2020

Three cases of makerspace integration in school library programs in conjunction with district initiatives: Literacy, design thinking, and STEAM

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Three cases of makerspace integration in school library programs in conjunction with district initiatives: Literacy, design thinking, and STEAM

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Abstract
Note: This study refers to three co-researchers who each collected data in their respective schools and collaborated in reviewing that data, but each separately authored a paper using that data; the co-researchers are Kris Baldwin and Lisa Tegels.

The purpose of this qualitative case study was to use a makerspace to explore whether a makerspace is being fully implemented to enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. It represents the analysis of one case in a three part study. The participants in this study included 40 students from three different school districts where the three co-researchers are teacher librarians. The three co-researchers analyzed student and teacher data from the three case study sites. Data sources included: (1) the teacher librarians’ reflections on their instructional activities, (2) student work samples and the accompanying teacher librarians’ assessment of each individual student’s work sample, and (3) classroom teachers’ reflections about their students’ involvement in the makerspace activities. Three commonalities emerged from the teacher librarians’ reflections on their instructional activities: support for district goals and initiatives was an intention in the design of the makerspaces in all three schools, the importance of collaboration was affirmed through this research, and the value of student reflection in learning. Each of the student work samples was evaluated in four different areas: design process, critical thinking, constraints and criteria, and literacy. The student work sample data showed that most students who participated in the makerspace projects met the standards addressed in the study. Three themes emerged from the collaborating teachers’ questionnaires including: student engagement, personal curiosity, and reading widely and deeply. This information suggests that a makerspace provides an engaging approach to educating students that meets standards and has applications across disciplines, allowing students to take ownership of their own learning.

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THREE CASES OF MAKERSPACE INTEGRATION IN SCHOOL LIBRARY PROGRAMS IN CONJUNCTION WITH DISTRICT INITIATIVES: LITERACY, DESIGN THINKING, AND STEAM

A Graduate Research Paper
Submitted to the
Division of School Library Studies
Department of Curriculum and Instruction
In Partial Fulfillment
Of the Requirements for the Degree
Master of Arts
UNIVERSITY OF NORTHERN IOWA

by
Sara Pflughaupt
August 2020
This Research Paper by: Sara Pflughaupt

Titled: Three Cases of Makerspace Integration in School Library Programs in Conjunction with District Initiatives: Literacy, Design Thinking, and STEAM

has been approved as meeting the research requirement for the Degree of Master of Arts.

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CHAPTER 1

INTRODUCTION

When most people think of libraries, they immediately think of books, but traditional library spaces are being altered. Recently in libraries everywhere, in addition to books, one may also spot enthusiastic groups of students working with power tools, craft supplies, and other forms of technology. This development is called a makerspace. A large number of libraries are making room for makerspaces to serve their patrons who are passionate about thinking, designing, and creating to solve problems both big and small.

Justification of Problem

Rendina (2015) states, “one of the main missions of the library has always been to make resources and materials accessible to all” (para. 2). Traditionally, these resources were print materials like books, magazines, newspapers, and reference materials. This expanded to include access to digital tools and resources such as computers, ebooks, and databases. This is shifting once again as libraries grow, expand, and transform based on the latest research and trends to include tools and areas for creation. Libraries have become less about providing informational resources for users to consume and more about providing the opportunity for users to combine knowledge and creativity in order to create something new. Rendina (2015) expresses that as makerspaces continue to grow more popular, libraries “must evolve or risk becoming irrelevant” (para. 5). It is vital that teachers understand the characteristics of a makerspace, the importance of makerspaces, and the connections makerspaces have to student learning.
Makerspace Characteristics

The word makerspace is a generic term. One makerspace can look very different from another. The YALSA Makerspace Resources Task Force (2014) has expressed that “makerspaces come in all shapes and sizes. Some are fixed rooms or structures, and some are temporary” (p. 2). Some spaces have storage areas, others use mobile carts and cabinets to transport equipment and materials. The tools and materials are of assorted types depending on the space’s purpose and planned learning outcomes. The founders of the space determine its resources based on its purpose, what the students are interested in designing, and, of course, budget. The YALSA Makerspace Resources Task Force (2014) states:

Whether a makerspace contains thousands of dollars worth of equipment, or is simply a cart full of tools, the goal of a makerspace is to facilitate making. The reality for most libraries is that they don’t have a dedicated space in which to make stuff, but they do have the capability to encourage making (p. 2).

Importance of Makerspaces

Makerspaces pair nicely with libraries as this is where information is stored, accessed, shared, and explored. Libraries are places where people gather; they have staff who are knowledgeable in finding and sharing information and can guide patrons through the inquiry process. A makerspace is highly individualized, yet lives within certain boundaries. It recognizes that no two students learn the same concepts at the same rate. Kurti, Kurti, and Fleming (2014) believe that “maker education fosters curiosity and tinkering, which in turn leads to better thinking through better questioning. This learning environment fosters enthusiasm for learning, student confidence, and natural collaboration” (p. 11). A makerspace provides the opportunity to take learning full circle
and encourages students to take ownership of their learning, which can also have the benefit of increasing student engagement.

**Connections to Student Learning**

Makerspaces help to create spaces for students to invent, collaborate, question, fix, reinvent, create, explore, and wonder. The American Association of School Librarians (AASL, 2018) *AASL Standards Framework for Learners*, has outlined six domains and competencies. These include inquire: build new knowledge by inquiring, thinking critically, identifying problems, and developing strategies for solving problems; include: demonstrate an understanding of and commitment to inclusiveness and respect for diversity in the learning community; collaborate: work effectively with others to broaden perspectives and work toward common goals; curate: make meaning for oneself and others by collecting, organizing, and sharing resources of personal relevance; explore: discover and innovate in a growth mindset developed through experience and reflection, and engage: demonstrate safe, legal, and ethical creating and sharing of knowledge products independently while engaging in a community of practice and an interconnected world. Montgomery and Madden (2019) state that “Novel Engineering is a strategy that requires students to identify a problem that arises in literature and engineer a solution to a conflict in the story” (para. 3). This approach requires close and careful reading and allows students to engage deeply with the text. While makerspaces do much more for students than tie into standards, it is important to note that making does tie in with curriculum. Spencer and Juliani (2016) states that making isn’t meant to be something that is squeezed in before or after a traditional unit. It’s not a culminating
It is a different way of organizing the curriculum. You do not need to take time out of the standards to create a separate space for these projects, they should work as an integrated part of the curriculum that is already being taught.

