 2013; Martinez & Stager, 2013). The décor should be purposefully chosen to inspire creativity, playfulness, and a sense of wonder as well as make clear that taking risks is encouraged and that failure is a learning opportunity (Kurti, et al., 2014a; Martinez & Stager, 2013). Some believe that one way to inspire creativity is to display a variety of levels of projects previously completed in the makerspace (Petrich, et al., 2013; Resnick & Rosenbaum, 2013). Martinez and Stager (2013), however, caution against providing completed projects as examples to students as this may stymie rather than inspire students' creativity and innovation.

**Safety.** Given that a school makerspace may include a variety of tools and technologies for student use, safety must be a consideration in the design and ongoing use of the space. Depending on the tools and technologies included, each makerspace should develop a list of safety rules of which students are aware (Makerspace Playbook, 2013; Martinez & Stager, 2013). According to Martinez and Stager (2013), it is important to have safety rules and to teach students to safely use the tools they need to create in the makerspace. However, this should be balanced with the need for creativity in the space. They further argue that one must be careful that the safe use of the tools does not become the “curriculum” of the makerspace.

**Design of Makerspace Activities**

The range of possible makerspace activities is endless, but there are guidelines that should be adhered to when designing an activity for a school makerspace. School makerspace activities should be based on student interests (Halverson & Sheridan, 2014; Kurti, et al., 2014b; Range & Schmidt, 2014), and should be designed as both “hands on” and “minds on,” focusing on the process involved in making rather than the end product (Quinn & Bell, 2013; Resnick & Rosenbaum, 2013; Sheridan, et al., 2014).
Activities should have multiple entry points and pathways to participation so students of varying knowledge levels can be challenged and successful and so students have freedom to explore within the theme of the project (Blikstein, 2013; Petrich, et al., 2013; Resnick & Rosenbaum, 2013; Sheridan, et al., 2014). Take, for example, a makerspace that provides resources for students to explore the area of electronics. The makerspace might include Squishy Circuits so that students with no knowledge of electronics could have quick success in lighting up an LED bulb. It might also include eTextile resources, allowing students to encounter electronics through the pathway of sewing material using conductive thread rather than through the use of traditional circuits and wires. Also included in the makerspace might be various electronic components students could use as their knowledge and skill level increases to build and power their own inventions.

**High tech and low tech activities.** Table 2-1 shows high tech and low tech activities that are commonly found in makerspaces and could be included in school library makerspaces. The list is not exhaustive; it is a sampling of common makerspace activities as seen in the literature.

<table>
<thead>
<tr>
<th>High tech activities</th>
<th>Low Tech Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D modeling/3D printing</td>
<td>Robotic/electronics/</td>
</tr>
<tr>
<td>Blender</td>
<td>computing projects</td>
</tr>
<tr>
<td>SketchUp</td>
<td>Lego Mindstorms</td>
</tr>
<tr>
<td>TinkerCAD</td>
<td>Little Bits</td>
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<tr>
<td>Computer coding</td>
<td>Arduino</td>
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<tr>
<td>Codeacademy</td>
<td>Makey Makey</td>
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<tr>
<td>Github</td>
<td>Raspberry Pi</td>
</tr>
<tr>
<td>Scratch</td>
<td>Squishy Circuits</td>
</tr>
<tr>
<td>Interactive textiles</td>
<td>NetLogo</td>
</tr>
</tbody>
</table>

Role of Makerspace Facilitator

The “teacher” role in a makerspace is quite different from the traditional role of “expert” classroom teacher. As students in a makerspace environment might have ongoing any number of projects involving a wide variety of content areas and concepts, it would be difficult for the teacher to be an expert on them all. In a makerspace, the teacher does not need to be an expert on all potential making projects, rather he assumes the role of facilitator of student learning. Makerspace facilitators who are experts and share their expertise can actually hamper student makers from becoming experts (Kurti, et al., 2014b). Facilitators of makerspaces should create a welcoming, supportive, and safe environment and design activities to spark interest in student makers (Gutwill, et al., 2015; Petrich, et al, 2013). They should allow students to struggle and even fail, but should be watchful of when students are losing interest or giving up and offer assistance in order to sustain student interest in the project (Gutwill, et al., 2015; Martinez & Stager, 2013). The assistance they provide might be in the form of providing resources for makers to self-instruct and learn what is needed to continue or in the form of asking questions rather than providing answers to help the maker see in what direction they might go to solve their current frustration (Houston, 2013; Resnick & Rosenbaum, 2013). Facilitators should recognize when a student maker is ready to increase the complexity of his project and deepen his understanding of the underlying concepts and assist the student in doing so (Gutwill, et al., 2015).

Developing Student Makers

A primary goal of educational makerspaces is to provide students with making and tinkering experiences that will help them develop a sense of identity as one who has a measure of control over the man-made designed aspects of his world (Oxman
Ryan, et al., 2016), one who can fix things when they are broken, tweak items to meet their individual purposes, or invent new items to meet their creative wants or needs. Through such experiences over time, the goal is for students to come to be self-directed learners who seek out the information they need to know in order to pursue their own interests to create and innovate (Barron & Martin, 2016; Oxman Ryan, et al., 2016). The goal is for students, over time, to develop an interest in making, to develop a maker mindset, and to develop an identity as a maker (Litts, 2015).

The development of a maker mindset and the set of skills and abilities that go along with such a mindset such as creativity, problem-solving, collaboration, and self-expression, rather than the development of particular content knowledge or the development of an interest in STEM careers such as engineering or computer science, is seen by some as the primary goal of an educational makerspace (Blikstein & Worsley, 2016; Dougherty, 2013; Kalil, 2013; Oxman Ryan, et al., 2016) and an end unto itself. This is not to say that gaining content knowledge, especially in STEM areas, is not an outcome of student participation in makerspaces (Oxman Ryan, et al., 2016). In fact, educational makerspaces are often discussed as places that can readily support the learning of STEM content and the building of interest in STEM fields. However, focusing on learning specific STEM or other content area skills as the primary outcome of student participation “would be to sadly miss the point” (p. 35) of the potential of makerspaces to empower students to “develop a sense of personal agency and self-efficacy” (Oxman Ryan, et al., 2016, p. 35) and to encounter and develop “different practices, strategies of designing, creating, thinking” (Resnick, Eidman-Aadahl, & Dougherty, 2016, p. 236) and to encourage all students, regardless of their future career
paths, to become “tinkerer-scientists” (Washor & Mojkowski, 2013, p. 200). A narrow focus on STEM in makerspaces also ignores the interests of many students to participate in making projects involving such areas as arts and crafts, cooking, fashion, and digital media (Peppler & Hall, 2016).

A maker mindset has been described by Dougherty (2013) as a growth mindset based on the writings of Carol Dweck (2006) in which makers “believe they can learn to do anything” (p. 10). There are several elements of the maker mindset that have been identified in the literature as holding significance for education: its playful nature; its asset- and growth-orientation; its failure-positive nature; and its emphasis on collaboration between makers (Martin, 2015). Lisa Regalla (2016) of Maker Ed outlines the characteristics of a maker mindset as follows: 1) A sense of curiosity; 2) An interdisciplinary approach to challenges; 3) Social emotional competence through play; 4) A disposition to share and collaborate; 5) A growth mindset; and 6) Resilience in the face of frustration.

Though there have been many trade journal articles published about makerspaces in the field of library science, there has been a lack of research studies conducted with a focus on library makerspaces, and school library makerspaces in particular (Moorefield-Lang, 2015). David Loertscher et al. (2013), however, have developed the uTEC Maker Model depicting the evolution of a student into a maker that could potentially be used to gauge the development of a maker mindset in students through participation in a school library makerspace environment. This model describes the developmental stages a student passes through in the use of a makerspace from lowest to highest level as Using, Tinkering, Experimenting, and Creating. It further
identifies dispositions that students purportedly develop as they move to higher levels of makerspace use which include various roles (e.g., presenter, mentor, etc.), actions (e.g., imagine, design, collaborate, etc.), and strategies (e.g., teamwork, persistence, problem-solving, etc.).

**Making as a Learning Process**

Throughout the literature on makerspaces, making is referred to as a process (Brahms, 2014; Litts, 2015; Sheridan, et al., 2014; Tseng, 2016; Vossoughi & Bevan, 2014) rather than as an event. However, though parts and pieces of the process of making are discussed in the literature, there is not agreement in the field as to how the process of making ought to be defined (Brahms, 2014). Nor is there available to those wanting to design and implement an educational makerspace wherein students get the opportunity to experience making as a learning process a concise description of what the process of making, and, in particular, the process of making as a learning process in an educational makerspace, entails.

**What Making Is Not**

One can begin to form an understanding of making as a process by looking at what the literature says that making is not. Making is not simply assembling pre-formed pieces according to a set of instructions into a finished product, be it a birdhouse, a robot, or a dollhouse (Resnick, et al., 2016; Resnick & Rosenbaum, 2013). Nor is making developing a solution to a prescribed design or engineering challenge with specific requirements for the design, such as designing a bridge that can support a certain number of pounds (Gutwill, et al., 2015; Peppler, et al., 2016; Petrich, et al., 2013; Resnick & Rosenbaum, 2013). Rather, making is a process that involves elements of playfulness, experimentation, and exploration that is more akin to tinkering
than to intentional design (Resnick & Rosenbaum, 2013). Resnick and Rosenbaum (2013) caution that making is often being incorporated into schools in ways that are out of line with the nature of making as described above, limiting the learning students experience through “making.”

Though the process of making may appear similar in the way it looks, making is also not equivalent with constructing an end project as part of a project-based learning unit or other inquiry-based learning unit (Dougherty, 2013; Gutwill, et al., 2015). While it is true that many who study makerspaces as learning environments tout project-based learning as a preferred teaching approach when incorporating making in schools (Blikstein & Worsley, 2016; Martinez & Stager, 2013; Wardrip & Brahms, 2016; Washor & Mojkowski, 2013), there are differences between the teaching method of project-based learning and the process of making (Wardrip & Brahms, 2016). One such difference is that within project-based learning, student projects are tied to a teacher prescribed curriculum topic and are intended to solve a problem, answer an overarching question, or show evidence of student learning about the content, whereas an important aspect of making is the autonomy of the maker to be self-directed in his choice of what to make based on personal needs, desires, or interests (Dougherty, 2013; Peppler, et al., 2016; Petrich, et al., 2013; Regalla, 2016). So, while some projects students create as part of a project-based learning unit may involve making as a self-directed, playful, exploratory, tinkering process as described by Resnick and Rosenbaum (2013), many other projects that result as part of such a unit would not. Making is a process that can support certain student projects that result from a project-based learning unit, but it is
not equivalent to project-based learning, in part because it is focused more on the process than on the end product.

**Elements of Making as a Process**

Though the literature on making as a learning process does not provide a concise description of what the process of making, and, in particular, the process of making as a learning process in an educational makerspace, entails, one can begin to put together a picture of this process from the various elements of making that are repeatedly mentioned in the literature.

One critical aspect of making, perhaps the aspect that differentiates it from other inquiry-based forms of learning, is that it is driven by the interests and/or needs of the individuals who are involved in the making (Litts, 2015; Peppler & Bender, 2013; Peppler, et al., 2016; Vossoughi & Bevan, 2014; Wilkinson, Anzivino, & Petrich, 2016).

The autonomy of each individual to create projects of their choosing is paramount to the process of making. As such, in a single makerspace, multiple various projects are typically ongoing simultaneously. Making is often referred to as a self-directed process, and the development of self-directed learners is seen as a goal of educational makerspaces (Resnick, et al., 2016).

Closely associated with the interest-driven nature of making is the idea that making is not tied to tightly-scripted, specific curricular goals (Blikstein & Worsley, 2016; Regalla, 2016; Resnick, et al., 2016) as is the case in other forms of inquiry-based learning, such as project-based learning. Rather, making is more closely akin to the idea of an emergent curriculum or emergent learning wherein each individual involved in the making process learns whatever it is he needs to learn in order to make whatever he has determined to make (Blikstein & Worsley, 2016; Brahms, 2014; Martin, 2015;
The literature often points to the approach to preschool and primary education taken in the city of Reggio Emilia in Italy as a similar example to how making addresses curriculum and learning (Galloway, 2015; Martinez & Stager, 2013). In Reggio Emilia, teachers determine curricular goals based on interests expressed by students, and these interests lead the focus and development of the curriculum. Making takes this a step further in that each individual within the makerspace may be pursuing a different project and, therefore, be pursuing a different learning path and mastering a different set of content (Blikstein & Worsley, 2016), offering a truly personalized learning experience for each individual.

Exploration is another important aspect of the process of making, and this is often referred to in the literature as tinkering. This is a playful activity wherein the individual messes around or experiments with various materials and tools without any particular goal in mind (Regalla, 2016). This is considered a valuable part of the making process, and some recommend focusing less on projects and more on tinkering in educational makerspaces as inspiration for personally meaningful projects often results from tinkering (Peppler & Bender, 2013). Once a personally meaningful project is identified, the individual may begin to jot down or draw out ideas of what the project will entail or how it will look in the end or possibly create a quick prototype of what they envision.

Making is a process that is based on the interests and/or needs of individuals, and, as such, it is oftentimes an individualized activity. However, several individuals can share the same interest or need, and making can then become a collaborative effort between multiple individuals. Even in cases where the making project is being taken on
by a single individual, the nature of makerspaces is for members to assist each other when needed or wanted (Litts, 2015; Regalla, 2016; Sheridan & Konopasky, 2016), so even within an individual project there can be times during which there is collaboration with others. Collaboration may also come before a project begins through brainstorming or discussing one’s interests with others. This collaboration can end, however, in the pursuit of an individual project. Moving in and out of these collaborative relationships as needed or wanted is another part of the making process (Gabrielson, 2013; Martinez & Stager, 2013; Peppler, et al., 2016).

Inherent in the process of making is continual feedback (Regalla, 2016; Resnick, et al., 2016). This feedback comes from a variety of sources and in a variety of ways. Individuals may ask for advice and receive feedback from adults or peers within the making community on a project that is not working as hoped. Or, they may receive kudos from others about a project that turned out well (Resnick & Rosenbaum, 2013; Tseng, 2016). Within the making process, feedback also comes from the created artifact itself in the form of whether or not it works or behaves as intended (Martin, 2015; Resnick, et al., 2016; Wilkinson, et al., 2016). This continual feedback from the artifact and the resultant reflection of and change in the maker’s thinking about how to successfully complete the project is at the heart of the constructionist philosophy that underlies making (Litts, 2015; Peppler & Hall, 2016).

MAKE magazine is a magazine for makers which highlights making projects. Maker Faires are gatherings of makers where they show others their creations and talk about how they made them. The popularity of Make magazine and the prevalence of Maker Faires evidences that sharing the products that result from as well as the
learning involved in the process is an important aspect of making (Peppler & Bender, 2013; Peppler, et al., 2016; Sheridan, et al., 2014). Sharing completed projects as well as knowledge gained through those projects is a fundamental tenet of the development of makerspaces, and is another important aspect of the process of making (Dougherty, 2013; Regalla, 2016; Rusk, 2016).

As some making projects can span a fair amount of time and as makers often learn what works and what does not through trial and error or through intentional research along the way, it is common for makers to document what they have tried and learned throughout the process (Martinez & Stager, 2013; Resnick & Rosenbaum, 2013). Not only does this documenting of progress help the individual maker keep track of what has already been done or tried throughout a long-term making project, it allows the project and the process to be more readily shared with others once the project is complete (Resnick, et al., 2016). Often, this progress is captured in a project notebook or journal (Qi, Dick, & Cole, 2016; Resnick & Rosenbaum, 2013), though it can also be captured with pictures, video, and text (Martinez & Stager, 2013). Some online sites allow individuals to post pictures of a completed project along with steps one can follow to complete it (Peppler & Bender, 2013). Other sites, such as the Build in Progress site developed by Tiffany Tseng (2016) allow student makers to document and show the actual process they followed throughout the making of the project.

Making is not a process wherein one can always create an initial product and then be done. Rather, making is often an iterative process (Dougherty, 2013; Regalla, 2016) wherein one makes a project through a series of starts and stops, going back to the beginning to learn additional information before being able to move forward again.
(Tseng, 2016; Wilkinson, et al., 2016). Once the project is complete, one often then needs to make changes because it did not work as expected or because improvements are desirable. It is this iterative nature of the making process that is believed to encourage persistence in student makers in an educational makerspace setting (Wilkinson et al., 2016).

**Making as a Discipline**

The process of making seems to share similar practices or processes with other disciplines. For instance, Brahms (2014) points out that the process of making involves asking questions and defining problems, practices also found in the disciplines of science and engineering, respectively. Litts (2015), in her study of makerspaces as learning environments, shows that the process of making shares the practices of brainstorming, iterating, and communicating with the design processes of such disciplines as engineering, art, and architecture. However, these and other researchers believe that while making shares some processes with other disciplines, it ought to be understood as its own domain with its own disciplinary practices rather than simply as an interdisciplinary process in support of other content areas (Brahms, 2014; Litts, 2015; Peppler, et al., 2016). Recent research helps bring into view the practices that may be particular to the process of making.

**Learning Practices of Maker Community**

To further understanding in the area of making as a learning process and the practices that are inherent to the process of making, Lisa Brahms (2014) used the theoretical framework of Communities of Practice to examine the making community through an analysis of four volumes of Make magazine. She identified the following
seven core learning practices as evident in the making community of practice, which are also helpful in thinking of making as a learning process in an educational makerspace:

1. Explore and question: Interrogation of the material properties of the context in order to find inspiration or to determine intention for a process or project.

2. Tinker, test, and iterate: Purposeful play, experimentation, evaluation, and refinement of the context.

3. Hack and repurpose: Harnessing and salvaging component parts of the made world to modify, enhance, or create a product or process.

4. Combine and complexify: Developing skilled fluency with diverse tools and materials in order to reconfigure existing pieces and processes and make new meaning.

5. Seek out resources: Identifying and pursuing the distributed expertise of others, includes a recognition of one’s own not-knowing and desire to learn.

6. Customize: Tailoring the features and functions of a technology to better suit one’s personal interests and express identity.

7. Share: Making information, methods and modes of participation accessible and usable by members of the community (pp. 20-21).

Brahms further used these core learning practices as a framework to observe two children participating in a museum maker environment for evidence of learning. She focused primarily on the core learning practice of seeking (social) resources and found that both children, one in conjunction with the learning practice of explore and question and the other in conjunction with tinker, test, and iterate, exhibited evidence of adopting this core learning practice of the making community.

Through interviews of thirteen expert makers in Vancouver, Canada, researchers (Milne, Riecke, & Antle, 2014) identified various habits, attitudes, and skills called on by these makers as part of their making process. Among these are the continuous search for project inspiration, a curiosity and desire for deep knowledge and understanding, confidence in solving problems, an attitude of failure as a way to learn, knowing how to
research to learn what one needs to know for a making project, and motivation that comes from choosing enjoyable projects. The overlap in the findings of these two studies of practices of adult makers begins to illuminate a common process of making that may be helpful in the design and implementation of educational makerspaces.

**Processes Similar to Making**

When thinking of making as a process, it is also helpful to look at process models that have been developed for similar processes, such as the creative design spiral developed by Mitchel Resnick (2007) based on his observations of the natural learning processes of kindergarten students. This model was later used by Resnick and others (Rusk, et al., 2009) as a way to view the design process of youth participating in design projects in the afterschool club known as the Computer Clubhouse. The steps of this iterative cycle of creativity are imagine, create, experiment, share, reflect, and imagine again. A student who had participated in a creative design process using the creative design spiral as a model of design and creativity was asked to give tips to other students who would be participating in the activity in the future (Resnick, 2007). The tips he provided include such things as “if you have no clue what to do, fiddle around,” “don’t be afraid to experiment,” and “keep your ideas in a sketch book” (p. 5). These and other of his tips echo some of the elements of the process of making discussed previously.

Martinez and Stager (2013) discuss multiple process models used in the field of design as well as various process models for design used in schools, including the creative design spiral developed by Mitchel Resnick. Due to a concern that students who are introduced to a design process diagram will view it as a prescriptive set of steps they must follow, they suggest a simple, three-step process for classroom making
and design which they refer to by the acronym TMI (Think, Make, Improve). For each of the three steps or stages of their TMI process, various examples are provided of activities students may do during this stage rather than a checklist of activities they ought to do. For instance, during the “Think” stage, students may do such things as brainstorm, predict, decide to work alone or with another, research, or plan among other activities. During the “Make” stage, students may play, tinker, build, experiment, deconstruct, document progress, or ask questions. Examples of processes students may partake in during the “Improve” stage include such things as conduct research, discuss the issue with others, ask an expert, change one thing at a time, or use different materials for the project. The many examples of activities students may utilize during the various stages of this TMI process build on the emerging picture of what a common making process may involve.

Mike McGalliard (2016) developed another process model specific to the Global Cardboard Challenge of which he was a part. The Global Cardboard Challenge, developed by the Imagination Foundation, is an annual fall event that involves children around the world building things from cardboard. The Global Cardboard Challenge was started based on the large and positive response of teachers and children to the story of Caine’s arcade, in which a young boy, Caine, built an arcade from cardboard boxes in his father’s auto parts store. The story of Caine’s arcade became a social media phenomena and the cardboard challenge has become a popular event in many schools and communities. McGalliard and his team observed children participating in the cardboard challenge and developed a framework or model to describe the creative process they used throughout. Based on Papert’s theory of constructionism and
adapted from Resnick’s creative design spiral, the Creative Play Spiral includes the following steps: inspire, imagine, build, play, and share (McGalliard, 2016). Though the creative play spiral exemplifies a process specific to the global cardboard challenge, it helps one further understand what a common process of making might include.

**Educational Making Process Model**

In an effort to form a concise description and understanding of the process of making in an educational setting based on how the process of making is discussed in the literature, I developed the Educational Making Process Model (EMPM) shown below in Figure 2-1. The EMPM provides both a visual of what making as a learning process may look like based on the various elements of such found in the literature as well as a brief description of each part of the process. The intent of the EMPM is not to approach student making in a prescriptive, step-by-step manner or as a prescriptive, step-by-step activity. Rather, my immediate goal in developing the EMPM is to assist the makerspace team of librarians in my school district who desire to design and implement a school library makerspace to better understand making as a learning process so as to design, implement, and facilitate their school library makerspaces in such a way to best afford students the opportunity to experience making as a learning process. A further goal in developing the EMPM is for it to serve as the basis of conversation and negotiation among those who study makerspaces as learning environments as to a possible common language or common definition of educational making as a learning process.
This process model is not intended to be followed in a step-by-step order. Rather, as represented by the gear-like design, all parts of the process interplay such that they work together toward a successful making process. Students may not take part in every part of the process for every making project.

**Inspiration** – What do you want to make?
Student determines something he wants to make (based on student interest rather than teacher-directed or curriculum-driven)
Student inspiration **may** come from
- Exploration in makerspace
- Playfulness
- Personal need/interest
- Sample projects
- Project idea resources (books, websites, etc.)
- Collaboration with others
- **Optional** Design Challenges or Project-Based Learning projects

**Ideation** – What do you imagine it to be like?
Student envisions the thing he wants to make
Student ideation **may** consist of
- Student imagining finished artifact
- Student drawing ideas for artifact
- Student writing out ideas for artifact
- Student creating quick prototype of artifact

Figure 2-1. Educational Making Process Model
**Making** – How will you go about making it?
Student brings his ideas to reality
Student making may involve
- Tinkering, Exploring, Attempting, Experimenting, Prototyping
- Planning
  - What materials/resources are needed (including human resources)?
  - What do you need to learn to make what you want to make?
- Gathering
  - Obtain the materials/resources you need
  - Learn what you need to learn to make what you want to make
- Building (Physical or digital)
  - May not be successful the first time
  - Problem-solve
  - Try again, and again, if necessary
  - Go back to previous making “steps” if necessary

**Iteration** – How can you make it better or different?
Student makes changes to original item to improve it or modify it
Student iteration may involve
- “Hacking” an existing item to improve it or modify its use
- Creating updated or improved version of an item student made
- Combining multiple items (existing or student made) for a new purpose or improved function
Student may choose to iterate based on
- Feedback from project (it isn’t working as planned or desired)
- Feedback from others (e.g., improvements needed to make item saleable)
- Artistic license (unique or creative way to repurpose an item(s))

**Sharing** – How can you show/tell others what you made & learned?
Student demonstrates to others what they made and what they learned in the making
Student sharing may involve
- Displaying/presenting project in school or community venue, such as maker faire
- Posting project details & learnings in online making forum
- Adding project details & learnings to making “portfolio”

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**Optional & Flexible Collaboration**
Students work with others as and when needed/wanted on making projects to both get and give help

**Continuous Feedback**
Students naturally receive continuous feedback from their making attempts (does it work or not) as well as from peers in the makerspace

**Documenting Progress**
Student documents what he has already done and what still needs to be done to help with organization of project and time

**Reflection & Formative Self-Assessment**
Student tracks what he tried, what worked, what didn’t, ideas for what to try next, as well as what he has learned

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Figure 2-1. Continued
Chapter Summary

In order to better ensure students gain from the many benefits of educational makerspaces and to encourage megachange in education, it is important that such spaces are purposefully designed (Brahms, 2014; Litts, 2015) based on an understanding of their underlying theories, the principles of makerspaces and making in general, and other related research. This literature review outlined the theories, principles, and other research instrumental to my understanding of educational makerspaces and that were influential in the design decisions made for the implementation of school library makerspaces in my school district. Additionally, this literature review built a case for making as a process and presented the Educational Making Process Model I developed that provides both a visual of what making as a learning process may look like based on the various elements of such found in the literature as well as a brief description of each part of the process. My goal in developing the EMPM was to assist the makerspace team of librarians in my school district to better understand making as a learning process so as to design, implement, and facilitate their school library makerspaces in such a way to best afford students the opportunity to experience making as a learning process.

Chapter Three of this dissertation will establish the design case framework that will be used for this study. It will also reiterate the study’s purpose and research questions, present the study’s conceptual framework, discuss the methods used for data collection and analysis, provide information as to the trustworthiness of the study, and discuss ethical considerations and limitations. Chapter Four will speak to research question one and will present the professional context of the study and the processes used and decisions made during the school library makerspace design process in my
district. Chapter Five will speak to research questions two and three, presenting and discussing the results of school library makerspace observations and interviews of students, a librarian, and a teacher I conducted as part of the study. Finally, Chapter Six will discuss both successes of school library makerspace implementation in my district as well as areas of possible improvement.
CHAPTER 3
METHODOLOGY

Restatement of Problem of Practice

Due to the various purported benefits of makerspaces, and because they seem a fit with school libraries, several school librarians in my district over the past several years began to incorporate makerspaces into their libraries. However, these makerspaces were being incorporated haphazardly based on what each individual librarian had read about makerspaces or had heard at conferences, on social media, through other librarians, or through other informal means. As library coordinator for the district, I recognized the need to ensure that we were purposeful in our design and implementation of these spaces so that they remained in keeping with the underlying principles of constructionist learning theory and helped meet the goals of the district library program. To that end, I formed and led a committee of librarians in my district who were interested in makerspaces to serve as a design team to develop makerspace implementation guidelines for the district library program. In order to retain an understanding of knowledge gained and design decisions made during the process as a resource to be used for future work, there was a further need to formally document the work of the makerspace design team. Utilizing a design case approach for this study was well-suited to meeting this need for documenting the process.

Purpose Statement

The purpose of this design case dissertation is to provide a detailed and thorough account of the design process the makerspace committee of librarians went through to bring makerspaces to the library program in my school district in order to preserve and share the precedent knowledge gained through the process (C. D.
Howard, 2011). While this dissertation represents only a snapshot of an ongoing design process, this account will include detailed information both about the design process itself as well as the resulting implementation of makerspaces based on the design and will speak to both the successes of the design as well as any areas for improvement.

**Research Questions**

According to C. D. Howard (2011), design cases have an overall singular focus in asking the question, “How did the design come to be as it is?” (p. 53). He further states that design cases seek to answer the question “What design resulted from the process?” (p. 49), and he stresses the importance of including a description of the user experience of the design to help readers better understand the design. In keeping with these foci, this design case dissertation seeks to answer similar questions.

Research Question 1: What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district?

Research Question 2: What is the resulting school library makerspace implementation?

Research Question 3: In what ways do students experience participation in the resulting school library makerspace?

**Conceptual Framework**

As this dissertation is written using a design case perspective, the conceptual framework for this study (Figure 3-1) outlines the reason or purpose for the initial determination to implement school library makerspaces in my school district as well as the scholarly literature, formal theories, and experiential knowledge that influenced the design process and the ultimate implementation of school library makerspaces. I developed the Educational Making Process Model based upon literature and theories related to makerspaces, and this process model then became part of the prior
experiential knowledge that, along with the other items shown in the conceptual framework, influenced the design process. Also reflected in the conceptual framework are the resulting makerspace implementation and user experience that will be described as part of the design case as well as the discussion that will be included of successes and areas of needed improvement.

Figure 3-1. Conceptual Framework for design case.

Research Design

The primary purpose of this dissertation is to serve as a design case for the design and implementation of school library makerspaces in my school district.

According to Boling (2010), a design case is “a description of a real artifact or experience that has been intentionally designed” (p. 2). C. D. Howard (2011) describes a design case as a “vehicle for sharing the knowledge gained by a design team through the process of creating a design for learning” (p. 41). Lawson (2004) refers to this as precedent, the unique knowledge that is gained by those involved in a specific design
process. The purpose of a design case is to preserve and pass on to others this precedent. Using a variety of data sources such as meeting notes, pertinent documents, qualitative observations, interviews, and pictures, I will provide a thorough description of the design process, the resulting makerspace implementation, and the ways in which students experience participation in the school library makerspaces designed and implemented in my school district.

**Design Case Framework**

C. D. Howard (2011), in his article titled “Writing and Rewriting the Instructional Design Case: A View from Two Sides,” provides guidance for those writing a design case in the form of an optional structure for organizing such a case which includes five categories. He emphasizes that this is only a possible useful framework for writing a design case rather than a structure being dictated for all design cases. Below is a description of each of the five categories suggested by Howard along with commentary as to how I incorporated each of these categories into this design case dissertation. A summary table is then presented (Table 3-1) of Howard’s categories and where they are located in this design case dissertation.

**Situating the design.** The first category suggested by Howard to include in a design case is that of situating the design. He recommends including in this category a thorough description of the context of the design as well as aspects of or changes in the context that motivated the design. I included in Chapter One of this dissertation information about school library makerspaces and what led to my professional interest in school library makerspaces. This serves to build the broader context of what motivated the design and implementation of these spaces in my school district.
Additional information about the specific context for this design is included in Chapter Four which describes the processes and decisions involved in the design.

As part of situating the design, C. D. Howard (2011) states that “rigorous design cases include . . . descriptions of the people who were involved in the design process” and “discussions of reading, previous designs, theoretical perspectives, and training influential in the designers’ thinking” in order to “elucidate the perspectives of the designers, in turn helping readers grasp the perspective of the case” (p. 43). Descriptions of the members of the makerspace design committee are included in Chapter Four of this dissertation. These brief descriptions provide information as to their overall experience in the field of education as well as their knowledge of makerspaces upon joining the design team. In addition to the description of my professional background and initial interest in school library makerspaces found in Chapter One, there is also information regarding my role in the design team in Chapter Four. Chapter Two, the literature review, serves as the discussion of readings and theoretical perspectives that influenced my thinking about makerspaces and to allow readers to understand the perspective from which I and the design team approached the design and implementation of school library makerspaces.

The final component Howard suggests including in the category of situating the design is a statement of why the author believes the design case is worth reading and why readers might find this design case interesting. My statement of why I believe others would find this design case about school library makerspaces of particular interest is included in Chapter Four.
Describing the design. The next category Howard presents as part of his optional framework for design cases is that of describing the design. He recommends presenting the narrative of the development of the design organized around the separate discussion of the components of the design rather than as a chronological account of the design process. According to Smith (2010), this narrative should address such things as the key decisions made, who was involved in making them, and what changes were made during the process. Another component Howard suggests as part of the category of describing the design is presenting a concrete illustration of the completed design. In addition to rich, thick textual narrative, Howard recommends using images, video, and audio, as appropriate to help describe the design.

My development narrative of the design process of school library makerspaces in my district makes up the majority of Chapter Four which addresses research question one regarding the processes and decisions involved in the design. As per Howard’s suggestion, the narrative is presented as separate discussions of the components of the design, though they are presented in roughly chronological order.

My description of the completed design, the school library makerspace at Elementary School Four, is presented as part of the Results chapter, which is Chapter Five of this dissertation. C. D. Howard (2011) states that the results of a design case is the design itself, so the Results chapter seems the most appropriate place for this description. I included rich, thick description to help readers better understand the design. Thick description is description whose level of specificity allows the reader to see and feel the setting and actions within the setting from the perspective of those in it (Creswell, 2014; Patton, 2002; Schutt, 2012). For instance, rather than stating
“students were excited,” one might instead state, “as students were standing in line to enter the dinosaur exhibit, they were chattering nervously about what they were about to see, and several of them were waving their hands to animate their thoughts. Others were standing on tip toe, attempting to see over the heads of their classmates to get a sneak peek into the room they were about to enter.” Oftentimes, thick description is presented in written form in research reports, but in a design case, it may also include multiple pictures, representations of various stages of the design process, documents, and other non-text artifacts (Boling & Smith, 2009; Smith, 2010).

Depicting the experience of the design. C.D. Howard (2011) stresses the importance of providing readers of a design case with a description of how users experience the design. He explains that this description can be used to show readers how elements of the design “interact with learners” (p. 48). Howard makes the point that in a design case, the results are not performance measures. Rather, the results of a design case are the design itself and the description of how users experience it. Smith (2010) reiterates this idea when he states that “in a design case, the central concern is to convey the designed artifact and/or experience in a coherent way so that the reader can store a vicarious, episodic memory of it” (p. 17).

My description of students’ experience of participation in the school library makerspace is included in Chapter Five, Results, after the description of the makerspace itself. This description includes discussion of specific design elements evident in the students’ experiences.

Transparency in the analysis. A design case will, certainly, include a discussion of ways in which the design was successful. However, according to C. D.
Howard (2011), a design case that discusses only the successes is little more than an advertisement for the design. As such, Howard suggests including a discussion of such things as any unexpected experiences that resulted from the design and areas where the design process or the resulting design itself might be improved. Howard contends that these design failures, as he refers to them, may be of the most help to readers who are dealing with similar issues or constraints in their own design context. I included a discussion of design failures and a reflection of ways in which the design could be improved in Chapter Six of this dissertation, Discussion and Implications.

**Items often removed from design cases.** C. D. Howard (2011) suggests that several items normally found in scientific studies are not appropriate for a design case and that reviewers often ask that they be “removed or reworked into a different perspective” (p. 52). One such item is the research methods section found in scientific studies. Howard states that rather than the research methods in a scientific study, a design case consists instead of a development narrative describing the processes and decisions made toward the finished design. However, to better fit the format of a dissertation, I included a more traditional Methods chapter in this design case, Chapter Three, that includes a discussion of the format of a design case, the data collection and analysis methods I used, and ways I ensured the trustworthiness of the design case.

Research questions are another element of a scientific study that are typically excluded from a design case. All design cases essentially try to answer the same question of how the particular design highlighted in the case came to be (C. D. Howard, 2011). This makes the inclusion of research questions in a design case awkward, according to Howard. Instead, design cases often include a problem statement or a
statement of the author’s reasons for wanting to share the knowledge gained from the
design process. However, in order to more closely adhere to a dissertation format and
to help guide the development of the design case within it, I did include research
questions in this dissertation which can be found both in Chapter One and in Chapter
Three. The research questions are in keeping with the goals of a design case to
determine how the design came to be and to provide a detailed description of the
design and of the user’s experience of the design.

The final items Howard lists as often removed from or reworked in a design case
are such things as design guidelines, lessons learned, and design principles. The
author of the design case should not attempt to prescribe specific guidelines or
principles for readers to follow in their own design process, nor would any lessons
learned in one design case necessarily apply to another. Rather, the design case
should provide a detailed enough description of the design process, design, and user
experience to allow the reader to take from it the precedent knowledge of most value to
him.

While I do include the makerspace design guidelines developed by the design
team as part of the description of the makerspace design process in my district, I do not
prescribe that others who are designing school library makerspaces adhere to these
exact guidelines. Too, while I discuss how the design of makerspaces in my district
might be improved upon, this discussion is not intended to be lessons learned that are
necessarily applicable to others’ design contexts, as the purposes and goals of
makerspaces may be slightly different in different contexts. In the table below, the items
in this category that I did include in this dissertation are listed under the heading of

“Included to Fit Dissertation Format.”

Table 3-1. Summary of placement of Howard’s design case categories in dissertation

<table>
<thead>
<tr>
<th>Dissertation chapter</th>
<th>Howard’s design case categories included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter one:</td>
<td>Situating the design</td>
</tr>
<tr>
<td>Introduction</td>
<td>Broader context (history of makerspaces and information about school library makerspaces) – aspects that motivated the design</td>
</tr>
<tr>
<td></td>
<td>Researcher’s professional interest in school library makerspaces</td>
</tr>
<tr>
<td></td>
<td>Included to fit dissertation format</td>
</tr>
<tr>
<td></td>
<td>Research questions included to fit dissertation format – based on goals of design cases</td>
</tr>
<tr>
<td>Chapter two:</td>
<td>Situating the design</td>
</tr>
<tr>
<td>Literature review</td>
<td>Discussion of previous readings and of theoretical perspectives that influence the my thinking regarding the design of school library makerspaces</td>
</tr>
<tr>
<td>Chapter three:</td>
<td>Included to fit dissertation format</td>
</tr>
<tr>
<td>Methodology</td>
<td>Research methods – discussion of design case format, data collection and analysis methods, design case trustworthiness</td>
</tr>
<tr>
<td></td>
<td>Research questions included to fit dissertation format – based on goals of design cases</td>
</tr>
<tr>
<td>Chapter four:</td>
<td>Situating the design</td>
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<td>School library</td>
<td>Specific context of design</td>
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<td>makerspace design</td>
<td>Researcher’s statement of why others might find this design case interesting</td>
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<tr>
<td>process</td>
<td>Descriptions of members of makerspace design team</td>
</tr>
<tr>
<td></td>
<td>Researcher’s role as part of the design team</td>
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<td>Describing the design</td>
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<td>Detailed description of processes and decisions involved in the makerspace design process</td>
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<td>Included to fit dissertation format</td>
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<td>Makerspace design guidelines are included that were developed as part of THIS design case, but these are not intended as prescribed design guidelines for others</td>
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<tr>
<td>Chapter five:</td>
<td>Describing the design</td>
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<tr>
<td>Results</td>
<td>Rich, thick description of completed design, a school library makerspace in action</td>
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<td>Depicting the experience of the design</td>
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<td>Rich, thick description of students’ experience participating in the school library makerspace, including elements of the design evident in students’ experience</td>
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<td>Chapter six:</td>
<td>Transparency in the analysis</td>
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<tr>
<td>Discussion and</td>
<td>Discussion and reflection of design failures, unexpected results, areas of possible design improvement</td>
</tr>
<tr>
<td>Implications</td>
<td>Included to fit dissertation format</td>
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<td></td>
<td>Lessons learned from design process and makerspace implementation, but not intended to be generalizable to others’ design contexts</td>
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Data Collection and Analysis

A primary goal of a design case is to provide a rich, thick description of the design process, the resulting design, and the user’s experience of the design, providing, as described by Geertz, “a sense of what it is like to experience that setting from the standpoint of the natural actors in that setting” (as cited in Schutt, 2012, p. 286). As such, multiple sources of data were collected and analyzed to help create this description. Below is a brief discussion of the data sources collected and analyzed to answer the research questions of this study.

Research Question One

Research Question 1: What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district?

Data Collection and Analysis

Research question one is answered through a detailed narrative account found in Chapter Four which describes the members of the makerspace design committee and presents the processes and decisions involved in the design of school library makerspaces organized around a separate discussion of the components of the design.

Biographical member data

Biographical data was collected from the nine members of the makerspace design committee (excluding myself) to assist with the descriptions of them. I first developed a Google survey asking each member to tell the “story” of how they came to learn about makerspaces and how they came to try implementing one in their libraries. They were asked to differentiate between their knowledge of and experience with makerspaces prior to and after joining the makerspace design committee. I used the
information in these surveys to type a rough draft of a description of each design team member.

Upon typing up these rough drafts, I realized additional information regarding the members’ professional experience in the field of education, and, specifically, in the field of library science, would also be informative. As such, I sent an email to each member asking how many years they had been in education, how many years they had been a library media specialist, how many years they had worked for their current school district (context of this study), and how many years they had been in their particular building/library. This additional information was incorporated into the rough draft descriptions of the design team members. Where I felt there were gaps in the information, I included questions within the text that I highlighted using the word processing highlight function to differentiate them from the description and to call attention to them.

Each member of the design committee was then asked to review my description of her and to provide feedback. Members provided additional information, corrections, or clarifications that I used to revise the descriptions. These descriptions were then included in Chapter Four to help situate the design (C.D. Howard, 2011).

**Document review**

As a member of the design team, I had first-hand knowledge of all processes and decisions involved in the design of school library makerspaces in my school district. As library coordinator for the school district who was leading the design team, I also had ready access to a wide variety of documents pertaining to the process. These included documents regarding the planning of the design committee meetings, documents and resources that were used for activities during the meetings, and various versions of
documents showing the work that resulted from the meetings. Table 3-2 shows the variety of documents I reviewed to assist with the description of the processes and decisions involved in the design of school library makerspaces, though not all of them were utilized in the final description.

Table 3-2. Design process documents reviewed by researcher

<table>
<thead>
<tr>
<th>Meeting planning documents</th>
<th>Documents and resources used during meetings</th>
<th>Results of committee work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makerspace meeting agendas from Fall 2016 meetings</td>
<td>Researcher’s meeting notes on agendas from fall 2016 meetings</td>
<td>Multiple versions of logic model showing revisions</td>
</tr>
<tr>
<td>Email communications between researcher and design committee members to determine best dates for meetings</td>
<td>Logic model draft with researcher’s notes from collaborative work at meetings</td>
<td>Multiple versions of innovation configuration map showing revisions</td>
</tr>
<tr>
<td>Screen shot of list of researcher’s calendar appointments showing dates of meetings and makerspace visit</td>
<td>Innovation configuration map template with researcher’s notes from collaborative work at meetings</td>
<td>Working version of makerspace “theme” areas with activities document</td>
</tr>
<tr>
<td>Online collaborative document for initial logic model creation (prior to first meeting)</td>
<td>Online collaborative document used to develop makerspace “theme” areas with activities</td>
<td>Multiple versions of guidelines for environment, activities, and facilitation showing revisions</td>
</tr>
<tr>
<td></td>
<td>Online collaborative document and various resources used to develop guidelines for environment, activities, and facilitation</td>
<td>Multiple versions of guidelines based on EMPM showing revisions</td>
</tr>
<tr>
<td></td>
<td>Researcher’s EMPM and online collaborative document used to develop additional guidelines based on EMPM</td>
<td>Multiple versions of mission and vision statements showing revisions</td>
</tr>
<tr>
<td></td>
<td>Hand-written brainstormed list of concepts for mission and vision statements</td>
<td>Google drive folders used as a resource repository for librarians wanting to implement makerspaces</td>
</tr>
<tr>
<td></td>
<td>Online collaborative document for revising mission and vision statements</td>
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<tr>
<td></td>
<td>Student reflections of participation in school library makerspace collected by one design team member</td>
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<td></td>
<td>District grant guidelines and instructions</td>
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<td></td>
<td>District K-3 science instructional alignment guides</td>
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<tr>
<td></td>
<td>Researcher’s meeting notes regarding makerspace connections to K-3 science instructional alignment guides</td>
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</table>
I reviewed the documents to determine which components of the design and of the design process to include in the development narrative and to ensure accuracy of events and timelines of the process. Many of these documents were used to write a rough draft of the narrative, and images of those documents were included in Chapter Four along with the textual description to provide the reader with a clearer picture of the processes used and the work that resulted from them.

