Elementary school library program integration with art, literacy, and STEAM through makerspaces

Kristi Baldwin

University of Northern Iowa

Let us know how access to this document benefits you

Copyright ©2020 Kristi Baldwin

Follow this and additional works at: https://scholarworks.uni.edu/grp

Part of the Art Education Commons, Elementary Education Commons, Library and Information Science Commons, and the Science and Mathematics Education Commons

Recommended Citation

Baldwin, Kristi, "Elementary school library program integration with art, literacy, and STEAM through makerspaces" (2020). Graduate Research Papers. 1494. https://scholarworks.uni.edu/grp/1494

This Open Access Graduate Research Paper is brought to you for free and open access by the Student Work at UNI ScholarWorks. It has been accepted for inclusion in Graduate Research Papers by an authorized administrator of UNI ScholarWorks. For more information, please contact scholarworks@uni.edu.
Elementary school library program integration with art, literacy, and STEAM through makerspaces

Find Additional Related Research in UNI ScholarWorks
To find related research in UNI ScholarWorks, go to the collection of School Library Studies Graduate Research Papers written by students in the Division of School Library Studies, Department of Curriculum and Instruction, College of Education, at the University of Northern Iowa.

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 Sara Pflughaupt and Lisa Tegels.

The purpose of this mixed methods case study was to find out how makerspace use might influence an inquiry-based focus in student learning through the use of design thinking. The researchers were interested in how makerspaces support the National School Library Standards and local school district goals. This study investigated literacy, critical thinking, and inquiry-based processes that might justify having a makerspace in an elementary school library.

Data analyzed from teacher librarian reflections, collaborating teacher questionnaires, and student artifact evaluation resulted in the identification of six general themes. The teacher librarian descriptions and reflections indicated that makerspaces provided support for district initiatives as well as the need for more student reflection time. According to the collaborating teachers, students showed personal curiosity, engaged in inquiry for individual growth, and were likely to engage in more diverse reading due to their makerspace projects. Student artifact data showed that a majority of students (mean=61%) who participated in the makerspace projects met standards from AASL, CCSS ELA, and NGSS that were addressed in the study.

This open access graduate research paper is available at UNI ScholarWorks: https://scholarworks.uni.edu/grp/1494
ELEMENTARY SCHOOL LIBRARY PROGRAM INTEGRATION WITH ART, LITERACY, AND STEAM THROUGH MAKERSPACES

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
Kristi Baldwin
August 2020
This Research Paper by: Kristi Baldwin
Titled: Elementary School Library Program Integration with Art, Literacy, and STEAM through Makerspaces

has been approved as meeting the research requirement for the

Degree of Master of Arts.

under the supervision of

First Reader: Karla Krueger, EdD
Second Reader: Joan Bessman Taylor, PhD.
Curriculum and Instruction Department Head: Robin Dada, PhD

Paper approved on ________________
First Reader Signature: ______________________________________
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 Sara Pflughaupt and Lisa Tegels.

The purpose of this mixed methods case study was to find out how makerspace use might influence an inquiry-based focus in student learning through the use of design thinking. The researchers were interested in how makerspaces support the National School Library Standards and local school district goals. This study investigated literacy, critical thinking, and inquiry-based processes that might justify having a makerspace in an elementary school library.

Data analyzed from teacher librarian reflections, collaborating teacher questionnaires, and student artifact evaluation resulted in the identification of six general themes. The teacher librarian descriptions and reflections indicated that makerspaces provided support for district initiatives as well as the need for more student reflection time. According to the collaborating teachers, students showed personal curiosity, engaged in inquiry for individual growth, and were likely to engage in more diverse reading due to their makerspace projects. Student artifact data showed that a majority of students (mean=61%) who participated in the makerspace projects met standards from AASL, CCSS ELA, and NGSS that were addressed in the study.
# TABLE OF CONTENTS

## CHAPTER 1. INTRODUCTION

- Justification of Problem
  - Student Inquiry and Collaboration
  - Design Thinking
  - Makerspace Implementation
- Rationale
- Uncertainties and Deficiencies on this Topic from Past Research
- Summary of Problem Statement
- Purpose
- Research Questions
- Assumptions and Limitations

## CHAPTER 2. LITERATURE REVIEW

- Student Inquiry
- Design Thinking
- Makerspace Implementation
- Summary

## CHAPTER 3. METHODOLOGY

- Research Design
- Participants
- Procedures
  - Data Sources
  - Data Analysis
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Design Thinking Process Stages</td>
<td>21</td>
</tr>
<tr>
<td>2  Percentage of Students Who Met the Standard</td>
<td>43</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
</tr>
</tbody>
</table>