**Rationale**

As libraries continue to grow, expand, and transform based on the latest research and trends, many include makerspaces. As makerspaces grow in popularity, teachers need to understand what a makerspace is, the importance of makerspaces, and the connections makerspaces have to the curriculum. This will inspire teachers to include the makerspace as an integral part of the learning experience in order to promote student learning.

**Uncertainty and Deficiencies**

A study by Montgomery and Madden (2019) depicted the connections between literacy and engineering design through novel engineering in a fifth grade classroom. In order to further understand the connection between literacy and engineering design, this study follows one of Montgomery and Madden’s suggestions for future research. The current study focuses on the use of a makerspace to explore the connections between literacy and engineering design in a fourth grade classroom.

**Summary of Problem**

Teachers may want to utilize their school’s makerspace, but may not know how the makerspace enhances student learning of Common Core Literacy Standards and other standards.
Purpose

The purpose of this qualitative case study is to use a makerspace to explore whether a makerspace is being fully implemented to enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards.

Research Question

1. To what extent are the activities taking place in a makerspace enhancing student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards?

Assumptions and Limitations

An assumption of this research paper is that some teachers are interested in learning about how Common Core Literacy Standards, Next Generation Science Standards, AASL Learner Standards, and makerspaces are connected in regards to learning. Another assumption of this research paper is that some teachers may hesitate to incorporate a makerspace without seeing a direct connection to their curriculum.
CHAPTER 2

LITERATURE REVIEW

The purpose of this study is to explore whether the makerspace is being used to enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. The three areas of prior research that inform this study are characteristics of makerspaces, the importance of makerspaces, and the connections makerspaces have to student learning.

Makerspace Characteristics

Makerspaces are exciting services being offered in many libraries, museums, and schools. Sheridan et al. (2014) sought to understand how different makerspaces function as learning environments by studying who participates in makerspaces, how and to what ends tools, materials, and processes are used in each makerspace, and to uncover needs related to the arrangements for learning, teaching, and collaborating in each space. To explore these questions, three different, purposefully selected makerspaces were discussed: Sector67, a member-based makerspace located in Madison, Wisconsin, and serving mostly adults; Mt. Elliott Makerspace, a community makerspace located in Detroit and serving primarily youth; and Makeshop, a museum makerspace located inside the Children’s Museum of Pittsburgh and serving largely young children and families visiting the museum, whose making is facilitated by adult makers. This comparative case study is based on over 150 hours of field observations and interviews as well as extensive analyses of artifacts, videos, and other documents to describe the features of these three makerspaces and how participants learn and develop through
complex design and making practices. In the end, a unified set of themes were identified that may be important findings for designers and researchers of makerspaces. Being a maker in these spaces involved participating in a space with diverse tools, materials, and processes; finding problems and projects to work on; experimenting with designs; becoming a member of a community; taking on leadership and teaching roles as needed; and sharing creations and skills with a wider world.

While Sheridan et al. (2014) researched makerspaces outside of education, Moorefield-Lang (2015) analyzed how makerspaces were integrated in library settings. For this study, twelve librarians were interviewed one-on-one. Interview respondents were librarians with makerspace locations in their libraries. Four were in school library settings, four in public library settings, and four in academic or university library settings. All of the interviews took place via Skype or Google Hangout. The focus of the interview was on the makerspace: implementation, decisions, successes, challenges, training, projects, and outcomes. The interviews were digitally audio-taped and then transcribed. Data was analyzed using qualitative data analysis software. Some common themes that were explored throughout the twelve interviews were patron and librarian training, decisions for implementation, successes, challenges, projects, and funding. The participants in the study shared many interesting perspectives on the topic of makerspaces and libraries, and each librarian’s makerspace had its own story. While makerspaces bring together innovators, thinkers, and creators, these spaces also require room, planning, resources, staff, and finances.
Adding to the findings of Sheridan et al. (2014) and Moorefield-Lang (2015), Koh and Abbas (2015) conducted research to investigate the competencies required for the successful performance of information professionals who work in library or museum learning labs and makerspaces. The researchers conducted interviews with professionals working in learning labs or makerspaces in the United States. Interviewees included five museum professionals, three librarians working in public libraries, and one professional working in a science center. Four worked in makerspaces and three in learning labs. The study included five females and four males. The professionals were interviewed via web conference using either Skype, Google Hangout (with audio and video), or by telephone, depending on their preference. All interviews were recorded and transcribed. Both researchers analyzed all transcripts and compared the results by conducting qualitative content analysis. The data provided timely insights on skills, knowledge, and attitudes required for information professionals. Professionals in these learning spaces viewed themselves as educators, which was not a dominant perspective of librarians or museum professionals in the past. Professionals in these learning spaces must be learners themselves who are flexible and able to adapt to the changing environment and technologies. They must facilitate learning for diverse users and be knowledgeable about theories of teaching and learning as well as user needs and behaviors. Professionals incorporate a range of low and high technologies into learning lab and maker programs. They work with people from different entities, partnering to provide programs, securing and implementing funds, and advocating for their labs.
The three previous studies provided characteristics of makerspaces both outside of the library setting (Sheridan et al. 2014; Koh & Abbas, 2015), and within the library (Moorefield-Lang, 2015). These researchers showed the value of makerspaces as learning environments that allow users to participate in different aspects of the learning process from observing, questioning, exploring, experimenting, collaborating, and reflecting.