Once I had a rough draft of the development narrative of the design process in hand, it was presented to the members of the design committee to review. The design committee was asked to provide feedback in the form of additional information about any processes that I had overlooked or corrections to my recollections of specific events. Though I am the library coordinator for the school district and assists building principals with the evaluation process for district librarians, I do not have direct evaluative authority over the librarians. Plus, the collaborative development and revision of various documents was a standard practice of the makerspace design committee. Therefore, I believe that the members of the design committee were comfortable providing honest feedback regarding the processes and events involved in the design of school library makerspaces. This feedback was then used to revise the development narrative.

**Research Questions Two and Three**

Research Question 2: What is the resulting school library makerspace implementation?

Research Question 3: In what ways do students experience participation in the resulting school library makerspace?
Data Collection

Data collection pertaining to research questions two and three consisted of qualitative observations of the makerspace and student participation in the makerspace, interviews with the school library media specialist overseeing the makerspace as well as with the classroom teacher who accompanied her students to the makerspace, and interviews with eight of the students who participated in it. In addition, I took pictures of the makerspace, students participating in the makerspace, and student projects. The paragraphs below provide more detailed information regarding the collection and analysis of this data.

Sampling: Resulting makerspace implementation

At the time of this study, there were twelve school libraries in my district with some level of makerspace implementation. Purposive sampling was used to select the library makerspace in Elementary School Four as the makerspace to be described in detail in Chapter Five as the result of the design process. The selection was determined based on the following criteria: the librarian was a member of the design committee; there was a dedicated space for the makerspace; participation in the makerspace was primarily student self-directed rather than based on a project-based learning unit or a design challenge; student makerspace participation took place during the regular school day; the building principal was supportive of the library makerspace and of participation in this study; and there was consistency in the group of students participating in the makerspace such that parental and student consent could be reasonably obtained.

Elementary School Four had a student enrollment of 506 with a free and reduced lunch percentage of 67.4 during the 2015-2016 school year. The student body
consisted of approximately 19.2% Black students, 15.8% Hispanic students, 6.9% Multiracial students, and 50.8% White students. The principal in this building is very supportive of the school library makerspace. In fact, the principal’s enthusiasm for makerspaces prompted the librarian to explore them and ultimately incorporate one in her library. Too, the principal dedicated the use of a former computer lab to the development of a school library makerspace, even having a section of concrete block wall removed so that a connecting doorway between the library and the makerspace could be installed.

The specific class observed participating in the makerspace was Mrs. Mosier’s 5th grade class, a class of 23 students consisting of 15 boys and 8 girls. This class was purposively selected on the recommendation of the school librarian as they had participated in the makerspace multiple times prior to the study and because the teacher was very supportive of the makerspace and her students’ participation in it. Too, as they were 5th grade, the librarian and I believed they would be more comfortable in an interview situation.

**Observations of school library makerspace**

For this study, I observed the library makerspace in Elementary School Four three times during students’ regularly scheduled bi-weekly 30-minute visits to the makerspace. I conducted qualitative observations of students in the makerspace primarily as a participant observer taking the role of a complete observer (Schutt, 2012). According to Schutt (2012), a complete observer is “a role in participant observation in which the researcher does not participate in group activities and is publicly defined as a researcher” (p. 287). The role of complete observer still allows the researcher to observe and interact with students while they are participating within the context of the
makerspace, but she is not participating in the activities with the students and her researcher status is known. In order for students to become accustomed to my presence and, therefore, not act differently than normal during the observations (Schutt, 2012), I visited the makerspace twice prior to the actual observations. I also took pictures of the makerspace itself, students participating in the makerspace, and student projects.

Prior to the observations, I developed the School Library Makerspace Observation Protocol seen in Appendix A to record notes or “jottings” (Schutt, 2012) during the observations. The rough draft of this protocol underwent review by my dissertation committee, and an additional section was added to record general observations during the students’ first ten minutes in the makerspace based on the advice of the committee. I piloted the revised observation protocol twice prior to the actual observations with Mrs. Mosier’s class to practice using it to record observations. One pilot was conducted with Mrs. Mosier’s class, and the other pilot was conducted with another 5th grade class in the same elementary school. During the first pilot, I arrived thirty minutes before students were expected in order to observe the makerspace itself. While students were working in the makerspace, I constantly roamed around attempting to catch snippets of student behaviors and conversations. At the end of the makerspace visit, however, I did not feel that I had gathered much useful data. During the second pilot while students were working, I stayed in one area for five to seven minutes, focusing on the behaviors and conversations of the student or students in that area before moving to another area of the makerspace to repeat the process. I felt I collected more useful data using this method, so this is the method I
used for the three observations that were part of this study. The observation data collected during both pilots regarding the makerspace itself as well as student behaviors that were captured during the pilot involving Mrs. Mosier’s class were included in the data analysis for this study.

The first section of the protocol allowed me to note such information as the school where the observation took place, the date and time of the observation, and the number of students present during the observation. It also provided space for me to record the physical attributes of the makerspace based on the design and facilitation guidelines developed by the makerspace design team. Individual areas in this section of the observation protocol align to guidelines developed by the design team regarding the aspects of the makerspace environment, activities, and facilitation. Additional individual areas in this section of the observation protocol align to additional guidelines developed by the team based on the EMPM. There is also an individual area in this section of the observation protocol for me to record additional attributes of the physical environment that may not fit into the other areas. I arrived at the school thirty minutes prior to the time students were scheduled to use the makerspace to take pictures of the space and to observe the space itself absent of students using this first section of the protocol.

Once students arrived to the space, I used the second section of the protocol to record student, librarian, and teacher actions, behaviors, and comments. The protocol included a section to record general observations during the first ten minutes of the students’ time in the makerspace and columns designated for observations of students, the librarian, and the teacher. Observations of the librarian and the teacher were
recorded in a single column, and I designated librarian observations with an “L” and teacher observations with a “T” within the column. While I did utilize this column a bit, the vast majority of data collected fell into the student behaviors column.

For the first ten minutes of each observation of student participation in the makerspace, I positioned myself in an area of the makerspace where I could observe the entire space and take note of what was happening. After the first ten minutes, I selected an area within the space where students were working on a project of interest, and stationed myself there for five to seven minutes to record student behaviors and conversations. After five to seven minutes, I would re-locate to another area of the makerspace to observe other students. During each observation, I was able to observe two to three different areas of the makerspace using this method. When I saw something of particular interest, I approached the students involved in the interesting act and questioned them to learn more. I had done this in my visits to the makerspace prior to the actual observations, so students were accustomed to this practice.

A third column on the School Library Makerspace Observation Protocol was dedicated to observer comments. The intent of this column was for me to record my thoughts or feelings during the observation, though I only used this column a few times during the study. I used a laptop to record observations on the protocol during each observation. In addition to these typed observations, I took pictures of students participating in the makerspace as well as of student projects.

The third and final section of the protocol had a space at the top to record information such as the school name, the date, and the time of the observation. The rest of the section was blank except for a heading indicating the blank space was to be
used for observer reflections and a summary of the observation. In the 30 minutes immediately following each live observation, I used this section of the protocol to write more detailed and highly descriptive field notes (Merrian, 2009; Patton, 2002) from the “jottings” on the previous sections of the observation protocol.

Interviews of students, librarian, and teacher

According to Patton, “we interview people to find out from them those things we cannot observe. . . . We cannot observe feelings, thoughts, and intentions” (as cited in Merriam, 2009). In order to get a clearer picture of students’ experience of participation in school library makerspaces, I conducted standardized open-ended interviews (Patton, 2002) of eight students who had participated in the observed makerspace. I planned to select students for interviews according to the following criteria: both males and females represented in the interviews; students participating in a variety of making activities, at a variety of phases in the making process, and at a variety of levels of engagement during their time in the makerspace visit so that a variety of perspectives would be represented; students who the librarian believes would be comfortable being interviewed; and students whose parents had signed consent for them to be interviewed. As it turned out, only eight students were eligible to be interviewed based on parental consent and child assent, so I opted to interview all eight students. The eight students interviewed consisted of two females and six males who were at a variety of phases in their making process during the study. All eight students were at a comparable level of engagement during the observations, however, so this selection criteria was not met. All eight seemed comfortable being interviewed and all eight had appropriate permissions to be interviewed.
I developed the student interview questions with the primary goal of collecting additional data regarding students’ experience of participation in the school library makerspace. Depicting the user’s experience of the design is one of the five categories C.D. Howard (2011) recommends including in the framework of a design case, and it is on this category that research question three of this dissertation is based. Questions one through three of the student interview protocol are general questions about the use of the makerspace intended to capture the student’s thoughts and feelings regarding their participation in the space. Questions four through twenty are aligned to the various parts of the EMPM I developed and on which several design and facilitation guidelines developed by the makerspace design committee were based. These questions are intended to help determine how successful the design of these spaces was based on the extent to which students experience making as a process within them. These questions are also intended to make clear which of the design and facilitation guidelines developed by the design team are evident in the user’s experience of the resulting makerspace implementation and which are not. Question twenty-one is intended to identify areas of needed improvement in the design of school library makerspaces from the perspective of students. This speaks to another of C.D. Howard’s (2011) categories, transparency in the analysis, wherein he recommends discussing both the successes of and areas of needed improvement in the design. The final student interview question is very open-ended and allows the student to tell me anything else about participation in the school library makerspace that he wants to share. The intent of this question is to capture additional aspects of the student experience of participation in the makerspace that may not fall into the areas of focus of the other
questions. The student interview protocol including the interview questions can be found in Appendix B.

After completing a rough draft of the student interview questions, on the advice of my committee chair, I reviewed existing literature regarding interview techniques with children to ensure they were appropriate for the grade level to be interviewed (Docherty & Sandelowski, 1999; Hatch, 1990; Irwin & Johnson, 2005; Kortesluoma, Hentinen, & Nikkonen, 2003; Krähenbühl & Blades, 2006). However, I felt the questions were in line with recommendations in the literature for 5th grade students, so no changes were made to the questions. Also on the advice of my committee chair, I conducted a pilot interview with a 5th grade student in a different class at Elementary School Four to ensure the interview questions would be easily understood and that no adjustments to the questions needed to be made prior to the actual student interviews that would be part of this study. Again, as the interview went well and I felt the student readily understood all questions, no changes were made, and the original questions were used to conduct the student interviews.

In addition to student interviews, I conducted a standardized open-ended interview (Patton, 2002) with the media specialist who oversees the makerspace in Elementary School Four and with the classroom teacher who accompanied her students in the makerspace. My purpose for these interviews was two-fold: to capture the librarian’s and the teacher’s perspectives of students’ experiences in the makerspace and to find out more about the librarian’s design and implementation of the makerspace.

I developed the librarian interview questions with the main goal of determining which design and facilitation guidelines developed by the design team were evident in
the resulting makerspace implementation by the librarian. Question one of the interview protocol (and any follow-up questions) aligns to design guidelines developed by the design team regarding the makerspace environment and activities. Question two is aligned to the Innovation Configuration Map developed by the design team which established acceptable parameters for makerspace implementation. Questions three through fifteen are aligned to the various parts of the EMPM I developed and on which several design and facilitation guidelines developed by the makerspace design committee were based. These questions are intended to help describe the resulting makerspace implementation based on the design guidelines and to determine how successful the design of these spaces was based on the extent to which the librarian facilitates student making as a process within them. The next section of the protocol, questions sixteen through nineteen, are intended to help identify areas of needed improvement in the design of school library makerspaces from the librarian’s perspective. This data will help address the recommendation of C.D. Howard (2011) to include in a design case not only the successes of a design but also design failures or areas of needed improvement. The final question on the librarian interview protocol is very open-ended and provides an opportunity for the librarian to tell me anything else regarding her students’ participation in the school library makerspace that she wishes to share. The intent of this question is to capture other aspects of student participation in the school library makerspace from the librarian’s perspective that may not fall into the areas of focus of the other questions. The librarian interview protocol including the interview questions can be found in Appendix C.
I developed the teacher interview questions with the primary goal of capturing an additional perspective of students’ experience of participation in the school library makerspace. This data helped address the category of depicting the experience of the design, one of the categories recommended by C.D. Howard (2011) for inclusion in a design case. Another goal of the teacher interview questions was to determine an additional perspective regarding which design and facilitation guidelines were evident in the resulting makerspace implementation and, therefore, part of the student experience of participation in the space. Questions one and two of the teacher interview address the teacher’s overall goals for her students’ participation in the makerspace to determine how they align with the acceptable guidelines for makerspace implementation developed by the design team and defined on the Innovation Configuration Map.

Questions three through fourteen are aligned to the various parts of the EMPM I developed and on which several design and facilitation guidelines developed by the makerspace design committee were based. These questions are intended to help describe the resulting makerspace implementation based on the design guidelines and to determine how successful the design of these spaces was based on the extent to which students experience making as a process within them. Questions fifteen through seventeen speak to areas of success and areas of needed improvement in the makerspace from the teacher’s perspective and help address C.D. Howard’s (2011) recommendation to include both in a design case. The final question on the teacher interview protocol, question eighteen, is very open-ended and provides an opportunity for the teacher to tell me anything else regarding her students’ participation in the school library makerspace that she wishes to share. The intent of this question is to
capture other aspects of student participation in the school library makerspace from the teacher’s perspective that may not fall into the areas of focus of the other questions. The teacher interview protocol including the interview questions can be found in Appendix D.

Student, librarian, and teacher interviews were audio recorded using my laptop computer as the recording device. Once all interviews had been conducted, they were transcribed by a professional transcription service. I then listened to the audio recordings of the interviews while reading through the transcripts, making corrections where needed. The audio recordings of the interviews were then deleted from my computer.

**Data Analysis**

I used thematic analysis (Braun and Clark, 2006) to analyze the data across both the observations and the interviews. The first step of thematic analysis is to become familiar with the data. As I am the one who conducted both the observations and the interviews for this study, I already had some familiarity with the data. I became more familiar with the interview data through the process of reading through each transcript while listening to the audio of the interview and making corrections as needed. Additionally, I read through each transcript another time and read through all observation data twice. Once I was sufficiently familiar with the data, I began two separate rounds of data analysis for research questions two and three.

I used a deductive or theoretical approach to thematic analysis to code for elements of the design that were found in the resulting makerspace. This deductive approach was based on the work of the makerspace design committee, including the Innovation Configuration Map and the various design and implementation guidelines.
developed by the team. I created an a priori list of codes based on the ICM and the design and implementation guidelines. Observation and interview data were uploaded into NVivo, software used to code data. I then began step two of the thematic analysis process, generating initial codes. I read through all interview transcripts and observation data in NVivo, applying to it the codes from the a priori list I previously created. When all data had been coded, I started searching for themes, which is the third step of thematic analysis.

Unfortunately, my inexperience with the NVivo program made this step more difficult than it might otherwise have been. Because I uploaded the observation protocols into NVivo in table format, I was unable to run an easy-to-read report of all data coded with the same a priori code. When attempting to do so, the report included not just a listing of each similarly coded data extract, but the complete table of data in which each extract originally appeared. This was not conducive to searching for themes, so I devised a different method for this step.

I set up an Excel spreadsheet which included a separate sheet for each of the a priori codes I had developed. I copied and pasted the coded data from NVivo for each of these codes onto the appropriate sheet and added a column on each sheet where I could record “noticings,” “summaries,” or “potential themes” from the coded data. I sorted and resorted the data on each sheet until it all fit into one (or sometimes multiple) of these “noticings.” I used a third column on each sheet to record the file names of any pictures that supported or exemplified the various potential themes. Once this was completed for each a priori code, I copied the “noticings” from each code onto a single new sheet within the spreadsheet. I then printed out the combined list of “noticings” and
cut them into individual strips which I then organized and reorganized into piles based on similarities between them. I applied a potential name to each resulting pile which I then continued to synthesize based on connections between them. Finally, I added another new sheet to the spreadsheet listing these potential themes and included pertinent data extracts along with each one.

Step four of thematic analysis involves reviewing the potential themes, and I next moved on to this step. I read through the themes developed for research question two as well as the data extracts supporting each, adding a few subthemes, tweaking the placement of some data extracts, and combining repeated data extracts. I also read back through all interview and observation data and added a few additional data extracts which supported the potential themes and subthemes. Once this step was complete, I added a final new sheet to the spreadsheet wherein I named and defined the two themes for research question two, which is the fifth step of thematic analysis. Rather than continuing to step six, writing the report, I next started the second round of data analysis for research question three.

For research question three, I used an inductive approach to thematic analysis in order to discover the students’ experience of participation in the makerspace. As I was already familiar with the data, I moved directly to step two, generating initial codes. To avoid the difficulty experienced with the data analysis for research question two, I first copied and pasted all information from each cell of the observation protocols into NVivo as text rather than as part of a table. I then read through all of the data and applied codes based on the data itself rather than on an a priori list as was done for research
question two. Seventy unique codes were developed and applied to the data during this step.

I next began to search for themes, step three of thematic analysis. I printed out the list of all seventy codes from NVivo, and used a color coding system with different colored highlighters to sort the codes based on similarities between them. I then began to develop potential themes into which each group of similarly highlighted codes would fit. After several drafts of potential themes, I developed a list of seven potential themes for research question three.

For step four of the thematic analysis process, reviewing potential themes, I read back through all data extracts now associated with each theme as well as the entire data set, slightly tweaking which data extracts were associated with which themes. I also eliminated one theme as it was not well-supported by the data, leaving six themes for research question three. I then set up cases in NVivo for each theme and associated each node of coded data falling within that theme with the case. I was then able to print out all data associated with each case, or theme, to use while writing the report for each theme. Finally, I set up an Excel spreadsheet for research question three wherein I named and defined each of the six remaining themes for this question.

Now that data analysis for both research question two and research question three was complete, I moved on to step six of thematic analysis, producing the report. The outcome of this step was Chapter Five of this dissertation, the Results chapter. During the writing of this chapter, I made additional adjustments to the names of the themes and subthemes and some of the specific data extracts associated with them as the organizational structure of the chapter evolved, though the themes and subthemes
identified through the data analysis process remained largely intact. Upon completing the rough draft of Chapter Five, I asked the librarian involved in the study to review it to ensure it rang true based on her experience working with students in the makerspace. A few minor changes were made based on the feedback of the librarian, such as a correction to the list of robots available to students in the makerspace and specific grants the librarian applied for to get funding for the makerspace.

**Design Case Trustworthiness**

Following is a list of elements of trustworthiness recommended by Kennon Smith (2010) in his article titled “Producing the Rigorous Design Case,” to establish trustworthiness in a design case. For each element, there is a discussion of what I did for each element to ensure the trustworthiness of this design case dissertation.

**Prolonged engagement with phenomenon under investigation.** As the library coordinator for my school district, I was directly involved in the design and implementation process of school library makerspaces in my district from the beginning. Along with other librarians in the district, I attended various conference sessions on school library makerspaces, read trade journal articles about them, and considered how they might fit into the school library program well before the makerspace committee of librarians interested in developing implementation guidelines was developed. I also led a summer session for district librarians interested in learning more about makerspaces, led a professional development session on makerspaces with all librarians during the school year, formed the makerspace committee of librarians, and led the meetings of the makerspace committee. Additionally, as a doctoral student of the University of Florida’s Educational Technology program, I spent the two years prior to this study reading literature pertaining to and learning about school library makerspaces.
In order to present a trustworthy account of students’ experience of participation in a school library makerspace resulting from the work of the design team, I observed the same group of students participating in one of the makerspaces three times. These observations occurred after I spent two previous sessions in the makerspace with this same group of students to ensure they were comfortable with my presence.

**Persistent observation of salient elements.** As library coordinator for my school district and as a member of and leader of the makerspace design team, I had first-hand knowledge of the prominent processes used and decisions made during the design of school library makerspaces. It is this knowledge that allowed me to determine which elements to highlight in the description of the design process. I also used this knowledge, along with observations of students participating in the space and interviews of students, the librarian, and the classroom teacher, to determine which elements to highlight in the description of the resulting school library makerspace.

**Triangulation of data.** In order to establish trustworthiness of my description of the process used to design school library makerspaces in my district as well as to describe the resulting implementation of those makerspaces, I used a variety of sources of data. Sources of data used include biographical information about members of the design team, documents pertaining to the design process, observations of students participating in the resulting makerspace, and interviews with students, the librarian, and the classroom teacher.

**Negative case analyses.** As part of the description of the design of school library makerspaces in my district in Chapter Four of this dissertation, I increased trustworthiness by presenting multiple versions of documents such as the Logic Model,
the Innovation Configuration Map, the mission and vision statement, and the design guidelines developed by the design team to show the changes that were made to the documents along the way to the final version. I also discussed both successes and areas for improvement in the resulting school library makerspace.

**Member checks.** To ensure accuracy in the description of the process used to design and implement school library makerspaces in my district, I utilized members of the design committee to review and provide feedback on my rough draft. Though I am the library coordinator for the school district and assists building principals with the evaluation process for district librarians, I do not have direct evaluative authority over the librarians. Plus, the collaborative development and revision of various documents was a standard practice of the makerspace design committee. Therefore, I believe that the members of the design committee were comfortable providing honest feedback regarding the processes and events involved in the design of school library makerspaces. Revisions to the rough draft were made based on this feedback.

Additionally, after I drafted the descriptive narrative of Elementary School Four’s school library makerspace and the ways in which students experience participation in it for Chapter Five, the librarian who oversees and facilitates this school library makerspace reviewed the chapter to ensure the themes and descriptions rang true based on her experience of working with students in the space. A few slight corrections were made to the chapter based on her feedback, such as the list of specific robots available to students in the space.

**Thick description.** To ensure the reader develops a deep understanding of the school library makerspace design process used, I included in the description such
things as the decisions made, who was involved, and changes that were made during the process. I also used thick description to ensure the reader gains a thorough understanding of the resulting makerspace implementation and the students’ experience of participation in it. Thick description is description whose level of specificity allows the reader to see and feel the setting and actions within the setting from the perspective of those in it (Creswell, 2014; Patton, 2002; Schutt, 2012). For instance, rather than stating “students were excited," one might instead state, “as students were standing in line to enter the dinosaur exhibit, they were chattering nervously about what they were about to see and several of them were waving their hands to animate their thoughts. Others were standing on tip toe, attempting to see over the heads of their classmates to get a sneak peek into the room they were about to enter.” Oftentimes, thick description is presented in written form in research reports, but in a design case, it may also include multiple pictures, representations of various stages of the design process, documents, and other non-text artifacts (Boling & Smith, 2009; Smith, 2010).

**Audit trails.** I kept an audit trail in the form of a folder holding the documents used during the document review. Documents held as part of the audit trail include original items such as hand-written notes regarding planning meeting times, hand-written meeting notes, and initial hand-written collaborative work. Also part of the audit trail are multiple versions of documents such as the Logic Model, the Innovation Configuration Map, the mission and vision statement, and the guidelines developed by the design team. Biographical information submitted by members of the design committee were also included as part of the audit trail. In addition, I developed an audit
trail as part of the thematic analysis of observations and interviews which traces how
the raw data were analyzed and how the resulting themes were identified.

**Ethical Considerations**

Prior to the start of the study, all IRB requirements were met, including participant
consent agreements. The nature of the study was explained to participating students,
librarians, and teachers so that they were aware of the questions the study hoped to
answer. All data collected was kept confidential, and pseudonyms were used in place
of student, librarian, and teacher names to protect participant privacy.

**Potential Limitations to Design**

As a design case, a limitation of the design is that no causal connections can
result. Rather, the design case is intended to provide a rich description of the design
and implementation process of bringing school library makerspaces to my school
district, the resulting makerspace implementation, and the students’ experience of
participation in the makerspace. The purpose of such is to record and preserve the
precedent knowledge of the design team. The results of this study might lead to new
research directions or assist others in future design processes rather than providing
specific answers.

**Subjectivity Statement**

I have worked in the school district that was the location of this study for fourteen
years. For most of those years, I served as a library media specialist at both the
elementary and middle school levels. During this study, however, I was serving in my
fifth year as Library Coordinator for the district. Though I do not have direct evaluative
authority over the district librarians, I do assist principals with the evaluation cycle by
conducting a management observation of librarians. My position is also considered a
leadership position in which I oversee the district libraries. While this afforded me a unique perspective of the design and implementation of school library makerspaces in my district, this relationship with the library media specialists also has the potential to have influenced this study.

I first learned about school library makerspaces through workshops sessions at a state library conference. I continued to learn more about them through various conference sessions, trade journal articles, conversations with other librarians, and a visit to a library makerspace in a neighboring school district. As a doctoral student, I focused on school library makerspaces as my area of specialization. As such, I had spent approximately one and a half years reading extensively about makerspaces prior to the formation of the makerspace design committee. I continued to read extensively about them after the committee began its work. There is the potential that my background in and knowledge of makerspaces impacted the design and implementation process described in this dissertation.

As library coordinator for my district, I was approached by a group of district librarians in the summer of 2015 who wanted to learn more about makerspaces, so I held a three-hour workshop in July of 2015 wherein attendees learned about makerspaces. In the fall of 2015, several media specialists expressed an interest in starting a makerspace in their library, so I formed and led a makerspace design committee in its work to develop guidelines for the design and implementation of library makerspaces in the district. The fact that I was both the researcher of this study as well as the library coordinator of the district who was leading the makerspace design committee may have influenced the study.
I made an ongoing effort throughout this study and throughout the data collection and analysis process to remain as objective as possible to combat the above limitations. I also used rich, thick descriptions of the design process, the resulting makerspace implementation, and students’ experience of participation in the makerspace as well as member checks of the resulting descriptions to further overcome the above limitations.

Chapter Summary

This chapter established the design case framework that will be used for this study. It also reiterated the problem of practice, the study’s purpose and the study’s research questions. Additionally, this chapter presented the study’s conceptual framework, discussed the methods used for data collection and analysis, provided information as to the trustworthiness of the study, and discussed ethical considerations and limitations. Chapter Four will speak to research question one and will present the professional context of the study and the processes used and decisions made during the school library makerspace design process in my district. Chapter Five will speak to research questions two and three, presenting and discussing the results of school library makerspace observations and interviews of students, a librarian, and a teacher I conducted as part of the study. Finally, Chapter Six will discuss both successes of school library makerspace implementation in my district as well as areas for improvement.
CHAPTER 4
SCHOOL LIBRARY MAKERSPACE DESIGN PROCESS

The purpose of this design case dissertation is to provide a detailed and thorough account of the design process the makerspace committee of librarians went through to bring makerspaces to the library program in my school district in order to preserve and share the precedent knowledge gained through the process (C. D. Howard, 2011). This account will include detailed information both about the design process itself as well as the resulting implementation of makerspaces based on the design and will speak to both the successes of the design as well as any areas of needed improvement.

This chapter will address the study’s first research question: What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district? I will first situate the design by describing the specific professional context of the design, stating why I believe this design case will be of interest to others, describing the members of the design team, and detailing my role in the design process and as a member of the design team. Next, I will describe in detail the most pertinent components of the design process based on my knowledge of the process as a member of the design team and on my review of pertinent documents pertaining to the design process. The description of these components will include decisions and changes that were made during the process. In addition to a textual description of the most pertinent components of the process, images of various documents relating to the design process will be provided, including the design and implementation guidelines developed by the design team for use by the district library program.
Professional Context

The following section of this chapter serves to situate the design of school library makerspaces in the context of my local district, one of the categories of a design case suggested by C.D. Howard (2011). This design case was developed in a large suburban school district in northwest Missouri. With nearly 20,000 students, it is one of the largest school districts in the state. The district currently consists of 21 elementary schools, 5 middle schools, and 4 high schools and plans to build two additional elementary buildings and to turn a current elementary school and a current middle school into sixth grade centers.

Student Demographics

As evident in the following data pulled from the state department of education website regarding student demographics for the 2015-2016 school year (“District Demographic,” 2016), the student body of this district is somewhat diverse, consisting of the following ethnicities: White (61.5%), Hispanic (13.4%), Black (12.8%), and Multi-racial (7.4%). The district’s student population also includes students of Asian, Indian, and Pacific Islander ethnicities, but the percentage of these student groups is unavailable at the district level. The district’s free and reduced lunch percentage is 48.6%, slightly below the state average of 51.7%.

School Library Facilities

The elementary libraries in this school district have brief, scheduled check-out times with each grade level on a weekly basis. During these scheduled check-out times, students are accompanied to the library by their teacher, and they have a set amount of time (usually 15-30 minutes) to find books and/or other materials to borrow from the library for the week. Students can also come to the library outside of their
scheduled check-out time to borrow books and/or other materials as needed. Elementary librarians have recently been added to the rotation of encore, or “specials,” classes, teaching 30 minute bi-weekly library lessons to provide common plan time for classroom teachers.

Middle school and high school libraries in this district operate on a more flexible schedule. The middle school libraries have regularly scheduled check-outs every few weeks, typically through the English Language Arts classes, while high school libraries operate on an “as-needed” check-out schedule. Rather than regularly scheduled library lessons, both middle school and high school librarians are available to collaborate with classroom teachers on an as needed basis for student research projects.

School Library Makerspaces in District

Of the thirty library facilities in this school district, twelve of them plan to have a makerspace of some sort in the library during the 2016-2017 school year. The implementation of these makerspaces is primarily based on an Innovation Configuration Map which outlines acceptable implementation parameters for these spaces. The Innovation Configuration Map was developed by a committee of librarians in the district who have begun to develop makerspace implementation guidelines for the district libraries. This design case will discuss the work of the makerspace design committee leading up to the initial implementation of these twelve school library makerspaces as well as additional design decisions made by the committee after the initial implementation.

Seven of the libraries that will have a makerspace this year are at the elementary level, though two of these facilities are run by the same librarian who is half-time at each of the two buildings. At the middle school level, four of the five library facilities plan to
have a makerspace during the 2016-2017 school year, but these will only be available to students after school as part of extended day activities. At the high school level, one of the four libraries plans to have a makerspace during the 2016-2017 school year.

As shown in Table 4-1, the schools wherein the above listed school library makerspaces are located are quite diverse from each other regarding student enrollment numbers, ethnic diversity, and free and reduced lunch percentages. Together, they represent well the various demographics of the schools within the district. The library facilities are diverse regarding how the library makerspaces are currently being implemented, some devoting a permanent space to the makerspace and others utilizing mobile carts due to the lack of a permanent space. Though there is much overlap in the activities and/or resources available in each makerspace, each library has the latitude to include specific activities and/or resources in the makerspace based on the needs and interests of its students. Together, these represent the current variety of types and implementations of makerspaces in the district’s library facilities.

Table 4-1. 2016 building demographics per state Department of Education

<table>
<thead>
<tr>
<th>School</th>
<th>Enrollment</th>
<th>Free &amp; reduced (%)</th>
<th>Asian (%)</th>
<th>Black (%)</th>
<th>Hispanic (%)</th>
<th>Indian (%)</th>
<th>Multi-race (%)</th>
<th>Pacific Islander (%)</th>
<th>White (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary 1</td>
<td>627</td>
<td>30.9</td>
<td>*</td>
<td>9.70</td>
<td>10.70</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>71.30</td>
</tr>
<tr>
<td>Elementary 2</td>
<td>498</td>
<td>79.9</td>
<td>11.20</td>
<td>22.10</td>
<td>14.10</td>
<td>*</td>
<td>7.20</td>
<td>*</td>
<td>40.00</td>
</tr>
<tr>
<td>Elementary 3</td>
<td>742</td>
<td>68.3</td>
<td>*</td>
<td>15.00</td>
<td>13.60</td>
<td>*</td>
<td>7.50</td>
<td>*</td>
<td>60.20</td>
</tr>
<tr>
<td>Elementary 4</td>
<td>506</td>
<td>67.4</td>
<td>*</td>
<td>19.20</td>
<td>15.80</td>
<td>*</td>
<td>6.90</td>
<td>*</td>
<td>50.80</td>
</tr>
<tr>
<td>Elementary 5</td>
<td>372</td>
<td>22.7</td>
<td>*</td>
<td>*</td>
<td>7.50</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>82.80</td>
</tr>
<tr>
<td>Elementary 6</td>
<td>332</td>
<td>52.6</td>
<td>*</td>
<td>14.20</td>
<td>*</td>
<td>9.60</td>
<td>*</td>
<td>*</td>
<td>68.70</td>
</tr>
<tr>
<td>Elementary 7</td>
<td>370</td>
<td>54.3</td>
<td>*</td>
<td>9.20</td>
<td>18.10</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>62.40</td>
</tr>
<tr>
<td>Middle School 1</td>
<td>924</td>
<td>44.7</td>
<td>*</td>
<td>8.10</td>
<td>13.20</td>
<td>*</td>
<td>7.5</td>
<td>*</td>
<td>66.00</td>
</tr>
<tr>
<td>Middle School 2</td>
<td>838</td>
<td>64.5</td>
<td>*</td>
<td>18.00</td>
<td>16.00</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>56.00</td>
</tr>
<tr>
<td>Middle School 3</td>
<td>1164</td>
<td>21.0</td>
<td>*</td>
<td>7.40</td>
<td>8.90</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>75.70</td>
</tr>
<tr>
<td>Middle School 4</td>
<td>812</td>
<td>61.6</td>
<td>*</td>
<td>16.60</td>
<td>15.00</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>55.40</td>
</tr>
<tr>
<td>High School</td>
<td>1439</td>
<td>43.9</td>
<td>*</td>
<td>11.00</td>
<td>14.50</td>
<td>*</td>
<td>8.80</td>
<td>*</td>
<td>61.50</td>
</tr>
</tbody>
</table>

*Percent suppressed due to potential small sample size
*"Building Demographic," 2016*
District Librarians Starting Makerspaces

Many of the librarians who plan to have a school library makerspace during the 2016-2017 school year have been part of the library program’s makerspace design committee. Therefore, they have some background knowledge of the philosophy behind makerspaces, have helped create initial makerspace implementation guidelines for the district’s library facilities, and are implementing their makerspaces based on these guidelines. Several of the librarians who plan to have a school library makerspace during the 2016-2017 school year, however, have either not been part of the makerspace committee or started implementing their makerspace prior to the formation of the design committee. As such, they were initially implementing the makerspace based on what they had seen at conferences, read in professional journals or online, or heard from other librarians who had started a makerspace. Moving from this haphazard approach to makerspace implementation to a more purposeful approach was the purpose behind the development of the makerspace design committee and the development of an Innovation Configuration Map outlining initial acceptable implementation parameters.

Why Makerspace Design Case Is of Interest to Readers

Another part of situating the design (C.D. Howard, 2011) is stating why the design case is of interest to readers. This design case is of particular interest to those attempting to implement makerspaces in their school libraries due to its use of the Educational Making Process Model I developed as the basis of a set of guidelines regarding the design and facilitation of makerspaces. Several librarians in the district started makerspaces based on what they had seen at conferences, read in professional journals or online, or learned through the release of initial implementation guidelines
The Educational Making Process Model (EMPM) was used by the design committee as the basis of additional design and facilitation guidelines for the district’s school library makerspaces. This design case will discuss the work of the makerspace design committee leading up to the initial implementation of school library makerspaces as well as additional design decisions made by the committee after the initial implementation, including those based on the EMPM.

The record of the processes used and decisions made in the design of school library makerspaces in my district as well as the guidelines for makerspace implementation developed by the design team could assist others in different contexts with their own makerspace design and implementation. The guidelines developed by the design team in my district should not, however, be considered a prescription for others to follow. Too, the EMPM could be used by others to support students in the process of making in an educational setting in order to provide the best opportunity for students to realize the many potential benefits of participation in these learning environments.

The design process described in this design case is relevant to me in my professional practice and to the librarians in my district as it has enabled us to be purposeful in our design and facilitation of school library makerspaces. It also has significance to the field of library science, as makerspaces have become quite popular in the field and many school librarians are implementing makerspaces in the hopes that they will have positive benefits to students. The design process described herein could assist any librarian in the field wanting to be purposeful about the design and
implementation of school library makerspaces in her context. The thorough description of the design process used to implement makerspaces in the school libraries in my district, and especially the use of the Educational Making Process Model within that design, also has relevance to the field of study of makerspaces as learning environments as the EMPM could contribute to the understanding of making as a learning process.

**School Library Makerspace Design Process**

In order to be purposeful regarding the design and implementation of school library makerspaces in my district, I formed a committee of school librarians to develop makerspace design and implementation guidelines to be used by district librarians when starting a library makerspace. All twenty-five of the district’s librarians were invited to be part of the committee, and those who were interested in serving on the committee signed up voluntarily. Of the district's twenty-five librarians (excluding myself), nine signed up to be part of the committee: five elementary librarians, three middle school librarians, and one high school librarian.

The committee began meeting during the spring semester of the 2015-2016 school year. Based on the work schedules of both myself and the librarians who volunteered for the committee, Friday was the day that worked best for the committee to meet during the school day. Meeting dates were set based on Friday dates and times (morning or afternoon) that allowed the highest attendance of committee members with the fewest substitutes needed to cover the librarians’ absence from school. During the spring semester of 2016, when a substitute was needed, it was paid for from my substitute budget. In the fall of 2016, the district’s professional development budget
began to cover the cost of substitutes when needed for committee members to attend meetings.

The first meeting of the makerspace design committee was Friday, March 11, 2016. The committee met five times during the spring semester of 2016, and all five meetings were from 9:00am to noon. During the fall semester of 2016, the makerspace design committee met five times, three times in the morning from 8:00am to 11:00am and two times in the afternoon from noon to 3:00pm. The committee met an additional four times during the spring semester of 2017. These meetings were all held in the morning from 8:00am to 11:00am. Though not all committee members were able to attend the meetings due to obligations in their buildings, a majority of members was in attendance at each meeting.

**Members of Makerspace Design Committee**

The makerspace design committee consisted of nine of the district’s library media specialists and myself. Each member of the committee, as is evident below, brought with her a different level of experience in the field of education, in the field of library science, and with the concept of makerspaces. The unifying factor of all members was the desire to learn more about the underlying principles of makerspaces and to bring the opportunity to create and innovate to students through the implementation of a makerspace in the school library. Members of the design team are described in the paragraphs below, as suggested by C.D. Howard (2011) as part of a design case.

Mrs. Morris is the library media specialist of Elementary School Two. She has been in the field of education for 31 years, the past 27 of which has been in her current school district, which is the context of this study. She has been a library media
specialist for the past 12 years, and is in her 8th year as the library media specialist at Elementary School Two. Her interest in makerspaces began a few years prior to the formation of the committee by reading about makerspaces online. She later had the opportunity to visit a library makerspace at a neighboring school district and became very excited about the opportunities it presented for her students. She took many notes and pictures of the makerspace and went to her principal to discuss the idea of starting one in her library. After convincing her building principal to go visit the neighboring district’s library makerspace, she gained his approval to move forward. Mrs. Morris wrote and received a district “site grant” to purchase items to begin a makerspace prior to joining the makerspace committee.

The first librarian in the district to begin to incorporate a makerspace into her library was Mrs. Aviary, the library media specialist at Elementary School Three. Mrs. Aviary has been an educator in her current school district, the context of this study, for 31 years, 10 of which have been as a library media specialist at Elementary School Three. Prior to the formation of the makerspace design committee, Mrs. Aviary had read extensively about school library makerspaces in books and in scholarly articles, participated in makerspace webinar sessions, and attended various workshop sessions about makerspaces at the state conference for school librarians. She also visited with librarians in other school districts who had already implemented makerspaces as well as a few of the students who had been participating in the makerspace and their parents. Mrs. Aviary also served on a long-range planning team for her building, wherein she worked with a team of teachers to research, plan for and begin to implement a school library makerspace in her library. This extensive prior knowledge of
and experience implementing a school library makerspace was quite valuable to the makerspace design team.

Mrs. Sprague has been in the field of education for seven years, the past six years as the library media specialist in her current district, the context of this study, at Elementary School Four. Prior to the formation of the makerspace design committee, Mrs. Sprague had already established a solid understanding of school library makerspaces. Though she had heard of them for some time, it was her building principal’s excitement about their potential impact on student learning after attending a STEM conference and her subsequent support that sparked Mrs. Sprague to move forward, learn more, and begin working toward establishing a makerspace in her own library. She began to follow various leaders in the field on social media and to read books about makerspaces written by these leaders. She also discussed various aspects of makerspaces with other library media specialists both locally and around the country through email, regional librarian workshops, and social media. This knowledge helped Mrs. Sprague begin to plan for and implement a makerspace in her school library, knowledge that Mrs. Sprague lent to the makerspace design committee upon its inception.

Mrs. Roberts is the library media specialist at both Elementary School Five and Elementary School Six, working half-time in each building. She has been in the field of education for 19 years, fifteen of which have been in her current school district. She has been a library media specialist for the past two years. Her first introduction to school library makerspaces was at a district meeting of elementary library media specialists where the idea was briefly mentioned and some ideas for possible
makerspace activities were explored. At a later professional development meeting of
district library media specialists, she had the opportunity to rotate through various
makerspace activities along with her colleagues. Though Mrs. Roberts joined the
makerspace design committee with minimal knowledge of the pedagogy behind
makerspaces and what it might look like in a school library, she was eager to bring the
experience of making to her students and was devoted to learning more and helping
determine how the district’s libraries might implement makerspaces.

Mrs. Ralston is an elementary library media specialist who splits her time
between two buildings, including Elementary School Seven, working half-time in
each. She has 17 years of experience in education, eleven of which have been as a
library media specialist. Mrs. Ralston has been in her current school district for nine
years. Prior to the formation of the makerspace design committee, Mrs. Ralston had
limited knowledge of school library makerspaces through a few articles she had read on
the topic and conversations she had with a few school librarians who had started
one. Though her knowledge of makerspaces was somewhat limited, she brought with
her not only a desire to bring making to her students, but years of involvement in school
librarian professional organizations at both the regional and state level where she has
served in a variety of leadership roles.

The library media specialist of Middle School One, Mrs. Michaels, has been in
the field of education for 19 years, all of which have been spent in her current school
district, the context for this study. She has been a library media specialist for seventeen
years and has served as the library media specialist at her current middle school for the
past six years. She became interested in makerspaces when colleagues in her building
began talking about wanting to start a place for students to be able to collaborate and “make.” Mrs. Michaels was curious and wanted to understand what they were and how she could be part of this space in her school. She joined the makerspace design committee to learn more about makerspaces and how she could create such a space for her students.

Mrs. Green, library media specialist at Middle School Two, is in her third year in the field of education, all of which have been as a library media specialist in her current school district and at her current middle school building. She first learned about school library makerspaces in her recent graduate classes in Library Science. She has done quite a bit of reading and research on makerspaces for various projects and papers in her graduate classes. Before joining the school district as a library media specialist, Mrs. Green worked for the local public library for three years where she assisted with research for a new public library branch wanting to begin a makerspace. She also incorporated maker activities into her programming as the Teen Librarian for the public library. Mrs. Green brings a wealth of knowledge about makerspaces to the makerspace design committee and currently offers an afterschool makerspace in her building.

Mrs. Tracy is the library media specialist of Middle School Four. She has been in the field of education for eleven years, all of which has been spent in her current school district. Her first year was spent as a library paraprofessional in one of the district’s middle schools, and she has been the library media specialist in her current middle school for the past ten years. She came to the makerspace design committee having done a lot of previous personal research on school library makerspaces. By reading
various books and articles, following leaders in the field of libraries and makerspaces on
social media, attending various conference sessions about makerspaces at a
conference on educational technology, and even taking an online continuing education
class about makerspaces through a well-known university, Mrs. Tracy gained an in-
depth understanding of makerspaces. This was beneficial to the makerspace design
committee in its work as she was able to offer ideas and suggestions to the group
during the design process.