1. Reflection/observation for Art Student 2
2. Reflection/observation for Art Student 11
3. Levels of standards met in each rubric category
CHAPTER 1

INTRODUCTION

In April 2009 President Barack Obama announced his Race to the Top initiative providing federal funding to K-12 schools providing support for the development of “new and creative ways to engage young people in science and engineering” with the intent of inspiring young people in the United States “to create and build and invent -- to be makers of things, not just consumers of things” (Remarks by the President, 2009, para. 69). The Race to the Top funding sparked schools across the United States to begin looking for ways to emphasize science, technology, engineering, and mathematics (STEM), and the word makerspace became part of the national educational vocabulary in the United States.

A makerspace is quite literally that, a space for making, but it has been more specifically defined by Blakemore (2018) as an “intellectual playground” to inspire deeper learning through questioning (p. 67). Makerspaces in general tend to be informal learning spaces (Walan, 2019) whereas traditional learning in schools has been more formally structured. This juxtaposition leads to questions about how a makerspace should be implemented. Hira and Hynes (2018) point out that while school makerspace activities are typically designed and implemented by teachers, makerspaces themselves tend to be hosted by teacher librarians. Thus, it is imperative that classroom teachers and teacher librarians work together to ensure effective makerspace integration. To support these collaborations, the role and structure of a makerspace in a school library as a means for supporting district and building initiatives needs to be better determined and defined.
Justification of Problem

In 2016, the American Association of School Libraries (AASL) issued a position statement in which they affirm that, “school librarians are instructors as well as collaborators with fellow educators in the pursuit of student learning in school libraries, classrooms, learning commons, makerspaces, labs, and virtual learning spaces” (p. 1). The AASL specifically includes “teach students how to be inquiring learners” and “guide students and fellow educators through the intersection of formal and informal learning” in their definition of the role of the school librarian (p.1). This expectation for teacher librarians to mix structured with unstructured learning sets the stage for discovering how makerspaces might impact student inquiry, student literacy skills, and student use of design thinking processes.

Libraries originally developed as a “hub for knowledge creation, processing, dissemination, and storage (Aiyeblehin, et al., 2018, p. 1). They exist to serve their community by providing resources that individuals might not otherwise be able to access. Aiyeblehin, et al., (2018) say the purpose of a school library is to promote literacy, today defined by some as transliteracy, or “the ability to read, write, and interact across a range of platforms and tools” and to support curriculum (p. 2). When schools are promoting science, technology, engineering, art, and mathematics (STEAM) content and literacy with design thinking processes, they often turn to makerspaces.

While makerspace implementation is popular today, school libraries do need to budget their limited human and fiscal resources in an efficient manner to provide those strategies and programs with the greatest leverage for positive influence on student
achievement. For the purpose of this research, student achievement is defined as a student's ability to demonstrate literacy strategies and apply a design thinking model to a task. As the role of makerspaces in elementary schools is still being defined, Garrison, FitzGerald, and Sheerman (2018) state that determining the influence of a makerspace on inquiry and design thinking would provide important knowledge for those looking to implement or update makerspaces in their libraries.

Thus, teacher librarians, especially those in elementary school libraries where foundational skills are being developed for later student success in a question-based collaborative learning environment at the secondary level would greatly benefit from an awareness of how to promote and support student inquiry with the implementation of learning environments such as makerspaces.

This case study focused specifically on the connection between makerspaces and the achievement of the AASL (2018) shared foundation of Explore (p. 104) through the use of a design thinking process in collaboration with classroom projects focused on art, literacy, and STEAM. Design thinking mimics the guided inquiry process described by Kuhlthau (2012) but without the critical element of facilitation which is needed at different levels during the inquiry process (p. 36). The influence of makerspaces on the use of design thinking processes by elementary school students is informed by scholarly research in the following three areas: student inquiry and collaboration, design thinking, and makerspace implementation.
Student Inquiry

The American Association of School Libraries updated their National School Library Standards in 2018 to include inquiry which can also be found in the standards for learners developed by the International Society for Technology Education (AASL, 2018, p. 54; ISTE, 2016) which encourages students to be empowered learners. An empowered learner is one who can follow the process of guided inquiry as described by Kuhlthau (2012) where students are able to identify their own questions to drive their investigation of a topic. According to Lateef & Adeyi (2019), the processes inherent for information literacy need to be taught early for students to internalize them and put them into practice later as a part of lifelong learning in a world where information is continually changing (p. 3).