**Importance of Makerspaces**

Makerspaces have the potential to make a significant impact on student learning and development. Li and Todd (2019) sought to understand the opportunities and desired outcomes of makerspaces in libraries from young people’s perspectives. A public library makerspace and a public middle school library makerspace located in New Jersey were selected for their study. A total of 21 young people in grades 6-10 were recruited from the users of these two library makerspaces and data was collected using field observations, individual interviews, photovoice, and focus groups. This data was analyzed with an initial round of coding using qualitative data analysis software. Findings showed that young people were driven to participate in makerspace activities for the opportunities to make, learn, hang out, and engage in personal interests. Through makerspace participation, desired outcomes included producing tangible objects, developing STEM (science, technology, engineering, and mathematics) knowledge, gaining real-life skills, preparing for careers, having fun, working in teams, developing friendships, and generating new interests. In conclusion, makerspaces play a comprehensive role in integrating formal and informal learning that may be beneficial for young people’s intellectual development.
Similar to Li and Todd (2019), Hussain and Nisha (2017) aimed to highlight the concept of makerspaces and their perceived benefit. Online survey techniques and random sampling were used for data collection. Overall, a total of 470 questionnaires were completed and the data collected was analyzed using simple statistical techniques. The findings indicated that 68.09% of respondents use makerspaces for academic and research purposes, and 25.53% respondents stated that library makerspaces were helpful for them in acquiring knowledge. It was reported that the majority (70%) of respondents indicated that the makerspace was valuable or highly valuable to users.

While Li and Todd (2019) and Hussain and Nisha (2017) researched makerspaces specifically, Bieraugel and Neill (2017) examined what types of spaces fostered creativity and innovation at one institution. Several spaces were chosen, five within the library and three outside the library. To assess how each space was used, questionnaire data was collected from students using one of eight selected locations. In total, 226 students responded with at least 25 responses collected per space. Based on the survey data, a number of statistical techniques were used to measure student perceptions of the types of learning and behavior associated with each of the selected spaces. The results indicated that the spaces differed significantly in their ability to support learning and behaviors. The on-campus makerspace located outside the library encouraged nearly all types of innovative behaviors and exploration. It is important that libraries use their spaces to foster the highest level of creativity and innovation, and makerspaces do just that.

Overall, the three studies above provide several examples of the benefits of makerspaces and the value they can have on student learning (Li & Todd, 2019; Hussain
& Nisha, 2017), specifically when it comes to innovation and creativity (Bieraugel & Neill 2017). These studies show the importance of makerspaces as platforms that foster making, learning, hanging out, and engaging in personal interests.

**Connections to Student Learning**

Students have the opportunity to learn a tremendous amount through maker-centered learning experiences. McCormick and Hynes (2012) explored how a literary context fosters student engagement in engineering practices. To do this, McCormick and Hynes examined the conversation and activities of two fourth grade boys, Harvey and Matthew, as they identified specific problems of characters, made assumptions, considered the constraints of the story setting, and creatively designed, tested, and built prototypes to solve the character’s problems. Throughout this experience, video data was collected to examine the types of discussions and actions over the course of the unit. The analysis of this case study involved transcribing video data and analyzing the students' interactions with each other, their teacher, and their artifacts in a research group setting. In the end, Harvey and Matthew demonstrated critical thinking skills, balanced numerous creative possibilities and design solutions with considerations of functionality for the characters in the story, feasibility for them to build and for characters to use, material strength, costs, and availability (for them and for the characters), ultimately optimizing their solution in the given amount of time. These findings confirm that complex problems created within a rich literary context can foster the emergence of engineering thinking and maker-centered learning.
Building on McCormick and Hynes (2012), Small (2014) described a study conducted by a research team at Syracuse University’s Center for Digital Literacy in collaboration with the Connecticut Invention Convention. They investigated the attitudes toward innovation activities, motivational supports, and information needs of young innovators in grades 4-8 as they progressed through the innovation process. The following research questions formed the basis of the study: In what ways are participation in innovative activities and students’ intrinsic motivation for innovating related? What are students’ information needs (resources, skills, technologies) during the innovation process? What roles do teachers and librarians play in supporting and facilitating student innovation? Is there a relationship between participation in innovation activities and interest in STEM learning? This mixed-methods study included an online survey and audio-recorded telephone interviews. A total of eighty-four children in grades 4–8 throughout the state of Connecticut completed the survey. Survey participants were purposefully selected for telephone interviews. Selection was based on gender, grade level, and location. A total of nineteen children were interviewed and survey data was analyzed using descriptive statistics. The findings showed that for these creative students, the benefits of participating in innovation activities went far beyond established learning standards, outcomes, and products. Participation in innovation activities sparked their curiosity, stretched their imaginations, and motivated their passion for solving authentic problems that help real people, teach them to be persistent and open-minded, and encourage both emergent and divergent thinking.
In addition to the research completed by McCormick and Hynes (2012) and Small (2014), Ortega (2017) examined early makerspace implementation at three sites in the Happy Hills School District. The following research questions guided the study: What are makerspaces and how are they being used in schools? What conditions are conducive to teacher use of makerspaces to provide instruction? What are the barriers that impede the use of makerspaces? The findings of this study were based on three sources of data: a survey of teachers in the district, in-depth interviews of seven district principals of schools with makerspaces; and nine observations of makerspace lessons in the district. Of the 70 survey respondents, 93% agreed that makerspaces had enhanced student learning. The interview data was coded into several categories including challenges and successes, conditions present on the campus, and specific leadership actions conducive to makerspace use. An observation protocol documented the setting, participant actions, tools, explicit and implicit learning objectives, and NGSS engineering practice within the lessons. This study showed that makerspace practices in the district are not guided by one specific model and that different models of use have emerged. Additionally, the study revealed a teacher training gap in using makerspaces resulting in missed opportunities for grade level connected learning. However, the study also found that teachers’ use of makerspaces provides hands-on experiences for students, which provide early engineering exposure. Common Core State Standards and Next Generation Science Standards require a more hands-on, applied approach to teaching and learning, and makerspaces offer the ideal environment to provide this type of instruction.
These three studies provided several examples of the connections makerspaces have to student learning in a wide variety of subjects. McCormick and Hynes (2012) explored how a literary context fosters student engagement in engineering practices. Small (2014) investigated the attitudes toward innovation activities, motivational supports, and information needs of students as they progressed through the innovation process. Ortega (2017) studied the ways in which the use of makerspaces provides hands-on experiences for students.