The only library media specialist starting a makerspace at the high school level
who is part of the makerspace design committee is Mrs. Foster. She has been in the
field of education for 18 years and has been a library media specialist for the past eight
years. She has served as the library media specialist for her current district in her
current high school building for the past three years. Mrs. Foster first learned about
makerspaces at a regional library conference where a public librarian spoke about a
newly formed makerspace in the public library. Since that time, Mrs. Foster wanted to
bring this opportunity to her students and began to consider how she might do so.
Unfortunately, in the school district where Mrs. Foster worked at the time, there was
little administrative or financial support for the idea of school library makerspaces. Mrs.
Foster brought to the committee a desire to start a makerspace as well as the
perspective of the importance of administrative and financial support to the success of
implementation.

**Researcher Role**

The researcher of this study is the library coordinator for the district where the
study was conducted. I serve half-time in the capacity of District Library Coordinator
and half-time as a librarian in one of the district’s high school media centers. I have
worked in the district since 2003, serving as a librarian for four years at one of its elementary schools and five years at one of its middle schools. I have held the position of District Library Coordinator in the district since 2012. I first learned about school library makerspaces through workshops sessions at a state library conference, and, while I found them an interesting concept, I was not yet convinced of their value to school libraries or to students. I continued to learn more about them through various conference sessions, trade journal articles, conversations with other librarians, and a visit to a library makerspace in a neighboring school district. As a doctoral student, I chose to focus on school library makerspaces as my area of specialization. As such, I had spent approximately one and a half years reading extensively about makerspaces prior to the formation of the makerspace design committee. I have continued to read extensively about them since the committee began its work.

As library coordinator for my district, I was approached by a group of district librarians in the summer of 2015 who wanted to learn more about makerspaces. In response, I held a three-hour workshop in July of 2015 during my school district’s summer professional development week wherein attendees read various articles about makerspaces I pre-selected and filled out a graphic organizer of what was learned about makerspaces. The top half of the graphic organizer had sections labeled “Learning Theories and Philosophies Behind Makerspaces,” “Makerspace IS:,” “Makerspace ISN’T:,” “Content Knowledge Learned Through Makerspaces,” and “Info, Tech, & 21st Century Skills Learned Through Makerspaces.” Upon completion of these graphic organizer categories, the attendees and I participated in open discussion about school library makerspaces wherein concerns were expressed and questions were
asked. Attendees were then given time to explore together a variety of additional print resources and websites to learn about various activities that may be found in a school library makerspace as well as challenges involved in implementing a school library makerspace. The bottom half of the graphic organizers had sections available for attendees to record the results of their exploration of both activities and challenges. Finally, one of the district librarians who had begun to bring makerspace activities into her library shared various print resources with the group as well as several makerspace activities she had already used with students.

In the fall of 2015, several media specialists expressed an interest in starting a makerspace in their library, so I formed a design committee in order to be purposeful in the design and implementation of these spaces. I have led the makerspace design committee in its work to develop guidelines for the design and implementation of library makerspaces in the district. The work of the committee is described below.

**Charting a Course for Planning and Implementation (Logic Model)**

Prior to the first meeting of the makerspace design committee, the group began work on its first task, the development of a logic model to guide its work toward the implementation of school library makerspaces. A logic model defines the purpose or objective of the project at hand, the resources available or needed for the project, the activities to be accomplished for the project to be successful, the deliverables that will be developed from the activities, and the short-, mid-, and long-term outcomes anticipated through successful implementation of the project. A logic model also includes potential evaluation questions to help assess the implementation process as well as the project outcomes. The logic model is the first component of the design to be discussed as part of describing the design (C.D. Howard, 2011).
During the spring of 2016, I was enrolled in a doctoral course through the University of Florida and was required to create a logic model. As a scholar-practitioner, I connected this assignment to the real need to set the direction for the implementation of school library makerspaces in my district. Therefore, in February 2016, I created an online collaborative document, shown in Figure 4-1, for the makerspace design committee to use to begin to develop a logic model. Over the next week and a half, committee members added activities to the document they felt the team would need to accomplish as well as anticipated and desired outcomes of the implementation of library makerspaces in our school district.

I then developed the first draft of the district Makerspace Logic Model, utilizing the input of the members of the committee to develop activities and outcomes. Figure 4-2 shows the initial rough draft I developed, which did not include potential evaluation questions. The rough draft of the Makerspace Logic Model was presented to the makerspace committee at its first meeting. I explained the purpose of a logic model and invited the committee to provide feedback and suggestions for additions or revisions. The committee suggested several revisions to the original logic model that I incorporated into future versions of the Logic Model. These included adding the development of a mission and vision statement to the list of activities; expanding the database of makerspace activities to include safety tips, recommended resources, and recommended technology; and emphasizing that the PR campaign to be developed would be educational in nature.
<table>
<thead>
<tr>
<th>Resources (Needed or Owned)</th>
<th>Activities</th>
<th>Outputs</th>
<th>Short-term outcomes (within first several months)</th>
<th>Mid-term outcomes (within first few years)</th>
<th>Long-term outcomes (7 years or more beyond)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2- Determine and implement scheduling that allows student use of makerspace</td>
<td>1- Use - students actually using the space</td>
<td>2- A definite idea of what works/what doesn’t</td>
<td></td>
<td>3- Successful space - possibly tied to curriculum - open for students - possible community members coming in to teach a skill once a month</td>
<td></td>
</tr>
<tr>
<td>5- Develop and implement a community PR campaign to garner support</td>
<td>4- Creativity and making answers</td>
<td>5- Community support</td>
<td></td>
<td>6- Increase in number of students enrolling in STEM college majors (especially girls)</td>
<td></td>
</tr>
<tr>
<td>17- Develop and implement a plan to garner donations/partnerships from major corporate partners</td>
<td>7- Increased student understanding of specific content skills</td>
<td>8- Common or consistent donations/donors</td>
<td></td>
<td>9- Increase in number of students interested in STEM careers (especially girls)</td>
<td></td>
</tr>
<tr>
<td>What # outcome? Survey our students and staff to find out their wants/needs/interests for the space. Each school might be different</td>
<td>10- Increased student &quot;soft skills&quot;</td>
<td>11- Increase in PBL and/or discovery learning opportunities for students</td>
<td></td>
<td>12- Define usage and how it is being used effectively with all students and teachers schedules</td>
<td></td>
</tr>
<tr>
<td>What # outcome? Speak with our administration to see what their vision is or if they have one for this space.</td>
<td>13- Increased student information literacy skills</td>
<td>14- Increase in growth mindset of students</td>
<td></td>
<td>15-</td>
<td></td>
</tr>
<tr>
<td>16- Increase student involvement by recruiting high school Science Olympiad teams to present their competitions to our students</td>
<td>16- Increased student engagement</td>
<td>17- Major corporate partner who would donate tools/materials/supplies (Lowe’s, Home Depot, Wal-Mart?)</td>
<td></td>
<td>18-</td>
<td></td>
</tr>
<tr>
<td>12- Team with Tech Connect / STEM staff members in each building to gain support</td>
<td>19- Active campaign to build awareness &amp; knowledge of makerspace definition/ purpose/ philosophy with administration, teachers, parents, &amp; students</td>
<td>20- Increase in student technology proficiency</td>
<td></td>
<td>21-</td>
<td></td>
</tr>
<tr>
<td>22- Support from CO and building administration for a district-wide initiative</td>
<td>23- Define area, student growth</td>
<td>24-</td>
<td></td>
<td>25-</td>
<td></td>
</tr>
<tr>
<td>25- Staff support, buy-in from staff, build awareness and staff development for staff</td>
<td>26-</td>
<td></td>
<td></td>
<td>27-</td>
<td></td>
</tr>
<tr>
<td>28- LMS confident facilitating makerspace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4-1. Makerspace Logic Model online collaborative document with committee member input.
**Objective:** The purpose of this project is to increase students' knowledge of and interest in STEAM content areas and STEAM career fields as well as to increase their overall information literacy, technology literacy, and 21st century literacy skills through experiences in successfully implemented school library makerspaces.

<table>
<thead>
<tr>
<th>Resources</th>
<th>Activities</th>
<th>Outputs</th>
<th>Short-term Outcomes</th>
<th>Mid-term Outcomes</th>
<th>Long-term Outcomes/Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through planning meetings with makerspace committee:</td>
<td>Deliverables from makerspace committee planning meetings:</td>
<td>First few months to first year after implementation:</td>
<td>First few years (2-5) after implementation:</td>
<td>Six or more years after implementation:</td>
<td></td>
</tr>
<tr>
<td>Makerspace committee consisting of library coordinator &amp; librarians willing to start and facilitate makerspaces in library:</td>
<td>Trained librarians to facilitate makerspaces in participating schools:</td>
<td>Increased confidence of participating librarians to facilitate makerspaces:</td>
<td>Increased in the number of school library makerspaces in the district:</td>
<td>District libraries and librarians are an integral, valued, and well-supported part of student learning experience:</td>
<td></td>
</tr>
<tr>
<td>Clearly defined idea of concept of makerspace:</td>
<td>Completed makerspace IOC checklist &amp; planning form for use in planning makerspaces:</td>
<td>Increased use of library and makerspace by students and staff:</td>
<td>Makerspaces implemented district-wide:</td>
<td>Makerspaces implemented district-wide:</td>
<td></td>
</tr>
<tr>
<td>Ideas for makerspace activities:</td>
<td>Detailed makerspace implementation plan for each interested library:</td>
<td>Increased student engagement, creativity, and “maker” mindset:</td>
<td>Increase in student STEAM content knowledge:</td>
<td>Increase in number of district students enrolling in STEAM college majors:</td>
<td></td>
</tr>
<tr>
<td>Makerspace resources (technology, supplies, furnishings, etc.):</td>
<td>Multiple pre-designed makerspace activities for librarians to pull from:</td>
<td>Increase in student background knowledge of STEAM concepts:</td>
<td>Increase in number of district students choosing STEAM careers:</td>
<td>Increase in number of district students outside of makerspace</td>
<td></td>
</tr>
<tr>
<td>Support of various stakeholders:</td>
<td>List of wants, needs, and interests for makerspace:</td>
<td>Increased student interest and confidence in STEAM subjects:</td>
<td>Increase in PBL and/or discovery learning activities for students outside of makerspace:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4-2. Rough draft of Makerspace Logic Model based on committee input.**
Other committee suggestions were not incorporated, such as adding the activity of tying makerspace activities to curriculum standards and moving the desired outcome of increased project-based learning opportunities for all district students from a long-term to a mid-term outcome. I opted not to add the activity of tying makerspace activities to curriculum standards because, as library coordinator for the district, this was not in keeping with the philosophy of student-directed personalized learning I wanted to implement in the district’s library makerspaces. Understanding the slow pace at which change in school districts can happen was behind my decision to not change the increase of district-wide project based learning opportunities to a mid-term outcome.

I made additional revisions to the Makerspace Logic Model over the next several weeks, adding and revising potential evaluation questions and tweaking the wording of several outcomes to be more measurable until a working draft was complete. The makerspace committee has referred to the logic model several times during its meetings to check its progress, to determine next steps, and to make adjustments to the model based on current circumstances and understandings. Figures 4-3 and 4-4 show revisions of the Makerspace Logic Model based on suggestions from the committee as well as the additions and revisions I made. Including the multiple versions of this collaboratively developed document showing the changes that were made to the document based on the input of the design team is in keeping with Smith’s (2010) suggestion that a design case should describe decisions made and changed throughout the design process. It also adds to the rich, thick description of the design, as suggested by Boling and Smith (2009).
Figure 4-3. Revised Makerspace Logic Model with initial evaluation questions added.
Figure 4.4. Current working version of Makerspace Logic Model, revised fall 2016.
Developing Acceptable Overall Implementation Guidelines (ICM)

With a project plan in place in the form of the Makerspace Logic Model, the makerspace design committee began work on the various activities necessary to the project. The first activity the design committee undertook was the development of an Innovation Configuration Map to establish guidelines for acceptable implementation of makerspaces in the district’s school libraries. This is the second component of the design to be discussed as part of describing the design (C.D. Howard, 2011). An Innovation Configuration Map is a component of the Concerns Based Adoption Model for technology integration in schools (“Innovation Configurations,” n.d.) which was originally developed in the 1970s. The purpose of an Innovation Configuration Map is to establish clear descriptions of various components of a new program or practice by describing ideal, acceptable, and unacceptable implementation of each component. These descriptions can then be shared across an organization so that everyone involved in the implementation of the new program or practice has a common understanding of implementation expectations. An Innovation Configuration Map is meant to be a living document that can be revised as the implementation of the new program or practice changes.

I developed an Innovation Configuration Map template for the design committee to use which included components of makerspaces that I felt were important as well as space for the design committee to add additional components. The template included columns for each component labeled “Optimal,” “Acceptable,” and “Unacceptable,” and these were to be used by the committee to define and describe implementation guidelines for each makerspace component. The committee spent two three-hour meetings developing the map.
Though six hours may seem like a lot to spend on this one activity, the time was spent by the committee engaged in deep discussions surrounding each component of makerspaces included on the Innovation Configuration Map and describing what each level of implementation should look like for the school district. Figure 4-5 shows the first draft of the Makerspace Innovation Configuration Map with my notes from the first meeting. Figure 4-6 shows the typed results of the first meeting regarding the Makerspace Innovation Configuration Map and my notes from the second meeting. As the level of knowledge of makerspaces and the learning theory of constructionism varied by committee member, the discussions also served as an opportunity for committee members to share their understanding of these concepts with each other, to ask questions, and for me, as library coordinator of the district, to clarify my vision of school library makerspaces in the district.

The result of this activity was two-fold: a concrete set of initial makerspace implementation guidelines was developed and shared with all district librarians to use if starting a makerspace (Figure 4-7), and the makerspace design committee now had a common understanding of how implementation of school library makerspaces in the district was to look. This common understanding helped focus the design committee’s future work. As with the Makerspace Logic Model, the design committee referred to the Makerspace Innovation Configuration Map throughout the design process. As the committee discussed such things as design elements, funding issues, makerspace scheduling, or safety concerns for makerspaces, invariably, one of the committee members would steer the conversation back the Makerspace Innovation Configuration Map for clarification.
Figure 4-5. Researcher notes on two-page ICM template from first committee meeting regarding ICM.
<table>
<thead>
<tr>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Involvement/Guest Makers</td>
</tr>
<tr>
<td>Role of Librarian</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Student Behavior?</td>
</tr>
<tr>
<td>Student Contracts?</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Staffing</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Materials/Technology</td>
</tr>
</tbody>
</table>

*Guest Makers*

Figure 4-5. Continued.
Figure 4-6. Typed results of first committee meeting regarding ICM with researcher notes from second meeting.
<table>
<thead>
<tr>
<th><strong>Activities/Workshops</strong></th>
<th>Parent waiver for use of dangerous equipment</th>
<th>No signage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety training for library media specialists, paras, and all makerspace staff</td>
<td>No or inappropriate level of adult supervision</td>
</tr>
<tr>
<td></td>
<td><strong>Safety signage</strong></td>
<td>Extremely dangerous equipment included in library makerspace</td>
</tr>
<tr>
<td></td>
<td>Full adult supervision of makerspace activities</td>
<td>Adding makerspace equipment or activities without understanding safety issues involved</td>
</tr>
<tr>
<td><strong>Activities/Workshops</strong></td>
<td>Completely student-interest driven; variety of materials available for students to pursue making projects of interest</td>
<td>To the extent possible, student-interest driven</td>
</tr>
<tr>
<td></td>
<td><strong>STREAM focused</strong></td>
<td>A mix of high- and low-tech activities</td>
</tr>
<tr>
<td></td>
<td>Workshop sessions offered on various making topics/equipment</td>
<td>To the extent possible, a mix of STREAM activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resources available (books, videos, etc.)</td>
</tr>
<tr>
<td><strong>Activities/Workshops</strong></td>
<td>Completely prescribed projects without student interest opportunities</td>
<td>Completely prescribed projects without student interest opportunities</td>
</tr>
<tr>
<td></td>
<td><strong>ONLY high-tech or ONLY low-tech activities</strong></td>
<td>ONLY high-tech or ONLY low-tech activities</td>
</tr>
<tr>
<td></td>
<td><strong>Limited to one category of activities (all art, all electronics, etc.)</strong></td>
<td>Limited to one category of activities (all art, all electronics, etc.)</td>
</tr>
<tr>
<td></td>
<td><strong>Extremely dangerous activities</strong></td>
<td>Extremely dangerous activities</td>
</tr>
<tr>
<td></td>
<td><strong>No resources provided or available for students to explore and learn new things</strong></td>
<td>No resources provided or available for students to explore and learn new things</td>
</tr>
</tbody>
</table>

Figure 4-6. Continued.
### School Library Makerspace Innovation Configuration Checklist

<table>
<thead>
<tr>
<th>Budget</th>
<th>Space/Storage/Display</th>
<th>Assessment</th>
<th>Community Involvement/Guest Makers</th>
</tr>
</thead>
<tbody>
<tr>
<td>District-provided funding for maintaining makerspace</td>
<td>Designated makerspace designed as makerspace (needs of space taken into design consideration)</td>
<td>Student self-assessments</td>
<td>YES</td>
</tr>
<tr>
<td>Adequate &amp; consistent funding</td>
<td>Large enough for average class size</td>
<td>Ongoing formative assessment of process, safety, participation</td>
<td></td>
</tr>
<tr>
<td>Inconsistent funding</td>
<td>Room for storage or materials and projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Display areas for student projects available</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vendors “levels” of projects displayed as examples</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designated space, but not designed as a makerspace</td>
<td>Assessment of content knowledge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile makerspace (on carts in library)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Makerspace bus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff spending own money only</td>
<td>No makerspace</td>
<td>Product A-F assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Makerspace “kits” checked out to classes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4-6. Continued.
<table>
<thead>
<tr>
<th>Role of Librarian</th>
<th>Facilitator of space of student learning</th>
<th>Teacher/class use w/o LMS presence</th>
<th>Completely a space that teachers come in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other (Student Behavior?)</td>
<td>Concern about destructiveness</td>
<td>Students highly engaged</td>
<td>Direct &amp; No involved in actual activities (change only of workspace)</td>
</tr>
<tr>
<td>Other (Staffing?)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Materials/Technology)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Guest Makers?)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation**
### School Library Makerspace Implementation for

<table>
<thead>
<tr>
<th>Component</th>
<th>Optimal</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling</td>
<td>Completely open access schedule for students and/or classes to come in whenever they have time.</td>
<td>To the extent possible, open access scheduling</td>
<td>No or extremely limited access</td>
</tr>
<tr>
<td></td>
<td>Flexible scheduling of librarian to be available to facilitate makerspace</td>
<td>All students have opportunity to use makerspace</td>
<td>Reward scheduling only</td>
</tr>
<tr>
<td>Purpose/Pedagogy</td>
<td>What do YOU want to make today?</td>
<td>Within set parameters, what do YOU want to make today?</td>
<td>THIS is what you will make today!</td>
</tr>
<tr>
<td></td>
<td>Student interest driven</td>
<td>Allows for student interest</td>
<td>Completely prescribed, cookie cutter projects that do not allow for student interest</td>
</tr>
<tr>
<td></td>
<td>Constructionism, experiential, discovery learning (learning by doing)</td>
<td>Some design-based challenges</td>
<td>Completely learning THEN doing</td>
</tr>
<tr>
<td></td>
<td>Growth mindset focus</td>
<td>Some activities aligned to standards</td>
<td>Used as a “resource room” for classes</td>
</tr>
<tr>
<td></td>
<td>Failure as a learning opportunity</td>
<td>MOSTLY learning by doing or learning while doing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone of proximal development – student experts helping other students achieve more</td>
<td>Growth mindset focus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zone of proximal development – student experts helping other students achieve more</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4-7.** District makerspace implementation guidelines sent to media specialists.
| Safety | Student safety training and makerspace use/behavior contracts  
Parent waiver for use of dangerous equipment  
Safety training for library media specialists, paras, and all makerspace staff  
Safety signage/Behavior signage  
Full adult supervision of makerspace activities | No training of students, library media specialists, paras, or makerspace staff  
No signage  
No or inappropriate level of adult supervision  
Extremely dangerous equipment included in library makerspace  
Adding makerspace equipment or activities without understanding safety issues involved |  

| Activities/Workshops | Completely student-interest driven; variety of materials available for students to pursue making projects of interest  
STREAM focused  
Workshop sessions offered on various making topics/equipment | To the extent possible, student-interest driven  
A mix of high- and low-tech activities  
To the extent possible, a mix of STREAM activities  
Resources available (books, videos, etc.) | Completely prescribed projects without student interest opportunities  
ONLY high-tech or ONLY low-tech activities  
Limited to one category of activities (all art, all electronics, etc.)  
Extremely dangerous activities  
No resources provided or available for students to explore and learn new things |

---

Figure 4-7. Continued.
### School Library Makerspace Innovation Configuration Map

<table>
<thead>
<tr>
<th>Budget</th>
<th>Adequate &amp; consistent district-provided funding for creating and maintaining makerspace (including apps needed)</th>
<th>Inconsistent district-provided funding</th>
<th>No funding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corporate donors/ business partners</td>
<td>Activity account use at librarian’s discretion</td>
<td>Only funding is library staff spending own money to maintain makerspace</td>
</tr>
<tr>
<td></td>
<td>Grants</td>
<td>Grants</td>
<td>Use of Program 12 for makerspace (Program 12 is for cataloged, circulating materials and supplies needed to circulate them)</td>
</tr>
<tr>
<td></td>
<td>Local donations</td>
<td>Crowd-funding</td>
<td>No makerspace</td>
</tr>
<tr>
<td></td>
<td>Crowd-funding</td>
<td></td>
<td>Makerspace “kits” checked out to classes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Space/Storage/Display</th>
<th>Designated makerspace designed as makerspace (needs of space taken into design consideration)</th>
<th>Designated space, but not designed as a makerspace</th>
<th>No makerspace</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large enough for average class size</td>
<td>Mobile makerspace (on carts in library)</td>
<td>Makerspace “kits” checked out to classes</td>
</tr>
<tr>
<td></td>
<td>Room for storage or materials and projects</td>
<td>Makerspace bus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Display areas for student projects available</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Various “levels” of projects or various approaches displayed as examples</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>“Failure” hall of fame</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### School Library Makerspace Innovation Configuration Map

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Community Involvement/Guest Makers</th>
<th>Role of Librarian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student self-assessments</td>
<td>Community experts (including in district – teachers and students)/ guest makers are invited to lead workshops to teach students particular maker skills or use of particular maker technology</td>
<td>Facilitator of space and of student learning</td>
</tr>
<tr>
<td>Ongoing formative assessment of process, safety, problem-solving, etc. by librarian</td>
<td></td>
<td>Assessing student process learning</td>
</tr>
<tr>
<td>Assessment of effectiveness of makerspace</td>
<td></td>
<td>Collaborate with teacher if class makerspace project</td>
</tr>
<tr>
<td>Assessment of content knowledge</td>
<td></td>
<td>Occasional use of makerspace by teacher without librarian presence when collaboration has taken place</td>
</tr>
<tr>
<td>Assessment of product completion</td>
<td></td>
<td>Library paraprofessional assistance and/or supervision of makerspace</td>
</tr>
<tr>
<td>Assessment of product on A-F scale</td>
<td>No community experts or guest makers involved with makerspace</td>
<td>Makerspace almost entirely used by teacher/class without librarian presence and/or collaboration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student use of makerspace completely teacher directed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Librarian as “keeper and cleaner of space” rather than as an instructional partner in activities</td>
</tr>
</tbody>
</table>

Figure 4-7. Continued.
As an Innovation Configuration Map is intended to be revised as project implementation changes and grows, the makerspace design committee revisited its original Makerspace Innovation Configuration Map when it met for its first meeting of the new school year in Fall 2016 and determined to make a few changes to one component. In the original map, optimal and acceptable levels of implementation for the component of Activities/Workshops placed an emphasis on STREAM (science, technology, reading, engineering, arts, math) activities. While the intent of emphasizing STREAM was to be inclusive of reading and arts in addition to STEM activities, the committee now believes that even this may be too narrowly focused. The Makerspace Innovation Configuration Map was revised by adding a phrase to reflect that the Activities/Workshops in the district’s library makerspaces should have a focus on student innovation and creativity within all content areas. In addition, the committee retained the STREAM acronym, as it still felt it was important to emphasize activities that are interdisciplinary in nature, but a plus sign was added at the end of the acronym (STREAM+) to note the inclusion of other content areas not represented by the acronym. As with the multiple versions of the logic model, including the multiple version of the ICM and describing the process used to develop it meets the suggestions of Smith (2010) and C.D. Howard (2011) for writing a rigorous design case and Boling and Smith’s (2009) guidelines for using rich, thick description in design cases.

Visits to Other Makerspaces

Several of the design committee members had not yet seen a school library makerspace in operation, so there was interest by the committee to visit some nearby school library makerspaces to assist with our design and planning work. During Spring 2016, five members of the design committee and I visited a middle school library
makerspace in one nearby district and an elementary school library makerspace in another nearby district. The group saw two very different makerspace implementations in these spaces. This was another important component of the design process that helps describe the design (C.D. Howard, 2011).

The middle school library had four rooms devoted to its makerspace. Two of these were large, re-purposed computer labs and two of these were smaller rooms that may once have been small group collaboration rooms. One of the larger rooms was an old computer lab with counters around the perimeter of the room. Signs were hung over sections of the counters to show what types of activities or resources were available in that area. For instance, one area had an “Electronics” sign displayed while another area displayed a “Take Apart Station” sign. In the center of the room was a large open area where students could build and test out marble runs, Lego roller coasters, or a programmable robot. The area was cordoned off by a “frame” of what appeared to be painted two by fours to keep students from casually walking through it as well as to contain such items as a Sphero programmable robot ball. The second large room was attached to the first and was used for hosting guest makers to share their knowledge with students or to teach students a particular skill such as bicycle repair. One of the smaller rooms was devoted to making music, and it housed an acoustic guitar and a few other instruments. It also housed a computer with Garage Band, Apple’s music editing software, installed for student use. Students could come to the makerspace for self-directed making activities before school, after school, or during a study skills period during the school day, and a few teachers brought classes for exploratory projects.
The elementary school library did not have a dedicated room for its makerspace. Rather, it had an area behind some bookshelves and below a set of stairs with some worktables and storage shelves for materials and resources with various sizes and shapes of containers labeled with the type of item it held. Students, however, depending on the project, were able to use the entire library for making activities. On the day of our visit, rather than self-directed making activities, students were assembling their culminating artifact of a project-based research unit tied to grade level curriculum that the librarian had facilitated. Every student was assembling the same artifact, and there was very little difference from one student’s end product to the next.

At its next meeting, committee members who visited the two neighboring makerspaces shared with the others what they saw. Several had taken pictures of signage, storage solutions, and makerspace décor on their cell phones, and they showed these pictures to those who were unable to visit the neighboring makerspaces. The committee discussed the differences in the two implementations and compared them with the guidelines that had been established through the Makerspace Innovation Configuration Map. The committee felt that the implementation at the middle school, because of the self-directed nature of student making, was closer to what the committee hoped to establish in our library makerspaces. However, the makerspace could also support individual student projects that stem from project-based learning units.

To learn more about various makerspace implementations, five members of the design committee and I visited an in-district makerspace housed in our new center for the district’s elementary gifted students. This makerspace is not in a library, but is a space with two dedicated classrooms that are connected by a workshop between them
that houses a table saw, drill press, jig saw, 3D printer, laser engraver, and other hand and power tools. This makerspace operates as a year-long course of study for students who sign up for it at the beginning of the year. Students are taught explicit lessons on the use of various makerspace tools, such as 3D design and printing, including how to troubleshoot the 3D printer. Students are given design challenges they work on in teams. On the day of our visit, student teams were working on a design challenge for a local small company that involved the creation of a promotional campaign along with a character to use in the campaign. Students were designing characters using the free 3D design software, Tinkercad, to be printed out later using the 3D printer.

This is quite a different implementation than what the design team has in mind for our school libraries. However, as the district’s gifted students spend one day a week at the gifted center and the rest of the week in our regular elementary schools, we realized these students could be “expert makers” in our library makerspaces and help others with their 3D making projects. We also learned that we can pull from the knowledge of the makerspace teacher at this facility who is willing to conduct training sessions for librarians on 3D printing, laser engraving, and other tools in their makerspace. Too, while our school library makerspaces are intended to provide self-directed making experiences, we also planned to offer optional design challenges. Seeing these students so deeply engaged in the promotional campaign design challenge reinforced our desire to offer these optional challenges in our school library makerspaces.

**Design Guidelines for Environment, Activities/Tools/Resources, and Facilitation**

Though the design committee already had the ICM in place to describe levels of optimal, acceptable, and unacceptable implementation of various components of school library makerspaces in our district, the team saw a need to develop a more detailed list
of design guidelines, as well. These guidelines would not only assist the design team as they continued their implementation of makerspaces but would become part of the training materials for other district librarians interested in starting a makerspace, and are another component included to provide a thorough description of the design (C.D. Howard, 2011). As with the other work the committee had undertaken thus far, the creation of these design guidelines was a collaborative effort of the group.

In preparation for this work, I created an online collaborative document based on my prior reading of the need to consider the aspects of environment, activities, and facilitation when designing a makerspace (Petrich, et al., 2013). The document also included an “other” section for design elements that may not fit into one of the above three areas. I then printed out various articles about makerspace design and marked several books about makerspaces with post-it notes to indicate sections dealing with their design. At a makerspace design committee meeting, these resources, along with pens and highlighters, were placed in the center of the table around which the committee sat. Each member opened the collaborative document on her computer and selected several of the print resources to review as well as the writing utensils of her choice. Though there were multiple copies of some of the articles, there were not enough copies for all design committee members to have the same resources to review. As each member found a design element in the literature that fit into one of the categories, she added it to the appropriate spot on the collaborative document. Some members of the committee also added to the document design ideas they had heard or seen at conferences or in their own reading about makerspaces. The collaborative list of guidelines developed during this activity is seen in Figure 4-8.
| Environment/Space | Offer a place to start creating.  
Encourage people to look around the space.  
Space should be bright and welcoming  
Inviting, sets the mood for innovation  
Bring outside world IN  
Space needs to be inspirational...materials visible and accessible “Open Shop” concept  
Provide several places for kids to share tips or write ideas  
Reflects resourcefulness  
Flexible—to change structure over time to meet needs/wants of participants  
Gender neutral room decorations  
May be mobile or a set area  
Free-form tinkering/open structure/madhouse/who the heck is in charge here  
Class group/we are all on the same page/possibly with other helpers like A+ students  
Open spaces for collaboration and sharing where multiple people  
Past projects as examples for inspiration  
Furniture lay-out to encourage collaboration when wanted or individual work when wanted  
The environment should be a comfortable place for learners to experience delight, failure, frustration, and deep engagement over time.  
Environment should be alive when learners are in the space.  
Activities or “centers” next to each other that can “cross pollinate” (e.g., textiles and electronics next to each other so students can do etextiles)  
Allow students to help you set up the space  
Have a modest supply of dozens of possibly useful materials on hand  
Design workspaces in ways that require people to meet and interact with other.  
Books, video links, etc., available in space for students to use to learn what they need to learn to make what they want to make |
|---|---|
| Activities/Tools/Resources | Resources visible, not just accessible  
Orient learners to available tools and materials  
Make sure to mention when new tools/materials are added  
Show examples that demonstrate a variety of thinking  
Encourage risk-taking  
Variety of print and digital  
Activities are designed with multiple pathways for learning to pursue  
Community connections and partnerships expand the “space” beyond the space  
Low floor, high ceiling, wide walls  
Evocative and invite inquiry  
Bring in skilled community members as experts  
Bring in other students as experts  
Tools and concepts as a MEANS, not an END  
Activities encourage complexifying over time (can do more complex things within the “same” project)  
Create as a studio/competition/cooperation  
Get steady donors - don’t buy new/dumpster or curbside dive...  
Use plastic drawers - visible materials/tools |

**Figure 4-8.** Design committee collaborative design guideline brainstorming activity.
Facilitation

Encourage risk taking
Allow time for discussion after - share highs/lows/ new skills learned
Have examples visible
Give suggestions, not directions
Observe learners - take notes of what you observe about their thinking/process/ where do they begin
Free-Form Tinkering - no restriction or evaluations. Whatever they want, whenever they want. Very few rules. Main rule Respect all. Took many years to get the space set up to work this way. Project models are key. 50 or so models, but free tinkering still allowed and encouraged. Use folder with a photo. Vs Class Group Tinkering - When kids know they won’t be back they don’t encourage big projects. The facilitators choose projects that are popular and they can instruct and work through deeper meaning. Frameworks - studio, competition, cooperation. Session focused on students! Not lecturing.
Encouraging students to share their learning, experiences and failures with others.
Show examples that demonstrate a variety of thinking
Ask questions about their thinking and process
Don’t prescribe solutions -- ASK QUESTIONS!
Listen to their ideas and show enthusiasm for the ideas
Encourage risk taking and experimentation
Offer Challenges
Celebrate moments of wonder, surprise, and joy
Presence of educators skilled in areas of making and informal learning
Let them fail/ get frustrated and support it!
Respond to a child’s question of what do I do now, with what do you do now and take them back to the model
Need to learn from the model and be weaned from directions
Themes as opposed to design challenges
Encourage engagement with people not just materials
Link projects to outside learning experiences
Make a call about whether you think a project will be successful or not and communicate that with kids early in the project (do the hard part first)
You’ll end up giving directions, give vague directions
Support and promote PROCESS (productive participation)
“What would you like to make today?”
“What do I need to learn to make it?”
Facilitation moves video library from Tinker Studio at Exploratorium

Other?

Assessment comes from direct feedback - did my project work or not?
Formative assessment - journal, reflections (What worked well? What didn’t? How can I improve it?)

Figure 4-8. Continued.
Throughout this activity, which lasted approximately 30-45 minutes, there was much discussion over the different design guidelines that various members found in the resources they were reviewing. Some guidelines found in the literature were surprising to several of the members, such as the suggestion that materials and resources be both visible and accessible within the makerspace. Many of the committee members used storage cabinets for materials and resources that have solid front doors, thereby keeping these items from being visible within the makerspace. This design guideline shifted the thinking of some of the committee members as to how to better make materials and resources visible in their makerspace.

I used the brainstormed list of guidelines as the basis of a formal makerspace design guidelines document for use by all district librarians. I combined commonalities or repetitions in design guidelines listed on the collaborative document. Some items listed on the collaborative document were not actually design guidelines, so I excluded them from the formal document. For instance, the tip about keeping an eye out for materials that others were going to throw away was not included as a design guideline. Other items were moved to a different category when it seemed to be a better fit. I added a few guidelines that were not in the original collaborative document, such as the need to ensure there are ample electrical outlets in the makerspace. I presented the rough draft of the formal document to the committee, and the group spent approximately 30 minutes collaboratively revising the document. The final design guidelines are shown in Figure 4-9. Including various versions of the guidelines meets Smith’s (2010) suggestion that rigorous design cases include artifacts or records from the design process as well as suggestions for using rich, thick description (Boling & Smith, 2009).
Library Program Makerspace Design & Facilitation Guidelines

When implementing a library makerspace as part of the Library Program, the following design and facilitation guidelines should be followed to the greatest extent possible. Each library will have unique constraints that will make the use of certain guidelines difficult or impossible. However, the goal of each library makerspace is to apply the following design and facilitation guidelines as fully as possible and continue to work toward greater application of them.

Guidelines for Design of Makerspace Environment
Space/Storage
- Areas where both individuals or groups can work simultaneously on projects as well as room to walk around
- Area for small group (collaboration and sharing) to gather for presentation/training session
- A variety of writeable surface options such as whiteboards or writable paint on walls and tables for students to share tips/write ideas
- Storage for materials, tools, and resources that allows both visibility and accessibility of these items
- Storage for students’ on-going projects
- Display area for sample projects and students’ finished projects
- Ample electrical outlets
- Adequate lighting
- Depending on tools/resources included, adequate venting
- Safety rules specific to tools/resources available in makerspace on display

Furnishings/Flexibility
- Furniture should be flexible and mobile to accommodate
  - the immediate needs of individual makers and groups of makers and to encourage individual and collaborative work
  - changes in the long-term making needs or desires of students
- Furniture should be durable, yet appropriate to the making process
- Furniture surfaces, where possible, should have writeable surfaces to encourage collaboration

Decor/Feel of Makerspace
- Bright and welcoming with gender neutral decor
- Natural lighting where possible
- Inspires playfulness, creativity, and wonder
- Communicates philosophy of maker mindset

Guidelines for Makerspace Activities, Tools, Materials & Resources
Activities
- Variety of both high tech and low tech activities available for exploration based on student interest
- Activities should provide quick success for beginners, room to expand for experienced students, and a variety of ways to interact with the concept (known as “low floor, high ceiling, wide walls”)
- Activity areas arranged to allow for integration with other areas (e.g., electronics and textiles close together so that students can combine for E-textiles)

Tools and Resources
- Tools, materials, and resources should be both visible and accessible to students
- Tools available should be appropriate to the grade levels served

Figure 4-9. Final makerspace design guidelines for district based on design committee work.
As stated in the brief introductory remarks to these guidelines, the expectation is that these guidelines be followed to the greatest extent possible. The design team realized that not every library would be able to fully implement these guidelines due to constraints present in that facility. For instance, many libraries do not have a separate
space that can be dedicated to a makerspace and will need to use mobile carts to provide a makerspace within the library. The team wanted to assure librarians who wanted to start a makerspace that they did not have to fully meet every aspect of the guidelines to offer this opportunity to students. At the same time, the design team wanted to stress that the librarian should continue to strive to meet the guidelines.

**Guidelines Based on Educational Making Process Model**

In addition to design guidelines for environment, activities, and facilitation, the committee developed guidelines to facilitate making as a process per the EMPM I created. At a previous meeting, I presented the EMPM to the committee and explained the purpose of the EMPM is not to require students to follow a step-by-step process for making projects. Rather, the intent is to help librarians understand the process of making in order to facilitate this process with students. The process used to develop these is discussed below to help describe the design (C.D. Howard, 2011).

Again, I set up a collaborative document, this time based on the EMPM, and the group worked together for approximately an hour discussing each area of the EMPM and adding potential design and facilitation guidelines to the document for each area of the EMPM (Figure 4-10). I used the collaboratively developed guidelines as the basis of a formal EMPM design and facilitation guidelines document. This was presented to the design committee and collaboratively revised. As only minimal changes were made to the rough draft during the collaborative revision process, only the committee’s final design and facilitation guidelines document based on the EMPM is shown in Figure 4-11. I have since made slight revisions to the EMPM. The most recent version with the latest revisions was presented in Chapter Two of this dissertation.
### Design and Facilitation Guidelines Based on Educational Making Process Model

<table>
<thead>
<tr>
<th>Dream It! Inspiration</th>
<th>Visualize It! Ideation</th>
<th>Create It! Making</th>
<th>Improve It! Iteration</th>
<th>Present It! Sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• YouTube videos</td>
<td>• Maker’s notebook of some sort to draw out ideas or write down ideas</td>
<td>• Books, videos, magazines, websites, etc. in the makerspace so they can learn what they need to learn to make what they want to make</td>
<td>• Encourage iterations by video taping or taking pictures of various attempts</td>
<td>• Share circle</td>
</tr>
<tr>
<td>• Showing them how to use different resources/tools in makerspace</td>
<td>• Online maker’s “notebook” of some sort (SeeSaw, OneNote, Build in Progress)</td>
<td>• Computer or iPad or some other technology “dedicated” to “research” in makerspace</td>
<td>• Ask question about “What would you do differently if you did this again? Anything?”</td>
<td>• Padlet with what we learned today</td>
</tr>
<tr>
<td>• OPTIONAL design challenges posted for those who want to do them</td>
<td>• Cheap materials for prototyping (cardboard, remnant material, paper to sew on)</td>
<td>• Guest makers to teach students certain skills, etc. they need to know to make what they want to make</td>
<td>• Failed projects &amp; “improved” projects - kind of like Pinterest Fails. In fact, encouraging “fails” and improvements as a “good” or “normal” thing to learn from</td>
<td>• Taking pictures/video, put in newsletters or school video announcements</td>
</tr>
<tr>
<td>• Having things around in “themed” stations that they can just tinker &amp; play with</td>
<td>• Cameras available if they want to take pictures of things they want to incorporate</td>
<td>• Encourage collaboration in makerspace between students and between teachers/librarians so they can pull on distributed knowledge of group</td>
<td>• Poster of “What can I do when I get stuck” - Emily will share with us</td>
<td>• Display shelves around school or display cases</td>
</tr>
<tr>
<td>• Instructables website</td>
<td>• Online 3D software - some are free (3D printer)</td>
<td>• Posters about growth mindset/motivational posters</td>
<td>• Expert wall - when a student has “mastered” a skill, students can add their name to it so others can go to them for help</td>
<td>• Some kind of school or district maker faire</td>
</tr>
<tr>
<td>• Pictures on makerspace website for school</td>
<td>• Free online mind mapping</td>
<td>• Trouble-shooting ideas/guide for certain areas in the space</td>
<td>• Maker’s notebook available</td>
<td>• Build in Progress or similar site</td>
</tr>
<tr>
<td>• Past projects on display</td>
<td></td>
<td>• Encourage problem-solving by asking questions rather than giving answers</td>
<td></td>
<td>• SeeSaw to share with parents or ClassDojo</td>
</tr>
<tr>
<td>• Inspiration notebook</td>
<td></td>
<td>• Poster of “What can I do when I get stuck” - Emily will share with us</td>
<td></td>
<td>• Publish projects on Instructables, Scratch</td>
</tr>
<tr>
<td>• Books with ideas</td>
<td></td>
<td>• Failed projects &amp; “improved” projects - kind of like Pinterest Fails. In fact, encouraging “fails” and improvements as a “good” or “normal” thing to learn from</td>
<td></td>
<td>• Students as guest makers to other grades, schools, etc.</td>
</tr>
<tr>
<td>• Guest Makers (to show possible projects)</td>
<td></td>
<td>• Poster of “What can I do when I get stuck” - Emily will share with us</td>
<td></td>
<td>• Encourage student to “apply” to actual maker faire at Union Station or Barnes &amp; Noble</td>
</tr>
<tr>
<td>• Example pictures/signs</td>
<td></td>
<td>• Failed projects &amp; “improved” projects - kind of like Pinterest Fails. In fact, encouraging “fails” and improvements as a “good” or “normal” thing to learn from</td>
<td></td>
<td>• “Success Fair” in library or showcase students’ projects during conferences (maybe in classroom)</td>
</tr>
<tr>
<td>• Scratch website for ideas for scratch and makey makey together</td>
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<td></td>
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<tr>
<td>• Links on webpage for each “station” that give them ideas or quick instructions</td>
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</tbody>
</table>

Figure 4-10. Design team collaborative design and facilitation guidelines for EMPM.
<table>
<thead>
<tr>
<th>Optional &amp; Flexible Collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Natural thing that is taking place</td>
</tr>
<tr>
<td>• Talk to them about working together, sharing ideas, teaching each other (expert wall helps with this)</td>
</tr>
<tr>
<td>• Talk to them about it not being a competition, but that we are all working together to learn and grow. We all help each other</td>
</tr>
<tr>
<td>• Placement of furniture can encourage collaboration</td>
</tr>
<tr>
<td>• Make it part of “expectations” at beginning (maker contract)</td>
</tr>
<tr>
<td>• “I can’t help you right now, but you might ask so and so”</td>
</tr>
<tr>
<td>• Make it a safe place to share ideas with each other - don’t box them in</td>
</tr>
<tr>
<td>• Can organization of supplies/resources help with this?</td>
</tr>
<tr>
<td>• Purposefully include materials that “require” collaboration or at least more than one person</td>
</tr>
<tr>
<td>• Purposefully announce things like, “If you want to learn to crochet, come over here and Mary Clare (student) will show you how.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Continuous Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Safe environment, trust the people in the space - how? Signage,</td>
</tr>
<tr>
<td>• Goes back to collaboration, sharing with each other and talking to each other about what they have made</td>
</tr>
<tr>
<td>• Have students leave sticky-notes with feedback comments or questions by the projects of others</td>
</tr>
<tr>
<td>• Facilitate feedback: Sentence starters, positive wording</td>
</tr>
<tr>
<td>• Padlet - you can “control” the feedback at first so that it is “constructive” to teach students how to give appropriate feedback. This also saves automatically so that you can come back to it later.</td>
</tr>
<tr>
<td>• Automatic feedback from project itself</td>
</tr>
<tr>
<td>• QR code - for kids to offer feedback on padlet or google doc</td>
</tr>
<tr>
<td>• Again, the “Pinterest fail” idea - you could “practice” having students give feedback without anyone’s feelings getting hurt while they are learning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Documenting Progress</th>
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</thead>
<tbody>
<tr>
<td>• Maker notebooks</td>
</tr>
<tr>
<td>• Build in progress (website)</td>
</tr>
<tr>
<td>• Digital notes/notebook - could this be used as a collaboration tool or troubleshooting or a way for others to get inspiration as well? (Notes on the Mac, even - they are sharable?)</td>
</tr>
<tr>
<td>• SeeSaw</td>
</tr>
<tr>
<td>• In a notebook at each station (or digital notebook), you could have a FAQ where students could leave questions and others could leave answers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reflection/ Formative Self-Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combine with Continuous Feedback? Or combine with documenting progress?</td>
</tr>
<tr>
<td>• In notebook, reflecting on what you did</td>
</tr>
</tbody>
</table>
Additional Makerspace Design & Facilitation Guidelines Based on EMPM

In addition to the above design and facilitation guidelines, librarians who are implementing library makerspaces in their school should strive to ensure students have the opportunity to experience making as a process as described in the Educational Making Process Model. Below is a copy of the model with suggestions for designing and facilitating the makerspace to support students in the making process.