Garrison, Fitzgerald, and Sheerman (2018) reference a similar theory from Kuhlthau, Maniotes, and Caspari that increased practice with guided inquiry might cause students to internalize the inquiry process. They also noted that students identified the important parts of guided inquiry as, “its independent nature, structure and pace, and focus on choice” (p. 15). The ability to apply skills effectively in unique situations is a key tenet of demonstrating student understanding according to Wiggins and McTighe (2005). Student engagement in an inquiry process was found by Sheridan, et al., (2014) to be common in makerspaces.

Design Thinking

Blakemore (2018) explains that students often struggle with being able to define a problem that needs solving. She refers to this as “problem scoping” which is integral to
the opening stages of inquiry (p. 68). Kuhlthau (2012) explains that students need time to explore before they are ready to identify a focus. She says that too frequently students jump into finding answers before they have effectively defined their question(s) or they are assigned an inauthentic question for which they simply go through the motions of providing research to address.

Chon and Sim (2019) show that design thinking promotes an emphasis on process by following an inquiry learning cycle, regardless of the labels given to each learning phase, which might vary among models. Design thinking is often part of STEAM topics.

Schools have been emphasizing STEAM education in recent years to promote scientific advancement and better career options for students upon graduation. In a review of educational research, McKinnon (2019) found it to be critical that, “K–12 education achieve effectiveness in building early conceptual knowledge in STEM disciplines and stimulating interest in STEM careers” (p. 6). In other words, the groundwork for the procedural thinking required for STEAM learning needs to be laid in elementary school to promote increased student success in this inquiry-based learning in the upper grades, post-secondary education, and post-baccalaureate STEM careers.

**Makerspace Implementation**

Maker education in its current form might only have gained popularity in the mid-to-late 2000s, but the philosophies driving the implementation of makerspaces have been en vogue since the era of public education in the United States began. Weiner, Land, & Jordan (2018) point out that makerspace theory has its roots in the works of such educational giants as Montessori, Dewey, Vygotsky, Piaget, and Papert (para. 10).
According to Fontichiaro (2019), those who are charged with makerspace implementation need to pay attention to their scope and sequence and build on these educational psychology foundations to ensure that students who are using the makerspaces are building new skills, rather than simply recycling the same skills in a different contextual package.

Similarly, Lock, da Rosa dos Santos, Hollohan, and Becker (2018) emphasize that schools need to focus beyond the creation of a makerspace and give attention to how to incorporate makerspaces in such a way that they foster deep learning. As Hira and Hynes (2018) caution, “As makerspaces become more common, there is a responsibility to ensure that students in a Makerspace are engaging in the pursuit of knowledge and development of self rather than engaging in a focus on economic benefits to the resource providers” (p. 2-3).

Makerspaces have been hailed as an ideal system for collaboration between classroom teachers and teacher librarians. In the words of one teacher quoted by Stornaiolo (2018), “The Lit Lab [makerspace], to me, has very much been a part of the design-thinking process in starting with the idea and having students come. Educators collaborate and now students are collaborating...Our school is in a design process.” (p. 365). In the case of this school, the makerspace came about through a need for promoting literacy while keeping with their making practice.

As such, sometimes schools are intentional in their creation of makerspaces to support district initiatives. Unfortunately a lack of research can lead to makerspace implementation that is ineffective or misaligned with its intended purpose. Makerspaces
can be too narrowly defined to meet the STEM prerogative in schools causing the space to lose its “community of practice” benefits. Phillips and Lee (2019) note that what and how people learn in a library makerspace may look different from the kind of traditional learning environment often observed in the dominant formal education system (i.e., direct instruction, specified curriculum, standards, and assessments), which can make incorporating the esprit de corps of the makerspace into the school library even more of a challenge.