Summary

Several studies above investigated the characteristics of makerspaces both in and out of the library setting in order to provide a better understanding of how different makerspaces function as learning environments (Sheridan et al., 2014; Moorefield-Lang, 2015; Koh & Abbas, 2015). Other studies examined the importance of makerspaces and the benefits they can have on student learning (Li & Todd, 2019; Hussain & Nisha, 2017; Bieraugel & Neill 2017). The most relevant benefits for K-12 students included making, learning, hanging out, and engaging in personal interests. Finally, some studies provided examples of the connections makerspaces have to student learning in a wide variety of subjects (McCormick & Hynes, 2012; Small, 2014; Ortega, 2017), specifically noting how a literary context fosters student engagement in engineering practices. To extend the work of the previous studies, this study explores whether a makerspace is being fully implemented to enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards.
CHAPTER 3

METHODOLOGY

The purpose of this qualitative case study is to use a makerspace to explore whether a makerspace is being fully implemented to enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards.

Research Design

A qualitative case study was used to conduct this research because “the phenomenon is examined in a natural setting and data is collected by multiple means” (Wildemuth, 2017, p. 51). Wildemuth provides additional characteristics of a case study that are applicable to the current research: case studies “focus on contemporary events”, and “include a variety of factors and relationships that can be directly observed” (p. 52). Overall, Wildemuth (2017) claims “the case study method is ideal when a ‘how’ or ‘why’ question is being asked about a contemporary set of events over which the researcher has no control” (p. 52).

Participants

The participants in this study included 40 students from three different school districts where the three co-researchers are teacher librarians. The students were selected for inclusion in this study based on their completion of a makerspace project. Each school district’s makerspace activity had a different focus depending on the district’s goals and initiatives. Twelve fourth grade students from one school district completed a literacy activity, 14 students (five fourth graders and nine fifth graders) from another school
district completed an interactive art activity, and 14 students (11 fourth graders and three fifth graders) from a third school district completed a Science, Technology, Engineering, Art, and Math (STEAM) activity. Three classroom teachers were also involved, one from each school district, as they provided reflection about their students’ involvement in the makerspace activities.

**Procedures**

**Data Collection**

This study used three data sources: (1) the teacher librarians’ reflections on their instructional activities, (2) student work samples and the accompanying teacher librarians’ assessment of each individual student’s work sample, and (3) the classroom teachers’ reflections about their students’ involvement in the makerspace activities. Data for this research study was collected by each researcher in their own school district at various points throughout the 2019-2020 school year.

The first data source included the teacher librarians’ reflections on their instructional activities. This helped the co-researchers better understand the structure of each activity as each school district’s makerspace activity had a different focus depending on the district’s goals and initiatives. The second data source, the student work samples, included photographs with observation notes (see Appendix A) from each researcher who was also a participant observer, and a video that was created by the Grant Wood Area Education Agency (buff.ly/2SJp94W). Accompanying the student work samples was the teacher librarians’ assessment of student work samples using a rubric (see Appendix B) which was adapted from Montgomery and Madden (2019) and aligned with Common
Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. The third data source included reflections from three collaborating classroom teachers, one in each school district, about their students’ involvement in the makerspace activities in response to an emailed questionnaire (see Appendix C). Wildemuth (2017) states that “survey research supports the collection of a variety of data, including the beliefs, opinions, attributes, and behaviors of the respondents” (p. 272).

**Data Analysis**

This study was completed using a qualitative content analysis. According to Wildemuth (2017), there are eight steps to qualitative content analysis. The first step is the preparation of data, and the second step is defining what will be analyzed. These first two steps were described above under data collection. The third step is to develop initial categories for data analysis. I formed categories based on each of the sections on the student rubric being used in this study: design process, critical thinking, constraints and criteria, and literacy. The fourth step is to test the initial categories on a sample of data, so the other co-researchers and I completed the student rubric (Appendix B) for a small group of students’ work. I focused on the data from the literacy activity. After testing the student rubric on a small group of students’ work the co-researchers and I discussed the recorded evidence regarding the presence or absence of the standards in the rubric from the student work samples across the three data sets (literacy, art, and STEAM).

The fifth step is to code all of the data, therefore, I analyzed the data for each student using the student rubric first and then compiling all sources of data from the co-researchers on a spreadsheet. The sixth step is to assess the coding for consistency: the
three of us co-researchers independently reviewed the completed coding across all students and made adjustments for inconsistent evidence. The seventh step is to draw conclusions from the coded data. To do this, I looked for themes of commonality or difference among students and for themes of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards most often met or unmet. Then I looked for clues in the evidence/notes that might help to explain how standards are being met and where improvements could be made. Upon completion of the project, the researcher used the coded data to determine the extent to which the activities taking place in a makerspace are enhancing student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. Finally, step eight is to report the method and its findings, which follows in Chapter 4.

**Limitations**

One limitation of this study is its reliance on the use of existing student project data due to school closures in response to the Novel Coronavirus. Another limitation is the sampling of student projects for inclusion in the study as this was limited to those with projects available to researchers at the time of the school closures. In addition, each of the sites selected a limited number of student work samples (Literacy - 12, Art - 14, STEAM - 14) that came from a larger set of student work that was available. The literacy data provides a good representation of the range of student work that was completed, though the 12 samples used in this study represent a convenience sample as they were the projects already photographed and because the researcher could remember the most about these specific projects. The art data includes higher scoring work than would have been
collected if the full sample had been used. The data represents students who had not only completed their projects, but were also in attendance at a specific “learning celebration” and had their project photographed during that event. The STEAM data represents higher quality work than what the average student might produce as student work was selected based on whose was most complete at the time the unit ended due to the Coronavirus. Students were expected to have all of their weekly reflections finished by the end of the unit, which technically didn't end for another five weeks.
CHAPTER 4

FINDINGS

The purpose of this study was to determine if makerspaces are enhancing student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. Three co-researchers analyzed student and teacher data from three case study sites. Data sources included (1) researchers’ (who were the teacher librarians) reflections on their instructional activities, (2) assessments of several samples of student work that were photographed and a video that was created by the Grant Wood Area Education Agency that included students’ reflection on their work, and (3) reflections from three collaborating classroom teachers about their students’ involvement in the makerspace activities in response to an emailed questionnaire.