Educational Making Process Model

This process model is not intended to be followed in a step-by-step order. Rather, as represented by the gear-like design, all parts of the process interplay such that they work together toward a successful making process. Students may not take part in every part of the process for every making project.

**Inspiration** – What do you want to make?
Student determines something he wants to make (based on student interest rather than teacher-directed or curriculum-driven)

Student inspiration may come from
- Exploration in makerspace
- Playfulness
- Personal need/interest
- Sample projects
- Project idea resources (books, websites, etc.)
- Collaboration with others
- **Optional** Design Challenges or Project-Based Learning units

Suggestions to Design for & Facilitate Inspiration
- Provide a variety of activities, resources, and materials for students to explore and tinker
- Provide resources for project ideas such as past projects on display, “Inspiration notebooks” with pictures of project ideas, links to websites with project ideas such as Instructables or YouTube, books or magazines that include project ideas
- Offer quick live or video tutorials that show the basics of how to use some of the activities, tools, and materials in the makerspace
- Offer optional design challenges
- Invite guest or expert makers to introduce students to possibilities
- Discuss with students their interests or needs to help them identify a making project

Figure 4-11. Final design and facilitation guidelines for district based on EMPM.
Ideation—What do you imagine it to be like?
Student envisions the thing he wants to make
Student ideation may consist of
- Student imagining finished item
- Student drawing ideas for item
- Student writing out ideas for item
- Student creating quick prototype of item

Suggestions to Design for & Facilitate Ideation
- Provide online or physical maker’s notebook for students to write out plans or draw out ideas
- Provide access to mind mapping programs for student planning
- Provide cheap materials for quick prototyping of ideas (cardboard, remnant material or paper to sew, etc.)
- Provide digital cameras or iPads for students to take pictures of ideas they want to incorporate into their projects
- Provide 3D software for students to design prior to making
- Question students about their ideas for their project and encourage them to explain how they see the project working/coming together

Making—How will you go about making it?
Student brings his ideas to reality
Student making may involve
- Tinkering, Exploring, Attempting, Experimenting, Prototyping
- Planning
  - What materials/resources are needed (including human resources)?
  - What do you need to learn to make what you want to make?
- Gathering
  - Obtain the materials/resources you need
  - Learn what you need to learn to make what you want to make
- Building (Physical or digital)
  - May not be successful the first time
  - Problem-solve
  - Try again, and again, if necessary
  - Go back to previous making “steps” if necessary

Suggestions to Design for & Facilitate Making
- Provide a variety of instructional resources (e.g., books, magazines, websites, database, videos) and technology in the makerspace for student use to learn what they need to learn to make what they want to make
- Ensure tools, materials, and resources are both VISIBLE and ACCESSIBLE to students
- Display posters about growth mindset and encourage this in students
- Display “help” posters such as “What Can I do When I Get Stuck?”
- Display trouble-shooting guides or FAQs for various activities/tools/resources for student use
- Encourage collaboration between students and with adults so students can benefit from distributed knowledge of group
- Display an “expert wall” where students can offer help to others in areas of strength
- Invite guest makers to mentor students
- Encourage problem-solving by asking questions rather than providing answers

Figure 4-11. Continued
Figure 4-11. Continued
Mission and Vision Statement

The development of a mission and vision statement was a suggestion of members of the makerspace design committee that was added to the Makerspace Logic Model as an activity to be accomplished. As with the other activities that have
been described thus far, the crafting of the mission and vision statement was a collaborative effort of the team. It is the final component included to describe the design (C.D. Howard, 2011). Though it was not on the meeting agenda for the day, several members of the committee mentioned the need for these statements at a design meeting, so I facilitated an impromptu brainstorming activity of ideas members thought should be included in such statements. As this was not a planned activity, I simply wrote members’ thoughts on a piece of paper rather than using an online collaborative document as seen in Figure 4-12. The check marks next to each item signifies its inclusion in the rough draft of the mission and vision statements, seen in Figure 4-13.

I presented the rough draft of the mission and vision statements to the makerspace design committee in the form of an online collaborative document, and the document went through two rounds of collaborative revisions before a final version was developed with which all members of the committee were satisfied. The first round of revisions used a process involving each committee member adding comments to the document during a meeting and the researcher later making revisions based on those comments. The second round of revisions comprised of the committee discussing final changes while viewing the collaborative document during a meeting and the researcher making the final changes on the spot. The final mission and vision statement is shown in Figure 4-14. Including the multiple versions of the mission and vision statement increase the rigor of this design case by showing decisions made by the design team as well as changes to those decisions made by the team throughout the design process as suggested by Smith (2010) and add to the rich, thick description of the design case (Boling & Smith, 2009).
Mission Statement
- not results-oriented, not outcomes-based (lost weight)
- process oriented ✓
- has its own process ✓
- personalized learning ✓
- discovering limitless
- discover, hinder, explore, wondering
- problem-solving, collaborating
- student-driven - curiosity, perseverance
- critical thinking ✓
- 3 model
- create conditions to inspire our learners to
  make - become makers - develop maker mindset
- self-directed learners
- inquiry-based
- participatory learners ✓
- uncover talents ✓
- originality
- innovative
- ideation

Figure 4-12. Design team brainstormed list of ideas for mission and vision statements.
Library Program Makerspace Mission Statement

The mission of the Library Program Makerspaces is to provide students with a student-driven, personalized, and self-directed learning environment primarily focused on the processes and practices of making rather than on the products that are the result of making by creating conditions which inspire students to become makers and to develop a maker mindset.

Making is a process that involves student-driven exploration, discovery, tinkering, experimentation, creativity, and innovation. Through the making process, students develop and use critical thinking, ideation, original thinking, and problem-solving and become engaged and participatory learners who come to discover unknown talents and interests.

A maker mindset is a growth mindset in which makers believe they can learn to do anything. It has a playful and curious nature, it is asset- and growth-oriented, it views “failure” as a learning opportunity and does not give up when frustrated, it emphasizes sharing and collaboration between makers, and it tackles problems from an interdisciplinary approach.

The Library Program views the making as a process and describe in the process model below, and it strives to design, implement, and facilitate its school library makerspaces in such a way that students have the opportunity to experience the process of making in this way. A primary goal of school library makerspaces is to provide students with making and tinkering experiences that will help them develop a sense of identity as one who has a measure of control over the man-made designed aspects of his world, who can fix things when they are broken, tweak items to meet their individual purposes, or invent new items to meet their creative wants or needs. Through such experiences over time, the goal is for students to come to be self-directed learners who seek out the information they need to know in order to pursue their own interests to create and innovate, to develop an interest in making, to develop a maker mindset, and to develop an identity as a maker.

INSERT EMPH HERE

Figure 4-13. Rough draft of mission and vision statements based on design committee’s brainstormed list.
Library Program Makerspaces

Mission Statement

Inspire students to become makers and to develop a maker mindset by providing a student-driven, personalized, and self-directed learning environment focused on the process rather than the products of making.

Vision

Making is a process that involves student-driven exploration, discovery, tinkering, experimentation, creativity, and innovation. Through the making process, students develop original and critical thinking, ideation, and problem-solving to become engaged and participatory learners discovering new talents and interests. A primary goal of school library makerspaces is to provide students with making and tinkering experiences that will help them develop a sense of identity as one who has a measure of control over the human-designed aspects of his world. This will encourage them to fix things when they are broken, tweak items to meet their individual purposes, or invent new items to meet their creative wants or needs. Through such experiences over time, students will become innovative, self-directed learners who seek out the information they need to pursue their own making interests and to develop a maker mindset.

A maker mindset is a growth mindset in which makers believe they can learn to do anything. It has a playful and curious nature, is asset- and growth-oriented, views “failure” as a learning opportunity, and does not give up when frustrated. A maker mindset emphasizes sharing and collaboration between makers, and it tackles problems from an interdisciplinary approach.

The Library Program views making as a learning process as described in the model below. It strives to design, implement, and facilitate its school library makerspaces so that students have the opportunity to experience the process of making in this way.

INSERT EMPM HERE

Figure 4-14. Final version of district mission and vision statements for school library makerspaces.
Work Still to Be Done

The makerspace design committee has completed much work toward the implementation of school library makerspaces in our district, such that any librarian wanting to start a makerspace in the district would have guidance for doing so. However, there are several additional activities yet to be completed by the team. Where the design committee’s work stands for each of these remaining activities is discussed below.

Training plan. Many of the deliverables already developed by the design committee will ultimately be incorporated into the training plan for other district librarians. Each summer, the district holds a week-long event consisting of a wide variety of professional development opportunities for which employees of the district can sign up and receive hourly compensation. The makerspace design committee hopes to complete its work during the Spring 2017 semester and offer its first makerspace training session for district librarians during the Summer 2017 professional development week.

Resource repository. The design committee has discussed what might be the best format to use to create a shared resource repository for district librarians regarding makerspaces. The team decided to create a shared Google Drive folder with several levels of subfolders within it that would be accessible to all district librarians. I have created this folder as well as multiple subfolders, and the makerspace design committee has provided initial feedback as to the subfolders included. The folder is currently only shared with the design committee, and at a future meeting, the committee will make final revisions to the subfolders. Some of the materials already created by the committee, such as the mission and vision statement and the design guidelines, have
been added to the appropriate folder. In addition, committee members are adding materials to the folders such as posters they created for their own makerspaces or tips and tricks they have learned through makerspace implementation. The contents of the repository are intended to evolve and change as more district librarians add to the subfolders over time.

**Interest survey.** As each school library makerspace should include materials and activities of interest to its students and staff, the design committee planned to develop a survey to determine those interests. However, the committee members have found in their initial implementation of makerspaces that the process of making is so new to students that they do not really know what making options might be available to them. Rather than a formal survey, the design committee has determined that, at this point, simply visiting with students while they are participating in the makerspace may be a better way to gauge their interest. When a survey is developed, based on committee input, it will list various activities and ask students to mark which ones they might want to participate in rather than asking students an open-ended question about their interests. This survey will be available for librarians to use, but it will not be mandatory to makerspace implementation.

**Funding.** The makerspace design committee has two distinct goals regarding funding of school library makerspaces. One is to secure a consistent source of district funding for makerspaces, and the other is to pursue donations, grants, and business partnerships. As library coordinator for the district, I currently set aside a small amount of my annual budget for the purchase of makerspace items for those who are part of the design committee. As the receipt of these funds was tied to their willingness to serve on
the committee and implement makerspaces rather than to this study, each member of
the committee, including the librarian involved in the study, received the same amount
to put towards the purchase of makerspace items. As library coordinator, I have
similarly provided funding to other librarians in the district wanting to implement other
new programs or initiatives. For example, I have provided funding to librarians wanting
to integrate Breakout boxes into their library instruction, a sort of problem-solving,
scavenger hunt activity that requires a number of lockable boxes and a wide variety of
types of locks. I have also spoken with the central office administrator to whom I report
about the possibility of adding a specific line to my budget for makerspaces, though it is
yet unknown if this additional money will be added.

The design committee has also done some work toward the pursuit of donations,
grants, and business partnerships. Several committee members have successfully
pursued various online crowd-funding opportunities, and they have shared the process
with the other committee members. I visited with the central office administrator who
oversees grants and was provided written guidelines and instructions for pursuing grants.
The next step is for the design committee to begin to develop a list of possible grants to
pursue. Finally, the committee reached out to the central office administrator who
oversees the district’s business partnership program for guidance. Committee
members were provided the name of the business partnership coordinator in their
building through whom they can work to reach out to business partners regarding
donations of time or materials. Once several committee members have worked through
this process, the committee will create written instructions that other district librarians
can use in the future.
**Promotional campaign.** While the design committee has discussed different possibilities for promoting school library makerspaces within our district, it has not completed any tangible work in this area yet. The design committee believed it was important to first develop our mission and vision statement as well as the design guidelines prior to developing any promotional materials. The committee plans such activities for the promotional campaign as developing an “elevator speech” regarding our mission and vision, inviting central office administrators to visit our makerspaces, arranging for student makers to present their projects to our Board of Education, and creating promotional videos regarding the benefits of school library makerspaces.

**Documenting student learning.** Though not one of the activities listed on the Makerspace Logic Model, as the design committee has worked toward other goals, the importance of documenting student learning through makerspace participation has become evident. The phrase “document student learning” was intentionally chosen to highlight the intent to allow each student to “show off” what he has learned through his individual making experiences rather than to assess students on a particular set of objectives or expectations. The makerspace design committee has initially discussed some options to document student learning such as the use of an online ePortfolio or the development of digital badges that students could earn, but no decisions have yet been made as to the process that will ultimately be used. Because the committee’s thinking has evolved regarding the importance of documenting student learning rather than assessing student learning in the makerspace, the assessment component of the Innovation Configuration Map will likely be revised by the committee at a future meeting.
Chapter Summary

This chapter addressed the study’s first research question: What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district? I situated the design by describing the specific professional context of the design, stating why she believes this design case will be of interest to others, describing the members of the design team, and detailing her role in the design process and as a member of the design team. Next, I described in detail the most pertinent components of the design process based on her knowledge of the process as a member of the design team and on her review of pertinent documents pertaining to the design process. The description of these components included decisions and changes that were made during the process. In addition to a textual description of the most pertinent components of the process, images of various documents relating to the design process were provided, including the design and implementation guidelines developed by the design team for use by the district library program. Chapter Five will speak to research questions two and three, presenting and discussing the results of school library makerspace observations and interviews of students, a librarian, and a teacher I conducted as part of the study. Finally, Chapter Six will discuss both successes of school library makerspace implementation in my district as well as areas for improvement.
CHAPTER 5
RESULTS

The purpose of this design case dissertation is to provide a detailed and thorough account of the design process the makerspace committee of librarians went through to bring makerspaces to the library program in my school district in order to preserve and share the precedent knowledge gained through the process (C. D. Howard, 2011). The previous chapter addressed research question one of this study, “What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district?” and provided detailed information about the design process itself. This chapter presents the results of research questions two and three of this study regarding the actual implementation of makerspaces and the ways in which students experience participation in them. Thematic analysis (Braun and Clark, 2006) was utilized to analyze the data resulting from observations and interviews and to determine the main themes related to research questions two and three. Each of these research questions and the themes associated with it will be discussed individually below. For each research question, a vignette will be provided to help the reader visualize the implementation of the makerspace (research question two) and students’ participation in it (research question three). Photographs I took during observations will also be provided as appropriate.

Research Question 2: What Is the Resulting School Library Makerspace Implementation?

The two main themes surrounding this question that resulted from thematic analysis are as follows: Intentionality in Makerspace Implementation which describes ways in which the resulting makerspace closely aligns with the various guidelines developed by the design committee as well as areas where it does not, and
Makerspace Implementation is Successful Overall which highlights ways in which the makerspace is viewed as a success while acknowledging changes and improvements the librarian hopes to make going forward.

**Vignette: Description of Makerspace**

There are two entrances to the school library makerspace at Elementary School Four. One is the original classroom door entrance leading from the main hallway into the room that once served as the school’s computer lab. Though some classes do enter the makerspace through this entrance, it is primarily used by teachers who are popping into the room to use the staff copy machine that is housed in the makerspace. The second entrance to the makerspace is within the library itself and is through a classroom door the principal had cut out of the cinderblock wall that used to separate the library from the computer lab. This was done to provide the librarian with a dedicated space for a makerspace. This is the entrance classes typically use for their regularly scheduled visits to the makerspace.

The makerspace is long and narrow, approximately 53’ long by 20’ wide, a fair amount of dedicated space for a makerspace in a time when enrollment is growing district-wide and space is hard to come by. When walking into the makerspace, it is easy to tell that the room was once the building’s computer lab, as remnants of its former purpose are still in place. The walls are painted a sterile bright white, their aseptic feel accentuated by the fluorescent lighting in the room. Several windows facing the main hallway, however, provide some additional lighting which tempers the sterility of the fluorescents. The floor is covered with commercial-grade blue carpet tiles with specks of reds and whites mixed in, and the two long walls of the space are lined with mauve counters where a classroom set of desktop computers used to sit. These
counters now serve as storage space for makerspace tools, resources, and materials as well as work space for students while in the makerspace. They also hold a few ongoing student projects. All along the mauve counters there are blue plastic school chairs with round metal legs for student use and electrical outlets where the many desktop computers used to be plugged in. These outlets now allow students many options of where to work on a makerspace project that requires electricity. Another remnant of its time as a computer lab, there are two large mauve storage cabinets at the end of one row of countertops that once held computer equipment. One of these cabinets now holds materials and supplies that students are free to use for makerspace projects while the other is still used for technology storage. Three rectangular school tables with round metal legs and wood laminate tops are spaced lengthwise down the center of the makerspace with more blue plastic school chairs around them to provide additional work space for students. Each table is large enough to seat approximately 6-8 students, and they are spaced so that there is walking room between them.

While the space itself is a repurposed computer lab and elements such as paint color and furniture style give it a typical and non-inspiring school classroom feel, it quickly becomes obvious as one looks a bit closer that this room is very different from a typical school classroom. It is, rather, a Makerspace, as declared by the large sign made up of individual letters that spell out the word. Each letter is made of different materials, such as the “A” made out of Legos, the “E” made out of crayons glued to Styrofoam, and the “K” made out of rulers, which adds a touch of whimsy to the room. For newcomers to the space or those who are not familiar with the term, there is a poster on the wall to the right of the sign entitled “What is a Makerspace?” This poster
defines a makerspace as a place to explore, problem solve, expand one’s imagination, be creative, challenge oneself, build things, and learn something new.

Posted on the walls along the counter at eye level are yellow 8 ½” x 11” signs announcing the types of makerspace activities and/or materials that may be found on that section of the counter. There are six such signs around the room as follows: Computers (Coding); Computers (Makey Makey); Science & Engineering; Building; Arts, Crafts, & Design; and Problem-solving. On the counter below each sign are tools, resources, and materials appropriate to its name. The two computer areas have several desktop computers for student use and the Makey Makey area additionally has several Makey Makey kits available. The Science & Engineering area has resources for tinkering with circuits and simple machines as well as some simple robot kits. Included in the Building area are such things as K’Nex, Legos, Contraptions (wood planks to build with), as well as building materials for younger students such as Goobis and IO blocks. The Arts, Crafts, & Design area has two sewing machines available for student use along with a large selection of material. Also included in this section is a variety of arts and crafts materials such as cardboard, pom poms, glue, popsicle sticks, googly eyes, and much more. The Problem-solving area includes optional design challenges students can choose to take on as well as items they can take apart to see how they work. The specific items available depend on what has been recently donated, such as a musical greeting card or a broken robotic jack-o-lantern Halloween decoration. These items are stored on the counters either in the boxes in which they came or in a variety of clear plastic tubs or storage containers with multiple clear-front drawers. Some items, such as a box of donated fabric for the sewing area, are stored on the floor below the
counter. Additional materials are available to students in the mauve storage cabinet at the end of one of the counters and in a few free-standing, rolling storage carts with multiple clear-front drawers. Each of these six areas also has information available to students they may need while working in the area. For example, the Makey Makey computer area has starter instructions for using Makey Makey while the Arts, Crafts, and Design area has instructions to thread the two sewing machines housed in this area as well as information on how to use the sewing machines and practice sewing sheets. Some areas also provide nonfiction books for students to consult to learn more about certain activities, such as using Little Bits, electronic circuit “bits” that snap together with magnets. Additionally, there is a mobile cart that houses a variety of robots which students can program during their time in the makerspace.

There are additional posters and décor on the walls that further help give one a sense of the makerspace. A clock designed to look like it is made from multiple gears serves a functional purpose while indicating that this is an active space where such things may be encountered. There are several posters encouraging students to develop a growth mindset. A few posters simply define the acronym, STREAM (science, technology, reading and writing, engineering, arts, and math). Other posters define behavior expectations for students using the space and are tied to the building’s overall behavior plan. One poster outlines for students a design process they may choose to use. Another poster provides steps for students to take who need help in the makerspace, including such things as “try to figure it out on your own,” “read the instructions,” and “consult the expert wall.” The expert wall consists of a large sheet of bulletin board paper hung on the wall which is labeled as the expert wall and is where
students write their name and their “expertise” within the makerspace. Students who need help with something, such as coding with Scratch, can find a peer’s name on the expert wall to consult for assistance.

Theme One: Intentionality of Makerspace Implementation

The makerspace described above did not come about by accident or at random. Rather, the librarian, Mrs. Sprague, was quite intentional in her design of various aspects of the makerspace and in her facilitation of student participation in it. As a member of the makerspace design committee, she used the guidelines developed by this team as the basis for the design and facilitation of her school library makerspace. The result of her intentionality is a makerspace that, in its implementation, is closely aligned to many of these guidelines. These three sets of guidelines (Innovation Configuration Map, Library Program Makerspace Design and Facilitation Guidelines, and the Design and Facilitation Guidelines based on the Educational Making Process Model) were discussed in Chapter Four, and the final documents were also included. Though the makerspace design committee developed these at different times during the design process as three separate sets of guidelines, they are related, and there is some overlap between them. Table 5-1 provides a brief description of these three sets of guidelines. The paragraphs below describe areas where the resulting makerspace closely aligns with the various guidelines developed by this group as well as areas where it does not. Table 5-2 at the end of the section provides a summary of makerspace areas of alignment and areas not yet aligned to the guidelines.
Areas of close alignment to guidelines

**Underlying pedagogy/purpose.** When asked in an interview about her goals for students in the school library makerspace, the librarian, Mrs. Sprague, quickly replied, “I want them to discover their own interests and have some freedom to create and problem solve through issues.” She further stated her desire to develop a growth mindset in her students and to provide a student-driven, self-directed environment where “the learning is very individualized,” and students “learn about who they are and what they’re interested in, what they like to do, and who they are as a learner.” When
explaining why she strives to reach these goals through the makerspace, Mrs. Sprague stated,

Our kids are so used to learning being, not prescribed, but, you know, like “Here is the learning target. This is what we’re focusing on. And we all need to have a pretty similar outcome today.” Like that. Because with the way that the state tests are, that’s just kind of the name of the game and how education is right now. Getting the chance to do some learning that’s totally self-driven is something that they don’t always get to do, and, they can do those things at home, but sometimes they don’t have the tools to do them at home. And so, especially being in a Title One [low socio-economic] school, we’re giving them a chance to do those things, and give them a little support, and maybe a little push, to achieve those things.

Mrs. Sprague also stated that she attempts to build student leadership and a sense of community in the makerspace by encouraging students to ask each other questions and support each other’s learning.

The purposes and goals Mrs. Sprague listed regarding her school library makerspace are closely aligned with the guidelines for such developed by the makerspace design committee found in the Innovation Configuration Map (ICM) the team developed which is provided in Chapter Four of this dissertation. This close alignment of the underlying purpose and pedagogy of the makerspace to the guidelines is intentional on the part of Mrs. Sprague, who, when asked about the work of the committee in relation to her makerspace implementation, stated “I feel we have fairly closely aligned with the philosophy of what we have discussed in our makerspace committee.”

**Schedule.** While the makerspace at Elementary School Four does not have a completely open access schedule as is “optimal” according to the scheduling guidelines listed on the ICM developed by the makerspace design committee, Mrs. Sprague has thoughtfully worked out a schedule that allows all students access to the makerspace.
The younger students in her building, kindergarten and first grade, were able to participate in makerspace activities during their bi-weekly library lesson time during the 4th quarter of the school year. For the older students, Mrs. Sprague made changes to her library check-out schedule to allow them consistent time in the makerspace. Previously, these students had a regularly scheduled 30-minute check-out time in the library every week. Mrs. Sprague increased the number of library materials they were allowed to have checked out at any given time and utilized one of the 30-minute check-out times on a bi-weekly basis for student makerspace time. So, students would check-out library materials one week during their regularly scheduled library visit and participate in the library makerspace the next week. Additionally, some students were allowed to work in the makerspace during their recess time, and some students could earn additional time in the makerspace as part of the school's behavior management program. Mrs. Sprague also provided open access to the makerspace on Friday mornings. She stated,

     Friday mornings is my open time that I get a lot of my clerical, weeding, cataloging kind of stuff done, and planning, and so I always give them that time. So, a lot of kids come down for 45 minutes or an hour, and then they have a lot more time, and individualized time with me to get bigger projects done."

This scheduling scenario is similar to what is described as “acceptable” implementation on the ICM.

**Budget.** While there is not adequate and consistent district-level funding for school library makerspaces, Mrs. Sprague has received some inconsistent district-level funding for the makerspace which I provided as the Library Coordinator for the district. She received this funding as a member of the makerspace design committee rather than due to her involvement in this study. All members of the makerspace design
committee received the same level of funding from my budget as did Mrs. Sprague. Mrs. Sprague has also received funding from her building’s PTA and has received many donations of materials from teachers and parents. Additionally, Mrs. Sprague set up a crowdfunding account through Donor’s Choose, and she has received funds for her makerspace in this way as well. Mrs. Sprague was also chosen to be one of a select group of teachers in the district to receive a set of 8 iPads to use with students, which she made available to students in the makerspace. As with the schedule, this is closely aligned to the “acceptable” implementation guidelines for budget found on the ICM.

**Makerspace environment.** The Library Program Makerspace Design and Facilitation Guidelines (MDFG) developed by the makerspace design committee include specific guidelines for three aspects of the makerspace environment: space/storage, furnishings/flexibility, and décor/feel of makerspace. In addition, both the ICM and the Design and Facilitation Guidelines based on the Educational Making Process Model (DFG-EMPM) include a few guidelines related to the makerspace environment. The paragraphs below will be organized by the three main aspects of the makerspace environment as outlined in the MDFG. The additional makerspace environment guidelines from the other two documents will be mentioned within these three main aspects of the makerspace environment where applicable.

Due in large part to the support of the building principal, the school library makerspace at Elementary School Four is housed in a designated space: a prior computer lab that was adjacent to the library. Over the summer of 2016, the principal had a doorway cut through the cinder block wall of the computer lab so that there was direct access to the space from the library. While the makerspace is in a repurposed
computer lab rather than a space specifically designed as a makerspace, it is large enough to accommodate an entire class of students, and, in these ways, meets the guidelines for space established in the ICM. Figure 5-1 below shows an overall view of the makerspace.

![Figure 5-1. Photos courtesy of author. Views of school library makerspace in elementary school four. A) Taken from inside door on library side, B) Taken from inside door on hallway side.]

While the space can fit an entire class of students, it does not necessarily allow students room enough to spread out to do the type of work that often takes place in a makerspace. When speaking of the space, Mrs. Sprague commented,

The space is really nice, but when you have 30 fifth graders in here, it gets really crowded. And then I feel it kind of limits what the kids are able to do and build and construct when they’re sitting elbow to elbow with someone else.

To combat this, and to provide more space for individuals and groups to work simultaneously on different projects per the guidelines, Mrs. Sprague extends the space by housing many of the robotics activities (Ollie, Ozobots, Dot & Dash) on a mobile cart in the library itself (Figure 5-2). Students who want to work with robots during makerspace time do so in the library as seen in Figure 5-2 below, which allows more space in the makerspace itself for students working on other projects.
Figure 5-2. Photos courtesy of author. Robots and other technology used in library during makerspace time. A) Mobile cart in library housing robots, iPads, and other technology, B) Student working with the Dash robot in the library during makerspace time.

Because the space once served as the building’s computer lab, there was already adequate lighting in place as well as ample electrical outlets. The room also has a large double-door storage cabinet that is used to store some makerspace supplies. While the doors do not allow the materials to be visible to students, the cabinet is unlocked and students freely get whatever materials they need from the cabinet. Other storage units in the room consist of a variety of plastic storage containers, both individual storage tubs and free-standing, multi-drawer storage cabinets on wheels. Mrs. Sprague intentionally purchased these in clear plastic so that the materials and resources stored in them would be both visible and accessible to students in keeping with the guidelines. The storage cabinets and other storage units are shown in Figure 5-3.

As a former computer lab, there are existing mauve laminate counters lining the two long walls of the room with approximately a dozen blue plastic chairs scooted under them. These counters serve both as storage space for makerspace resources and as workspace for students. There are also three laminate top rectangular tables in the
center of the room with chairs around them that provide additional work space for students. While these tables and chairs do not have casters on them, they are lightweight, so they can be easily moved as needed to accommodate various projects or student collaboration. Again, this furniture was purposefully selected by Mrs. Sprague with the needs of students in mind as is evident in her comments below when asked about the furniture in the makerspace.

We have three tables sort of along the center that are all very light-weight, easy to move. The chairs are all very light-weight. . . This one [table] and the far one are brand new that were bought with building funds to put in here. I asked for things to be lightweight, easy to move, so that we could be a little bit more flexible with how we used the space, how we organized it. I wanted places for kids to be able to collaborate, and with the rectangle shape of the room, the long rectangular tables seemed to be the best solution.

The furniture selected for the makerspace, while not mobile, is lightweight yet durable enough to meet the guidelines established for furniture in MDFG and the DFG-EMPM regarding flexibility and the ability to arrange it to encourage collaboration.

Figure 5-3. Photos courtesy of author. Various storage units for materials and supplies in the makerspace. A) Large mauve storage cabinets with doors and rolling clear-front, multi-drawer units, B) Various storage tubs and clear-front, multi-draw units on counters.

The colors of the walls, carpet, counters, and chairs in the makerspace were already established when it served as the school’s computer lab and were beyond the
ability of the librarian to change. However, Mrs. Sprague added several elements to the
makerspace that helped it meet the guidelines that the décor should inspire playfulness,
creativity, and wonder, and that the space should communicate the philosophy of a
maker mindset. One of the most obvious is the large Makerspace sign made up of
individual letters, each made from different materials such as an “E” made out of
crayons glued onto a foam letter and an “A” made out of wood, that spans
approximately eight feet of wall space. Mrs. Sprague explained the sign and her
purpose for creating it as follows.

I wanted to set kind of the tone for this space to be a creative space no
matter how low or high tech. So, I came up with this idea . . . instead of
just like printing out a poster that says "makerspace." . . . Each letter of the
makerspace, of the word "makerspace" is slightly different, um, to kind of
give the kids an idea of what kind of things they might want to do in here,
or what kind of materials they might want to use, and just reflect the
creative spirit of this space.

Another piece of décor I noticed during makerspace observations that inspires a sense
of playfulness and wonder is the wall clock that looks like it is made from several gears.

The makerspace sign and the gear clock are seen in Figure 5-4.

Figure 5-4. Photos courtesy of author. A few pieces of décor found in the school library
makerspace. A) Makerspace sign with each letter made from different
materials, B) Gear clock.
Mrs. Sprague also intentionally included several gender-neutral posters as part of the makerspace décor to encourage students to develop a growth mindset or a maker mindset. These posters not only define a growth mindset, but they guide students on behaviors they can practice to develop such a mindset. Encouraging a growth mindset or maker mindset in students is a guideline that shows up in all three sets of guidelines developed by the makerspace design committee.

Another guideline related to the décor of the makerspace specific to the DFG-EMPM is to include items that provide students with information regarding where to go for help. Mrs. Sprague included a “What Do I Do if I Need Help” poster in the makerspace which encourages students to do such things as ask a neighbor, read the instruction manual, or find a peer “expert” to help you. When asked about the poster, she explained it as follows.

I've tried to make it [the makerspace] as user friendly as possible, where kids can find things and access things on their own. And I encourage them to ask each other questions and not just immediately come to me so that they are building leadership roles within their own classes and supporting each other's learning, and building that sense of community. And so, it gives them steps. Before they come ask me, you have to do these four or five things to check and try to get your help, help that you might need before you come to me.

To help students find a peer expert, Mrs. Sprague has an expert wall hanging in the makerspace. This is a piece of bulletin board paper where students can write their name and their expertise so that peers can come to them if they need help with something within their area of expertise. The expert wall aligns with all three sets of guidelines developed by the makerspace design committee.

Activities/tools/materials/resources. Mrs. Sprague set up the school library makerspace in Elementary School Four to have six different activity areas which
students can choose to explore. There is a sign marking each area so that students know what to expect in each area. The six activity areas currently in the makerspace include Computers (Coding); Computers (Makey Makey); Science & Engineering; Building; Arts, Crafts, & Design; and Problem-solving. These six areas are in close proximity of each other within the makerspace, and their arrangement is such that students could easily integrate elements from one area, such as building, with elements from another area, such as electronics, to create a project incorporating both. An example might be a Ferris Wheel built from K’Nex that uses Little Bits to make it move.

In addition to the six activity areas, there is a mobile cart which houses a variety of robots which students can program while in the makerspace. As per ICM and the MDFG, there are both high-tech and low-tech activities in which students may participate that touch on a variety of the STREAM content areas. For instance, students may choose a high-tech science and technology related activity such as coding Dash, a remote-controlled robot, to drive up to the librarian and say her name. Alternatively, students may choose a low-tech arts related activity such as sewing a purse from fabric of their choosing.

Many of the activity areas also meet the guideline of including activities with a low floor, high ceiling, and wide walls, meaning that beginners can experience quick success (low floor), more experienced students can be pushed further (high ceiling), and there are a variety of ways for students to interact with the theme of that area (wide walls). An example of this can be seen in the variety of robots available for students to program while in the makerspace. For beginners, there is Code-A-Pillar, a robot toy made up of approximately ten individual segments that connect to make a caterpillar
approximately two feet long. Each individual piece codes the caterpillar to make a particular movement (turn right, turn left, go straight, etc.), and the caterpillar’s path depends on the order in which the student chooses to connect them. For more experienced students, there is Dash, a robot that students can code using the programming language, Blockly. Further, there are a variety of robots which students may interact with in different ways, including a few snap-together robot kits that perform only a few built-in functions, Code-A-Pillar, Dash and Dot, Ozobot, and Ollie.

Some tools, materials, and resources stored in the large cabinet that was a remnant from the room’s time as a computer lab are not visible to students when the cabinet doors are closed, though students are free to get materials out of the cabinet whenever needed. Mrs. Sprague has purchased many additional plastic storage containers for the makerspace that do allow their contents to be both visible and accessible to students, meeting a guideline listed in both the MDFG and the DFG-EMPM. Within these containers is a wide variety of materials for students to choose from for their making projects. For instance, in the Arts, Crafts, & Design area, students have access to glue, markers, popsicle sticks, pipe cleaners, different colors of wire, duct tape of a variety of colors and patterns, material, buttons, yarn, thread, pompoms, googly eyes, paint, stencils, beads, crayons, cardboard, colored paper, and much more.

Students also have access to tools such as scissors, a hot glue gun, and two sewing machines. Mrs. Sprague is cognizant, however, of the dangers of certain tools that are often found in makerspaces, and she limits the tools she includes in the makerspace based on this.

With elementary, even having them use the hot glue gun was like, “Oh, good grief, I don’t know if I’m ready for this.” . . . But there are limitations
on the tools they are allowed to use. You know, we don’t have like wood and saws in here right now. And we don’t have a lot of big things they are dismantling or putting together. It’s more small scale. They have done some bigger things like cardboard and things, but even cutting the cardboard is a little hard with elementary – finding sharp enough scissors that they’re not going to cut themselves with. . . With little kids . . . there’s a limitation on what they’re able to do safely at this age.

There are seven desktop computers available for students to use in the makerspace along with eight iPads for use with the robots or for such things as stop motion animation. There are also a variety of print resources in the makerspace for student use as needed. For instance, there are nonfiction books about Makey Makey, Scratch, and Little Bits that are on display within the areas that house these items. Next to the sewing machines is a stack of books for kids that include both project ideas as well as simple instructions to learn to sew, knit, or crochet. Additionally, as mentioned previously, there is an expert wall that lists the names and areas of expertise of students’ peers who they can turn to as a resource in the makerspace. Providing these various resources are all in line with the guidelines developed by the makerspace design committee.

**Facilitation.** As per the ICM guidelines, Mrs. Sprague serves in the role of facilitator of the makerspace. Through both researcher observations and interviews with the librarian, the classroom teacher, and students, it became evident that she did so in such a way that is closely aligned to many of the guidelines in the MDFG and the DFG-EMPM. For instance, while the librarian, library paraprofessional, and classroom teacher assist students when and as needed, students participating in the makerspace work on a variety of different activities or projects that are primarily student-driven and self-directed. For students who do not yet know what project they want to make, the librarian strives to encourage them using such methods as discussing with them their
goals and interests or helping them find project inspiration in their area of interest using tools such as Pinterest.

Once a student has an idea for a making project, rather than telling students what they need to do to make it, Mrs. Sprague often encourages them to think about what they want their project to look like before they get started. At times, she has the student explain his project idea to her, and she asks questions of him about it when clarification is needed. At other times, she has students draw out the dimensions of their planned project to ensure they match what the student has in mind. At still other times, the librarian encourages the student to make a prototype of his project to work out any glitches in his planning/thinking. Mrs. Sprague explained it as follows.

Sometimes, they will make a small prototype, and we’ll try to work out the kinks before they move on to the final one. Especially with sewing, like having them draw out the sketch first. Or, they’ll tell me, “I’m going to make a pillow. It’s going to be two inches by thirty-six inches.” And I’m like, “I want you to really sketch that out first, and I want you to tell me what thirty-six inches by two inches looks like.” And they’ll come back to me and say, “Oh, yeah, that’s not going to work. That doesn’t make sense.”

She continued later in the interview as follows.

In the craft station, to avoid wasting and to encourage them to follow sort of a design process. . . they have to do a sketch and some sort of plan with dimensions of what they’re going to make and be able to thoughtfully explain it to me. Sometimes, it’s like, “I’m making a picture frame.” Okay, great! Sometimes it’s like, “I’m making a bird feeder, but it needs to be able to be outside.” They kind of think it through with me together, and we talk about available materials that might work, but it’s allowing them to take a minute and stop before they just get out the glue and scissors and everything and start gluing it together.

When a student encounters a challenge during an activity or project, the librarian has a variety of strategies she uses to facilitate student making. She sometimes encourages students to turn to peers in their own class or whose names are listed on
the expert wall for assistance. At other times, she encourages students to problem-solve on their own, a move that is very intentional on her part, as her automatic reaction at times is to just help the student right away. Mrs. Sprague said when interviewed,

Sometimes, they get frustrated when they are trying something new and it doesn’t work the first time, and sometimes, I’ll immediately step in and try to start helping them. But then, it’s like, you know what, I want you to try a few different things first. And they get so excited when they’ve solved a problem and they’ve figured it out on their own.

At other times, Mrs. Sprague may sit down with a student to help them figure something out. Rather than Mrs. Sprague being the expert in this scenario, she and the student are oftentimes working and learning together. An example of this was observed when a student could not get the Ozobot robot to work as he wanted it to. Mrs. Sprague sat down with the student, and they read through the instruction manual included with the robot to learn together what to do. She sometimes works directly with a student to teach him a particular skill he needs to know for his making project, such as when she taught a student to hand sew a basic stitch to repair a tear in an armrest reading pillow.

Mrs. Sprague discusses student activities and projects with them and encourages them to think about what they could do differently next time or ways they could work toward increased complexity. “I do encourage them to think, ‘Okay, now that you’ve done this, what could you do to take it a step further?’” She goes on to say how she sometimes takes direct action to push students to go further. She said,

I know the robots and stuff, there are things they can do where they just drive them around. . . On the Dot and Dash robots, Dash specifically, there is an app called “go” where it’s just driving them around. I’ve hidden that app so they have to use the Blockly app now, because I want them to push themselves a little further now that they are comfortable with how the robot works. I know they can drive it around, but I’m sort of nudging them to push it a little further, to take it a step further.
When a student was asked where he got the idea to program robots in the makerspace, he commented, “from the [library] teacher. She said, ‘Don’t just drive it; try to program them. It’ll be more challenging.’”

Mrs. Sprague also makes a point to provide students feedback on their projects and she encourages students to give each other feedback, as well. She also strives to help them reflect on their efforts. She explained as follows.

A lot of the adults, including myself, will ask them questions about what they’ve done, and I feel like that leads them to some thinking that they realize they’ve accomplished something. . . Sometimes, they’ll make things, and they don’t realize that they’ve done something pretty remarkable. And, you know, trying to encourage them to, or show them connections to the real world to help them realize, this is a pretty big deal. Like, this is something that, these skills could lead you into something, a career that could really take you places. Because a lot of times I think they don’t necessarily realize what they have accomplished. I think through those conversations is where they realize what they have accomplished.

Areas not yet closely aligned

While the resulting makerspace implementation is closely aligned to the guidelines in many areas, there are several areas the research showed where it is not yet so aligned. These areas are discussed in the paragraphs below.

Guest makers. All three sets of guidelines developed by the makerspace design committee mention inviting guest makers to the makerspace to conduct workshops and/or to teach individual students a particular skill, such as soldering. The school library makerspace in Elementary School Four, however, has not yet had guest makers visit and work with students. In part, this may be due to the fact that the makerspace design committee has not completed its work in this area, which involves putting together a list of potential guest makers for various activities/skills as well as putting
together procedures for inviting guest makers to the makerspace while complying with
district policies and procedures regarding outside visitors to its buildings.

**Makerspace environment.** The environment aspect of the MDFG calls for
storage in the makerspace for ongoing student projects as well as areas for the display
of both sample and completed projects. The room that houses the makerspace was
previously the building’s computer lab, and it retains many of its original features, as it
was not specifically designed or renovated as a makerspace. Therefore, there is not
adequate shelving or cabinets for the storage and/or display of student projects. The
guidelines also call for an area within the makerspace for group presentations and/or
lessons, but no such area exists within the makerspace. However, Mrs. Sprague does
use the instructional area of the library for this at times. Finally, the guidelines call for
writeable surfaces for students in the space, both on the walls/doors, etc. and on the
table tops. Currently, no such writeable surfaces are available in the makerspace.

**Educational Making Process Model guidelines.** The makerspace design
committee did not finalize the DFG-EMPM until January 2017. This was midway
through the first year of implementation of the school library makerspace in Elementary
School Four and approximately two months before I began observations and interviews
for this study. As such, it is not an unexpected finding that there are some areas where
the makerspace is not yet closely aligned with this set of guidelines. One such area is
Sharing. While Mrs. Sprague encourages students to ask each other questions and tell
each other about their making projects within the makerspace, there are not currently
opportunities provided for students to share their projects or their learning to the larger
school, district, or community audience.
Continuous Feedback is another part of the EMPM to which the makerspace is not yet closely aligned. Again, Mrs. Sprague does strive to provide feedback to students and encourages students to talk to each other about their learning, but this portion of the EMPM emphasizes training students to give appropriate feedback as well as providing opportunities for them to provide feedback to others outside of their own class. In these specific ways, the makerspace is not yet closely aligned with this part of the EMPM.

The makerspace is also not yet closely aligned to the Documenting Progress portion of the EMPM. It was found through student interviews that a few students devised their own method of documenting progress, such as a group of girls who made a checklist of all the things they wanted to do for their project. However, students do not use any of the listed online tools to document their progress, nor are they provided a physical “maker’s notebook” to use as needed to document their progress. In addition to this being a fairly new guideline, another reason the makerspace may not yet be closely aligned to this is because there is not adequate storage for ongoing student projects, thereby decreasing the number of ongoing projects students make, and decreasing the need for students to keep track of what they have already accomplished.

While Mrs. Sprague does have conversations with some students regarding what they have made and done, Reflection & Formative Self-assessment is another part of the EMPM to which the makerspace is not yet closely aligned. Students do not use online tools or a physical maker’s notebook to reflect on their making attempts or on their learning throughout the making process, identifying neither areas of success nor areas of potential growth or improvement.
Table 5-2. Summary of results of how makerspace implementation aligns to Makerspace Design Committee guidelines.

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<tr>
<td>Areas closely aligned</td>
<td>Scheduling • School day access • Purpose/pedagogy • Student-interest driven • Growth mindset • Expert wall • Safety • Tools limited • Activities/workshops • Student-interest driven • Variety of materials • Print resources • High- and low-tech • STREAM+ • Budget • District, PTA, crowdfunding • Space/storage/display • Designated space • Can hold entire class • Storage (mostly visible and accessible) • Role of librarian • Librarian as facilitator</td>
<td>Environment • Space/storage • Individuals and groups • Storage for materials • Adequate lighting • Ample outlets • Furnishings/flexibility • Lightweight/flexible • Robots in library • Décor/feel of makerspace • Creativity/playfulness • Gender-neutral • Growth mindset • Expert wall • Activities/tools/materials/resources • High- and low-tech • STREAM+ • Low floor, high ceiling, wide walls • Easy integration • Student-interest driven • Materials visible and accessible • Technology • Print resources • Appropriate tools • Librarian: • Discusses interests • Asks questions • Encourages peer help, problem-solving • Provides feedback</td>
<td>Inspiration • Student-interest driven • Librarian discusses interests • Librarian helps students find project ideas • Variety of materials, resources, activities • Ideation • Students plan or prototype projects • Making • Growth mindset encouraged • Steps to get help • Expert wall • Most materials visible and accessible • Variety of materials, resources, activities • Print resources • Problem-solving encouraged • Iteration • Changing or improving project encouraged • Optional &amp; flexible collaboration • Furniture allows for collaboration • Continuous feedback • Feedback from project • Feedback from librarian • Feedback from peers</td>
</tr>
<tr>
<td>Areas not yet aligned</td>
<td>Community involvement/guest makers • No guest makers/workshops</td>
<td>Environment • Space/storage • No storage for ongoing or completed projects • No instructional space • Furnishings/flexibility • No writable surfaces • Activities/tools/materials/resources • No guest makers/workshops</td>
<td>Inspiration • No guest makers/workshops • Sharing • Larger community • Continuous feedback • Students not trained • Feedback limited • Documenting progress • Reflection/formative self-assessment</td>
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Theme Two: Makerspace Implementation Is Successful Overall

The second theme to emerge through data analysis regarding the resulting makerspace implementation was that the librarian, teacher, and students involved in the study consider it to be an overall success, though all participant types mentioned some specific improvements they would like to see going forward. The ways in which the makerspace implementation is considered a success by the participants as well as the improvements they hope to see are discussed below.

Ways in which makerspace is considered a success

Librarian. Mrs. Sprague feels that the makerspace is a success because of her students’ positive feelings towards participating in it and because of the growth she sees in them as learners. When interviewed, she explained why she believes it is a success as follows.

I feel like it's successful because the kids love it, and the kids are excited about it, and the kids are learning and growing before our eyes. We can see it. We can see the progress they're making. We can see the things that they are ... We can see what they're doing. We can see their learning happening. So, in that regard, I think it's really a success. They are trying new things. They are getting more confident in themselves as learners. They're working together. So, I mean, valuable learning things are happening. So, in that regard, I think it is a success. Now, there are certainly things I can improve on, and I will.

She further stated that the majority of students are deliberate regarding their use of time in the space. She commented,

We have some kids who will come in and fiddle around and not be on task and kind of waste the time. But, for the most part, a lot of them are really excited to have free learning time, and they take it pretty seriously, and they don’t waste time. They come in, and they use the time very wisely.

During the interview, Mrs. Sprague spoke of students who were pursuing their own interests in the makerspace and making things to meet a personal need. She told
the story of a young female student who needed something to hold her collection of
tickets she earned for positive behavior in her classroom. She determined she was
going to figure out something she could make to solve this problem, and she ended up
making a zippered pouch in the makerspace for this purpose. This student-driven,
rather than curriculum-driven, aspect of the makerspace is another way in which Mrs.
Sprague believes the makerspace is a success.

Students also seem to be gaining 21st century skills through participation in the
makerspace, another way Mrs. Sprague believes the makerspace to be a success.

When speaking of this in the interview, she stated,

they're not just playing, they're working together. They're collaborating. They're designing. They're tinkering and problem solving and thinking critically and there is, there is a lot of value to this time. As little [time] as it may be, there is value here.

A final reason that Mrs. Sprague views the makerspace as a success is
because teachers in her building, some of whom were at first skeptical, have come to
see benefit in the makerspace. In her words,

I think the teachers have started to really buy into it. At first, I think some of them were like, "What, what is this?" Where's our computer lab, you know. And it's like, "Okay, I see, I can see what's happening now, and I think, I think this is valuable. I see the merit in this."

Classroom teacher. Mrs. Mosier, the classroom teacher whose students were
the subject of my observations, also believes the makerspace has been successful. In
part, this is due to the growth she has seen in her students through participation in the
makerspace. She believes they have “learned to be independent. I feel like they’ve
learned to be problem solvers. I feel like they’ve been able to try something new
without being afraid of failure, which, I think, are all great life skills.” Her belief regarding
the success of the makerspace is also based on her students' positive feelings about
participating in it. When asked in an interview if she felt the makerspace was a success, she replied,

I just love coming in here, and they do to, because they get to express themselves in ways that they can’t with our high standards for the curriculum. So, it’s things that they never would have gotten to do, at least not yet, in the classroom. So, that’s why I think it’s successful. They’re learning problem-solving; they’re learning those skills, and they’re creating things that they’re proud of.

Students. Through observations of students participating in the makerspace, I found that students, by and large, were purposefully engaged in a self-directed project or activity for the entirety of their time in the makerspace, and that they seemed to enjoy their time in the space. In addition to these observations, students expressed their appreciation of the makerspace, stating such things as, “I like how the makerspace is;” “it’s fun in there;” “it’s been really good;” “I think it’s really awesome,” or, “it makes me really happy.” One female student, when asked how she felt about participating in the makerspace, responded that “using the makerspace is really creative, and it’s really good to help people express their own creative style.” Both researcher observations and student interviews indicate that students who have participated in the makerspace consider it a success.

Improvements participants hope to see going forward

While all three types of participants felt that the makerspace was a success overall, all three also had some specific improvements they would like to see in the makerspace going forward. These improvements are discussed in the paragraphs below.

Librarian. While students have consistent bi-weekly time scheduled in the makerspace and some opportunities to visit the makerspace during recess or as a
positive behavior reward, Mrs. Sprague identified the schedule as an area she would like to be improved upon going forward. She indicated that students are not able to complete ongoing projects in a timely manner within the current schedule, and they often forget about projects they started and stored in the makerspace by their next scheduled visit. Mrs. Sprague hopes to find a way for students to have increased access to the makerspace.

Another area where Mrs. Sprague hopes to see improvement is regarding the storage and display of student projects as well as the storage of materials and resources. Regarding the storage of projects, Mrs. Sprague commented, “I want to figure out a better way to do shelving and storage of projects that we can do more continued, continued, larger scale or more complex things that last over several weeks.” She has the support and financial backing of her principal to make changes to the space to better accommodate this need, and she is considering what is the best option for the space. She stated,

With the way the room is though, I just haven’t quite figured out how to do shelving. How to do storage where it is accessible for the kids. You know, where they are not climbing up a ladder to get to their pieces.

Mrs. Sprague hopes to make this change in the upcoming school year.

Mrs. Sprague also hopes to make changes regarding the facilitation of the makerspace so that students’ making experience aligns more closely with the DFG-EMPM. Overall, she would like to encourage students to be more deliberate in their approach to participating in the makerspace now that they have some previous experience with it.

Now that we know what the makerspace is. We know what that time is for. Really stopping and planning and thinking about our purpose, and being intentional with what we are doing. And, you know, if we need to do some
research beforehand, doing that to help the process and help make your design more efficient, or whatever the case may be. But adding a little more level of thoughtfulness and planning to it, I think, would be beneficial.

While she already does several things in her facilitation of the space that align closely to the Inspiration portion of the EMPM, she would also like to make improvements in this area. She shared that she wants to do a better job next year of posting pictures of finished student work to kind of give them ideas of things they might want to do to inspire them a little bit. Or make a book of pictures of things they did. Or, you know, it could be an online thing. An online portfolio of things the kids have done that they can see. Because I know that gives the student inspiration for what they want to do next.

As mentioned in a previous section above, the makerspace is not yet closely aligned to the Sharing portion of the EMPM. Mrs. Sprague is aware of this and has ideas to improve the makerspace in this area, as well. When asked about the opportunities students have to share their projects or their learning, she stated,

This is something that I want to work on too. . . I'd like them to do more things where they could share out what they're doing in the makerspace. That's something that I haven't done enough of this year, I don't think, where they're sharing their own stuff with others. I know in the classrooms, a lot of them use like Educreations or Canvas or Classdojo to share their work with their parents. So, maybe giving them a chance to use the iPads to share, to take pictures of what they are doing in here, or take videos and then share them with their families or share them with each other. It would be nice to have a platform, maybe like on my library website, where they could post, or they could airdrop things to me and I could post it on the library website, where they could share with each other. Because I think that would add to their sense of accomplishment and pride in what they are doing. And maybe even encourage them to push themselves a little further because they want to show what they can do, what they are capable of.

She then spoke of a group of boys who made a stop-motion animation video in the makerspace and were able to share this at a spring student showcase. She stated that
she would like to give all students the opportunity to display their making projects during this showcase or during parent-teacher conferences.

Two other related areas of the EMPM where Mrs. Sprague would like to make improvements are Documenting Progress and Reflection and Formative Self-Assessment. While a few students were found through student interviews to develop a checklist to document their progress, students are not currently provided resources to do so in the makerspace. During the interview with Mrs. Sprague, she mentioned the idea of a maker’s journal that some other school librarians she knows provide for students in the makerspace. She sees these journals having potential to improve both students’ ability to document their progress and to reflect on their learning in the makerspace. She stated, “that might be helpful to have, so they can like note down, write down the date and what they were working on, their thoughts and kind of what they learned so they can step back in next time.” Mrs. Sprague also mentioned that she would like students to have more time in the makerspace devoted to reflection. These are improvements she hopes to make in the upcoming school year.

Teacher. During the interview with Mrs. Mosier, the classroom teacher whose students I observed, she mentioned a few areas of change or improvement she would like to see in the makerspace. Firstly, she would like to see more “focused areas” for the boys in the makerspace, many of whom currently spend their makerspace time in the library with Mrs. Sprague using the various robots available. Mrs. Mosier stated that she would like to be able to see what these students are doing, as she currently spends the time in the actual makerspace with the students who are working there.
Mrs. Mosier also would like to see additional resources provided for students in the makerspace to get project ideas. As an example, she mentioned a set of books with craft or project ideas as something that might be helpful in this regard. Finally, Mrs. Mosier felt students should be given more time outside of the makerspace to research what they want to make so that they are focused with their time in the makerspace. However, this would take away from students tinkering or exploring in the makerspace, part of the overall making process as outlined in the EMPM.

**Students.** During student interviews, they were asked what changes or improvements they would make to the makerspace if they could. Their answers largely centered around the addition of various activities they would like to try or an increase in the materials available to them for making projects. One student, for instance, mentioned that the makerspace should have “a bit more robotics ... like a little bit complicated, more complicated ones.” Similarly, another student wanted to have the opportunity to build a drone in the makerspace. Regarding available materials, a female student stated that if she had the power to make a change, she would “probably put, like, clay in there because people like to make pottery and stuff.” This same student also would add “more markers and more paper and more organized stuff. Um, more things that people need, like more fabric, stuff like that” to the makerspace. Other students mentioned adding more resources for hand sewing, adding more Legos, and adding more print resources such as instruction manuals for students to use in the makerspace as potential improvements.

A few students’ ideas for improvements went beyond a simple request for additional activities or materials. One male student stated that the makerspace
sometimes gets “a little bit boring” because there is “less things to do over time.” To solve this problem, he thinks “the school should support the makerspace more and put some of their budget on the makerspace to add more things.” Another male student commented that he felt the slowness of the older computers available in the makerspace limited what he was able to do and that he would like to see newer computers available to students. Though they did not mention it as an area of improvement, several students talked about not having enough time to make the projects they wanted to make. Therefore, additional time is an area of potential improvement that was evident through student interviews.

Several students referred to a few makerspace rules that they indicated were restricting the projects they could do in the makerspace. First, there is the rule to use your time wisely and to not waste resources in the space. This rule was put in place because some students were “goofing around” in the makerspace and quickly using up materials and resources by just thoughtlessly gluing things together with no project idea or goal in mind. Some students, it seems from the interviews, took this to mean that they were not allowed to use materials to tinker or to build a prototype of an idea or to make multiple iterations of a project until they could get it to work, thereby limiting what they did while in the makerspace. One male student, when speaking about a project he was trying to get to work, stated, “well, I kind of quit doing them, cuz I never was really able to do them, and I was kind of like wasting materials and that, but it kind of was cool to think of it, cuz if we were able to do it, uh it would be pretty cool.” Another male student mentioned in the interview that he only used Legos or the robots when in the
makerspace. When asked about the reason for this, he specifically mentioned this rule, as seen in the interview excerpt below.

Researcher: Why do you choose to work with the Legos or the robots instead of doing the other stuff?

Student: I think because there is nothing, like, to make. Not since we have the new rule.

Researcher: What's the new rule?

Student: Um, spend like ... to spend your time wisely and don't waste the stuff.

Researcher: So, because of that, you use just the robots and the Legos?

Student: Mm-hmm (affirmative).

The other seemingly innocuous makerspace rule that was referred to in student interviews was the rule to choose an activity area to work in for that makerspace visit. This rule was put in place as a student management strategy so that students who were extremely excited to be in the makerspace, especially when they first had access to it, were not chaotically running around the room from one area to another. It was intended to help students focus their efforts during their visit to the makerspace. It seems from student interviews, though, that it had the unintended consequence of students thinking they could not integrate elements of one activity area with elements of another, though such integration is included in the guidelines developed by the makerspace design committee. A female student referred to this specifically in her interview, and, as seen in the excerpt below, her suggested improvement is in relation to this rule.

Researcher: If you had the power to change something in the makerspace, what would you change to make it better?

Student: Well, I would take the arts and crafts area and, uh, keep it with the sewing because sewing is like arts and crafts. Because sometimes you can paint the fabric to make some designs.
Researcher: Gotcha. So, you said earlier that you go in and you choose one section and you stay there, and what you’re saying is you would like to be able to kinda go to both those.

Student: Mm-hmm (affirmative).

While both rules seem quite reasonable, student interviews indicate that the above misconceptions regarding them may need to be clarified with students.

**Research Question 3: In What Ways Do Students Experience Participation in the Resulting School Library Makerspace?**

The six main themes that were developed through thematic analysis that speak to this question are as follows: Students experience adults as facilitators of making process; Students have access to makerspace at a variety of times; Students participate in a wide variety of self-directed projects and activities within the limitations of time, resources, safety issues, and makerspace rules; The majority of students are purposefully engaged in and enjoy participation in makerspace; Student making experience compared to EMPM; Students benefit from participation in makerspace.

**Vignette: Student Participation in Makerspace**

At 9:50 AM on a Monday morning, Mrs. Mosier’s class arrives at the library for their bi-weekly visit to the makerspace. After entering the library, students take a seat on the floor in front of the circulation desk for a few brief instructions from Mrs. Sprague, the librarian, and from Mrs. Mosier. Students who are interested in sewing are encouraged by Mrs. Mosier to expand beyond making pillows, something many have already done. Mrs. Sprague reminds students who are wanting to make an arts and crafts project to first draw out a design for their project and show it to either Mrs. Sprague or Mrs. Mosier prior to starting. Students are eager to get to the makerspace, and a few girls, anticipating that the instructions are coming to a close, stand up and get
into a “runner’s stance” in order to be able to get to the makerspace as soon as they are dismissed.

When students are dismissed to begin working, the majority of the class heads quickly to the makerspace, where a bottle neck forms as students attempt to enter through the makerspace door. Students at the end of the line begin to encourage their classmates up ahead to “go, go, go,” as they are impatient to access the makerspace and begin work on their projects. Once students get into the makerspace, they immediately disperse to the different areas of the space, depending on what they had chosen to work on for the day, and they begin to gather the materials and supplies needed for the day. Two girls go to the arts and crafts area and start pulling out supplies such as paints, markers, and a glue gun while another girl begins drawing out a design for an arts and crafts project. A girl who brought material with her sits down to get started measuring and cutting while another girl sits at the sewing machine ready to begin sewing. One boy begins working with a Connex kit while another boy begins building with the Gravity Maze kit. Several girls continue working on cardboard projects they started previously, one building a dollhouse, and two others building a castle. A group of boys is at a center table starting a Lego project. One boy grabs a box of Snap Circuits to begin tinkering with it while another two boys start building with Contraptions planks. Two other boys begin to plan a design for an owl they want to sew out of felt and other material while two girls are browsing through the books about sewing at the sewing station. The busy excitement in the room is palpable.

While most students entered the makerspace when dismissed to get started, other students stayed in the library itself where Mrs. Sprague remained with the
technology cart. The technology cart is where the makerspace’s various robots and technology activities are housed. The cart and its contents stay in the library so that students have more room to manipulate the robots after programming them. One boy is driving the Ollie robot around the library using the iPad while another boy is working with the Dash robot. He has the included xylophone accessory on the robot and is attempting to program Dash to play music. Two other boys are working with the librarian, learning the basics of using the Ozobot robot with the iPad. A mixed group of boys and girls is working together on a Stickbot Studio stop-motion animation project. Students are intently focused and engaged and appear to be having fun as they laugh, cheer, and call friends over to see what they were able to get the robot to do or to show them a clip of their stop-motion animation video.

The librarian, library paraprofessional, and classroom teacher roam around the space asking students about their projects, answering students’ questions, and offering assistance as needed, such as tutoring a female student on how to use the sewing machine or helping to troubleshoot when the iPad won’t open the Ozobot app. Students also talk to each other about their projects, and they, at times, seek assistance from classmates. There is an “expert wall” in the makerspace that students consult to see which classmate has an expertise in a particular area so they can ask them for help when needed. While students talk, laugh, and have fun in the makerspace, the majority of them work on their projects and activities the entire time without much direction from the adults. When a few students get off-task, the librarian, library paraprofessional, or classroom teacher re-directs them back to a project or activity.
At 10:15 AM, Mrs. Sprague asks students to begin to clean up and get ready to head back to class. There is a sense of a collective groan in the room, as the thirty minutes went by very quickly and many students do not want to quit working on their projects. Two girls ask permission to continue for just a few minutes more so they can get to a good stopping point, a request which is granted them. A few students ask Mrs. Sprague if she can please have certain materials on hand for their next visit, as they will be needed to continue their project. Some students proudly show the projects they made today to their friends and to the teacher. Within just a few minutes of flurried activity, students have put away their projects and activities and have the makerspace relatively clean. They line up and head back to the classroom.

**Theme One: Students Experience Adults as Facilitators of Making Process**

Students participating in the library makerspace at Elementary School Four experience a student-centered learning environment wherein the adults in the space serve as facilitators of their making process. The adults in the space include the library media specialist, the library paraprofessional, and the classroom teacher. Ways in which they facilitate student making as seen in the data are discussed below.

**Adults give brief directions/instructions.** One way student making is facilitated by the adults in the makerspace is by providing brief directions or instructions to students on a variety of topics when and as needed during their time in the makerspace. For instance, at times, Mrs. Mosier’s class gathered at the librarian’s desk prior to entering the makerspace. Mrs. Sprague and/or Mrs. Mosier would then spend a few minutes giving students brief directions such as reminding them to draw out their ideas for arts and craft projects with dimensions and show them to an adult, reminding them of behavior expectations for their time in the makerspace, or simply letting
students know the librarian would be in the makerspace on her computer to help students who want to look up project ideas on sites such as Pinterest. After these brief directions, students were released to work on the activity or project of their choice.

At other times, brief instructions were given to individual students while they were working on activities or projects. For instance, the librarian was observed working directly with a male student for a few minutes, showing him the basics of how to use the software for the Ozobot robot and some of the options it offered. After just a few minutes, she left him to work and experiment, stating that she would be back to see if he had any questions or needed any help. Mrs. Mosier, the classroom teacher, was observed directing a male student who was working on a hand sewing project to be sure to leave enough thread at the end to be able to tie a knot. Sometimes, the directions were related to classroom management, such as when Mrs. Sprague directed a male student to please not intentionally crash the Ollie robot into the circulation desk.

As students’ time in the makerspace was nearing an end, the adults were also observed giving students brief directions regarding cleaning up the space before leaving. These instructions were mainly directed at the whole group, though they were, at times, directed at individual students who were not cleaning up an area as they should.

**Adults as resource for projects/activities.** Another way adults serve as facilitators of student making is by serving as a resource for the project or activity on which a student has chosen to work. This might be in the form of the librarian providing the actual physical materials a student needs for their project, such as when two female students were working to build a cardboard castle, and they needed toilet paper rolls.
They told the librarian of their need, and she replied that she would talk to the building custodians to procure some toilet paper rolls for the girls’ project.

At other times, Mrs. Sprague, the librarian, delivers whole-group instruction on something that students can then utilize in the makerspace. For instance, when asked how they knew how to do some of the coding for their makerspace projects, two male students stated that the librarian taught them. One male student said, “we kind of tested it out in library lesson on the computer, like, took coding lessons. And also, on the SmartBoard, she kind of showed us how to do things.”

Adults also provide assistance as needed for individual students who are stuck and do not know how to proceed with their project or activity or who need to learn a particular skill in order to proceed. For example, the library paraprofessional was observed working individually with a female student who was making a zippered pouch. The material was cut out and ready to be sewn, but the student did not know how to use the sewing machine. The library paraprofessional walked the student through sewing her pouch, giving her tips and advice, and answering her questions along the way, even explaining to the student that she needed to sew her pouch with the “right” sides together so that when she was finished, she could turn it inside right and the seams would be hidden inside.

Students were aware that they could use the adults as a resource for their projects. When a student mentioned in an interview that he wanted to sew but didn’t know how, he was asked what he could do. He replied, “ask the teacher to teach me how.” Another student, when asked to describe what one would see happening in the
makerspace stated, in part, that one would see “people sewing, sewing and talking to the teacher about their plans.”

When asked in an interview how students go about making once they have a project in mind, the librarian’s reply clearly shows that adults are the facilitators rather than the directors of student making. She replied,

If they have questions for me, I come over and try to help. Or the library paraprofessional tries to help, or their classroom teacher tries to help. But for the most part, they do it themselves. I mean it's really self-directed and student driven.

**Adults not always experts.** During one of my observations of the makerspace, a male student was having difficulty getting the Ozobot robot to do something that he wanted it to do. The librarian noticed his frustration, and suggested he get out the instructions that came with the robot to see if they would help him. She even stayed and helped the student read through the instructions. It seemed from the observation that she was looking for the answer along with him, as if it was something she did not yet know how to get the robot to do. Whether she actually did know the answer or not, she facilitated the situation such that it seemed that she was learning right along with the student. Later, during my interview of the librarian, she stated that there were, indeed, times when students had questions in the makerspace and she had no idea of the answers. She truly was a co-learner with her students in many cases. Too, she encouraged students to turn to more knowledgeable peers to help with their making projects rather than to the adults, as oftentimes other students were more knowledgeable than the adults about various activities in the makerspace.

Mrs. Mosier, the classroom teacher, reiterated that the adults in the space were not always the experts in the room, and were, instead, facilitators. She commented that
when students would ask her questions about things in the makerspace that she was not knowledgeable about, she would reply, “I don’t know more about this stuff than you know about this stuff so you need to figure it out or ask a friend to help you.”

**Adults asking questions about projects/activities.** Asking questions and talking to students about their projects or activities is another way the adults facilitate student making. This questioning has various results with students, but still serves to facilitate the process. For instance, the library paraprofessional was observed questioning a group of approximately eight male students who were sitting together at a table, each with a tub of Play-do. Through that conversation, it became clear that this group of boys was “goofing off,” and the library paraprofessional was able to re-direct them to more productive use of their time in the makerspace.

Another time, the librarian was observed talking with a pair of boys who were working with the Ozobot robots, asking them what were their goals, or what it was they were trying to get the robot to do. This turned into a somewhat lengthy interaction in which the librarian began working with the students as a sort of third partner. The students ended up, at the librarian’s encouragement, each creating a track for their Ozobot and racing them against each other, calling over some of their classmates to witness the “epic race,” as one of the students deemed it. When the race was over, the librarian questioned the students on what they learned from the outcome and what they would try differently next time, thereby facilitating student learning and reflection. This is an example of what Mrs. Sprague described in her interview regarding students receiving feedback in the makerspace. She stated, “as I’m walking around, I try to
Adults encouraging students to “take it a step further.” When asked in an interview where he got the idea to program one of the robots rather than just drive it as a remote-controlled toy, a student replied that it was the librarian who encouraged him to do so.

Researcher: Where did you get the idea to do things like make the robot make sounds and stuff? Where did the idea come from to do that?

Student: From the teacher. She said, "Don’t just drive it, try to program them. It'll be a little more challenging."

Researcher: And is that your classroom teacher or is that the library teacher?

Student: The library teacher.

This is an example of another way the adults facilitate student making in the school library makerspace: encouraging students to take their projects/activities a step further, or complexify them. This is a phrase the librarian used multiple times during my interview of her, that she worked with students and encouraged them to “take it a step further” regarding their projects. This might happen prior to a student starting a project, as when she was observed encouraging a student to think about what goals he had for the robot with which he was working rather than just playing with it. Or, it might happen after a student had completed a project. During the interview, Mrs. Sprague described, for instance, students who complete their first sewing machine project. She then asks them, “now that you’ve done this wallet, how would you use those skills to take it a step further and make maybe a cover for a journal or a bag or whatever the case may be.” She further stated her reasoning for encouraging them in this way.
I do think it is an important next step to encourage them to think beyond what they have just made – push it a step further and add some complexity to it. Because, yeah, they could make 17 pillows, but what are you learning? What are you doing to improve yourself as a learner each time you make a pillow? Are you making it a little differently? Are you making it for a different purpose?

In these ways, then, students experience adults as facilitators of their making process during their participation in the school library makerspace.

**Theme Two: Students Have Access to Makerspace at a Variety of Times**

Students involved in this study had access to the makerspace at a variety of times within their school day. All students in the study had regular and consistent access every other Monday for 30 minutes during their regularly scheduled library visit. Mrs. Sprague set up the schedule so that students checked out library materials or participated in the makerspace during their scheduled library visit on alternating Mondays.

Students in this study also had the option to use their 30-minute recess time on Tuesdays and Fridays to work on projects in the makerspace. Four of the eight students interviewed mentioned that they had used some of their recess time to go to the makerspace to work on projects. Mrs. Sprague, the librarian, also spoke of a group of boys from a class other than the one observed for this study who used approximately two months of their recess time to complete a stop-motion animation video on which they were working.

Students in this study were also able to earn additional time in the makerspace as part of the building’s overall behavior plan. For exhibiting positive behavior, students earn behavior points in the form of tickets that can be used to “purchase” a variety of rewards. Time in the makerspace is one of the rewards available for students to
purchase. Mrs. Sprague sets aside time in her schedule on Friday mornings to work with students who choose to use their tickets for additional makerspace time. Mrs. Sprague comments that “a lot of kids come down for 45 minutes or an hour, and then they have a lot more time, and individualized time with me to get bigger projects done, so that helps with the time constraints a little bit.”

**Theme Three: Students Participate in a Wide Variety of Self-Directed Projects and Activities within the Limitations of Time, Resources, Safety Issues, and Makerspace Rules**

While in the makerspace, students experience a lot of freedom to spend their time in the activity area of their choosing, either tinkering with one of the provided activity kits or working on a self-directed making project within the limits of time, resources, safety, and rules. As such, when one walks into the makerspace when students are present, one sees a wide variety of activity taking place simultaneously. Students are spread out at various workstations: seated at the tables in the center of the makerspace; working at the counters that run along the two long walls in the makerspace; or programming robots in the library. Some projects or activities in which students participate may not involve technology at all (low tech) while for other projects technology may be an integral part (high tech). Some projects or activities only take one visit to the makerspace to complete while other projects may continue for several weeks. Any given student may be in the planning stage of an ongoing project, in the middle of a project, or nearing completion of a project.

Students were asked during their interviews to describe what one would see when walking into the makerspace. One student replied that one would see people sewing and talking to the teacher about their plans . . . some kids playing on Legos and some coding. And sometimes, see kids draw and
sometimes see kids build stuff like cars or trains and . . . other buildings. And I also saw somebody messing with the robot.

The student’s description matches what I observed. The following excerpts from my field notes describe what I observed during the first few minutes of two makerspace observations.

2/27/17 - A group of eight boys grabbed tubs of play-doh and went to a table. Four girls at the arts and crafts area getting supplies. One girl drawing out a design for arts and crafts. One boy building with Connex. Another building with Gravity Maze. A group of three girls building with cardboard.

4-10-17 - Several girls went to craft area and started pulling out paints, markers, glue gun, etc. Another girl brought in with her some material, and she sat to get started making her project. One boy got a box of snap circuits to begin making something with it. Another two boys started using Contraptions. Two boys working together on a box of K'nex. Two boys working to plan out/draw out a design for an owl [sewing project]. One boy working in the library area with a robot.

The following paragraphs describe some of the wide variety of low tech and high tech activities and projects students were involved in during their participation in the makerspace.

Low tech projects

The paragraphs below describe several low-tech activities and projects students participated in while in the school library makerspace. They are divided into those that took only one makerspace visit to complete (one and done) and those that took more than one makerspace visit to complete (ongoing). This is just a sampling of the types of activities and projects in which students participated. Project descriptions came from researcher observations as well as from interviews with students and with the librarian.

One and done. One example of a low-tech project students made that took only one makerspace visit was a birthday card that two girls made for their friend. According
to one of the girls, it was made from paper that had “fine stuff around it. It was like metallic, shimmery blue. . . and it had three little balloons that said Happy Birthday.”

Another example of this type of project is a Lego rover a male student built during one makerspace visit. This young man sought me out at the end of the makerspace visit to tell me about it. Based on the tone of voice he used as well as his actions, he seemed very proud of what he had built. Per my field notes,

He told me he came up with the idea for it all by himself and that he made it all by himself. He built the rover to have two rows of wheels: a row of smaller wheels on the inside and a row of larger wheels on the outside. He said he wanted it to last for a long time to be passed down, and that he did not want it to be destroyed. He referred to it as his “favorite build.”

As he did not want it destroyed, he placed the rover in the Lego tub still intact rather than taking it apart at the end of makerspace time. Figure 5-5 shows the student’s Lego rover project.

A female student spent one makerspace visit making a picture frame. According to my field notes, the student

made a picture frame, pink construction paper with “jewels” glued around the outside and ribbons attached to the top that she can use to hang it on the wall. She told me she was going to put in it a picture of herself and her friend.
Other students participated in a variety of low-tech activities during a single makerspace session. Such activities I observed include a pair of boys working with a set of plastic gears trying to make a series of them work together and an individual male student attempting to build a bridge with the Contraptions planks that he could roll the included ball across without the bridge collapsing.

**Ongoing.** Other projects that students participated in, while still low-tech, took more than one makerspace visit to complete, several being ongoing for many weeks. One example of such a project was a cardboard dollhouse one female student was making which can be seen in Figure 5-6. The following excerpt from my field notes are from the first time I observed the student working on this project.

One girl had an ongoing cardboard project where she was building her own dollhouse. She had been working on it several weeks, so it was already quite extensive. It had cardboard dividers inside (maybe dividers for an industrial size box of crayons?) that she connected sideways to the back of her box to make “beds” in the house.

There were several other students making ongoing cardboard projects, including a group of three girls making a “Littlest Pet Shop” café and a pair of girls making a castle.

Figure 5-6. Photos courtesy of author. Student’s low-tech ongoing cardboard dollhouse project. A) Student working on project during makerspace visit, B) Detailed view of ongoing cardboard dollhouse project.
Another ongoing low-tech project I observed students making was zippered pouches, shown in Figure 5-7. I observed two female students working on various stages of this project. Below is the excerpt from my field notes describing the students’ work on this project during one observation.

Two girls came in and immediately got to work on a project they seemed to have planned out ahead of time. Both girls brought material to the makerspace with them. One of the girls had printed instructions from an Internet site on how to make a zipper pouch, and she had these instructions with her, and she seemed to be following them. The other girl had a pocket folder with her. In one pocket was a list of project ideas she hoped to make. In the other pocket seemed to be instructions for a project. Both of these girls was cutting out their material into rectangles, and they were taking care to make sure the rectangles were the same size. One girl had bright pink material, and she used the first rectangle she cut out as a template to cut out the second rectangle. I went to observe other students for a bit, and when I came back, this girl was just finishing up sewing the seams of her pouch around three sides of her rectangles using one of the sewing machines. The library para was seated at the other sewing machine next to her, and she was giving the girl tips and advice about her sewing. She told her that when you sew your seams, you want to put the "right" sides of your material together so that you can then turn it inside right and not see your seams. She was helping the girl turn her pouch inside right just as the class was exiting the makerspace.

Figure 5-7. Photos courtesy of author. Students working on low-tech ongoing zippered pouch project. A) Preparing materials according to printed instructions, B) Beginning to cut fabric into rectangles.
There were several other ongoing sewing projects taking place in the makerspace over the course of this study. These include a pair of male students who were observed sewing an owl from felt and other material; a female student who told me during an interview about a bag she made for her mom as a Christmas present; and a male student who was observed making a blue felt puppet with big googly eyes and hair made from a green pipe cleaner. A few of these projects can be seen in Figure 5-8.

A male student told me during his interview of an ongoing Lego project he and his friends had worked on wherein they were building a Lego hotel. According to the student, this low-tech project took a few weeks to complete.

Figure 5-8. Photos courtesy of author. Additional low-tech ongoing student makerspace projects. A) Two boys working on an owl sewing project, B) Blue felt puppet made by a male student.

High tech projects

The paragraphs below describe several high-tech activities and projects students participated in while in the school library makerspace. They are divided into those that took only one makerspace visit to complete (one and done) and those that took more than one makerspace visit to complete (ongoing). This is just a sampling of the types of activities and projects in which students participated. Project descriptions came from researcher observations as well as from interviews with students and with the librarian.
One and done. During researcher observations of the makerspace, she witnessed a group of boys working with the Snap Circuits electronic components kit trying to create a working electrical circuit that would run the included fan. They were successful, and they excitedly showed me that they could hit a switch they had included in the circuit to release the fan, which would then fly several inches into the air. This group of boys tinkered with the Snap Circuits during the entire makerspace session, but packed everything up and put it away at the end of the session. Though they might choose to work with Snap Circuits again the next time they were in the makerspace, they would need to begin again on creating circuits as nothing was retained upon which they could build the next time.

During an interview, a male student told me of another high-tech activity that he and a group of friends participated in during a makerspace session. Though he was not able to name the device he and his friends were using, I surmised from his description that it was the Makey Makey kit. He described his experience as follows.

One time with my old friends, we made it so that like if we, um, we like put our thumbs onto some wires and stuff, and every time we'll high five, put a five or a fist pump, a YouTube video will go on. . . We were using, um, it was like a keyboard coding thing.

This is another example of a high-tech activity that was completed in a single makerspace session.

Ongoing. The most notable example of an ongoing high-tech student project came to me through the interview with Mrs. Sprague, the librarian. She told me of a group of fifth grade students who taught themselves stop-motion animation and voluntarily spent their recess time creating a stop-motion animation Lego video. She explained,
They made like a five-minute long stop-motion video, which, anybody that's done them before, it is a long process. I mean that's hundreds and hundreds of individual still frame images. And it probably took them two months of recess times to do it.

Several other high-tech activities in which students participated may well have been ongoing, depending on whether students saved the programming they did during each session or if they started over from scratch the next time. For instance, one young man told me in his interview that he created animated figures using the Scratch programming language. He stated,

I made it walk around. Like um, change to different figures. There's three different figures. One, one's standing still. Actually, only two. One's standing still, and one walking. And I kinda put that on a loop. . . Also, I made some music behind it.

It is unknown whether this student saved his Scratch programming to come back to later, but since the work could be saved and continued, I am including this as an ongoing project.

Other high-tech projects that could be saved to continue later and are therefore being counted as ongoing projects include students who created tracks on the iPad for the Ozobot robot to follow as well as students who programmed the Dash robot to perform various commands. As with the previous Scratch example, it is unknown whether the students saved their programming and continued it later or if they started over each time. However, as the programming could be saved and continued, these activities are being counted as ongoing. A few of these potentially on-going high-tech projects are shown in Figure 5-9.
Figure 5-9. Photos courtesy of author. Potentially ongoing high-tech student projects. A) Student testing out Ozobot robot on track he designed on iPad, B) Student attempting to program the Dash robot to play music using the xylophone accessory.

Project limitations

While students participating in the school library makerspace experience a lot of freedom regarding activities and projects in which they have a personal interest, there are several limitations to the activities and projects they can choose. There are limitations of time, resources, and safety as well as unintended barriers resulting from rules that have been put in place for using the makerspace.

Time. When asked during an interview what limitations there were, if any, regarding the projects students could make, Mrs. Sprague, the librarian, stated that, among other things, “time is a limitation.” I observed several students in the makerspace who ran out of time to accomplish their goals for the day. For example, a male student was working one day to make a spider using construction paper for the body and pipe cleaners for the legs. He at first was attempting to use the hot glue gun to attach the legs, but he was having trouble getting the hot glue gun to work. He then decided to use Elmer’s glue to attach the legs. However, before he was able to get very far, time was called to clean up. This same student, when asked during an interview if
he showed others the projects he made in the makerspace, commented that he might show them briefly, but that “we don’t have much time in the makerspace, so, I have a few minutes, [then] we’re about to leave.” I also witnessed two girls who were working on a collaborative cardboard castle project and hoped to attach second story dentil molding design during that makerspace session. Time was called to clean up before they had the final piece attached, though they did get permission to attach it before cleaning up.

During student interviews, several students mentioned ways in which time was a factor in or limitation to the activities and projects they chose or that they were able to complete during makerspace time. One male student talked about how he and another student were struggling to figure out how to complete a Gravity Maze challenge, building the marble run in such a way to get the marble to the designated target as specified on the challenge card included with the kit. He described how, when they didn’t know what to do, they “tried to see which one went first, . . . the gray, the orange, or the green, and we didn’t really know.” When asked if they ever figured it out, his reply was that “we didn’t have enough time.”

Another student spoke about trying to use a robot mouse kit where the student can build a path to a piece of plastic cheese and program the mouse to navigate to it. The student stated, “I didn’t really know what I was doing, and by the time I found the instructions, it was time to go.” The student also mentioned that he did not return to this activity in a future makerspace session.

Yet another student told me of his desire to make dog toys which, according to the interview with the librarian, he had plans to sell. He did not know how to go about
making the dog toys. When I asked him what he did at this point, he replied, “I didn’t really know how to do that, and so I wanted to look up online, but I guess there just wasn’t enough time in the week to make ‘em.” This student abandoned the idea of making the dog toys, as he did not feel there was enough time to pursue it.

**Resources.** There are many materials and resources available and accessible to students in the makerspace that they may use for their making projects. I witnessed many instances of students freely getting into storage bins or the storage cabinet to get whatever supplies they needed for their project. During interviews, students were able to name various supplies available for them to use. One student stated, “there’s googly eyes, popsicle sticks, fabric, and other stuff. Those are mostly some of the stuff I can name off the top of my head.” When asked if she could use any of those items, she replied affirmatively. Another student, when asked where she and her friends got the materials they needed for their collaborative cardboard project, replied,

> We looked around the room for things we could use. We found the cardboard to use as the actual room. We used popsicle sticks and duct tape for the tables and beads for the drinks. All the things we used were in the makerspace.

While there are a wide variety of materials and resources available to students in the makerspace, the librarian stated in her interview that lack of materials can be a limitation for student projects. She stated, “in some ways, we have a lot of resources, but there is always, I think, going to be a need for more, especially the consumable stuff. So, that can be sort of a limitation, depending on what we have.” One specific area the librarian mentioned where this was the case was with building materials such as Legos and K’Nex. She told me that, when the makerspace first opened, students who had ongoing Lego or K’Nex projects could store them in a storage bin to come
back to later. However, students forgot about their projects stored there and “the storage bins and things when they were storing Lego projects and things, things were getting left behind, and then all of the resources were getting sucked up and left over in the storage bins.” As a result, students, as a general rule, are not allowed to store and continue Lego or K’Nex projects, but must take them apart at the end of each makerspace session, limiting the projects they can make with these building materials. More of these resources would help alleviate this limitation.

Students also mentioned several materials or resources they would use if they were available in the makerspace, such as clay, additional Legos, more paper, markers, and fabric, and even the tubes from mechanical pencils. However, as one student aptly said in his interview, “it’s not like, um, the makerspace isn’t like you have everything in the whole world.”

I also noted during observations that the makerspace does not yet have tools available to students such as a 3D printer or a laser engraver, thereby limiting the types of projects students can create.

**Safety issues.** During her interview, Mrs. Sprague listed safety issues as another limitation to the activities and projects students can choose in the makerspace. As she says,

> There are limitations on the tools they are allowed to use. You know, we don’t have like wood and saws in here right now. And we don’t have a lot of big things they are dismantling or putting together. It’s more small scale.

While these limitations are completely reasonable, they do limit the projects students may choose to make.
**Unintended barriers.** Additional limitations to the activities and projects students can choose in the makerspace resulted as unintended consequences of several rules that were put in place. The following rules themselves seem quite reasonable, yet student interviews showed that barriers to student making projects resulted.

As discussed in a previous section of this dissertation, the librarian instituted a rule that students were not to waste resources in the makerspace. Rather, she asked them to be thoughtful about the projects they wanted to make and to do a bit of planning prior to grabbing random materials and beginning to glue them together. While this rule is understandable given that students were quickly using up supplies, several students mentioned this rule during their interview as a reason they did not attempt certain projects. One male student pointed to this rule as the reason he only worked with the robots rather than making other projects. Another male student identified this rule as the reason he quit trying to make a project with which he was experimenting.

Also discussed in a previous section of this dissertation is the rule regarding choosing a single area to work in during the whole of a makerspace session. Again, while this rule seems a reasonable way to maintain classroom management, it led some students to believe they could not combine elements of one area with elements of another to create an integrated project. In particular, a student mentioned that she wanted to be able to combine a sewing project with the arts and crafts area, as she thought she might like to paint on the fabric she was using.