Reflections on Instructional Activities

Each of the researchers (who were the teacher librarians) for the study wrote a description of their district’s instructional makerspace activity and reflected on their experience. Three commonalities emerged from the researchers’ descriptions: support for district goals and initiatives was an intention in the design of the makerspaces in all three schools, importance of collaboration, and the value of student reflection in learning.

District Goals and Initiatives

The first commonality found in the researchers’ descriptions is that each of the makerspace activities was designed to support the district’s goals and initiatives rather than to specifically promote the makerspace and/or the library’s curriculum. For example, the literacy activity was created to support the implementation of the Lucy Calkins
Reading Unit of Study in the fourth grade classrooms. The art activity was developed to engage students in design thinking while promoting STEM-related content and satisfying a district equity goal. The STEAM activities emerged from a partnership with the Science Center of Iowa, which led to a district makerspace focus.

**Collaboration**

The second commonality found in the researchers’ descriptions is that each of the teacher librarians mentioned the importance of collaboration. For example, the teacher librarian for the literacy activity “collaborated with the fourth grade teachers...to create an activity that would engage students in making and connect to the learning happening within their classroom.” The teacher librarian for the art activity worked with the art teacher to “provide students with a project to work on during both art and media that met individual content standards but was also a fun way to get students interested in programming and artistic creations.” The teacher librarian for the STEAM activities partnered with the Science Center of Iowa for “professional development that focused on how to introduce and engage students in hands-on, makerspace type learning” and then “provided an opportunity for students to engage with highly interactive, hands-on learning.”

**Student Reflection**

The third commonality found in the researchers’ descriptions is the value of student reflection in learning. For example, the teacher librarian for the literacy activity stated that giving students time for self reflection “allowed students to make personal connections to the characters in the book and deepen their understanding of the themes,
life lessons, and detailed explanations within the text while celebrating all that they had learned throughout their first reading unit.” The teacher librarian for the art activity found that when students had to “create a notecard to list out what their artwork would be and then to brainstorm ideas for which sounds (i.e. computerized sound effects of various animals, objects, and etc.) to choose” it was much more obvious which students were “getting things done and who was spinning their wheels” and may have needed more assistance. The teacher librarian for the STEAM activities had “students fill out exit slips at the end of each class period telling me which station they were at, something they learned, and something they wanted to learn more about.” This provided the teacher librarian with feedback regarding “which centers were most engaging and ideas for future centers,” and it also helped the students “take their learning to a deeper level.”

**Assessment of Student Work Samples**

Each of the student work samples (12 from the Literacy site, 14 from the Art site, and 14 from the STEAM site) was evaluated in six different areas, according to the rubric (see Appendix B): design process, critical thinking, constraints and criteria, and literacy (in three parts). It should be noted that while the rubric was designed for use by teachers to assess student work in order to see whether students are meeting objectives, the rubric’s purpose in this study’s context is to show a broad view of whether or not the standards in the rubric are being met. To this end, the advantage to having this view across three schools helps to again broaden the view of whether these makerspace activities are helping students and schools meet said standards. And further, by concentrating on what is working well and where there may be gaps may further inform
teacher librarians as they continuously revise instruction using their makerspaces. The co-researchers adapted this rubric from Montgomery and Madden (2019) by eliminating some of the categories that did not apply to all three of the schools’ student projects. But even after eliminating some areas, the rubric of six areas used to score 40 students' work generated 240 data points. And while the researchers reviewed all data together, it should be noted that the intent of this qualitative case study is not to analyze all 240 student scores. Rather the intent is to focus on what works so that this understanding can be further scrutinized through analysis of student work, the teacher librarian reflections, and the teacher reflections. Table 1 shows a small subset of the scoring data generated through use of the rubric; it only shows the number of top scoring student work samples for each of the six rubric areas, by each of the three schools. Top score means all three researchers independently scored that student work as a 3 on a scale of 1-3. This allows the focus to be on how well the makerspace instruction is helping students meet standards. Those standards areas in the rubric that are met by few students may point to areas that need instructional development and reinforcement.
Table 1

*Number of Students That Received a Score of Three from All Co-Researchers*

<table>
<thead>
<tr>
<th>Standard</th>
<th>Literacy Site (N=12)</th>
<th>Art Site (N=14)</th>
<th>STEAM Site (N=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Process</td>
<td>5 (42%)</td>
<td>3 (21%)</td>
<td>5 (36%)</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>5 (42%)</td>
<td>4 (29%)</td>
<td>5 (36%)</td>
</tr>
<tr>
<td>Constraints &amp; Criteria</td>
<td>5 (42%)</td>
<td>3 (21%)</td>
<td>8 (57%)</td>
</tr>
<tr>
<td>Literacy 1</td>
<td>6 (50%)</td>
<td>5 (36%)</td>
<td>12 (86%)</td>
</tr>
<tr>
<td>Literacy 2</td>
<td>8 (67%)</td>
<td>6 (43%)</td>
<td>6 (43%)</td>
</tr>
<tr>
<td>Literacy 3</td>
<td>1 (8%)</td>
<td>1 (7%)</td>
<td>1 (7%)</td>
</tr>
</tbody>
</table>

While the purpose of this analysis was not to sort out all scores, the analysis below summarizes and highlights for each standard where students’ achievement and samples of their work fall within the instructional supports that were provided with these makerspace activities.

**Design Process**

The first area used to assess the student work samples was focused on the design process. The design process is a series of steps that students follow to come up with a solution to a problem or accomplish a certain task. This connects to the AASL Learner Standard for Explore, V.A.3 that states, “Engaging in inquiry-based processes for personal growth.”

Five of the 12 students who completed the literacy activity received the highest score possible from all three researchers, three of the 14 students who completed the art activity received the highest score possible from all three researchers, and five of the 14 students
who completed the STEAM activities received the highest score possible from all three researchers, meaning they met this standard.