The final rule that resulted in an unintended barrier to student making was that the Play-doh and model magic were taken away from all fifth graders because some
students were not being responsible with it. During his interview, one male student commented,

I was planning on using Play-doh and model magic, but the time I wanted to do it, it got taken away because people weren’t using it correctly because they were just using it just to use it and they weren’t learning anything.

Again, the general rule is reasonable given that students were misbehaving with the material, but it had the unintended consequence of resulting in a barrier to making for this student.

**Theme Four: Majority of Students Are Purposefully Engaged in and Enjoy Participation in Makerspace**

While some students were observed, in the words of the librarian, just “fiddling around” in the makerspace, doing such things as intentionally and repeatedly running one of the remote-controlled robots into library furniture or simply playing with Play-doh, the majority of students were found to be purposefully engaged in and enjoying their time in the makerspace.

**Purposeful engagement**

Several student behaviors I observed while they were participating in the makerspace show that students were purposefully engaged during their time there. When students arrived at the makerspace for their scheduled bi-weekly visit, for instance, they were very excited to enter into the space. During one observation, students were lined up in a straight line entering through the makerspace door, and a bit of a bottleneck formed at the front of the line. Students towards the back of the line began saying, “go, go, go,” attempting to speed up their peers at the front of the line so that they could enter the makerspace and get started. Another time, I observed students, upon entering the makerspace, running to the activity area where they wanted
to work for the day. This excitement to enter the space and quickly dispersing to their chosen work area was seen in all observations I conducted.

Once students were in the makerspace, they were eager to get started on their self-chosen activity or project. As seen in Figure 5-10, immediately upon entering the makerspace, students began to get out the materials and/or resources they needed during their time in the space. Some students were seen in the library with the librarian selecting which robot they wanted to work with for the day. Other students were seen getting materials and supplies from the large storage cabinet in one corner of the room or from the clear front multi-draw cabinets in the arts and crafts area. Still other students brought their own materials and supplies, and began unpacking them and spreading them out so they could get started on their project. This was the case with a female student who was observed bringing in materials for a sewing project she was going to start. The excerpt below from my field notes describes her actions.

One young lady came in with a stack of material. Each piece was folded into a rectangle that was about 5 inches by 3 inches, [the stack] approximately 1/2” deep. They were colorful and patterned, each one different from the others. She also had several zippers that she brought with her. She immediately got to work unfolding one piece of material, using a ruler to make measurements and marks on the material, and cutting it out the way she needed it. She was quite focused and intent on her project, and it seemed that she had planned it out prior to stepping into the makerspace. She was ready to use the time she had in the makerspace to actually get work done on the project.

Still other students pulled out ongoing projects that were stored in the makerspace to continue work on them, such as one young lady who was making a dollhouse out of a cardboard box. Most students, like the ones highlighted above, came into the makerspace with a seeming purpose in mind and started working toward that purpose as quickly as possible.
A) Students disperse to various areas upon entering the makerspace, B) Two girls get out arts and craft supplies for their makerspace project.

The scheduled time for students to be in the makerspace was thirty minutes, and most students worked intently on their activities or projects the entire time, not wanting to stop working when time was called to begin cleaning up. An example of this from my field notes was a male student who was working with the Gravity Maze kit, a kit wherein students build a marble run using the varying sizes of towers included in the kit to transport their marble to the designated target. While this student was not the primary focus of my observation that day, I was “sitting in close proximity to him during the observation. He was working quite intently and quietly the entire time, even waiting until the last minute to clean up and head back to class.” Another example from my field notes shows two female students working together on an ongoing cardboard castle project every minute possible during their makerspace time. I wrote,

These girls worked the entire time that was available, and they nearly got all of the sides complete before time was called to clean up. They had one more side to tape, and they asked permission to finish taping it before cleaning up, which they received permission to do. . . They then worked quickly together to clean up, put all tools away, and store their project to work on again next time.
During one observation, I wrote in my field notes that there seemed to be a “busy excitement” in the air for most students, with the exception of a few boys who seemed to be off-task. I further described the feel in the space as follows in my field notes,

The rest of the kids were very engaged in what they were working on. Several, like the girl with the material and the zippers, the girls with the cardboard castle, the girls with the pet shop, the boys with the K’nex, the boy using snap circuits, and the boys working with the gravity maze were very focused and seemed excited for the time to work. They were heads together, talking about the project or activity, asking questions of each other, all hands in grabbing parts to put together (gravity maze), etc. There seemed to be a buzz in the air for most students. When time was called to begin to clean up, several students commented that it had gone quickly, or that they wanted to keep working.

During the interview with Mrs. Sprague, she commented about her students’ engagement for the whole of their makerspace time. She said, “for the most part, a lot of them are really excited to have free learning time, and they take it pretty seriously, and they don’t waste time. They come in, and they use the time very wisely.”

**Student feelings about makerspace**

Not only are students purposefully engaged during their time in the makerspace, but they enjoy the time they spend there. During my observations, I witnessed students who, while attempting to get the Ozobot robot to move along a track they had made on the iPad, would “smile, laugh, and speak” to each other, giving me the impression that they were “expressing their excitement” about the work they were doing. Not only did students talk about the activity in which they were involved, however. I noted that another group of boys who were also using the Ozobot robot “seemed to really enjoy their time,” “talking about what they were doing, but also using the time to talk about personal things like what movie they wanted to go to that weekend.”
Both the librarian and the classroom teacher mentioned during their interviews that their students had positive feelings towards participation in the makerspace. The librarian commented that “the kids love it, and the kids are excited about it.” The classroom teacher stated that “they just love being in here,” and “they’re always sad to leave.”

Students themselves expressed that they enjoy their time in the makerspace in a variety of ways during their interviews when asked how they feel about participating in the makerspace. Students commented that the makerspace is “really awesome,” “it makes me happy,” that it is “the funnest part of school,” and that they were “pleased” to be able to use it. One female student further commented, “it’s a really fun place. You can literally go beyond your imagination in there. It’s just like a room where you can go in, make whatever you want, and it comes to life.” A male student expressed his appreciation for what he learned in the makerspace, stating, “it makes me excited and educated because I get to learn new stuff in the makerspace sometimes.” Another male student said he thinks “it’s a very good privilege because I get to experience stuff new that I wouldn’t see regularly every day. I get to experience more with technology, and I get to learn more about the world and experience my creativity.” Yet another male student more concisely summed up his feelings by simply stating, “Makerspace is wonderful.”

**Theme Five: Student Making Experience Compared to Educational Making Process Model**

The next theme to be discussed in the paragraphs below is how students’ making experience compares to the making process outlined in the EMPM. I developed the EMPM to assist librarians in my school district to better understand making as a
learning process so as to design, implement, and facilitate school library makerspaces in such a way to best afford students the opportunity to experience making as a learning process. While the EMPM is not intended to be a step-by-step making process which all students need to follow, the paragraphs below discuss how students, overall, were found to experience each part of the EMPM in the resulting makerspace that was the subject of this study.

**Inspiration**

The “Dream It!” or Inspiration step of the EMPM centers around the idea that students participating in a school library makerspace will select making projects based on their personal needs or interests rather than completing teacher-directed or curriculum-driven projects. While interviews showed that the librarian and classroom teacher did at times suggest a project, such as sewing purses, or encourage a student in a certain direction, such as programming rather than simply driving the remote-controlled robots, the overall experience of students in the makerspace was in keeping with the Inspiration step.

**Where students get project ideas.** I observed students working on a variety of self-selected activities or projects in the makerspace based on their personal needs or interests. They were asked during interviews where they get the ideas for the projects they make. Students’ answers indicate that their project ideas are, indeed, student-driven rather than teacher- or curriculum-driven. One female student, when asked where she and her friends got the idea to make a Littlest Pet Shop café, replied, “my friends have been thinking that Littlest Pet Shop are pretty fun toys. They’re just little small animals. And they thought about making small little areas for the Littlest Pet Shops to hang out.” Another female student who was working on the same project
reasoned, “I didn’t have very much things in my room to put my toys in, so I just thought
to make stuff so my toys would have a good home.” A male student expressed a similar
reason for choosing his making project, stating, “I was playing this game that I have,
and it didn’t have a crossbow weapon, and I thought, [I] could try to make a mini design
of it.”

When asked where her students’ project ideas came from, the librarian told of a
female student who chose to make something to fulfill a personal need.

We have little star tickets that the kids make for rewards. I had a girl make
a little wallet to hold those. I mean, it was like . . . , “I need something to do
this, and so I’m gonna go, and I’m gonna plan it, and I’m gonna make it,
and I’ve found a solution to my problem in the makerspace.”

Students who do not yet have a project in mind have resources available in the
makerspace to help them find inspiration. I observed two female students browsing
through the kids’ sewing ideas books in the makerspace as well as another female
student who was browsing Pinterest for project ideas. Another option for students is to
tinker with various activities in the makerspace until they determine what they want to
make. As one male student put it, “it’s not all just about learning. . . You just get to
explore.” Student exploration is also in keeping with the Inspiration step of the EMPM.

**Why students choose the projects they do.** Students were further asked in
interviews why they chose the projects or activities they did rather than others. Again,
their answers show their decision was student-driven rather than teacher- or curriculum-
driven. One of the female students involved in the Littlest Pet Shop café project stated
that they chose this project over others “because we knew that they were pretty special
to us.” A male student who had chosen to do coding stated, “I guess I just . . . like using
the computers.” Another male student replied that he and his friends chose the projects
they did because “they just seemed like the stuff we wanted to make,” while another male student replied the projects he chose “just seemed the more interesting than other things.”

**Ideation**

When a student has a making project in mind, he may then follow the “Visualize It!” or Ideation step of the EMPM. However, as the EMPM is not a step-by-step process, the student may experience this step in conjunction with the Inspiration step, or possibly not at all. Ideation involves the student envisioning how he wants his completed project to look. He may simply visualize it in his mind. He may draw or write out ideas for the project. He may even create a quick prototype of his idea. The librarian facilitates student ideation in the arts and crafts area through the implementation of a requirement that students draw out their idea for their projects and discuss them with her before beginning the project. This requirement was put in place, according to the interview with Mrs. Sprague, to “avoid wasting [materials] and to encourage them to follow sort of a design process.” In the other makerspace activity areas, there is not such a requirement in place at this time. Rather, as Mrs. Sprague stated in her interview, “in the other stations, as of now, they kind of dive in, start playing and problem solving as they go. But in the future, I think it’d probably be a good idea to have them plan ahead too.”

Several times during makerspace observations, I witnessed students drawing out designs for arts and crafts projects. The librarian, library paraprofessional, and classroom teacher were all observed reminding students to do so prior to starting an arts and crafts project. Other students were observed using Pinterest to find a specific example of a general sewing project they had decided to make, such as the exact
zipper pouch they would make, thereby visualizing how their completed project would look. When asked if she knew how she wanted her project to look before starting it, one female student’s answer shows that she did experience this step of the EMPM. She replied,

I knew what I wanted it to look like. . . I had the picture in my mind. . . I drew it out on a piece of scratch paper. I drew out what the design and what the building would be.

A male student, after explaining to me how he went about making a mini crossbow toy in the makerspace, was asked if he drew this out ahead of time. The student replied that he did not, but that the idea “was in my head.” Some students, then, did experience this step of the EMPM as part of their own making process.

Other students, however, did not seem to experience this step of the EMPM as part of their own making process. As acknowledged by Mrs. Sprague in the quote above, students in areas of the makerspace other than arts and crafts tend to start tinkering without having a firm idea of how their completed project will look. For example, one male student who spoke of working on a K’Nex project was asked if he knew what he wanted it to look like prior to starting. He replied, “I want it to look like a motorcycle, but I’ll add a few things here and there.” I then asked how he went about making the motorcycle, and he responded, “I just messed around with the pieces, and I tried some new things, and then I found what fits the best and, um ... it took me a long time, but at the end it was worth it.” Though this student had a general idea of how he wanted his completed project to look, he did not have a detailed plan of how to go about making it. Interestingly, though the student stated that “it was worth it,” he later stated that he was unhappy with the way the motorcycle turned out. When asked if any project did not turn out the way he wanted it to, the student stated,
I guess the motorcycle because the wheels didn't really move well. The only thing it'll do is that you could either make it stand or you could take out the piece that holds the wheels, but the wheels would come off.

Another example of a student not experiencing the Ideation step of the EMPM is a male student who was attempting to make a Mento launcher. When asked if he knew how he wanted his final project to look before he started, he stated, “I kind of just figured it out cuz I’ve never really seen anyone make a Mento launcher, so I never have imagined what it looked like.” Similar to the student attempting to make a K’Nex motorcycle with only a general idea of how it might look, this student was unsuccessful in creating a working Mento launcher.

**Making**

The next step listed in the EMPM is the “Create It!” or Making step. Though this step is listed third in the EMPM, students may participate in this step without first having participated in the previous two. The Making step of the EMPM is where the student brings to fruition whatever it is that he has determined to make. The student may approach this step in different ways. He may jump in and start tinkering, exploring various materials and resources, attempting to create the item he has envisioned. Conversely, the student may approach the making step in a more thoughtful way, determining and then gathering the materials, resources, and knowledge needed to proceed. He then creates the physical or digital artifact he envisioned, which may involve problem-solving through multiple attempts or even circling back to a previous step of the EMPM, such as Ideation, as necessary. Researcher observations and interviews showed that the approach of students participating in the school library makerspace to the Making step of the EMPM ranged from a tinkering approach to a much more planned and thoughtful approach.
The student mentioned in the previous section who was attempting to build a K’Nex motorcycle is an example of a student who approached the Making step of the EMPM from a tinkering perspective. Once he knew he wanted to make a K’Nex motorcycle, he “decided to . . . mess around with the parts.” He stated that this sometimes leads him to “make something that’s really good, and I wasn’t even planning to do,” but this was not the case with the motorcycle, which did not turn out as he hoped it would. Another student approached his K’Nex project in a similar way. He decided to make a K’Nex crane after seeing a picture of one on the box. When asked how he went about making it, he replied, “I kind of just tested it out. Seeing what I can do. . . kind of experimenting with it.” He stated that his crane turned out “skinnier” than an actual crane and “kind of simple,” but that it was “still good, to me.”

Some students were somewhat more thoughtful about the materials they would use for their project, but still took a tinkering approach to the actual creation of their project. One of the female students involved in creating a Littlest Pet Shop café out of cardboard with a group of friends talked about how they went about beginning to make their project once they knew what they wanted to make. She stated that they “thought about the supplies we needed to use. Then we brought them out, and we started building.” When asked to expand about how they went about building it, she replied, “we kinda just started putting stuff together.” Another female student who was building a miniature house for her dolls out of cardboard talked of using a similar approach. When asked how she went about making this miniature house, she replied, “I first had to plan it. Then, I got all the supplies to make it. Then, I started building it.”
questioned further about what the building of the dollhouse entailed, she stated that she used her imagination and made it up as she went along.

Yet other students approached the Making step of the EMPM in a much more planned and thoughtful way. I observed a pair of female students who took this type of approach to the Making step. These girls were both working on making zippered pouches. The excerpt below from my field notes of a makerspace observation show that these students approached this step with much more planning and thought than the previously mentioned students. They gathered the materials they needed as well as the information they needed to make the pouches successfully.

Two girls came in and immediately got to work on a project they seemed to have planned out ahead of time. Both girls brought material to the makerspace with them. One of the girls had printed instructions from an Internet site on how to make a zipper pouch, and she had these instructions with her, and she seemed to be following them. The other girl had a pocket folder with her. In one pocket was a list of project ideas she hoped to make. In the other pocket seemed to be instructions for a project. Both of these girls were cutting out their material into rectangles, and they were taking care to make sure the rectangles were the same size. One girl had bright pink material, and she used the first rectangle she cut out as a template to cut out the second rectangle. I went to observe other students for a bit, and when I came back, this girl was just finishing up sewing the seams of her pouch around three sides of her rectangles using one of the sewing machines.

Often a part of the Making step of the EMPM is learning what you need to learn for your project or activity. Interviews showed that students went about gaining this necessary knowledge in a variety of ways. A male student who used Scratch programming language to create animations explained that he learned to make them both through formal and informal means.

I kind of tested it out in library lesson on the computers; like, took coding lessons. . . I also watched different people do it, other people’s
animations, and I figured out, “Hey, I could do this: make this figure walk around.”

Several students mentioned turning to an adult as a means of learning what they needed to know. One student stated that the librarian taught him coding while another student said he could “ask the teacher to teach me how” to sew, as he wanted to make a sewing project, but did not know how. A female student who wanted to make a sewing project said she “would ask her mom if she could teach me.” However, she stated that she might alternatively “look up a video, or, I actually have a sewing book.” She was not the only student to mention watching videos as a way to learn a necessary skill. A male student who wanted to make a puppet said he had been “Googling it at home, watching videos.” Yet other students made use of the resources included with an activity kit to know what to do. One male student who used the Snap Circuit set to build working circuits and who often programmed the Ozobot robot, said he utilized “the instructions on the paper and on the tablet” to know what he needed to do.

Another aspect of the Making step is to problem-solve through multiple attempts to reach successful completion of one’s project. Both Mrs. Sprague and Mrs. Mosier spoke in their interviews of how their students were problem-solving in the makerspace. Mrs. Sprague used, as an example, a group of male students who created a stop-motion animation video. Rather than being taught how to create it, this group of boys “figured it out.” She talked about how they had encountered some challenges during the process, stating, “I know in the stop-motion animation stuff, they've had some issues that they've come across. Or like the setting up a green screen, you know, making sure that’s working right.” However, with her assistance, the students were able to overcome these difficulties and complete their video. As Mrs. Sprague stated, “I don't think there’s
been anything major that we've come across that hasn't been something that we can solve eventually."

Mrs. Mosier gave the example of two female students who had to problem-solve through some challenges they encountered during a sewing project. She stated,

I had some girls who really wanted to make something for one of the other teachers here, so they were making her a bag, and as they moved along, they realized they made a mistake. So, they kind of had to back up and problem solve and said, "Okay, what can we do to fix this," and so some things got taken apart, or some things got scrapped and they started over again.

Students did problem-solving not just when making a project, but also when participating in an activity within the makerspace. I observed two male students using a set of plastic gears during their time in the makerspace. They wanted to make a series of multiple gears that would turn together. Rather than giving up when they could not get the gears to turn, they kept trying different combinations of gears while talking with each other about what they might do to get it to work. They worked intently the entire time in the makerspace and were eventually successful in getting the series of gears to turn.

I interviewed one of the male students who was using the gear set. He told of a time that he was attempting to build a bridge with the Contraptions planks that are available in the makerspace. While he was eventually successful in building the bridge, he told me that “there were many retries because they obviously fall,” and that he kept trying, “until none of them fell, and I did it.”

**Iteration**

Another step in the EMPM is the “Improve It!” or Iteration step, wherein a student determines to update, make improvements to, or repurpose a project he made or a
previously existing item or items. While the librarian encourages students to think about how they might change or improve a project they have made, observations and interviews show that this is a step of the EMPM that some students follow as part of their own making process while others do not. A few students did speak during interviews of making changes or improvements to their projects, yet other students felt that their first attempt was “good enough.”

One female student who made a cardboard house for her dolls did make improvements to her completed project. She stated that her first version of the house “didn’t turn out anything like the picture” she had drawn, so she decided to make changes. She “laid out the first one” to “see what I needed to correct on it.” On the next version of the house, she “made it taller and bigger because not all the stuff that I was planning to put in there didn’t fit.”

A male student spoke of building a hotel out of Legos. While it turned out well, he decided to make some changes to it. He said, “when you go downstairs to eat breakfast in the hotel, I felt like I just wanted to add a little bit of Halloween into it, so I tried to make it like Halloween tables.” Another male student spoke of attempting to use Legos “to make a house. . ., and it ended up looking like a garden.” Rather than taking it apart, he “just kept trying to make it a house,” by making the walls taller.

While these students made changes or improvements to their projects, other students did not think changes or improvements were needed, even when their project did not turn out as expected or desired. For instance, one male student stated that the K’Nex motorcycle he attempted to make did not turn out the way he wanted “because the wheels didn’t really move well. The only thing it’ll do is that you could either make it
stand or you could take out the piece that holds the wheels, but the wheels would come off.” Rather than attempting to make changes or improvements, he “just decided I won’t use it to drive it around. I guess I’ll just . . . use it as a model.” Similarly, a male student who was attempting to build a K’Nex crane stated that, while he expected it to “look like an actual crane,” it turned out “kind of more skinnier” and “kind of simple.” However, he did not see a need to change or improve it, stating that “it was still good, to me.”

Another male student provided some insight into why this might be the case for some students. When asked during his interview if anything he attempted to make did not turn out the way he wanted, he replied, “there’s really no way to not make something correctly, cuz it’s just your imagination taking over.” When nothing you make is incorrect, there would be no need to correct or improve it.

**Sharing**

“Present It!” or Sharing is yet another step of the EMPM which allows students an opportunity to show others the project they made as well as what they learned through the process of making it. While students often showed their projects to friends, classmates, and their teacher or took them home to show their families, they did not have formal opportunities to share their projects and learning with larger audiences such as displaying projects in the library or the school, presenting projects at a school maker faire, or posting projects in an online forum. Due to the lack of storage shelving, students could not keep ongoing or completed projects on display in the makerspace itself for others to see and provide feedback. One exception to this was the group of boys who created the stop-motion animation video. Mrs. Sprague posted their video on YouTube and shared it through Facebook. Students were able to easily show others their video, and many additional people viewed it on Mrs. Sprague’s Facebook page.
Despite not having formal opportunities to share their projects and their learning, students are eager to do so. Mrs. Sprague spoke of this during her interview. When talking of how students spend their time in the makerspace, she commented, “most of them are really trying to learn something new and make something new that they are proud of, that they can show off.” She also spoke of their eagerness to share their learning in relation to the expert wall on which students can add their name and their area of expertise so that other students can come to them for assistance. She stated, “they’re always so proud to get to put their name on the wall. Like, ‘I've been working on this. Do you think I can put my name on the wall now?’”

I witnessed the eagerness of students to share their projects during observations of the makerspace. During one observation, I stopped a female student on the way out of the makerspace to see the project she made that day. It was a picture frame made from pink construction paper with “jewels” glued around the outside and ribbons attached at the top to be used to hang it on the wall. She seemed quite happy to show me her project and tell me all about it, including that she was going to put in it a picture of herself and her best friend. During this interaction, I was approached by a male student wanting to tell me all about the Lego rover he made that day. He even re-entered the makerspace to retrieve the rover, which he had left intact in the container of Legos, to show me. This student, while not one I sought to speak to because he did not have parental consent to participate in the study, was very proud of his project, referring to it as his “favorite build,” and was quite eager to show it off.

During another observation, I was approached by a female student who wanted to show me what she was making that day. The excerpt below describes the scene.
[The student] sought me out to tell me that she was making a paint palette today. I went to where she was working to take a look. She had cut a circle, approximately 8 inches in diameter, from cardboard, and she cut a thumb hole in one side of it. The thumb hole was not a circle. Rather, it was a circle with a slit that went all the way to the edge of the palette. It was set an inch or two in from the edge. The girl had taken various colors of paint, around 10 different colors, and put a 1 1/2 inch or so circle of each color in various spots around the cardboard. It looked like a paint palette that might be used by an actual painter. I asked if it was something she planned to use to paint with or if she was making it to go with one of the other projects she had made... She said she was planning to use it to paint. I asked her how she was going to use it to paint since the paint would be dry. She said that she would be able to squirt a bit of paint as she needed it onto the dried paint, using it as a kind of guide to where each color should go. I asked her if she painted much at home, and she said that she did.

Optional and flexible collaboration

Optional and Flexible Collaboration is part of the EMPM, though it is not an actual step of the making process. Rather, this is an associated process that influences the overall making process, as students may choose to collaborate with others at different times throughout their projects. Students experienced this part of the EMPM in a variety of ways. Some students chose to work on individual projects during the course of this study, while others chose to collaborate with others. Those who collaborated with others did so at varying levels, including helping others, working side-by-side with someone on separate projects, and working collaboratively with others on a shared project. The paragraphs below speak to students’ experience at each of these levels of Optional and Flexible Collaboration.

Working individually. Throughout the study, I observed several students working individually on projects or activities. During one observation, I saw an individual male student working with the Gravity Maze kit, another male student working individually with the Dash robot, a third male student working individually using the
Geoboard application on an iPad, an app that allows the user to create and manipulate a variety of geometrical shapes by stretching virtual bands around virtual pegs, and a female student working individually on an ongoing cardboard dollhouse project. I also observed students over the course of the study working individually on such things as creating a construction paper picture frame, making a cardboard paint palette, tinkering with Snap Circuits, and building with the Contraptions planks. Interestingly, the students mentioned above who I observed working individually at these times were observed working collaboratively with other students at other times, with the exception of the female student working on the cardboard dollhouse project. Students moved in and out of collaborative partners when and as needed or desired. Figure 5-11 shows students working individually on makerspace activities.

![Image A](image1.jpg)  ![Image B](image2.jpg)

Figure 5-11. Photos courtesy of author. Students working individually in the makerspace. A) Student working with a Connex electronic piano kit, B) Student working with the Gravity Maze kit.

**Helping others.** One way students collaborated in the makerspace was by helping others when needed. This was a minimal and short-term type of collaboration. For instance, one male student mentioned in his interview that another student helped him get logged into the Scratch website. Another student told of a short-term reciprocal collaboration where each student taught the other to do something with one of the
robots. The student said, “I taught him how to make it go straight and then go backwards because usually it’s going all over the place.” In turn, the other student taught him “how to go to the part where you can make the robot do sounds and stuff.” A female student helped another student in a very practical way. She says, “they didn’t know how to use a hot glue gun, and they burnt themselves. So, I helped them figure out how to use it and not burn yourself.” A final example of this type of minimal and short-term collaboration was the male student who needed temporary help putting parts of his Mento launcher project together. He explained, “I needed help, like him holding it in the area so I could put the duct tape around it.”

**Working side by side on separate projects.** Throughout the study, students were also observed working on separate projects, but choosing to do so next to a classmate. During these times, students seemed to enjoy the natural camaraderie of time spent with a friend. Additionally, they were able to ask questions of, share resources with, and get advice from this person while working on their individual projects. I witnessed an example of this type of collaboration during an observation when two male students were working on individual K’Nex projects, one student building a crane and the other building a car. The following excerpts from my observation and field notes show that these students were enjoying each other’s company and helping each other though they were working on individual projects.

While he was building it [the crane], he leaned over to [the other student] to ask what piece he should use to get it to do what he wanted. [He] talked to him for a minute, and the two boys dug through the tub to find a piece they thought would work.

The boys work well side by side, though they are not building a collaborative project. They help each other find pieces they need, ask each other questions about what piece to use to make their project the way they want it, and try to answer each other’s questions.
The boys were working on separate projects, but they got each other’s opinions along the way, visited about some completely unrelated things, and shared the tub of K’Nex without fighting over them.

I observed these same two male students during another observation working side-by-side in the arts and crafts area on separate projects, one making a felt puppet and the other making a spider out of construction paper and pipe cleaners. Students can be seen working side-by-side on individual makerspace projects in Figure 5-12.

![Figure 5-12. Photos courtesy of author. Students working side-by-side on individual projects. A) Students working side-by-side on individual Lego and K’Nex projects, B) Students working side-by-side on K’Nex crane and K’Nex car projects.](image)

Another example of students working side-by-side on separate projects was found in the female students who were making zippered pouches. I observed them multiple times sitting together at one of the tables in the center of the makerspace, working on their own zippered pouch. Both girls had a folder with project ideas they wanted to make in the future and/or instructions for making the zippered pouches that they seemed to have printed from the Internet. During one observation, they were looking together at one of the sewing project books in the makerspace. During another observation, they both had their material spread out on the table and were cutting out rectangles from it, preparing to sew their pouches. While I did not focus on this pair of
Working collaboratively on shared project. Other students chose to work collaboratively on a shared project. Several examples of this type of collaboration happened during this study. One such project was a Littlest Pet Shop café that a group of three girls was building out of cardboard and other materials. These students were observed working on different parts of this project, but working toward the shared goal of completing the café. They were also observed discussing how to proceed when something new was introduced to the mix, such as a new material or supply that was found to be available. The excerpt below from my field notes provides a description of these students working together on this project.

Two girls I observed were working together with a third girl on an ongoing project. They were sitting at the counter along the perimeter in the craft area. They were making a Littlest Pet Shop café out of cardboard and other materials. They said they had worked on it several times previously, but then stopped working on it for a while. They were now getting back to it. Though there were three girls working on it, they were only building one pet shop. The outside had an "open" sign hung outside the "door." It was not just written or drawn on the cardboard. They had cut out a small piece of cardboard and written "open" on it, connected a small piece of rope to it, and taped it on the "shop" next to the door. Next to the open sign, one of them had written "open 24 hours" on the pet shop. Inside the pet shop were various pieces that were cut out from paper or cardboard and colored/decorated. These signified things such as the counter, a display table, etc. There were even pictures/decoration on the wall of the shop. The girls were working together, but on separate tasks toward their project. One was tearing small bits of different colors and patterns of tissue paper, crinkling them into "balls" and putting them into a small, clear plastic jar about the size of a prescription jar (but not). She told me these were gumballs that were going to go on display in the pet shop. Another was sorting out different types of beads into a similar jar, and this was going to be another type of candy on display in the pet shop. While the first one continued to work on the tissue paper gumballs, the other two went to the big storage cabinet for additional supplies. They were digging through the cabinet together, looking for something specific, though I am
unsure what they were looking for. After some time, the second girl left the third girl to continue looking and came back to work on the pet shop. The third girl came over moments later with a sheet of horse stickers. One girl gasped excitedly, and the three girls started to discuss what they should do with the stickers. After a few moments discussion, they seemed to come to an agreement, and one girl started "directing" the others with specific tasks. This was done in a friendly manner, and the other girls responded favorably, asking clarifying questions as to what specifically they were to do.

During a student interview, I asked the female student who had been directing the others how they know who is going to do what when they work on a collaborative project. She replied, “usually they let me decide because I'm kinda like the leader or something. So, I leave friend one to do what she does best and I leave friend two to do what she does best.” These girls are seen working together on this project in Figure 5-13.

![Figure 5-13. Photos courtesy of author. Group of girls working collaboratively on a shared project. A) Each girl working on a different part of the project, B) One girl gets supplies for the group from storage cabinet.](image)

One of the other girls who was working on the collaborative project described above told me of another collaborative project they had completed: a “little paper that said BFF on it.” She described their collaboration, stating that

She [her friend] would hold the hot glue gun. She would put down the glue, and then I would put on, like, a shell or a sequin.” She said they knew who was going to do what because “we discuss it before we do it.
I witnessed or learned through interviews about several other shared collaborative projects during the time of this study, including a pair of boys sewing an owl project, a pair of girls building a cardboard castle, and the group of girls highlighted above making a birthday card for another of their friends. When discussing the collaboration that was taking place between students in the makerspace, the librarian described it as “more a natural sort of collaboration . . . that I hadn’t seen as much in the library before this.” A few of these additional shared collaborative projects are seen in Figure 5-14.

![A) A pair of boys sewing a shared owl project, B) A pair of girls building a shared cardboard castle.](image)

**Figure 5-14.** Photos courtesy of author. Additional shared collaborative projects. A) A pair of boys sewing a shared owl project, B) A pair of girls building a shared cardboard castle.

**Continuous feedback**

Throughout the process of making a project or working on an activity, students get feedback either from the project or activity itself or from others. Therefore, Continuous Feedback is another related process included as part of the EMPM. While students did receive feedback from the projects they made or the activities in which they participated, feedback from others was limited, as they did not have the opportunity to share their projects or their learning beyond their classroom and their home.
Students often received instantaneous feedback when attempting to program the various robots available in the makerspace or when attempting to manipulate something on the computer screen through coding. For instance, the student attempting to program the iPad so that the Ozobot robot would follow the path he created would get feedback as to his success or failure immediately upon starting the robot upon the track. It would either behave as he expected, spinning or moving fast where he intended, or it would not. Similarly, the student attempting to program the Dash robot to interact with the included xylophone accessory would get fast feedback when Dash either did, or did not, play music.

Students also received feedback from the projects and activities they did in the makerspace that did not involve technology. During interviews with me, students spoke of things they made in the makerspace that did not turn out as they had hoped. The male student whose K’Nex crane was “more skinnier” than he had imagined it to be and the male student whose K’Nex motorcycle’s wheels would not turn are but two examples of students receiving feedback from their low-tech projects. Other examples include the female student whose cardboard dollhouse turned out to be too small to fit the toys she had planned to use with it, the female students who had to redo parts of the bag they were sewing for a teacher, and the male student whose Lego house turned out looking more like a garden, being too flat and wide. Not all feedback students received from their projects was negative, however. The female student who sought me out to show me the cardboard paint palette she made and the male student who eagerly shared with me the Lego rover he built received feedback from their projects that they had turned out well.
The activities in which students participated in the makerspace also provided them with continuous feedback. For instance, the pair of boys mentioned earlier who were working with a set of plastic gears trying to make a series of them work together got continuous feedback when the gears would either turn or not. Similarly, the male student attempting to build a bridge from the Contraptions planks received feedback each time the planks fell as well as when he was ultimately successful in building the bridge.

While the feedback students receive from others is limited as they do not have much opportunity to share their projects or their learning to a wider audience, both Mrs. Sprague and Mrs. Mosier strive to provide feedback to students and encourage students to give feedback to each other. Mrs. Sprague stated in her interview that she believes the makerspace is conducive to students providing each other with feedback.

She explained further that

They really do work together a lot and collaborate and feed off of each other and give each other feedback. There’s not a lot of formal feedback, I mean, there’s a lot of conversational feedback. . . So, I think there is a lot of student to adult, but also student to student feedback and conversations happening about what they are doing.

Mrs. Mosier also believes that her students provide each other feedback in the makerspace. She stated in her interview, “I think that if somebody is making something that somebody else is really excited about, they go tell them. They’re like, ‘Oh, that’s so cool! What are you doing?’”

I asked students during interviews if others had ever told them what they thought of the projects they made. Some students said they had not received feedback from others, but most students said they had. A male student stated that Mrs. Mosier had provided positive feedback, saying that she liked his projects. He stated that she “pretty
much says it to everything that we make.” Several other students stated that friends had commented that their projects were “cool,” and that some asked how they made their projects. One female student received feedback from others that was not as positive. She stated regarding feedback on her project that “somebody said that they really didn’t like it though.”

**Documenting progress**

Another associated process that is part of the EMPM is Documenting Progress. Encouraging students to document their progress allows them to know exactly where they left off with their project during their previous makerspace visit so that they can immediately begin again during their next visit. The DFG-EMPM developed by the makerspace design committee suggest providing students with a physical or digital maker’s notebook to use to document their progress or guiding them to use an online tool designed for this purpose, such as the Build in Progress site discussed in Chapter Two of this dissertation. As this is a guideline that Mrs. Sprague has not yet fully implemented in the makerspace, students, as a whole, did not experience documenting their progress as part of their making process during this study.

While students are not yet provided a formal means to document their progress in the makerspace, observations and interviews found that a few students developed their own way to do so, and had, therefore, incorporated this into their overall making process. When asked during an interview how she and her friends knew where they left off and what they needed to do next for their ongoing collaborative project, the student replied, “we usually set up the whole thing and figure out what we’re supposed to do next because we have a checklist.” She shared that this was not something provided to them by the teacher or librarian, but something that “we all came up with.” When asked
if the entire class came up with it, she replied, “no, just my three friends. Well, we, like, check off what we’ve done and then not check off what we have[n’t] done.” She further explained that they keep the checklist in the cardboard box they are using to make their project.

During multiple observations, I witnessed a pair of female students working on a sewing project wherein they were making zippered pouches. Both girls had put together a folder that contained project ideas for the future as well as step-by-step instructions for making the zippered pouches. These girls, then, were able to refer to the instructions during each visit to the makerspace to know exactly what they needed to do next to make the pouches. This served as a way for them to document their progress during their ongoing sewing project.

**Reflection/formative self-assessment**

The final associated process included in the EMPM is Reflection/Formative Self-Assessment. Here, students would thoughtfully consider and keep track of what had worked, what hadn’t worked, what they might try next, and what they had learned while working on a project or activity. Again, the DFG-EMPM developed by the makerspace design committee suggest providing students with a physical or digital maker’s notebook to use for such reflections or guiding them to use on online tool designed for this purpose, such as the Build in Progress site discussed in Chapter Two of this dissertation. They also suggest asking students questions about their projects, what they have tried, what worked, what did not, and what they learned, to facilitate reflection and self-assessment. As mentioned in the previous section, students are not yet provided with a maker’s notebook, nor do they use online sites such as Build in Progress, so they do not formally track their reflections or the things they have learned
in this way. Interviews and observations showed that many students did not experience Reflection/Formative Self-Assessment as a regular part of their overall making process. While Mrs. Sprague does have conversations with students about their projects and encourages them to think about what worked, what did not, and what they might want to try next time, no students were found who were keeping track of such reflections nor of what they had learned.

**Theme Six: Students Benefit from Participation in Makerspace**

Based on both interviews and observations, students seem to experience several benefits through their participation in the school library makerspace. The paragraphs below discuss the benefits to students found through data analysis of observations and interviews, the final theme for Research Question Three.

**Learning in the makerspace.** Though unique to each individual participant, students learn a variety of skills or build background knowledge in a variety of areas through the projects and activities in which they participate in the makerspace. When asked in an interview what she felt students had learned from their time in the makerspace, Mrs. Sprague, the librarian, commented that they had learned coding and other technology skills “beyond just how to use the computer to learn the curriculum” such as how it works, how it functions, and how to use it to communicate; practical skills such as sewing; social skills such as working together and asking questions about each other’s work, and prior knowledge in areas such as engineering. Mrs. Sprague’s beliefs about her students’ learning were largely borne out in student interviews as well as in my observations.

The majority of students interviewed mentioned coding or programming as something they learned through participation in the makerspace. Some students
mentioned coding or creating animations on the computer using the Code.org website or Scratch programming language while others talked of coding various robots, such as Dash and Ozobot. Several students had experience with coding both on the computer and with the robots. One student talked of how he appreciated the opportunity to learn coding as he saw a connection to a potential real-life career. He commented,

I feel doing coding with Dot and Dash is kind of cool, cuz it also teaches you how to do it during real life, like if you were an engineer or something, and you build robots, and you wanted to code them. This is kind of like a practice one first . . . so then you know what you already need to do.

Both Mrs. Sprague and Mrs. Mosier also spoke in their interview of a group of fifth grade boys who learned, with very little direction from the adults, to do stop-motion animation and created a 5-minute long video.

Students also spoke in interviews of the practical skills they had gained in the makerspace. These included such things as knowing “how big of scissors you need to use to cut cardboard,” learning how to use a hot glue gun without burning oneself, and “getting better at painting.” Several students spoke of sewing, particularly using the sewing machine, as a skill they learned in the makerspace. From both observations and interviews, it was found that both male and female students chose to make projects involving the use of the sewing machine. One male student was excited to learn how to make knots at the beginning and end of a line of sewing on the machine, stating,

It was kind of cool to do it with a sewing machine, cuz it’s kinda different, cuz you have to go forward and back, like at the very ends. Like, you go a little bit back, forward, and back a little.

He was further excited to learn that, when making a pillow,

you also have to leave one side of it open, so then you can put the stuffing in . . . It’s kind of hard to do it, the last part when you put the stuffing in, cuz it’s like you have to jam it.
Mrs. Sprague noted in her interview that learning to sew “made them think a little bit more about how hard it is to make clothing and how valuable their clothing is, but it’s given them some practical skills that they might not have had as well.”

I observed many instances of students working together on joint projects or side-by-side on separate projects during which they utilized the social skills of working together or asking each other questions. For instance, two female students were working together to make a cardboard castle, and on the day of my observation, they were working to add dentil molding around the top of the castle. Below is an excerpt from my field notes describing what I saw.

During the observation, these girls worked quietly and collaboratively. It seemed that they were on the same page as to what they wanted to do to the castle, as I heard no disagreement between them. Rather, their discussions focused on the next step to take. They seamlessly worked together to accomplish their seeming task of getting the second story façade built around the rest of the castle. One would work on cutting out a piece of cardboard to fit and cutting out the dentil molding around the top while the other would work to cut pieces of duct tape. They discussed things like how hard it was to cut the cardboard. The one would hold the cardboard in place on a side of the castle while the other cut a slit in the bottom of the piece with scissors where it overhung the side and needed to be trimmed. She then proceeded to cut the extra length off the piece. One would hold the cardboard back in place while the other used a piece of duct tape to attach it. They worked together so well that they switched tasks naturally as one had a hand free or saw that an “assist” was needed. It was hard to keep track of who was doing what from moment to moment as it was almost like four hands and one mind.

In this case, the students jointly discussed and decided what the design should look like, split between them the tasks of cutting the design in the cardboard, cutting the cardboard to fit the castle, and taping it to the castle. They talked while they worked, asking questions or making suggestions, anticipating how they might help each other.

Students, though they were unable to articulate specific principles or concepts they had learned, did seem to gain prior knowledge in a variety of areas through
participation in the school library makerspace. For instance, I observed a pair of boys working together in the makerspace with a set of plastic gears. They were attempting to connect multiple gears in a pattern that would still turn. Though they did not fully understand the principles they needed to follow to make the gears work as they wanted them to, the conversation between the boys shows that they were gaining prior knowledge that could be useful in the classroom when learning about force and motion. The excerpt below from my field notes captures the boys’ conversation while working together to try to get the gears to turn, as seen in Figure 5-15.

They proceed to just work together, digging various gears out of the box, adding them to the base, trying to make the gears work. They ask questions of each other and comment along the way. "Nope, that is too tight on the gears." "Try to find another piece that will work." "Let's just try this other piece." "Nope, too tight again." They each equally add gear pieces to the base, talking to each other about what they are doing along the way. "We need a medium one." "Too tight." "It takes patience." "That makes the movement somewhat chunky." "How are we going to do this?" "Oh, I got it, I got it." "How are we going to connect it?" "I don't know." "Wait, wait." "Oh, there's singles." All the while, the boys are using trial and error to figure out how to make a long series of gears spin. "Maybe we can move this somewhere." "Let's change these." "It's basically the same thing, but the red is here." "I know, but it may make it easier. Want to know why? It's using less force, so it will be easier. Cause you're not trying to push as much." "I see the reason why."

Figure 5-15. Photos courtesy of author. Boys working together to get a series of gears to turn. A) Both boys beginning to add gears to the base, B) Adding additional gears to base and trying to get them to turn.
Another student, when asked what he felt he had learned through participation in the makerspace, began telling me about tinkering with a set of wooden planks called Contraptions with which students can build ramps, bridges, or scaffolding. The set also includes two balls of differing weights that students can roll down the ramps they build. The student talked about learning that “mass matters,” that the heavier ball “can knock down the blocks easier,” and that “the more mass there is, the faster it’s [the ball] going to fall [go down the ramp].”

Yet another student hinted at building prior knowledge through his use of the Snap Circuits kit, a set of snap together electronic components allowing students to build working electrical circuits and connect such things as a fan or a buzzer. When asked what he needed to do to make the fan work with the Snap Circuits, he mentioned such things as “connect the battery,” use a blue component and “put it on the battery, and then connect it to the fan.” He also mentioned that “there was a switch on it,” and that this was “how you connect the electricity, and then to the switch, and then it ‘ons’ the fan.” When asked what he learned from using Snap Circuits, he answered, “teamwork,” as he often tinkered with Snap Circuits with a friend. His answer, however, shows that he is unable to articulate specific concepts he may have learned, though his previous description of his interaction with Snap Circuits showed he was certainly building prior knowledge.

**Developing 21st century skills.** As seen in the excerpt above, when asked what he felt he had learned from tinkering with Snap Circuits in the makerspace, the student in the above scenario replied, “teamwork.” This is one of the “soft skills” or 21st century skills identified in Table 1-1 of this dissertation which students are purported in
the literature to develop through makerspace participation. A female student, referring
to a collaborative project she and two of her friends were working on in the makerspace,
stated a similar idea, saying, “we all teamwork to create one thing.” Mrs. Mosier also
stated in her interview that one benefit to her students of participation in the
makerspace was teamwork.

Creativity is another 21st century skill some students mentioned during their
interviews that resulted from participation in the makerspace. One male student listed
“expand my creativity” as one of the things he felt he had learned in the makerspace.
Three other students, one female and two males, also spoke of creativity as an outcome
of participation in the makerspace, stating the makerspace helps them “express their
own creative style,” allows them to “open up their creative side,” and that they could
“experience my creativity” while in the makerspace.

Both Mrs. Sprague, the librarian, and Mrs. Mosier, the classroom teacher, spoke
in their interviews of 21st century skills they believed their students gained through
participation in the makerspace. In addition to teamwork or collaboration and creative
thinking, they also mentioned such skills as problem-solving, critical thinking,
independent learning, and exhibiting a growth mindset. Mrs. Mosier felt that “as the
year went by their mindset changed” from their time in the makerspace. She stated,

I feel like they’ve learned to be independent. I feel like they’ve learned to
be problem solvers. I feel like they’ve been able to try something new
without being afraid of failure, which I think are all great life skills. I’m really
proud of what they’ve become and I want to take that back into my
classroom and give them more opportunities to do more things in science
the same way.

Through observations of students participating in the makerspace, I also found
that many students remained focused on their making activities or projects for the
entirety of their time in the makerspace. Many students were observed entering the makerspace and immediately gathering the materials they needed for the day. Some brought materials or printed instructions with them to the makerspace, showing that they had been planning their making project prior to their time in the makerspace. They would then get started on their self-directed activity or project and remain intently engaged in it until time was called to clean up. Many of these students expressed disappointment at having to stop working on their activity or project for the day. These behaviors show that students were exhibiting focus, another of the 21st century skills listed in Table 1-1 as developing through makerspace participation.

Playful learning is yet another soft skill listed in Table 1-1 as developing through participation in a makerspace, and I witnessed many examples of this during my observations of students in the makerspace. This was often seen with students who were working with the various robots available in the makerspace. To a casual observer, seeing students driving a remote-controlled robot around the library floor such as Dash or watching a smaller robot such as the Ozobot make his way around a track drawn on an iPad may look like simple playing. While these students certainly appeared to be having fun, and while they may have started out simply driving the robots or running a built-in program, I found during observations that these students were also learning how to code these robots. While their coding skills were not yet very sophisticated, as they were not programming the robots to follow lengthy or complicated routes, students were observed attempting to program the robots to “go fast” or to spin. In interviews, students spoke of programming the robots to “make sounds,” or to interact with included accessories, such as the xylophone that is included with the Dash robot.
Students were also seen participating in playful learning with other activities such as the Contraptions planks. Each of the wooden planks in this set is approximately 4 ½” long, 1” wide, and ¼” deep. There are no connectors, so students stack them in various ways to build bridges, ramps, or other structures. Several students were observed using these planks during makerspace time, which, as with the robots, looks like playing. However, in an interview, one of the male students who had been observed using these planks talked about his attempts to build a bridge with them. He stated that “there were many retries, because they obviously fall,” but that he kept trying “until none of them fell” and he was finally successful in building the bridge. He further stated that he “figured out” that he needed to “put about a couple blocks on the ground, as a rim, like a little edge” stacked a certain way to support the other planks. In addition to playing, then, this student seemed to be learning about structures.

**Chance to shine.** Another benefit Mrs. Sprague has noticed for her students through participation in the makerspace is that it provides students with an opportunity to excel who may not do so in the more traditional classroom setting for a variety of reasons. For instance, she spoke of a group of boys, some of whom got in trouble in the classroom, but who chose to spend much of their recess time working on a video project in the makerspace. She stated,

It’s students that are a little bit quieter and some that deal with behavior issues, but it’s given them this outlet and this creative time to do this that they didn’t even know they were interested in. But they, they took the stuff. They figured it out. I did not show them anything about how to use it. I just had the iPads and told them that we had a stop-motion app. And they got the Legos, and I think they had seen the Lego movie, which is stop-motion animation, and it sort of sparked their interest, but they did it all themselves. And it has been really astonishing what they are able to do when they have a little bit of time and a little bit of, of support and resources, what they are able to accomplish.
She also told about students who were not always academically successful in the classroom, but were successful using Snap Circuits to build working circuits and connecting things like a fan. She said,

Some of the students who I think struggle a lot with academics were able to sit down and play and sort of figure things out. And some of the things they were able to make were really impressive. And maybe it helps build their confidence up a little bit more, and allow them to see that they do have some strengths in areas maybe they didn't even know were areas to explore.

She further spoke of students who find that they have interests in areas that they, or others, might not expect through participation in the makerspace. She told the story of one male student who found he had an interest in coding.

There was a boy in fifth grade who um, we did some of the code.org lessons together in class. But he went above and beyond that... He made like a little game out of coding. This was a student that I didn't foresee that being an interest for him. He's typically a little bit more athletic, and sometimes has a “too-cool-for-school” attitude. But he got so excited about this, and he was so proud to put his name on the expert wall and show kids about coding, and it was just really exciting seeing that transformation.

As seen in the sections above, the results of this study show that students benefit in a variety of ways through participation in the school library makerspace.

**Chapter Summary**

This chapter addressed research questions two and three of this study: “What is the resulting school library makerspace implementation?” and “In what ways do students experience participation in the resulting school library makerspace?” I presented a vignette of the resulting makerspace implementation, and then discussed the two main themes surrounding research question two that resulted from thematic analysis. The two main themes were as follows: Intentionality in Makerspace Implementation which described ways in which the resulting makerspace aligns with
various guidelines developed by the makerspace design committee as well as areas where it does not, and Makerspace Implementation is Successful Overall which highlighted ways in which the makerspace is viewed as a success while acknowledging changes and improvements the librarian hopes to make going forward. Next, I presented a vignette of student participation in the makerspace and discussed the six main themes surrounding research question three that resulted from thematic analysis. Those six main themes were as follows: Students experience adults as facilitators of making process; Students have access to makerspace at a variety of times; Students participate in a wide variety of self-directed projects and activities within the limitations of time, resources, safety issues, and makerspace rules; The majority of students are purposefully engaged in and enjoy participation in makerspace; Student making experience compared to EMPM; and Students benefit from participation in makerspace. Chapter Six will discuss both successes of school library makerspace implementation in my district as well as areas of possible improvement.
CHAPTER 6
DISCUSSION AND IMPLICATIONS

The purpose of this design case dissertation was to provide a detailed and thorough account of the design process the makerspace committee went through to bring makerspaces to the library program in my school district so as to preserve and share the precedent knowledge gained through the process (C. D. Howard, 2011). According to C. D. Howard (2011), design cases have an overall singular focus in asking the question, “How did the design come to be as it is?” (p. 53). He further states that design cases seek to answer the question “What design resulted from the process?” (p. 49), and he stresses the importance of including a description of the user experience of the design to help readers better understand the design. In keeping with these foci, this design case dissertation answered the following similar questions.

Research Question 1: What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district?

Research Question 2: What is the resulting school library makerspace implementation?

Research Question 3: In what ways do students experience participation in the resulting school library makerspace?

Research question one was answered through a detailed narrative account found in Chapter Four which described the members of the makerspace design committee and presented the processes and decisions involved in the design of school library makerspaces organized around separate discussions of the components of the design. Biographical information about the members of the makerspace design committee as well as a wide variety of documents pertaining to the design process were the data sources I reviewed and analyzed to answer research question one. For research questions two and three, data were collected through qualitative observations,
interviews, and pictures and were analyzed using Braun and Clark’s guidelines for conducting thematic analysis (2006). My methods were described in greater detail in Chapter Three of this study. Results pertaining to research questions two and three were provided in Chapter Five of this study.

This final chapter will discuss the results of the study in the context of both successes and areas for improvement and will discuss how the results align to existing literature. Recommendations to others wanting to undergo a similar design and implementation process will be included, as well, based on lessons learned through the design and implementation of makerspaces in my district. The chapter will then discuss the implications of the results to my professional context, to other school districts wanting to design and implement school library makerspaces, to the field of library science, and to the study of makerspaces as learning environments. Finally, I will recommend potential areas for future research of school library makerspaces.

**Research Question One: Design Process**

The first research question of this study asked, “What processes and decisions were involved in the design of school library makerspaces in the researcher’s school district?” The resulting chapter addressing this question, Chapter Four, first described the specific professional context of the design, stated why I believe this design case will be of interest to others, described the members of the design team, and detailed my role in the design process as a member of the design team. Next, the chapter described in detail the most pertinent components of the design process based on my knowledge of it as a member of the design team and on my review of pertinent documents pertaining to the design process. The description of these components included decisions and changes that were made during the process. In addition to a
textual description of the most pertinent components of the process, images of various documents relating to the design process were provided, including the design and implementation guidelines developed by the design team for use by the district library program. The sections below discuss ways in which this design process was successful, areas where the process could be improved, and recommendations for others wanting to undergo a similar design process based on lessons learned from the process.

**Design Process Successes**

One way in which the design process was successful is that the makerspace design committee was focused during its meetings on specific tasks it needed to accomplish to implement makerspaces in the district, making the best use of limited meeting time. Prior to the first meeting of the makerspace design committee, members worked collaboratively using a shared online document to develop a logic model to guide its work toward the implementation of school library makerspaces. The logic model, which was later collaboratively revised by the group, defined the group’s purpose for implementing school library makerspaces in the district, the resources available or needed for implementation, the activities to be accomplished for the project to be successful, the deliverables to be developed from the activities, and the short-, mid-, and long-term outcomes anticipated through the implementation of school library makerspaces. The committee often referred to this document to focus its efforts, and it was instrumental to the successful completion of much of the work accomplished by the group.

Similarly, the makerspace design committee established a shared understanding of school library makerspace implementation expectations early in the design process.
through the collaborative development of an Innovation Configuration Map specifying “optimal,” “acceptable,” and “unacceptable” implementation for various components of school library makerspaces. The discussions in which the members of the committee engaged to establish the ICM served to allow committee members to share their understanding of makerspaces and of the learning theory of constructionism with each other, to ask questions, and to allow me, as library coordinator of the district, to clarify my vision of school library makerspaces in the district. Establishing this shared understanding so early in the design process allowed the committee to use this as the foundation for its other work, including the development of a mission and vision statement and of guidelines for the design and facilitation of school library makerspaces. Operating on this shared foundational understanding of acceptable makerspace implementation is another way in which the design process was successful.

The makerspace design committee utilized a variety of collaborative processes as discussed in Chapter Four to develop the mission and vision statement and the guidelines for the design and facilitation of school library makerspaces mentioned above. Though each member of the committee brought with her a different level of experience in the field of education, in the field of library science, and with the concept of makerspaces, all members shared the desire to learn more about the underlying principles of makerspaces and to bring the opportunity to create and innovate to students through the implementation of a makerspace in the school library. Therefore, all members approached the development of these various documents with an open mind, engaging in meaningful discussions, and willingly changing their perspective
when an alternative perspective made more sense or when literature reviewed by the group showed such a change was warranted. This open-mindedness and willingness to change perspectives was a strength of the group and was another important way in which the design process was successful.

Many members of the makerspace design committee had the opportunity to visit nearby school library makerspaces to see how others were implementing them. They then shared with the rest of the committee what they learned from these visits, and the group discussed these makerspace implementations in comparison to the planned implementation in our district. This is another way in which the design process was successful, as these discussions helped the committee further clarify goals for implementation.

Another success of the design process is that, due to the committee's collaborative development of the ICM, the mission and vision statement, and the several sets of guidelines for the design and facilitation of school library makerspaces, this core group has a solid common understanding of how school library makerspaces in the district are to be designed, implemented, and facilitated. This common understanding allows this group to share a unified message regarding makerspace implementation with other librarians, teachers, administrators, parents, and other interested parties. Too, while there may be differences in their makerspaces based on the needs and challenges of each building, this common understanding ensures a level of consistency regarding the principles and philosophies underlying the implementation of these spaces.
A final way in which the design process was successful is that there are several tangible artifacts that have resulted thus far through the collaborative efforts of the makerspace design committee that can be shared with other librarians in the district who want to start a makerspace. These artifacts include the ICM, the MDFG, the DFG-EMPM, and the Mission and Vision Statements. The ability to share these documents and the underlying principles and philosophies contained within them across the district to all librarians will help ensure consistency in the implementation of school library makerspaces not just within the design team, but throughout the entire district library program.

**Design Process Areas for Improvement**

While the design process used by the makerspace design committee was successful in many ways, there are areas where it could have been improved. One such improvement pertains to the scheduling of meetings. Friday was selected as the day that meetings would be scheduled as this was the day the highest number of committee members, including myself, were available to attend during the school day. Specific dates were chosen based on the availability of committee members to attend with the fewest substitutes needed to cover scheduled classes or events.

Over the course of three semesters, the committee met twelve times, each meeting lasting three hours. While this is a substantial amount of time, the committee was unable to complete all its designated tasks during these meetings. As such, the design process would be improved by scheduling additional meetings, or, perhaps, full-day rather than half-day meetings, allowing additional work to be completed. Another option might be to schedule meetings outside of the school day, perhaps in the evenings or on weekends, so that more members of the committee would be readily
available to attend. Given that these meetings would be outside of contracted work
hours, there would be a cost to the district to pay the committee members for their
attendance, precluding this as an option if funding were not available. Yet another
option would be to assign tasks to individual committee members to be completed prior
to the next meeting, but this would be somewhat problematic as it would again be
requiring librarians to put in additional work beyond their contracted hours without
compensation. My school district offers Professional Growth Courses (PGC) in the
evenings and on weekends for which faculty are paid to attend. Setting up a PGC with
the planning and implementation of school library makerspaces as its goal might be a
way to both pay librarians for their attendance and require “homework” to be completed
in between classes.

Another area where the design process could have been improved is in regards
to communication, including communication with other librarians in the district, with
central office administrators, and with the Board of Education. Though at the time of
this study, the makerspace design committee had not yet completed the shared online
resource repository where district librarians could access the mission and vision
statement and the guidelines for makerspace implementation developed by the group,
these documents were emailed to all district librarians upon completion. However,
emails containing dense information such as this are easy to “save for later” when one
has more time to digest their contents and then, inadvertently, forget about. I believe
this, or something similar, happened in regards to the documents sent to district
librarians containing the work of the makerspace design committee, as I was contacted
multiple times by librarians wanting to start a makerspace asking if any such guidelines
existed. Additionally, at a makerspace training I conducted after the study was completed, several district librarians were unaware of the specifics of the guidelines developed by the committee. Therefore, a better plan to communicate the work of the team to district librarians throughout the design process would be a useful improvement. Perhaps in addition to emailing the documents to district librarians, it would be helpful to devote a bit of time in the monthly meetings I have with them to reviewing the details of the documents.

Similarly, the design process would have been improved by including a plan to communicate the work of the committee with central office administration and with the Board of Education. While one task included on the team’s logic model is to develop a promotional campaign to communicate with these groups about the concept and benefits of school library makerspaces, it would be helpful to communicate with these groups throughout the process. Sharing the work of the committee as well as completed student projects with central office administrators and the Board of Education in the early stages of the design process could lead to additional support for the overall work.

Design Process Recommendations to Others

For those who might want to undergo a similar design process to the one described in Chapter Four of this study, I offer several recommendations to better ensure a successful process. It is recommended that several of the members of the design committee have at least a basic knowledge of the project or initiative to be implemented, and that all members are passionate about its success. In this case, though their level of knowledge of makerspaces varied, many committee members had read articles, attended workshops, or spoken to colleagues about makerspaces prior to
joining the committee. While other members had little to no knowledge of makerspaces, having several members who had some prior knowledge helped ensure more meaningful discussions in the early meetings. If it is not possible to include members who have prior knowledge of the project or initiative to be implemented, I recommend developing a pre-requisite set of resources to be reviewed by the committee prior to the first meeting. Alternatively, the first meeting could be devoted to guided exploration of the project or initiative.

Regarding committee members, it is also recommended that members be selected for the committee, in part, based on their ability to work collaboratively with the team, including their willingness to remain open-minded and to change their perspective on things when warranted. In the case of this study, the members of the design committee possessed these qualities, but it was simply the “luck of the draw” rather than an intentional act. I suspect the design process would not have seen the same level of success if the members did not possess such qualities, and I recommend not leaving this to chance when forming the design team.

Perhaps it was because district librarians tend to be a fairly small and close-knit group, but the meetings ran very smoothly and were quite efficient and effective despite the fact that no group norms had been established regarding expected behaviors of the committee. Such norms may include expectations such as follows: Meetings will begin and end on time; No sidebar discussions will take place during meetings; and Treat each other with dignity and respect. I recommend, especially when working with a group who may not be as well-known to the team leader as the makerspace design
committee was to me, establishing group norms at the first meeting and reminding the group of those norms at the beginning of each subsequent meeting.

As discussed above in the design process successes section, the collaborative development of a logic model to focus the work of the team and the collaborative development of an ICM to establish a shared understanding of acceptable implementation of the project or initiative was important to the overall success of the design team in this case. I recommend both these activities be included in the design process for the implementation of a similar project or initiative to the one discussed in this study.

Similarly, the collaborative development of guidelines for the design, implementation, and facilitation of school library makerspaces in my district established a high level of consistency in the implementation of makerspaces in the libraries of the committee members, and, as these are shared with librarians across the district, they will help establish this high level of implementation consistency across the district. At the same time, the guidelines take into account that there are various needs and challenges individual buildings face, so they allow for some flexibility in how they are implemented in each building. For instance, the ICM lists as optimal implementation that a makerspace be housed in a designated space, but it allows for mobile makerspace carts under acceptable implementation as not all schools can provide a designated space. Another example of this flexibility is seen in the DFG-EMPM that lists suggestions of how to design for and facilitate each part of the EMPM. Each building can meet these guidelines by selecting from the list of suggestions those that
work best for their situation, or by developing other methods that better meet the needs of their building and their students.

Beginning in the Fall of 2016, the second semester during which the makerspace design committee met, the district’s professional development budget began covering the cost of substitutes for members of the committee who needed one to attend the meetings. This was extremely helpful to continuing the work of the committee, but it was not something I planned for ahead of time. Rather, as an afterthought, I reached out to the professional development department to ask if any funds might be available for this purpose. I recommend contacting the professional development department in one’s district, if one exists, even before selecting design team members to discuss funding options for various meeting scenarios or for providing substitutes if meetings must take place during the school day. Whether funding is available or not, more effective planning can take place when one knows the options.

For those hoping to develop a design case based upon a design process such as the one discussed in this dissertation, I have a few additional recommendations. It was extremely important to the development of this design case to have access to a wide variety of documents related to the design process, including the multiple versions of collaboratively developed and revised implementation guidelines and the mission and vision statement. It is highly recommended, then, that the person hoping to write a design case put a system in place to track and organize all print and digital documents used as part of the process for later review. In addition to organizing the documents developed through the process, it is equally important to ensure that all aspects of the design process are documented in some way, to the extent possible, such as the
processes used by the design team in the development of implementation guidelines and decisions made and changed along the way. The description of these processes and decisions is an essential part of a design case, adding greatly to the precedent knowledge others may take away from the case (Smith, 2010).

If the one writing the design case is also a member of the design team, I recommend that once a committee meeting has begun, focus on the work at hand rather than on the design case. A design case is to be a description of real work that has taken place, including both successes and areas for improvement. The fact that one is writing a design case to describe the processes and decisions made should not drive what processes are used or what decisions are made. Rather, the design case should be separate from the design process, and it should provide an honest reflection of what took place, good or bad, during the design process. According to Smith (2010), “the design process does not necessarily have to be rigorous in order to be the basis of a rigorous case” (p. 15). He further states that “it will be difficult to develop a rigorous case if there are not artifacts and records in some form from the design process, whatever the process may have been” (p. 15).

**Research Question Two: Resulting Makerspace Implementation**

Research question two of this study asked, “What is the resulting school library makerspace implementation?” Chapter Five of this study presented the two main themes surrounding this question that resulted from thematic analysis of the data: Intentionality in Makerspace Implementation, which described ways in which the resulting makerspace closely aligned to the various guidelines developed by the makerspace design committee as well as areas where it did not, and Makerspace Implementation is Successful Overall, which highlighted ways in which the makerspace
was viewed as a success while acknowledging changes and improvements the librarian hoped to make going forward. The sections below discuss the results of research question two in the context of the overall successes of the makerspace implementation, areas for improvement, and recommendations for others wanting to implement a school library makerspace in their own setting while highlighting where these results align to existing literature.

**Makerspace Implementation Successes**

As discussed in Chapter Five, Mrs. Sprague, the librarian at Elementary School Four, was intentional in her design and facilitation of the library makerspace, striving to closely align to the various guidelines developed by the makerspace design committee. This close alignment to the guidelines is one way in which the resulting makerspace implementation was successful. The guidelines developed by the makerspace design committee upon which the school library makerspace was based, were, themselves, based largely on existing literature about makerspaces. Therefore, the resulting school library makerspace implementation also closely aligns in many ways to the makerspace literature. The paragraphs below discuss not only the close alignment to the committee’s design guidelines as a success of the makerspace implementation, but also the areas where the makerspace implementation aligns to existing literature. Table 6-1 provides a summary of the areas of alignment of makerspace implementation to existing literature.
One area where the resulting makerspace implementation aligns to makerspace literature is in its underlying pedagogy and purpose. As seen in Chapter Five, one of Mrs. Sprague’s main goals for the library makerspace in Elementary School Four is to provide a place where students can pursue their own creative interests, experience
individualized learning, and become self-directed learners. This is very much in keeping with existing makerspace literature which stresses that the process of making is driven by the interests and/or needs of the individuals who are involved in the making (Litts, 2015; Peppler & Bender, 2013; Peppler, et al., 2016; Vossoughi & Bevan, 2014; Wilkinson, et al., 2016) and that the development of self-directed learners is a goal of educational makerspaces (Barron & Martin, 2016; Oxman Ryan, et al., 2016; Resnick, et al., 2016).

Mrs. Sprague also spoke of encouraging a growth mindset in her students and encouraging a sense of community by having students support each other’s learning. Dale Dougherty (2013) based his idea of a maker mindset on the writings of Carol Dweck (2006) regarding a growth mindset, and the development of a maker mindset is another goal of student participation in educational makerspaces identified in the literature (Litts, 2015). The idea of developing a sense of community is closely aligned to existing literature which emphasizes community as an essential element of makerspaces (Brahms, 2014; Litts, 2015). Further, Mrs. Sprague’s encouragement of students to support each other’s learning parallels literature which describes makerspaces as being centered around the shared use of space, tools, and materials as well as on the collaboration between and support of members of various levels of expertise during the process and practices of making (Washor & Mojkowski, 2013). The literature also points to the distributed nature of knowledge and learning in a makerspace and the opportunity for members of a makerspace to take advantage of the knowledge and skills of other individuals within the space (Brahms, 2014; Cohen, et al.,
While students in Elementary School Four do not have complete open access to the library makerspace, Mrs. Sprague successfully found a way to adjust her schedule so that all students in her building had the opportunity to experience participation in the makerspace. This is consistent with makerspace literature that lists access to all as a reason why educational makerspaces are a good fit for school libraries (Halverson & Sheridan, 2014; Houston, 2013; Wong, 2013). The literature also discusses the importance of funding for the makerspace to be successful, and the challenges that can be faced in securing an adequate budget (Kurti, et al., 2014a; Plemmons, 2014). While additional funds are needed for the library makerspace in Elementary School Four, Mrs. Sprague successfully obtained enough tools, materials, and resources through some district-level funding, her building PTA, donations, and crowdfunding to implement the makerspace.

Another area where the resulting makerspace implementation closely aligns to existing literature is in regards to three aspects of makerspace design: environment, activities, and facilitation of the makerspace. Considerations for the first design aspect, environment, include space/storage, furniture/flexibility, and décor. As seen in Chapter Five, the library makerspace in Elementary School Four is located in a designated space that was previously a computer lab. The space is quite large, with enough space for individuals and groups to simultaneously work on self-directed projects with room to walk around while work is being done. There is quite a bit of storage for tools, materials, and resources, and there is adequate lighting and ample electrical outlets. In
these ways, the makerspace implementation is closely aligned to suggestions in the existing literature regarding this aspect of the makerspace environment (Houston, 2013; Martinez & Stager, 2013; Petrich, et al., 2013; Range & Schmidt, 2014).

Regarding makerspace furniture/flexibility, existing literature recommends that furniture in the makerspace should be flexible, mobile, and should encourage collaboration. At the same time, however, the makerspace should readily accommodate those who desire or need to work on a project independently. The needs of both individuals working alone and groups working collaboratively should be met through the flexible use design of the space (Gutwill, et al., 2015; Houston, 2013; Kurti, et al., 2014b; Petrich, et al., 2013; Resnick & Rosenbaum, 2013). While some elements of the school library makerspace in Elementary School Four were beyond the librarian’s ability to readily change, such as the built-in counters that ran along the two long walls of the space, she did design the space with flexibility in mind, and her design choices are in keeping with the recommendations in the literature. Mrs. Sprague selected lightweight tables and chairs that, while not on casters, were easy to rearrange to accommodate students’ making needs. The tables running down the center of the makerspace provided space for individual students to work or for groups to work collaboratively, if desired. The counters running along the walls provided space more conducive to individual work, though some students elected to work collaboratively here, as well. Students working with robots had the flexibility to expand beyond the makerspace itself and to use the entire library so they could maneuver the robots without running into others or chancing the robots getting stepped on.
While the paint color in the makerspace was another element beyond the librarian’s ability to readily change, she did carefully select other elements of the makerspace décor. The posters she chose to display in the space were gender-neutral, focusing on such things as explaining the concept of a makerspace, defining and encouraging a growth mindset, defining the STREAM acronym, presenting a design process students could choose to use, and providing steps for students to follow when they needed help. Mrs. Sprague also included specific décor to reflect the creative spirit of the space, such as the makerspace sign she created and the gear clock she hung in the space. These elements of the décor align to recommendations in the literature that paint colors, posters, signs, etc. should be “gender-friendly” or “gender-neutral” and that the décor should be purposefully chosen to inspire creativity, playfulness, and a sense of wonder (Blikstein, 2013; Kurti, et al., 2014a; Martinez & Stager, 2013).

The resulting makerspace implementation is also closely aligned to existing literature in the makerspace design aspect of activities. According to existing literature, activities available to students in the makerspace ought to include both high-tech and low-tech options (Abram, 2013; Blikstein, 2013; Dixon & Ward, 2014; Fredrick, 2015; Kurti, et al., 2014a; Martinez & Stager, 2013; Range & Schmidt, 2014; Resnick & Rosenbaum, 2013; Thomas, 2013). As seen in Chapter Five, the school library makerspace in Elementary School Four offers six different activity areas to students ranging from a low-tech arts and crafts area to high-tech computer coding and robotics areas, in keeping with the recommendation of the literature.

In each activity area, there are a variety of ways for students to interact with the theme of the area, some activities allowing students with no experience to find quick
success and other activities challenging more experienced students. This is very much in line with makerspace literature which suggests that makerspace activities should have multiple entry points and pathways to participation so students of varying knowledge levels can be challenged and successful and so students have freedom to explore within the theme (Blikstein, 2013; Petrich, et al., 2013; Resnick & Rosenbaum, 2013; Sheridan, et al., 2014). This is another way the makerspace is successful regarding the design aspect of activities.

The final makerspace design aspect wherein the resulting makerspace implementation is closely aligned to existing literature is in the facilitation of the makerspace. Results of the study seen in Chapter Five show that Mrs. Sprague created a welcoming space where students pursued projects and activities of interest, similar to what is suggested in the literature (Petrich, et al, 2013). She encouraged students to learn what they needed to know for their activities and projects in a variety of ways, including “figuring it out,” using resources available to them in the makerspace, in the library, or online, or asking for assistance from more knowledgeable peers. Mrs. Sprague even included an expert wall in the makerspace to facilitate this process. While she and the other adults offered assistance to students when needed, learning from the adults was not emphasized as the primary way for students to gain the knowledge they needed for their projects and activities. This is consistent with makerspace literature discouraging adults from being the experts in the space (Kurti, et al., 2014b). When she noticed a student exhibiting frustration, rather than providing the answer they needed, Mrs. Sprague often discussed the activity or project with the student. She asked questions and assisted the student through the process of finding
the answer needed to continue. Mrs. Sprague also used a variety of methods to encourage students to complexify their activities or projects, such as encouraging students to program the robots rather than simply driving them around. Mrs. Sprague’s facilitation of the school library makerspace, then, is closely aligned to the recommendations for makerspace facilitation found in the literature (Gutwill, et al., 2015; Houston, 2013; Resnick & Rosenbaum, 2013).

Another way in which the resulting makerspace implementation was successful is that, as seen in the results of this study, all participant groups expressed during interviews that students enjoyed their time in the space, and researcher observations and the librarian interview indicated that the majority of students were engaged during their time in the makerspace. The literature suggests that sustained engagement of students is a benefit often seen in makerspaces in schools (Peppler & Bender, 2013), so this result is consistent with the literature.

Librarian and teacher interview results showed that students seem to be gaining 21st century skills through participation in the makerspace. For example, the librarian and teacher mentioned that students were collaborating, thinking critically, problem-solving, and expressing creativity. These are but a few of the 21st century skills suggested in the existing literature that students gain through participation in makerspaces (Blikstein, 2013; Bowler, 2014; Gutwill, et al., 2015; Kalil, 2013; Makerspace Playbook, 2013; Martin, 2015; Petrich, et al., 2013; Pisarski, 2014; Vossoughi & Bevan, 2014; Washor & Mojkowski, 2013).

A final area of success of the resulting makerspace implementation is that teachers in the building, who at first were skeptical, came to see the value of their
students’ participation in the makerspace. For school library makerspaces in my district to be successful long-term, it is important for others to buy in to them and to be supportive of them. That teachers in this building so quickly came to see the value of this space to their students bodes well for the possibility of gaining support for school library makerspaces from other teachers, principals, and central office administrators.

**Makerspace Implementation Areas for Improvement**

While the implementation of the library makerspace in Elementary School Four experienced a great deal of success, there are areas where the implementation could be improved. For instance, though Mrs. Sprague was able to make adjustments to her library schedule that allowed all students to have the opportunity to experience participation in the makerspace, they do not have completely open access to the space, and their time in the makerspace is very limited. This resulted in students not having enough time to complete projects or choosing not to pursue a project in which they were interested for fear they would not have time to complete it. Mrs. Sprague may be able to find ways to offer students additional time in the makerspace, such as sponsoring an after-school makerspace club or hosting evening or weekend makerspace events. However, substantial improvements may only come through the examination and restructuring of the school day, devoting a segment of the day to student personalized learning, during which students could choose to work in the makerspace. While this is beyond the control of the librarian to change, personalized learning has become a topic of conversation in my school district.

The makerspace budget is another area for improvement. While I have provided some district-level funds from my budget to support school library makerspaces across the district, there is not funding devoted specifically to support them. While the funds I
contributed and the donations the librarian procured were sufficient to launch the makerspace, consistent, dedicated funding is necessary to sustain it.

Regarding the makerspace design aspect of environment, one area where the makerspace implementation is lacking is in storage space available for both sample projects and ongoing student projects. This lack of storage space for projects precludes the makerspace from following the suggestion found in some makerspace literature to display a variety of levels of previously completed projects in the makerspace (Petrich, et al., 2013; Resnick & Rosenbaum, 2013). It also limits the projects students can make, as they cannot store ongoing projects in the makerspace, and, therefore, may not choose to pursue such a project.

While the school library makerspace in Elementary School Four provides a wide variety of tools, materials, and resources for student use, there are areas for improvement in this aspect of the makerspace design, as well. Bringing in guest makers as a resource for students wanting to learn a specific skill is included in the guidelines developed by the makerspace design committee but is not currently being done in the makerspace. As mentioned in Chapter Five, this is, in part, because the design team has not completed its work in this area, and procedures for bringing guest makers into the building while still following district policies regarding visitors still need to be developed. However, guest makers would be a valuable resource for student makers, so this is an area where improvement could be made.

Another resource that should be added to the makerspace is a maker’s notebook available to students in print and/or digital format that they could use to plan projects, document their progress, and reflect on their process and their learning. This is another
guideline of the design team that has not yet been implemented but that would improve makerspace implementation. In addition to a maker’s notebook, providing additional print and digital resources in the makerspace for students to use to gain the knowledge they need for their projects would improve makerspace implementation. There are some print resources currently available to students in the makerspace for this purpose, but they are not prominently displayed and are, therefore, easy to overlook. Making these existing resources more visible to students would be another area for improvement.

During interviews, students mentioned a variety of additional resources and activities, listed in Chapter Five, that they would like to have added to the makerspace. Determining specific resources and activities all students would like to see included in the makerspace through an interest survey or checklist and then purchasing as many as possible for inclusion in the makerspace would be another way to improve the makerspace implementation. Also, expanding the technology available to students to include such things as 3D printers and laser engravers would be a useful improvement which would allow students many more project options.

As the DFG-EMPM were not finalized by the makerspace design committee until January 2017, midway through the first year of implementation of the school library makerspace in Elementary School Four and only a few months prior to the start of this study, it was not a surprising finding that there were areas where the makerspace was not yet closely aligned to these guidelines. However, makerspace implementation would be improved through closer alignment to them. In particular, implementation would be improved by more closely aligning to the Sharing, Documenting Progress, and Reflection/Formative Self-assessment portions of the DFG-EMPM.
The makerspace implementation could also be improved by rethinking some of the rules that have been implemented for the space that have led to some unintended consequences to student making or by clarifying these rules for students so that they no longer negatively impact student making. The two rules that were discussed in Chapter Five are as follows: don't waste the resources found in the makerspace, and choose one activity area to work in during your makerspace visit. These rules led to some students not selecting certain projects because they did not think they could explore, tinker, or make unsuccessful prototypes, and some students who did not think they could integrate elements of one activity area with those of another to create a project that was a combination of both. Perhaps the development of a reflective form for the librarian overseeing the makerspace would help bring such issues to light.

Finally, the implementation and facilitation of the school library makerspace could be improved with the development and delivery of a training program for librarians specifically on facilitation of a makerspace. While the design committee has developed various sets of guidelines, it has not yet developed a specific training program for the facilitation of a makerspace. Doing so would likely lead to improvements in makerspace implementation and even closer alignment to the design team’s guidelines.

**Makerspace Implementation Recommendations to Others**

Especially if implementing school library makerspaces across a district with multiple sites, I strongly recommend to others the development of guidelines that can be used for the design, implementation, and facilitation of these spaces. Theme one of research question two found that these guidelines can be utilized by the librarian to intentionally design the school library makerspace. While it is likely that not every guideline will be met by every district site due to the individual needs and challenges of
each building, the existence and intentional use of these guidelines for makerspace implementation was found in theme two of research question two of this study to lead to an overall successful implementation closely aligned in many ways to existing literature regarding makerspaces. It is important to note that I recommend that others develop their own guidelines for the design, implementation, and facilitation of school library makerspaces using a similar process to the one described in this study rather than attempting to adopt the guidelines developed in my school district. The purpose, philosophy, and needs of another’s district are likely to be different from those of my district, and the guidelines for the design, implementation, and facilitation of school library makerspaces would likely need to be different as well.

Though I strongly recommend the development of guidelines as stated above, I also recommend moving forward with implementation even if not every guideline has yet been met. As seen in theme two of research question two, the school library makerspace in Elementary School Four experienced many areas of success even though it had not yet implemented all of the guidelines of the design team. While the expectation is that the makerspace will continue to implement more of the team’s guidelines, students were still able to participate in the makerspace and to begin to experience making as a learning process in the meantime.

I also recommend developing and implementing a training program for facilitators of the space that goes beyond learning about the philosophy and guidelines. Rather, the training should teach librarians how to facilitate student making. This would allow for increased consistency in the facilitation of the makerspaces just as the guidelines allowed for consistency in the design and implementation of the spaces, and would help
address an area for improvement to implementation mentioned in theme two by the librarian, specifically, increasing alignment to the EMPM.

Finally, I recommend developing a promotional campaign to educate others (teachers, principals, central office administrators, school board, parents) about the underlying philosophy and purpose of makerspaces and to highlight them in action. This is an activity included on the logic model to be completed by the design committee in my district, but that has not yet been accomplished. I recommend making this a priority earlier in the process to help gain much needed support for the makerspaces. Gaining such support might alleviate other areas for improvement mentioned in theme two by participants, such as establishing consistent funding or determining ways to allow more time in the schedule for students to participate in the makerspace.

Research Question Three: Student Participation in Makerspace

Research question three of this study asked, “In what ways do students experience participation in the resulting school library makerspace?” Chapter Five of this study presented the six themes surrounding this question that resulted from thematic analysis of the data: Students experience adults as facilitators of making process; Students have access to makerspace at a variety of times; Students participate in a wide variety of self-directed projects and activities within the limitations of time, resources, safety issues, and makerspace rules; The majority of students are purposefully engaged in and enjoy participation in makerspace; Student making experience compared to EMPM; and Students benefit from participation in makerspace.

The sections below discuss the results of research question three in the context of the overall successes of student participation in the makerspace, areas for
improvement, and recommendations for others regarding student participation in the makerspace while highlighting where these results align to existing literature.

**Student Participation Successes**

This section discusses the ways in which students’ experience of participation in the resulting makerspace was successful as well as discussing areas where students’ experience of participation aligns with existing literature. Table 6-2 provides a summary of this alignment which is discussed in the paragraphs below.

When Seymour Papert (1991b, p.19) shared his vision of constructionist learning environments, he described them as places where “children are engaged in constructing things,” where they “are engaged in activity they experience as meaningful,” and where they are “advised by an empathic, helpful consultant-colleague-teacher.” He stressed the importance of these learning environments supporting students’ pursuits of personally meaningful projects and being facilitated by the availability of technology and supportive adults (Papert, 1991b; Papert, 1993a; Papert, 1993b). As seen in the results of this study, the library makerspace in Elementary School Four operates as a student-centered environment wherein students select projects and activities of their choice based on their interests or needs. There is some technology available to them to support their making process, and the adults in the space facilitate rather than direct student making efforts. That students experience participation in the makerspace as self-directed learners in the pursuit of personally meaningful projects and activities and are supported by adults who facilitate their making process, closely echoing Papert’s description above, is a significant way in which student participation in the makerspace was successful.
<table>
<thead>
<tr>
<th>Area of student participation success</th>
<th>Supporting citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-directed learners in the pursuit of personally meaningful projects and activities supported by</td>
<td>Papert, 1991b; Papert, 1993a; Papert, 1993b</td>
</tr>
<tr>
<td>adults who facilitate their making process</td>
<td></td>
</tr>
<tr>
<td>All students have some opportunity to participate in school library makerspace</td>
<td>Halverson &amp; Sheridan, 2014; Houston, 2013; Wong, 2013</td>
</tr>
<tr>
<td>Students choose projects based on personal interest or needs</td>
<td>Litts, 2015; Peppler &amp; Bender, 2013; Peppler, et al., 2016; Vossoughi &amp; Bevan, 2014;</td>
</tr>
<tr>
<td></td>
<td>Wilkinson, et al., 2016</td>
</tr>
<tr>
<td>Students participate in a variety of high- and low-tech projects and activities, ongoing and one-</td>
<td>Abram, 2013; Blikstein, 2013; Dixon &amp; Ward, 2014; Fredrick, 2015; Kurti, et al., 2014a;</td>
</tr>
<tr>
<td>and-done</td>
<td>Martinez &amp; Stager, 2013; Range &amp; Schmidt, 2014; Resnick &amp; Rosenbaum, 2013; Thomas, 2013</td>
</tr>
<tr>
<td>Students purposefully engaged during their time in makerspace</td>
<td>Gutwill, et al., 2015; <em>Makerspace Playbook</em>, 2013; Martin, 2015; Peppler &amp; Bender, 2013</td>
</tr>
<tr>
<td>Students experience Inspiration phase of EMPM, based on existing literature</td>
<td>Litts, 2015; Peppler &amp; Bender, 2013; Peppler, et al., 2016; Vossoughi &amp; Bevan, 2014;</td>
</tr>
<tr>
<td></td>
<td>Wilkinson, et al., 2016</td>
</tr>
<tr>
<td>Students experience Ideation phase of EMPM, a similar step found in other processes</td>
<td>Martinez and Stager, 2013; McGalliard, 2016; Resnick, 2007</td>
</tr>
<tr>
<td>Students experience Making phase of EMPM, variety of approaches, individualized learning</td>
<td>Blikstein &amp; Worsley, 2016; Brahms, 2014; Martin, 2015; Sheridan, et al., 2014</td>
</tr>
<tr>
<td>Students experience Iteration phase of EMPM, similar to aspect of making seen in literature</td>
<td>Dougherty, 2013; Regalla, 2016; Tseng, 2016; Wilkinson, et al., 2016</td>
</tr>
<tr>
<td>Students experience Optional and Flexible Collaboration</td>
<td>Gabrielson, 2013; Litts, 2015; Martinez &amp; Stager, 2013; Peppler, et al., 2016;</td>
</tr>
<tr>
<td></td>
<td>Regalla, 2016; Sheridan &amp; Konopasky, 2016</td>
</tr>
<tr>
<td>Students learned STEM-related skills as coding and seemed to gain background knowledge in other areas</td>
<td>Britton, 2012; Houston, 2013; Peppler &amp; Bender, 2013; Quinn &amp; Bell, 2013; Vossoughi &amp;</td>
</tr>
<tr>
<td>such as force and motion</td>
<td>Bevan, 2014; Worsley &amp; Blikstein, 2014</td>
</tr>
<tr>
<td>Student recognized skills he learned as helpful for a future STEM career</td>
<td>Blikstein, 2013; Britton, 2012; Houston, 2013; Kalil, 2013</td>
</tr>
<tr>
<td>Students who participated in the school library makerspace practiced several of the 21st century</td>
<td>Blikstein, 2013; Bowler, 2014; Gutwill, et al., 2015; Kalil, 2013; <em>Makerspace Playbook</em>,</td>
</tr>
<tr>
<td>skills found in the literature</td>
<td>Martin, 2015; Petrich, et al., 2013; Pisarski, 2014; Vossoughi &amp; Bevan, 2014; Washor &amp;</td>
</tr>
<tr>
<td></td>
<td>Mojkowski, 2013</td>
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</table>
As discussed previously, all students in Elementary School Four have some opportunity to participate in the school library makerspace. Additionally, some students used the makerspace during their recess time, and yet others earned additional time in the makerspace as part of the building’s overall behavior plan. One of the reasons given in the literature for locating a makerspace in the school library is that it is one of few spaces in a school that all students have access to, regardless of their class schedule (Halverson & Sheridan, 2014; Houston, 2013; Wong, 2013). While the amount of time students in this study had in the makerspace was less than ideal, that all students in the school were able to experience participation in the makerspace at some level is another area of success, and it reinforces the point made in the literature regarding the placement of makerspaces in school libraries.

Another area of success regarding student participation in the makerspace was the finding that students had autonomy to choose making projects or activities based on personal interests or needs, and, as such, a wide variety of individual projects were observed taking place simultaneously during any given makerspace visit. The student autonomy seen in the study echoes existing literature which shows that an important aspect of the process of making is that it should be driven by the interests and/or needs of the individuals involved in the making (Litts, 2015; Peppler & Bender, 2013; Peppler, et al., 2016; Vossoughi & Bevan, 2014; Wilkinson, et al., 2016).