One example of a student project with perfect scores in the design thinking section came from Literacy Student 3 (see Figure 1). This student started the project with a design in mind, and worked hard on each step until they felt that their project was complete. They used a cereal box, wrapping paper, popsicle sticks, scissors, and tape to create their final product. As directed, this student had a plan from the beginning to create a flap opening for their suitcase, similar to a traditional suitcase, so that they could put items inside. This was an element that several other students forgot.

Figure 1

*Literacy student 3 work sample*

Another example of a student project with the highest scores from all three researchers in the design thinking section came from Art Student 10 (see Figure 2). This student designed a piece of interactive art that represented four animals on a branch, and they found or made sounds to illustrate each of those animals. This student inserted either
paper clips or brass fasteners on the back of their artwork and connected the wires so that the four animals were separated from the branch just enough so that if someone puts a finger on the branch and then touches each of the four animals with their other hand, that animal’s sound is activated.

Figure 2

_Art student 10 work sample_

A third example of a student project with perfect scores in the design thinking section came from STEAM Student 3 (see Figure 3). This student began the process by looking at the different styles of marble run pieces available and talking about which ones would work best to create a slow-moving design. Once they had decided which pieces would work best, they sorted through the available pieces and pulled out the ones they preferred. Through trial and error, building, testing, and tweaking their design this student and their partner were able to create a marble run design that kept the marble running at a low speed from start to finish.
Critical Thinking

The second area used to assess the student work samples was focused on critical thinking. The co-researchers were looking for students to ask relevant and thoughtful questions to develop ideas and apply them in many ways. This connects to the AASL Learner Standard for Explore, V.B.1 that states, “Problem solving through cycles of design, implementation, and reflection,” and Explore, V.C.1 that states, “Expressing curiosity about a topic of personal interest or curricular relevance.”

Five of the 12 students who completed the literacy activity received the highest score possible from all three researchers, 4 of the 14 students who completed the art activity received the highest possible score from all three researchers, and 5 of the 14 students
who completed the STEAM activity received the highest possible score from all three researchers, meaning they met this standard.

One strong example of a student project with perfect scores in the critical thinking section came from STEAM Student 8 (see Figure 4). This student was working with Snap Circuits to create their own design rather than recreating an example from the instruction booklet. This student developed their design through trial and error. They knew that they needed a power source, connectors, and a feature piece (light, fan, or speaker) in order to create a circuit and when things didn’t work immediately rather than giving up they continued to work until they were successful. In fact, this student’s creation allowed them to use the same circuit design, but they could switch out the feature pieces to run the fan, light, or speaker.

Figure 4

*STEAM student 8 work sample*
In contrast, an example of a student project with less than perfect scores in the critical thinking section came from STEAM Student 1 (see Figure 5). This student used the OSMO and the iPad to explore the game Detective Agency. This task is fairly predetermined, so there is little critical thinking involved. However, the student is responsible for setting up their workspace in a manner that allows them to complete the assigned task.

Figure 5

*STEAM student 1 work sample*

I did Detective Agency in Osmo. I explored in Cairo, Egypt for a missing painting, and used the spy glass to search for clues like Uncle Tony.

**Constraints and Criteria**

The third area used to assess the student work samples was focused on constraints and criteria. The co-researchers were looking for students to not only work within the constraints and criteria, but also consider and adjust depending on the resources that were available at school. This connects to the AASL Learner Standard for Explore, V.D.1 that
states, “Learners develop through experience and reflection by iteratively responding to challenges.”

Five of the 12 students who completed the literacy activity received the highest score possible from all three researchers, 3 of the 14 students who completed the art activity received the highest score possible from all three researchers, and 8 of the 14 students who completed the STEAM activity received the highest score possible from all three researchers, meaning that they met this standard.

One strong example of a student project with perfect scores in the constraints and criteria section came from Literacy Student 9 (see Figure 6). This student wanted to create a suitcase with wheels, and they wanted the opening for their suitcase to be a circular hole in the center that could be closed to keep things from falling out. Because wheels were not available, this student did the best they could with the wood scraps that were provided. This student also used the wood scraps to plug the circular hole in the center of their suitcase to achieve the design they were hoping for. While this student was not sure what materials would work best at first, they experimented with several different materials before choosing to use a cereal box, construction paper, wood scraps, scissors, and hot glue to create their final product.
In contrast, an example of a student project with lower scores in the constraints and criteria section came from Art Student 2 (see Figure 7). This student attempted to recreate an example that was shared, rather than coming up with a new idea. The student only had one sound code instead of four, and they used the “click flag” event as a trigger (which is the default) instead of creating arrow events as was the expectation to match the Makey Makey. This student completed the art part of the project with some success, but clearly struggled with the coding.
**Literacy**

The final section of the rubric is referred to as the literacy section due to its overall connection to the AASL Learner Standard for Explore, V.A.1 which states, “Reading widely and deeply in multiple formats and writing and creating for a variety of purposes.” With that being said, this section of the assessment rubric is broken down into three different categories. These three categories are aligned with Common Core Literacy Standards and Next Generation Science Standards.

The first literacy category refers to students correctly identifying several conflicts in a novel and evaluating the different conflicts to determine which one the character would benefit most from solving. This connects to the Common Core Standard, ELA RL.5.2 that states, “Determine a theme of a story, drama, or poem from details in the text, including how characters in a story or drama respond to challenges or how the speaker in a poem reflects upon a topic; summative the text.” It also connects to the Next Generation Science Standard, 3-PS2-4 which states, “Define a simple problem that can be solved through the development of a new or improved object or tool.” Six of the 12 students who completed the literacy activity received the highest score possible from all three researchers, five of the 14 students who completed the art activity received the highest score possible from all three researchers, and 12 of the 14 students who completed the STEAM activity received the highest score possible from all three researchers, meaning that they met this standard.

The second literacy category refers to students explaining the characteristics, mood, and features of the setting and characters. It also talks about students thinking from the
character’s point of view to determine what would be a logical step within the time and place of the book. This connects to the Common Core Standard, ELA RL.4.3 that states, “Describe in depth a character, setting, or event in a story or drama, drawing on specific details in the text (e.g., a character’s thoughts, words, or actions).” It also connects to the Next Generation Science Standard, 5-ESS3-1 which states, “Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.” Eight of the 12 students who completed the literacy activity received the highest score possible from all three researchers, 6 of the 14 students who completed the art activity received the highest score possible from all three researchers, and 6 of the 14 students who completed the STEAM activity received the highest score possible from all three researchers, meaning that they met this standard.

The third literacy category refers to students accurately summarizing the text by stating the main points and a few key supporting details that connect to the theme and plot of the story. This connects to the Common Core Standard, ELA RL.4.2 that states, “Determine a theme of a story, drama, or poem from details in the text; summarize the text.” It also connects to the Next Generation Science Standards, 3-LS3-2 and 3-LS4-2, that state, “Use evidence to construct and support an explanation.” One of the 12 students who completed the literacy activity received the highest score possible from all three researchers, one of the 14 students who completed the art activity received the highest score possible from all three researchers, and one of the 14 students who completed the STEAM activity received the highest score possible from all three researchers, meaning that they met this standard.
One exemplary student project with perfect scores in all three literacy categories came from Art Student 11 (see Figure 8). This student had a design for a piece of interactive art that required six connections, although they were only required to have four. Because this was more than the teacher librarian was able to assist them with doing, the student did their own research and used different but effective codes and connected them into an if/then statement. Throughout this process the student asked multiple questions about how the circuitry worked, how to connect the Makey Makey, and how to find or generate sounds. Thus the student scored well in the three literacy standard areas assessed with the rubric: (1) to identify a problem to be solved per NGSS, as one does in analyzing the plot and conflict in a story per the CCSS, (2) to identify possible solutions per NGSS, as one also does in analyzing details of the story setting and characters, and (3) construct and support an explanation per NGSS, as one does in summarizing themes in a story per the CCSS. There was a great deal of critical thinking represented in this project and the student ended up creating something which was more advanced than anything that had been discussed in class.
Collaborating Teacher Questionnaires

Three collaborating teachers were invited to reflect on their students’ involvement in the makerspace activities in response to an emailed questionnaire that included three questions framed using the following themes: student engagement, personal curiosity, and reading widely and deeply.

**Student Engagement**

In the questionnaire responses, all three collaborating teachers mentioned observing high levels of student engagement. The literacy teacher stated, “Throughout this whole process, students were actively engaged in the makerspace project.” The art teacher rated student engagement as, “over 50%.” The STEAM teacher specifically recalled the “excited comments” students made prior to library media class.
Personal Curiosity

In the questionnaire responses, all three collaborating teachers identified moments of student curiosity about a topic of personal interest resulting from their participation in the makerspace activities. The literacy teacher said students “showed curiosity about how the book related to them” which helped the students reach a deeper level of understanding of the text. The art teacher said that “Students connected their personal interests shown through the subject matter/theme and sounds they chose.” The STEAM teacher said, “Students were able to choose topics of interest during nonfiction units of study that were often fueled by a connection to how things go together, which was impressed upon them through the creative side of makerspace activities.”

Reading Widely and Deeply

Participation in the makerspace activities seemed to encourage students to read widely and deeply as the literacy teacher shared that students were, “more open in discussing how their books did or did not relate to their own lives” and that, “the text to real world connection was a big takeaway from this project.” The art teacher shared that, “Students were likely encouraged to search online for and read more about interactive art and artists who use technology in their artwork.” The STEAM teacher shared that the makerspace activity “stirred interest” and helped to “drive their selections” in the library.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this qualitative case study was to explore how use of a makerspace can enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. The participants in this study included 40 students from three different school districts where the three co-researchers are teacher librarians. The three co-researchers analyzed student and teacher data from the three case study sites. Three data sources were used including: (1) the teacher librarians’ reflections on their instructional activities, (2) student work samples and the accompanying teacher librarians’ assessment of each individual student’s work sample, and (3) the classroom teachers’ reflections about their students’ involvement in the makerspace activities. Three commonalities emerged from the teacher librarians’ reflections on their instructional activities: their support for district goals and initiatives, the importance of collaboration, and the value of student reflection in learning. Each of the student work samples was evaluated in four different areas, according to the rubric: design process, critical thinking, constraints and criteria, and literacy. The student work sample data showed that most students who participated in the makerspace projects met the standards addressed in the study. Three themes emerged from the collaborating teachers’ questionnaires including: student engagement, personal curiosity, and reading widely and deeply. This information suggests that a makerspace provides an engaging approach to educating students that meets standards and has applications across disciplines, allowing students to take ownership of their own learning.
Conclusions

This study began with the question, to what extent are the activities taking place in a makerspace enhancing student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards? I found two conclusions related to this overarching research question. First, while making outside of the curriculum certainly has value, to have the most meaning, students need to be engaged in making that connects to the learning happening throughout their core subject areas, and this was demonstrated in the current study through meeting core literacy standards that overlapped with other aligned standards. By creating an intentional lesson design that includes time for making, the makerspace becomes an extension of the learning process, rather than an event in and of itself. This supports the idea previously shared by Spencer and Juliani (2016) that making isn’t meant to be something that is squeezed in before or after a traditional unit. It’s not a culminating project. It is a different way of organizing the curriculum. Teachers do not need to take time out of the standards to create a separate space for these projects; they should work as an integrated part of the curriculum that is already being taught.

A second conclusion is that makerspaces provide opportunities for well-rounded learning experiences as they allow students to tap into multiple subjects and multiple skill sets in connected ways and take ownership of their learning. Kurti, Kurti, and Fleming (2014) believe that “maker education fosters curiosity and tinkering, which in turn leads to better thinking through better questioning. This learning environment fosters enthusiasm for learning, student confidence, and natural collaboration” (p. 11). This was
echoed in the findings of the current study as each of the collaborating teachers affirmed that they noted higher levels of student engagement and curiosity. This suggests that a makerspace gives teachers the ability to increase meaningful learning opportunities for students and design curricular opportunities that build connections across grade levels and content areas.