As discussed in Chapter Five, students in the school library makerspace in Elementary School Four participated in both high-tech and low-tech as well as “one and done” and ongoing projects and activities in the makerspace. This is again consistent with the expectations for the types of projects and activities that would be seen in a

The results of this study also showed that the majority of students enjoyed their time in the makerspace and were purposefully engaged during the entirety of their visit. This is another area of success regarding student participation in the makerspace, and one which also aligns to existing makerspace literature. As seen in Chapter Five, students were excited to enter the makerspace, eager to get started on their projects, worked on those projects during the entirety of their visit, and were disappointed when time was called to be done for the day and clean up. Some students were seen to have planned their projects ahead of time outside of makerspace time and even brought the necessary materials and supplies for their projects with them so they could spend their time in the makerspace working on the project. These observed student behaviors hearken back to existing literature wherein sustained student engagement is consistently seen as a purported benefit of makerspaces in schools (Peppler & Bender, 2013). A study conducted in the Tinkering Studio (Gutwill, et al., 2015) identified “displaying motivation” as one indicator of engagement observed in those participating in making activities. Elsewhere in the literature, making activities are said to be motivating and engaging (Martin, 2015) and makers are said to be “intrinsically motivated” (Makerspace Playbook, 2013). Students observed as part of this study were purposefully engaged during their time in the makerspace and, consistent with the
literature, displayed behaviors as listed above that could certainly be described as motivated.

Though the makerspace design committee did not finalize the DFG-EMPM until January 2017, halfway through the first year of implementation of the school library makerspace in Elementary School Four and just a few months prior to the start of this study, results found that students still experienced making as a process aligned closely to many of the phases of the EMPM. As the EMPM was developed based on existing literature, student participation in the school library makerspace successfully replicated many elements of the making process identified in the literature. Results of the study showed, for instance, that students participating in the school library makerspace selected making projects based on their personal needs or interests rather than completing teacher-directed or curriculum-driven projects. This not only aligned to the “Dream It!” or Inspiration step of the EMPM, but also aligns to literature that emphasizes the importance to the making process of individuals selecting projects based on their own interests and/or needs (Litts, 2015; Peppler & Bender, 2013; Peppler, et al., 2016; Vossoughi & Bevan, 2014; Wilkinson, et al., 2016). Students were also observed exploring various activities in the makerspace without a particular goal in mind, and one male student even stated that the makerspace was “not all just about learning. . . You just get to explore.” Student exploration is part of the Inspiration phase of the EMPM, and it is also discussed in the literature as a valuable part of the making process, though it is often referred to in the literature as tinkering. Some in the literature even recommend focusing less on projects and more on tinkering in educational
makerspaces as inspiration for personally meaningful projects often results from tinkering (Peppler & Bender, 2013).

Study results also showed that some students experienced the “Visualize It!” or Ideation phase of the EMPM during their participation in the school library makerspace. During this step, students begin to visualize their project in their heads or to draw out or write down plans for their project, something that was also seen repeatedly in the literature. Similar steps are found in three processes discussed in Chapter Two of this study as being somewhat like the process of making, the “imagine” step of the creative design spiral (Resnick, 2007), the “think” step of the TMI process (Martinez and Stager, 2013), and the “imagine” step of the Creative Play Spiral (McGalliard, 2016).

Students in the study also experienced the “Create It!” or Making step of the EMPM through participation in the school library makerspace. Students in the study were observed utilizing a variety of approaches to this step of the EMPM. Some students utilized a tinkering approach to making, experimenting with the materials or resources at hand without a solid plan in mind. Other students took a more planned and thoughtful approach, determining and then gathering the tools, resources, and knowledge needed and then problem-solving through possibly multiple attempts to create a completed project. The variety of approaches to the Making step taken by students are similar to some of the learning practices Brahms (2014) identified in her study of the adult making community, specifically “tinker, test, and iterate” and “seek out resources.” That the knowledge being gathered is individual to each student and is based on the specific needs of the project at hand is also consistent with existing
literature (Blikstein & Worsley, 2016; Brahms, 2014; Martin, 2015; Sheridan, et al., 2014).

Though not as prevalent in the study’s findings, at least a few students experienced the “Improve It!” or Iteration step of the EMPM as part of their making process, making changes or improvements to their projects that did not turn out as expected or desired. Existing literature states that making is often an iterative process (Dougherty, 2013; Regalla, 2016) wherein one makes a project through a series of starts and stops, going back to the beginning to learn additional information before being able to move forward again (Tseng, 2016; Wilkinson, et al., 2016). While this is a step of the EMPM that needs to be further encouraged in students, I consider it a success that at least a few students experienced iteration as part of their making process during the course of the study.

Another phase of the EMPM that students exhibited as part of their making process during the study was Optional and Flexible Collaboration. Some students chose to work on projects or activities individually. However, even when this was the case, other students assisted them in a variety of ways when and as needed or desired, which is consistent with existing literature (Litts, 2015; Regalla, 2016; Sheridan & Konopasky, 2016). Study results also found that students collaborated with others by working side-by-side on separate projects and by working collaboratively on shared projects. This, too, is consistent with existing literature which showed that collaborating with others as needed or wanted is another part of the making process (Gabrielson, 2013; Martinez & Stager, 2013; Peppler, et al., 2016).
Study results also showed that students experienced Continuous Feedback as part of their making process, another part of the EMPM. Existing literature suggests that continual feedback is inherent to the process of making (Martin, 2015; Resnick, et al., 2016; Wilkinson, et al., 2016), and that students may receive this feedback from a variety of sources and in a variety of ways. According to the literature, students may receive kudos from others about a project that turned out well (Resnick & Rosenbaum, 2013; Tseng, 2016). The study found that while feedback from others beyond their own classmates was limited, students in the school library makerspace in Elementary School Four did receive feedback in this manner, though, at times, the feedback was negative. Students in the study also received feedback from the projects they made or the activities in which they participated. This finding is consistent with existing literature which states that feedback also comes from the created artifact itself in the form of whether or not it works or behaves as intended (Martin, 2015; Resnick, et al., 2016; Wilkinson, et al., 2016).

Another area of success of student participation in the school library makerspace is that students seemed to benefit in several ways from their participation. Results of the study found that students learned such STEM-related skills as coding through makerspace participation while also seeming to gain background knowledge in other areas such as force and motion. Some students stated that they increased their ability in more art-related areas, such as painting, or were observed learning a new practical skill, such as sewing. This finding echoes the broad agreement seen in the literature that makerspaces could have a potential positive impact on student learning in the areas of science, technology, engineering, and math (STEM) as well as the arts.
(STEAM) (Britton, 2012; Houston, 2013; Peppler & Bender, 2013; Quinn & Bell, 2013; Vossoughi & Bevan, 2014; Worsley & Blikstein, 2014). During an interview, one student referred to the fact that the coding he was learning in the makerspace would be helpful if he someday became an engineer. This may indicate that, as the literature suggests, makerspaces provide an entry point for students to develop an interest in STEM and STEM-related careers (Blikstein, 2013; Britton, 2012; Houston, 2013; Kalil, 2013).

Existing makerspace literature purports that students stand to gain 21st century skills through participation in a makerspace (Blikstein, 2013; Bowler, 2014; Gutwill, et al., 2015; Kalil, 2013; Makerspace Playbook, 2013; Martin, 2015; Petrich, et al., 2013; Pisarski, 2014; Vossoughi & Bevan, 2014; Washor & Mojkowski, 2013). Results of this study found that students who participated in the school library makerspace practiced several of the 21st century skills found in the literature, including teamwork, collaboration, problem-solving, critical thinking, independent learning, a growth mindset, focus, and playful learning.

A final way in which student participation in the makerspace was a success is that students who did not always do well in the traditional school environment excelled in the makerspace. Some students who often got into trouble in the regular classroom became very engaged in creative pursuits in the makerspace. Students who were not always academically successful in the classroom were able to explore concepts in the makerspace and experience success with them. Students were able to expand beyond how others typically saw them, such as athletic, to discover new interests in the makerspace.
Student Participation Areas for Improvement

As seen in the section above, there were many areas of success regarding students’ experience of participation in the school library makerspace. However, there are several ways in which their experience of participation could be improved. One such improvement, which was also listed as an area of improvement for makerspace implementation, is for students to have more time in the makerspace to work on their projects. While results of the study showed that all students had some opportunity to participate in the makerspace during scheduled library times and that some students had access to the makerspace at other times such as during their recess, the amount of time students get in the makerspace is quite limited. This time limitation was found to impact students’ choice of projects: some students opted not to pursue certain projects in which they were interested because they did not have enough time to complete them. Rather, these students chose less complex projects or activities because they fit within the time constraints. Providing more time for students in the makerspace, then, could improve the way in which students experience participation by allowing them to pursue more complex projects of personal interest.

Regarding student projects, there are other ways students’ makerspace participation could be improved in this area. While some students chose projects that took more than one makerspace visit to complete, many of the projects students made were quite simplistic. Some students chose to make a more simplistic project because that was their interest at the time or perhaps because they were unsure what else to make. For these students, the librarian and other adults can encourage increased complexity in their projects. However, other students seem to have chosen more simplistic projects for other reasons, such as the time constraints mentioned above, the
lack of storage for ongoing projects, a lack of resources such as enough Legos for students to keep their projects intact between makerspace visits, and misconceptions regarding the integration of elements from various activity areas into a single project. Addressing and making improvements to the issues underlying these reasons for student choice of simplistic projects would improve students’ experience of makerspace participation by removing barriers to their pursuit of more complex projects.

Interestingly, the projects student chose to make seemed, overall, to be impacted by gender notions. Intentionally including materials and resources in the makerspace that provide an entry point for students into areas where they might otherwise be hesitant to participate is another way student participation could be improved regarding projects. E-Textiles, which have been shown to allow an entry point into computer programming for some students, especially young girls (Kafai, et al., 2014), is one example of the type of materials that could be included to improve this aspect of student participation.

Another improvement to the way in which students experience participation in the makerspace would be through increased facilitation of student making as a process as defined in the EMPM. While study results showed that students did experience many of the phases of the EMPM as part of their making process, other phases of the process have yet to become part of students' making process. For instance, students did not have opportunities to share their projects and their learning beyond their classroom. Sharing completed projects and the knowledge gained from making them is seen in the literature as an important aspect of making (Dougherty, 2013; Regalla, 2016; Rusk,
2016) as well as one of the core learning practices of the adult making community (Brahms, 2014).

Two other parts of the EMPM that could improve the student experience of participation if more intentionally facilitated as part of the student making process are Documenting Progress and Reflection/Formative Self-Assessment. Results showed that a few students developed their own way of tracking their progress during a making project. However, students were not provided with resources such as a maker's notebook to use to document their progress or to use for reflection and self-assessment, nor were they encouraged to do so by the adult facilitators. Existing literature, though, shows that it is common for makers to document what they have tried and learned throughout the making process (Martinez & Stager, 2013; Resnick & Rosenbaum, 2013) as it helps the individual maker keep track of what has already been done or tried throughout a long-term making project and it allows the project and the process to be more readily shared with others once the project is complete (Resnick, et al., 2016). Providing students with opportunities to share their completed projects and their learning as well as providing them with a maker's notebook and encouraging them to document their progress and to participate in reflection and self-assessment would improve their overall making experience, increase their ability to articulate what they have learned, and encourage their development as makers.

**Student Participation Recommendations to Others**

Just as I strongly recommended that others develop guidelines on which to base makerspace design, implementation, and facilitation related to research question two, I strongly recommend that others base student participation in the makerspace on a well-defined process of student making, such as the EMPM. Having an agreed upon
definition of the process of student making in place allows greater consistency in how students experience making across all makerspaces in an organization. Theme five of research question three showed how student participation in the makerspace can be aligned to the EMPM.

Whether others adopt the EMPM or develop their own definition of the process of student making based on their own review of the literature, I also recommend considering the success of the makerspace based on the degree to which students are developing as makers who experience making as a process rather than on the completion of certain projects or the development of a certain set of skills by all students. A measurement tool to gauge this type of success would need to be created.

Finally, as mentioned as a recommendation related to research question two, I recommend that a specific training program be developed and implemented for the facilitation of the makerspace based on the EMPM or other definition of the process of student making adopted by an organization. This would help alleviate some of the areas of improvement listed above where students were not experiencing certain steps of the EMPM as part of their own making process as was shown in theme five for research question two.

**Implications**

This design case dissertation served to document the processes used and decisions made by a team of librarians in my school district who worked to develop guidelines for the implementation of makerspaces in the district’s libraries. The study also described the resulting makerspace implementation and the ways in which students experienced participation in the resulting makerspace, discussing both areas of success and areas for improvement. The sections below discuss the implications of
the results of the study for my professional practice and local context, for other school
districts wanting to implement library makerspaces, for the field of library science, and
for the study of makerspaces as learning environments.

**For Researcher’s Professional Practice and Local Context**

As library coordinator for my school district, I led the makerspace design
committee through the process of developing guidelines for the implementation of
school library makerspaces in our district. As such, the ways in which the design
process was a success as well as ways in which it could be improved as discussed
earlier in this chapter have direct implications to my professional practice and local
context. While the work of the makerspace design committee is nearly complete, there
will be other occasions in my position when I will need to make use of a similar process
to implement another program or initiative. The results of this study will help me make
needed adjustments to the design process to ensure an even higher level of success in
those future endeavors.

The results of research questions two and three of this study have more
immediate implications for my professional practice and local context. The results of
these two research questions were discussed above showing the areas of success and
areas for improvement of the resulting makerspace implementation as well as for the
ways in which students experience participation in the school library makerspace. This
information will allow me to work with the makerspace design committee as well as with
any other librarians in my district who have implemented a makerspace to make the
adjustments needed to improve the makerspace implementations as well as the
students’ experience of participation in them. Some immediate areas of improvement I
plan to encourage are to ensure the display of completed projects as well as the storage
of ongoing projects, to provide students with a resource to use and to encourage them
to document their progress and to reflect on their process and their learning, and to
provide opportunities for students to share their completed projects and the knowledge
gained through making them. Multiple themes discussed in Chapter Five for both
research question two and research question three showed that these elements were
lacking and that this was impacting the student making process.

For Other Districts

The results of this study also have implications for other districts wanting to
implement school library makerspaces. As a design case dissertation, the main
purpose of this study was to preserve the precedent knowledge gained by the design
team through the design and implementation of school library makerspaces in my
district and to pass this on to others. I believe that the detailed descriptions of the
design process itself, the resulting makerspace implementation, the students’
experience of participation, and the discussion of the areas of success, areas for
improvement, and researcher recommendations have accomplished that goal. Other
districts wanting to implement school library makerspaces could learn from the process
and results described in this study and use the knowledge gained to conduct their own
design and implementation process.

While I do not recommend that other districts simply adopt the guidelines that
were developed by the makerspace design committee in my district, I do recommend
that other districts develop their own guidelines. The detailed processes described in
this study provide other districts a potential framework to use for the development of
their own guidelines. I also recommend that other districts adopt a common definition of
the making process that they hope to facilitate in students. In this case, other districts
may want to adopt the EMPM presented in this study that was developed based on existing literature rather than developing their own, and I encourage them to do so.

For Field of School Library Science

Makerspaces have become quite popular in the field of library science, and many trade journals in the field discuss school library makerspaces and provide advice about starting one (Canino-Fluit, 2014; Loertscher, et al., 2013; Range & Schmidt, 2014). However, there has been very little research done on school library makerspaces. The results of this study have implications for the field of school library science in that it adds to a very limited body of knowledge on this topic.

While descriptive in nature, this study provides school librarians detailed information about a process that might be used to design and implement school library makerspaces as well as what a resulting makerspace implementation might look like and how students might experience participation in the makerspace. Those who are new to the concept of makerspaces could benefit from these detailed descriptions, including the vignettes included as part of the study results. More importantly, however, the presentation of the EMPM provides school librarians a way to understand student making as a process that can be intentionally facilitated.

For the Study of Makerspaces as Learning Environments

The results of this study also add to the growing body of knowledge of makerspaces as learning environments, very little of which has thus far focused on school library makerspaces. The major implication of this study for this body of knowledge is the EMPM I developed as a way to understand making as a process. I developed the EMPM based on the elements of making repeatedly found in existing literature. It is my hope that the EMPM can lead to a common understanding within the
field of educational making as a process that can be intentionally facilitated. This common understanding of educational making as a process could then become the basis of research into the best methods to facilitate this process to develop student makers.

**Future Research**

This study was conducted with one class of students in a single elementary school. Conducting additional studies focusing on research questions two and three of this study with other classes of students, in multiple elementary schools, or in school libraries with makerspaces on mobile carts would be useful to see if similar themes resulted. This is one area where future research could be conducted.

A design case is descriptive in nature and is not intended to show a causal connection between such things as student participation in a school library makerspace and academic achievement. As such, this study did not attempt to make any such statements of causality. However, there are several areas of research stemming from the results of this study where such causal connections could be explored. One avenue for future research would be exploring the connection between student participation in the makerspace and learning of various content area knowledge. This study showed that students seemed to gain background knowledge in some content areas, but further research could explore whether and to what degree students are gaining such knowledge as a result of makerspace participation. Similarly, future research could explore the connection between students’ participation in the makerspace and the development of 21st century skills such as confidence, teamwork, problem-solving, and growth mindset. This study revealed that the librarian and the classroom teacher
believed that their students were gaining these skills through makerspace participation, but future research could explore the possibility of a causal connection.

As mentioned in the discussion of the results of research question three earlier in this chapter, the majority of projects and activities students chose to participate in during their time in the makerspace seemed to be impacted by gender notions. Future research could explore whether the introduction of materials intended to allow students access into areas they might otherwise be hesitant to attempt has an effect on their project choices.

Many students who were part of this study participated in makerspace activities related to STEM areas, and at least one student mentioned how the skills he was learning in the makerspace would be helpful if he someday chose to be an engineer. Future research could explore this area to determine if a connection exists between student participation in the school library makerspace and an interest in STEM subject areas and/or STEM careers.

Another potential area of future research is to explore the reasons why some students were found in this study to be just “fiddling around” rather than to be engaged in making projects or activities. Are these students disengaged from the making process during every makerspace visit, or just during some visits? What are the reasons for their disengagement? How do seemingly innocuous rules that govern student behavior in the makerspace impact their level of engagement? Understanding why these students are disengaged may help develop ways to better engage them in the process.
A final area of future research is in relation to the EMPM. While students were found in this study to experience many steps of the EMPM as part of their own making process, there were other steps that they did not experience. Why? Is it because these guidelines were so new that the librarian had not yet had the chance to fully implement them? Are some steps harder to implement, requiring even greater intentionality on the part of the facilitator than what was seen in this study? Can certain steps of the process only become part of a student’s making process after the adoption of other steps? Would these steps “naturally” become part of the student making process over time as students further develop as makers? Research in this area could lead to adjustments to the EMPM to better match what students experience or to better ways to facilitate student making as a process.

**Researcher Reflections**

I learned a lot about myself through the process of working with the design committee to design and implement school library makerspaces in my school district. Working through this process and developing a design case based upon that process has helped me identify some areas of strength in my leadership abilities as well as some areas where I could improve. As to strengths, I have come to realize that I am quite an organized and detail-oriented person. This helped not only during the process of planning, organizing, and facilitating the makerspace design committee meetings, but also during the development of the design case based upon the process, as I was easily able to review and provide examples of various documents, including different versions of the guidelines developed by the team. I have also come to realize that my leadership style is very inclusive of other’s ideas and truly collaborative in nature. While I may come to a meeting, for instance, with my own idea of how something could be done, it is
important to me to get input and ideas from other team members and to truly consider them as viable alternatives. As a leader, though it admittedly makes me a bit uncomfortable in the moment, I appreciate others challenging my thoughts and ideas with those of their own. Rather than obstinately holding to my own ideas simply because they are mine, I look at this as an opportunity to see another perspective or another way the problem could be approached, and I have, at times, abandoned my own idea for someone else’s as I recognized that theirs was the better idea. I believe these strengths served the makerspace design process well and will be equally valuable to future projects in which I might be involved.

This process has also helped me identify areas where I could make improvements to my leadership. I was fortunate to work with a hard-working and professional group of librarians who made up the makerspace design committee. However, as a leader, I need to do more going forward into other projects to establish group norms to set the stage for how meetings will be run and for the level of work and professionalism expected from team members to ensure the same positive outcome for those future projects. Another area of improvement for my personal leadership style is to ensure a greater level of communication to concerned parties outside of the design team itself. In this instance, I could have done a better job of keeping the other librarians in the district informed about the team’s progress as well as some central office administrators who may have more quickly provided support for makerspaces. This is a lesson I will take with me going forward as I take on other projects: to have a communication plan in place to keep these various stakeholders better informed of progress.
This dissertation represented only a snapshot of an ongoing process to design and implement school library makerspaces in my district. Since the study concluded, additional progress has been made to bring the opportunity of making to the students in my district. For instance, several members of the design team conducted a session on school library makerspaces during the district’s Summer 2017 professional development week. This session was geared toward classroom teachers wanting to learn more about the school library makerspaces recently implemented in their buildings, though several librarians who wanted to start a makerspace were also in attendance. The session discussed the learning theory of constructionism and the purpose and goals of the district’s school library makerspaces. Participants also had the opportunity to interact with many of the items their students encounter in the makerspaces, such as Makey Makey, Squishy Circuits, Scratch programming, Sphero, stop-motion animation, and craft activities such as origami.

Another area of progress pertains to the school library makerspace that was the focus of this study. There was a change of building leadership, and the new principal proved to be supportive of the school library makerspace as was her predecessor. With her support, the makerspace has undergone many changes since this study. The mauve counters lining two walls of the space were removed, and new lightweight mobile tables were purchased to take their place. Some space was left along the walls where storage units were placed rather than filling the entire wall with tables. Additional shelves were installed at approximately eye level along one of the walls to allow for the display of sample projects or the storage of ongoing student projects. The principal also purchased several lightweight tables with dry erase tops to replace the tables that had
been in the center of the makerspace. Additional changes, such as adding a presentation space and a Lego wall to the room are planned. Three additional elementary libraries have started implementing a makerspace since this study, while another four elementary libraries plan to start implementing one very soon.

Also since this study was completed, a district-level committee has been formed to work toward the Board of Education’s goal of developing and implementing innovative instructional practices. One such practice that has been identified is school library makerspaces. The committee is led by the district’s Assistant Superintendent of K-8 Instruction. Other members include the Directors of Elementary and Secondary Curriculum, Instruction, and Professional Development, the Lead Coordinator of Instructional Technology, the Coordinator of the district’s online learning program, and myself. Regarding school library makerspaces, the committee’s plan is to expand them to all of the district’s libraries, encourage collaboration between the librarian and classroom teachers on opportunities to incorporate student making, and financially supporting the makerspaces to ensure they all include a base level of tools, materials, and technology. This work is in its early phases, yet it is exciting to have the support of the Board of Education and district-level administration to expand making opportunities to our students.

**Concluding Remarks**

School library makerspaces have become quite popular in the field of library science, and are being incorporated into many school libraries. However, these spaces are often being implemented in a haphazard way, based on what the individual librarian has read about makerspaces in trade journals or heard about them at conferences, on social media, through other librarians, or through other informal means. This design
case dissertation showed that these spaces can be purposefully designed to remain in keeping with the underlying principles of constructionist learning theory and to help meet the goals of a district library program. Further, this study showed that the resulting makerspace implementation based on the design as well as the ways in which students experience participation in the makerspace can be successful in many areas, while areas of improvement also were found. In addition to providing detailed descriptions of the processes used, the decisions made, and the resulting makerspace implementation and student experience of participation, I also provided recommendations to others wanting to implement school library makerspaces in their own context. After discussing the implications of the study’s results for my professional practice and local context, for other school districts wanting to implement library makerspaces, for the field of library science, and for the study of makerspaces as learning environments, I suggested several areas for future research in the area of school library makerspaces. Finally, I reflected both on what I learned through the design process as well as providing information as to progress that has been made in the design and implementation of school library makerspaces in my district since the study was completed.
## APPENDIX A
SCHOOL LIBRARY MAKERSPACE OBSERVATION PROTOCOL

<table>
<thead>
<tr>
<th>Environment</th>
<th>Inspiration</th>
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<tr>
<td>• Storage/Space</td>
<td></td>
</tr>
<tr>
<td>• Furnishings/Flexibility</td>
<td></td>
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<tr>
<td>• Décor/Feel of Makerspace</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Activities/Tools, Materials, &amp; Resources</th>
<th>Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Activities</td>
<td></td>
</tr>
<tr>
<td>• Tools, Materials, &amp; Resources</td>
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<table>
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<tr>
<th>Facilitation</th>
<th>Sharing</th>
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**Additional Observations Regarding the Physical Space**
Makerspace Observation Protocol

<table>
<thead>
<tr>
<th>School:</th>
<th>Librarian:</th>
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<tbody>
<tr>
<td>Grade Level:</td>
<td>Teacher:</td>
</tr>
<tr>
<td>Number of Students:</td>
<td>Date:</td>
</tr>
<tr>
<td>Observation:</td>
<td>Time of</td>
</tr>
</tbody>
</table>

| General Observations of First 10 minutes |

<table>
<thead>
<tr>
<th>Observer Comments</th>
<th>Student Actions/Behaviors/Comments</th>
<th>Librarian (L) or Teacher (T) Actions/Behaviors/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>School:</td>
<td>Librarian:</td>
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<td>Grade Level:</td>
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<td>Teacher:</td>
<td>Date:</td>
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<tr>
<td>Observation: __________ - __________</td>
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</tr>
</tbody>
</table>

| Observer Reflections/Summary of Observation |
APPENDIX B
STUDENT INTERVIEW PROTOCOL

Student Name: __________________________ Date: ______________

Introduction to Interview
Hello! I’m Mrs. Anderson, and I have been working with librarians, including yours, to start school library makerspaces for students to use. I’m really interested to find out what it is like for you to use the makerspace, the kinds of things you do in the makerspace, and how you feel about using the makerspace. I really appreciate you letting me ask you some questions about those things. I want you to know that I am not looking for a certain answer to these questions. I really just want to get your thoughts and feelings, ok?

Student Interview Questions

General Questions about Student Experience Using Makerspace
1. About how many times have you used the makerspace?
2. Walk me through what it is like for you to use the makerspace. If I were to visit the makerspace with you, what would we see, hear, and do?
3. How do you feel about using the makerspace?

Questions Aligned to Educational Making Process Model

Dream It! Inspiration
4. Tell me about some of the things you have done or made in the makerspace.
5. Why did you do or make those particular things instead of other things?
6. Where did you get the idea to do or make those things?

Visualize It! Ideation
7. So, once you knew what you wanted to do or make, what did you do next?
8. Did you know exactly what you wanted your end result to be or look like before you started? IF YES: How did you figure out what you wanted it to be or look like?

Create It! Making
9. How did you know how to do or make those things?
10. Have you ever not known how to do something for a project? IF YES: What did you do about that?
11. What tools or materials did you need to make those things? Where did you get those items?
Improve It! Iteration
12. Is there something you tried to do or make in the makerspace that did not work or did not turn out quite how you wanted it to? IF YES: Tell me about that.

13. IF YES TO 12: So, what did you do when it didn’t work or didn’t turn out as you wanted?

Present It! Sharing
14. When you are finished making something, what do you do with it?

Optional & Flexible Collaboration
15. Have you ever helped someone else with something they were trying to do or make in the makerspace? IF YES: Tell me the story about that.

16. Has someone else ever helped you with something you were trying to do or make in the makerspace? IF YES: Tell me the story about that.

17. Have you ever worked together with others in the makerspace on a project? IF YES: Give me some examples of you working together with others on a project.

Continuous Feedback
18. Has anyone else in the makerspace told you what they thought of something you made? IF YES: Tell me about a time when that happened.

Documenting Progress
19. Have you ever had a project that took more than one visit to the makerspace to complete? IF YES: How did you remember what you needed to do next when you came back?

Reflection & Formative Self-Assessment
20. Think back on all the things you have done in the makerspace. List for me as many things as you can that you feel you have learned while using the makerspace.

Question Regarding Areas of Needed Improvement for Makerspace
21. If you could change something about the makerspace, what would you change?

Question Allowing Open-Ended Response from Student Regarding Makerspace
22. What else would you like to tell me about using the makerspace?

Conclusion to Interview
Thank you so much for sharing your thoughts and feelings about makerspaces with me. Your answers will be very helpful.
APPENDIX C
LIBRARIAN INTERVIEW PROTOCOL

Librarian Name: ________________________________ Date: ________________

Introduction to Interview
Thank you for taking the time to talk to me today. I want to ask you some questions about your school library makerspace. My goal is to learn more about the design of the physical space, your goals for students using the space, how you facilitate student making in the space, and what you perceive to be your students’ experiences in the space. Please provide as much detail as possible when answering the questions.

Librarian Interview Questions

Questions Aligned to Guidelines for Environment and Activities
1. Tell me about the physical set up of your makerspace. POSSIBLE FOLLOW-UP QUESTIONS ABOUT: Furniture, Décor, Activities, Electricity, etc.

Question Aligned to Innovation Configuration Map
2. What are your goals for students through participation in your library makerspace?

Questions Aligned to EMPM

Dream It! Inspiration
3. What are some things students have done or made in your makerspace?

4. Where did the ideas for those things come from?

5. What limitations are there, if any, on student making projects?

Visualize It! Ideation
6. Once students know what they want to make, how do they go about making it?

Create It! Making
7. What challenges have you seen students encounter in the makerspace?

8. How have you helped them overcome those challenges?

Improve It! Iteration
9. In what ways, if any, do you encourage students to make multiple attempts at a project or to improve upon a project?

Present It! Sharing
10. What opportunities do students have to share their projects with others?
Optional & Flexible Collaboration
11. In what ways, if any, have you seen students work together or help each other in the makerspace?

Continuous Feedback
12. In what ways do students get and give feedback in the makerspace?

Documenting Progress
13. For projects that take more than one makerspace visit to complete, how do students remember where they left off and where to start on the next visit?

Reflection & Formative Self-Assessment
14. What are some things you believe students have learned through use of the makerspace?

15. How do students know or realize what they have learned?

Questions Regarding Areas of Needed Improvement for Makerspace
16. As a member of the makerspace design committee, you are aware of the guidelines we developed for makerspaces including the Innovation Configuration Map, the guidelines for environment, activities, and facilitation, and the additional guidelines based on the EMPM. Have you found any of these guidelines difficult or impossible to implement? IF YES: Which ones?

17. One by one, talk to me about why it has been difficult or impossible to implement and any suggestions you have to make it easier or better.

18. Do you feel your makerspace has been a success? Why or why not?

19. What changes or improvements do you think need to be made?

Question Allowing Open-Ended Response from Librarian Regarding Makerspace
20. What else would you like me to know about your students’ participation in your makerspace?

Conclusion to Interview
Thank you for sharing your thoughts and feelings about your makerspace design, your goals for students using your makerspace, how you facilitate student making, and your perceptions of student experiences in the makerspace. Your answers will be very helpful.
APPENDIX D
TEACHER INTERVIEW PROTOCOL

Teacher Name: __________________________________ Date: ____________________

Introduction to Interview
Thank you for taking the time to talk to me today. I want to ask you some questions about the school library makerspace. My goal is to learn about your goals for students using the space and your perception of your students’ experiences in the makerspace. Please provide as much detail as possible when answering the questions.

Teacher Interview Questions

Questions Aligned to Innovation Configuration Map
  1. What are your goals for your students using the library makerspace?

  2. Have you seen any of those goals met? IF YES: Give me some examples of how you have seen those goals met.

Questions Aligned to EMPM

Dream It! Inspiration
  3. What are some things your students have made in your makerspace?

  4. Where did the ideas for those things come from?

  5. What limitations are there, if any, on student making projects?

Visualize It! Ideation
  6. Once your students know what they want to make, how do they go about making it?

Create It! Making
  7. What challenges have you seen students encounter in the makerspace?

  8. How have they overcome those challenges?

Improve It! Iteration
  9. In what ways, if any, have you seen students make multiple attempts at a project or make improvements to a project?

Present It! Sharing
  10. What opportunities do students have to share their projects with others outside of the makerspace?
Optional & Flexible Collaboration
11. In what ways, if any, have you seen students work together or help each other in the makerspace?

Continuous Feedback
12. In what ways do your students get and give feedback in the makerspace?

Documenting Progress
13. For projects that take more than one makerspace visit to complete, how do your students remember where they left off and where to start on the next visit?

Reflection & Formative Self-Assessment
14. What are some things you believe your students have learned using the makerspace?

Questions Regarding Areas of Success & Areas of Needed Improvement for Makerspace
15. Do you feel it has beneficial to your students in other ways to participate in the makerspace? IF YES: Tell me about some of the benefits you have seen.

16. Do you feel the makerspace has been a success? Why or why not?

17. What changes or improvements do you think need to be made?

Question Allowing Open-Ended Response from Teacher Regarding Makerspace
18. What else do you think I should know about your students’ use of the makerspace?

Conclusion to Interview
Thank you for sharing your thoughts and feelings about your goals for your students in using the makerspace and your perceptions of student experiences in the makerspace. Your answers will be very helpful.
APPENDIX E
PARENT/GUARDIAN LETTER

March 7, 2017

Dear Parent of Guardian,

My name is Susan Anderson, and I am the District Library Coordinator for _______. I am also a doctoral candidate at the University of Florida in the field of Educational Technology working under the supervision of Dr. Kara Dawson. For some time, I have been working with a group of school library media specialists in the district to design and implement school library makerspaces. For my dissertation, I am writing a design case dissertation which will describe the processes used and the decisions made by this team in the design of school library makerspaces. Additionally, my dissertation will describe a school library makerspace and student participation in the makerspace. I would like your permission to include your student in this study.

I will observe students participating in the school library makerspace three times during the months of March through May during their regularly scheduled visit to the makerspace. I will take notes of what is observed, and I will interact with students as they are participating in the makerspace to gather additional information from them about what is being observed. Pictures of students participating in the makerspace and of student projects will also be taken that may be included in the final dissertation. Pictures will not show students’ faces, and no names of students will be included.

With your permission, I will interact with your student while he or she is participating in the makerspace to gather additional information about what I observe and I may interview your student about his or her participation in the school library makerspace. Approximately 6-10 students, both male and female, will be selected for interviews who are participating in a variety of making activities, at a variety of phases in the making process, and at a variety of levels of engagement during their time in the makerspace visit so that many perspectives are represented. The interview will be conducted in the school library during the school day, and it will be audio recorded and transcribed. I will use the audio recordings and transcripts solely for writing my dissertation. Upon completion of the dissertation, the audio recordings will be destroyed.

You and your child have the right to withdraw consent for your child’s participation at any time without consequence. There are no known risks or immediate benefits to the participants. No compensation is offered for participation, though any student who returns a signed form will receive a free pencil. Once I have your consent, I will ask your student for his or her assent to participate. Please return the signed consent form to your child’s teacher by Friday, March 7, 2017.

Thank you,

Susan R. Anderson, Ed.S.
District Library Coordinator

Please check the appropriate space below, then sign and return this form to your child’s classroom teacher by Friday, March 7, 2017. All students who return a signed form will receive a free pencil.

I have read the procedure described above. I voluntarily give my consent for my child ________ to participate in Susan R. Anderson’s research project “School Library Makerspace Design and Implementation in a Large, Midwestern School District: A Design Case Dissertation.” I have received a copy of this description. I understand that I may withdraw my child from the study at any time without consequence.

I do not wish for my child ________ to participate in Susan R. Anderson’s research project “School Library Makerspace Design and Implementation in a Large, Midwestern School District: A Design Case Dissertation.”

________________________  ________________
Parent/Guardian Signature  Date

________________________  ________________
Parent/Guardian Signature  Date
Dear Student,

My name is Mrs. Anderson, and I am a student at the University of Florida. I am trying to learn more about what it is like for you to participate in your school library makerspace, so I am conducting some research to find out.

I will be observing your class three times while you participate in the makerspace, and I will be writing down some of the things I see and hear. I will be asking some of you about what you are doing in the makerspace, and I will be interviewing several of you to find out more about what you think and how you feel about participating in the school library makerspace.

There are no risks to you if you agree to participate in this study, though you may feel a bit nervous about being observed or being interviewed. I assure you that if you are interviewed, there are no right or wrong answers to my questions. I just want to know how you think and feel about using the makerspace. If there is a question you don’t like, you don’t have to answer it. Also, anything I observe you do in the makerspace and anything you tell me in an interview will be kept confidential. That means I won’t tell anyone else in the school about it, and when I write about it in my report, I will use a fake name instead of your real name.

Whether or not you agree to participate in the study, you will still get to use the makerspace. I just will not include the things you say or do in my study, and I will not interview you. Your parents have already said that you may participate in this research study. Would you be willing to participate in the study?

____ Yes
____ No

________________________________________
Print Your Name

________________________________________
Your Signature

Date
APPENDIX G
DESIGN TEAM INFORMED CONSENT FORM

Makerspace Design Team Informed Consent Form

Title: School Library Makerspace Design and Implementation in a Large, Midwestern School District: A Design Case Dissertation

Introduction
As you know, I am a current doctoral candidate at the University of Florida pursuing a doctorate in the field of Educational Technology working under the supervision of Dr. Kara Dawson. I am also the District Library Coordinator for [Redacted]. Also as you know, I have been working with a group of school library media specialists in the district to design and implement school library makerspaces in several of our library facilities. For the dissertation portion of my doctoral program, I am writing a design case dissertation which will describe the processes used and the decisions made by this team in the design of school library makerspaces. Additionally, my dissertation will describe a school library makerspace environment as well as the student experience of participation in the makerspace.

Purpose
The main purpose of my research is to preserve a record of the processes used and the decisions made during the design process of school library makerspaces in the district so that ourselves and others might benefit from the knowledge gained through the process. Another purpose of my research is to identify both areas of success in the design and implementation of school library makerspaces in the district as well as areas of possible improvement in order to ensure the best student experience in these learning environments.

Description of Study
As part of my research, I will gather data from a variety of sources including the review of documents pertaining to the work of the design team, biographical information from members of the design team, observations of a school library makerspace and observations of students while they are participating in the makerspace. I will also conduct interviews with the librarian who oversees the makerspace, the classroom teacher whose students are participating in the makerspace, and a few students to ask about their experience participating in the makerspace.

What You Will Be Asked to Do
As a member of the makerspace design team, you will be asked to provide biographical information about yourself to assist with the description of the design process of school library makerspaces. To maintain your confidentiality, a pseudonym will be used in place of your name and in place of the name of your school when reporting this information as part of this dissertation. You will also be asked to review rough drafts of descriptions of various processes and events that took place as part of the overall design process to help ensure their accuracy.
I will also observe one school library makerspace three times as part of this study. If your makerspace is selected to be observed, you will be asked to help distribute and collect parent and student informed consent forms. Additionally, if your makerspace is selected to be observed, you will be asked to participate in a single interview lasting no longer than one hour. The purpose of this interview is to learn more about students' experience of participation in the school library makerspace and to learn more about the design of your makerspace. This interview will be conducted in the school library after school, and it will be audio recorded and transcribed. The audio recordings and transcripts will be available only to myself and my dissertation committee to be use solely for educational purposes. Upon completion of the dissertation, the audio recordings will be destroyed.

Voluntary Participation
You may choose not to participate in this study without repercussions. Even if you do agree to participate, you may withdraw from the study at any time without repercussions.

Risks, Benefits, and Compensation
There are no risks nor direct benefits to you from participation in this study. There is no compensation for participation in this study.

Sharing of Study Results and Confidentiality
All data gathered from this study will be maintained in a secure location. The study results will be shared as part of a doctoral dissertation. The identity of all participants will be kept confidential and pseudonyms will be used to identify individual participants when reporting results.

Additional Information Regarding Study or Rights as a Participant
If you have any questions about this study you may contact me, Susan Anderson, at [samanthaa@coe.ufl.edu](mailto:samanthaa@coe.ufl.edu) or my faculty supervisor, Dr. Kara Dawson, at [dawson@coe.ufl.edu](mailto:dawson@coe.ufl.edu). If you have questions or concerns about your rights as a participant in this research study you may contact the IRB02 Office, University of Florida Institutional Review Board, P. O. Box 112250, Gainesville, FL 32611-2250, (352) 392-0433.

I have read the procedure described above. I voluntarily give my consent to participate in Susan R. Anderson’s research project “School Library Makerspace Design and Implementation in a Large, Midwestern School District: A Design Case Dissertation.” I have received a copy of the study purpose and description. I understand that I may withdraw from the study at any time without consequence.

______________________________
Librarian Printed Name

______________________________
Librarian Signature

______________________________
Date
Title: School Library Makerspace Design and Implementation in a Large, Midwestern School District: A Design Case Dissertation

Introduction
My name is Susan Anderson, and I am a current doctoral candidate at the University of Florida pursuing a doctorate in the field of Educational Technology working under the supervision of Dr. Kara Dawson. I am also the District Library Coordinator for [REDACTED]. For some time, I have been working with a group of school library media specialists in the district to design and implement school library makerspaces in several of our library facilities. For the dissertation portion of my doctoral program, I am writing a design case dissertation which will describe the processes used and the decisions made by this team in the design of school library makerspaces. Additionally, my dissertation will describe a school library makerspace environment as well as the student experience of participation in the makerspace.

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Description of Study
As part of my research, I will gather data from a variety of sources including the review of documents pertaining to the work of the design team, biographical information from members of the design team, observations of a school library makerspace and observations of students while they are participating in the makerspace. I will also conduct interviews with the librarian who oversees the makerspace, the classroom teacher whose students are participating in the makerspace, and a few students to ask about their experience participating in the makerspace.

What You Will Be Asked to Do
I will be observing your students as they participate in the school library makerspace three times as part of this study. As part of my observations, I will also be noting your behaviors, actions, and comments while interacting with students in the makerspace. Too, you will be asked to participate in a single interview lasting no longer than one hour. The purpose of this interview is to learn more about students’ experience of participation in the school library makerspace from your perspective and to learn more about the design of the makerspace. This interview will be conducted in the school library after school, and it will be audio recorded and transcribed. The audio recordings
and transcripts will be available only to myself and my dissertation committee to be used solely for educational purposes. Upon completion of the dissertation, the audio recordings will be destroyed.

**Voluntary Participation**
You may choose not to participate in this study without repercussions. Even if you do agree to participate, you may withdraw from the study at any time without repercussions.

**Risks, Benefits, and Compensation**
There are no risks nor direct benefits to you from participation in this study. There is no compensation for participation in this study.

**Sharing of Study Results and Confidentiality**
All data gathered from this study will be maintained in a secure location. The study results will be shared as part of a doctoral dissertation. The identity of all participants will be kept confidential and pseudonyms will be used to identify individual participants when reporting results.

**Additional Information Regarding Study or Rights as a Participant**
If you have any questions about this study you may contact me, Susan Anderson, at [insert contact information] or my faculty supervisor, Dr. Kara Dawson, at [insert contact information]. If you have questions or concerns about your rights as a participant in this research study you may contact the IRB02 Office, University of Florida Institutional Review Board, P. O. Box 112250, Gainesville, FL 32611-2250, (352) 392-0433.

I have read the procedure described above. I voluntarily give my consent to participate in Susan R. Anderson’s research project “School Library Makerspace Design and Implementation in a Large, Midwestern School District: A Design Case Dissertation.” I have received a copy of the study purpose and description. I understand that I may withdraw from the study at any time without consequence.

_____________________________________
Teacher’s Printed Name

_____________________________________
Teacher’s Signature Date
LIST OF REFERENCES


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BIOGRAPHICAL SKETCH

Susan R. Anderson received her undergraduate degree in secondary English Education from Missouri Western State University in 1997 and began working as a school librarian for the Osborn R-0 School District in Osborn, Missouri the same year. She has earned a Master of Arts in library science, an Education Specialist in educational technology, and an Education Specialist in educational administration from the University of Missouri. She most recently received a Doctor of Education from the University of Florida in curriculum and instruction with a concentration in educational technology in 2017. Susan serves as the library coordinator for a large suburban school district in northwest Missouri and an adjunct faculty librarian at a local community college. Her research interests include school library makerspaces, digital versus print recreational reading of K-12 students, and teaching methods for information and technology literacy curriculum.