**Recommendations**

The benefits of makerspaces are many and varied. While they do not come without their challenges, the makerspaces in this study showed an impact on student learning and development through the meeting of standards. Despite current circumstances in which online teaching is needed, it is important to continue to find ways to incorporate making into the existing curriculum through virtual makerspace opportunities. Given the prior research previously discussed in this study and the research completed by the three co-researchers in this study, there is room for future research development. This study was based on existing student project data due to the school closures in response to the Coronavirus which prevented the original data collection plan as intended for this study. A replication of this study using the original plan to provide students with a three week novel engineering makerspace unit would provide more extensive data to support the level to which makerspaces might enhance student learning of Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. Throughout this study, it also became apparent to the three co-researchers that there was considerable overlap between the Common Core Literacy Standards, Next Generation Science Standards, and AASL Learner Standards. These
connections warrant further investigation. Finally, this study indicates that being more intentional when collaborating with classroom teachers could have an increased impact on the achievement of content area standards and district initiatives. While collaboration was not a focus for the study, the data collected showed the impact of these types of learning opportunities for students and teachers.
REFERENCES


Wildemuth, B. M. (2017). *Applications of social research methods to questions in information and library science*. Santa Barbara, CA: Libraries Unlimited, an imprint of ABC-CLIO, LLC.

**APPENDIX A**

**OBSERVATION NOTES OF STUDENT WORK SAMPLES**

Student #______

| **Design Process:** | Was there evidence of the student utilizing the design process?  
Did the student complete each step before moving on to the next?  
Was the product tested and revised to achieve success?  
Did the student share information regarding the evolution of the product? |
|---------------------|-------------------------------------------------------------------|
| **Critical Thinking:** | Did the student ask relevant and thoughtful questions?  
Did the student construct ideas by consolidating perspectives? |
| **Constraints & Criteria:** | Did the student work within the constraints and follow the criteria for the activity?  
Did the student make any adjustments due to the resources available? |
| **Literacy:** | Did the student correctly identify several conflicts in the novel?  
Did the student explain the characteristics, mood, and features of the setting and characters?  
Did the student think from the character’s point of view?  
Did the student accurately summarize the text by stating the main points and a few key supporting details that connect to the theme and plot of the story? |
APPENDIX B

STUDENT RUBRIC

Adapted from Montgomery and Madden (2019)

Student # __SAMPLE____

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Process</strong></td>
<td>The engineering design process was used to guide each step. Each step was completed before moving on to the next. This included planning and designing the product, and adapting as challenges were encountered. The product was tested and revised as needed until successful. An explanation was provided as to why the product may be different from the original plan.</td>
<td>The engineering design process was used to guide each step. Each step was completed before moving on to the next. This included planning and designing the product, and adapting as challenges were encountered.</td>
<td>The engineering design process was not followed.</td>
<td>No Evidence Available</td>
</tr>
<tr>
<td>(AASL, 2018. Explore. V.A.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Critical Thinking</strong></td>
<td>The student asked relevant and thoughtful questions to develop ideas and applied them in many ways. The student constructed ideas by consolidating perspectives.</td>
<td>The student asked relevant and thoughtful questions. The student constructed a single idea.</td>
<td>The student did not ask relevant and thoughtful questions. The student essentially recreated a model/followed directions.</td>
<td>No Evidence Available</td>
</tr>
<tr>
<td>(AASL, 2018. Explore. V.B.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AASL, 2018. Explore. V.C.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Constraints &amp; Criteria</strong></td>
<td>The student worked within the constraints and criteria and they considered and adjusted for the constraints and criteria of the resources available at school.</td>
<td>The student worked within the constraints and criteria OR the student considered and adjusted for the constraints and criteria of the resources available at school.</td>
<td>The student did not work within the constraints and criteria or the constraints and criteria of the resources available at school.</td>
<td>No Evidence Available</td>
</tr>
<tr>
<td>(AASL, 2018. Explore. V.D.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Literacy 1</strong></td>
<td>The student correctly identified several conflicts in my novel. The student evaluated the different conflicts and thought about</td>
<td>The student correctly identified several conflicts in my novel.</td>
<td>The student could not identify the conflicts in my novel.</td>
<td>No Evidence Available</td>
</tr>
<tr>
<td>(ELA RL.5.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reading widely and deeply in multiple formats and writing and creating for a variety of purposes. (AASL, 2018. Explore. V.A.1)
<table>
<thead>
<tr>
<th>(NGSS, 3-PS2-4)</th>
<th>which one my character would benefit most from solving.</th>
<th>The student identified the problem and was able to determine an appropriate solution.</th>
<th>The student correctly identified the problem.</th>
<th>The student could not identify the problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Literacy 2</strong></td>
<td><strong>(ELA RL.4.3)</strong> (NGSS, 5-ESS3-1)</td>
<td>The student explained characteristics, mood, and features of the setting and characters. The student thought from the character’s point of view and what would be a logical step for him or her within the time and place of the book. The student also thought about how the setting affects the character’s actions and decisions. The student was able to identify an appropriate and logical solution.</td>
<td>The student explained characteristics, mood, and features of the setting and characters. The student was able to identify an appropriate solution.</td>
<td>The student could not solve the problem.</td>
</tr>
<tr>
<td><strong>Literacy 3</strong></td>
<td><strong>(ELA RL.4.2)</strong> (NGSS, 3-LS3-2) (NGSS, 3-LS4-2)</td>
<td>The student accurately summarized the text by stating the main points and a few key supporting details that connect to the theme and plot of the story. The student mentioned the main characters, setting, and conflict and solutions. The student appropriately described their design including the problem and solution.</td>
<td>The student accurately summarized the text by stating the main points and a few key supporting details that connect to the theme and plot of the story. The student briefly described their design, but did not include all elements.</td>
<td>The student did not describe their design.</td>
</tr>
</tbody>
</table>
APPENDIX C

TEACHER QUESTIONNAIRE

1. What observations can you share regarding student engagement throughout the makerspace project? (AASL, 2018. Explore. V.A.3)

2. In what ways, if any, were students showing curiosity about a topic of personal interest or using inquiry for personal growth as a result of participating in the makerspace project? (AASL, 2018. Explore. V.A.3)

3. In what ways do you think students might have been encouraged to read widely and deeply in multiple formats through their participation in the makerspace project? (AASL, 2018. Explore. V.A.1)