Another concern regarding the makerspace movement is that it is propagating white privilege by casting various arts into traditional American white middle class practices. Vossoughi, Hooper, & Escuede (2016) suggest that by focusing on the makerspace as a way for white males to reconnect with the nostalgic past of shop class and home economics, makerspaces can continue to disadvantage those for whom making is a means of survival, not something fun to do in their spare time (p. 208). It is important when creating a makerspace in a school library setting to encourage increased equity. Access to a library makerspace can support all students in developing academic tenacity or “grit” to be successful in school (Carello, 2017). Koh et al. (2019) indicate in their case studies that library makerspaces in particular promote knowledge creation, access, learning, and equity and diversity. As outlined in a review of literature by Vossoughi, Hooper, & Escuede (2016, p. 310), more research studies document the movement of makerspace implementation into education arenas that include democratizing access for all, inquiry for all, and expanded access to STEM fields stating,

“There is also a growing number of makers, educators, and researchers who self-identify with the movement and leverage the resources opened up by the first group to advance various educational agendas, such as engaging young people in
personally compelling, creative investigations of the material and social worlds (Brahms, 2014; Martinez & Stager, 2013); democratizing access to the tools, skills, and discourses of power previously available only to experts (Blikstein, 2013; Halverson & Sheridan, 2014); and expanding participation in STEM fields through interest-driven, multidisciplinary learning environments (Martin, 2015).”

**Rationale**

There exists a need for research focused on makerspace implementation in the elementary setting. According to Vongkulluksn et al. (2018), most studies that investigate design thinking in makerspaces have been focused on the middle or secondary level. In addition, schools need to know how to effectively implement a makerspace in a manner that truly disrupts traditional instruction to encourage students to adopt an inquiry-based focus in their learning, as modeled through a design thinking process.

**Uncertainty and Deficiencies on this Topic from Past Research**

A study by Shekleton (2015) depicted the need for understanding student use of inquiry learning in a 1:1 learning environment. In order to further understand students’ use of inquiry learning in different environments, this study is following Shekleton’s suggestion for future research to understand “what student achievement would look like when inquiry research is strictly content related” (p. 40). As such, this study gives attention to student use of inquiry and design thinking in a makerspace environment to promote art, literacy, and STEAM instruction.

**Summary of Problem Statement**

Although makerspaces are popular, more research is needed to inform teacher librarians how to structure them in the school library learning environment to promote student inquiry as evidenced through the use of a design thinking process.
Purpose

The purpose of this mixed methods case study is to describe how the use of design thinking in a makerspace might influence student inquiry to promote the AASL standards.

Research Questions

1. How might makerspaces promote AASL standards through inquiry and design thinking?
2. To what extent does participation in a makerspace support district and building goals related to literacy and critical thinking?

Assumptions and Limitations

This study assumes that a makerspace is available in the elementary school setting and that a design thinking process is being included through both direct and indirect instruction as part of the makerspace experience. The scope of this study is limited to three elementary school projects conducted in a single semester.
CHAPTER 2

LITERATURE REVIEW

The purpose of this study is to describe how the use of design thinking in a school makerspace might influence students’ use of inquiry and collaboration. Makerspaces are inherently social and collaborative places where inquiry takes place. However, the inclusion of a focus on using design thinking to engage in inquiry is not inherently part of a makerspace. Prior research related to this topic has focused on the need to teach student inquiry and collaboration as necessary 21st century skills and how the implementation of makerspaces with an emphasis on design thinking as a process to explicate those skills might best facilitate the internalization of inquiry.

Student Inquiry

Garrison et al. (2018) stated that inquiry learning is a timely topic given the need for 21st century skills and as such their study replicated earlier research they had done to explore student perceptions and interpretations of guided inquiry (GI) and address a gap in the empirical research available on GI. Their research question attempted to discover how students use guided inquiry while engaged in research projects, including the level to which they perceive its helpfulness. Guided inquiry and the information search process are commonly accepted as having value in the teaching of an inquiry process, and they share three main characteristics: an independent, or self-guided, nature; a set structure and pace; and a student-driven choice of topic, or emphasis on the “third space” where student interests and content area demands overlap. After looking at the process journals, surveys, focus group interviews, and student products from twenty-one Year 9 students in
an Australian K-12 school, the researchers found through the use of Likert scales, SLIM coding, and coding based on the work of Patton and Vaughn that student work showed growth in their depth of understanding of the selected content and having a set thought structure, or thinking process, helped students to complete their projects. A recommendation from the researchers was to pay careful attention to the design of the process journal, or thinking process, as it influenced all of the remaining components in the project.

Shekleton (2015) also indicated the importance of inquiry learning with a quote from the 2007 AASL standards that “inquiry provides a framework for learning” (p. 2). Her research focused on the need for better understanding of student participation in inquiry while in a 1:1 learning environment (e.g., each student has their own computer). While the inquiry approach has been tied to best practices in 1:1 learning environment, Shekleton examined how collaborative instruction and student achievement affected inquiry learning with a 1:1 ratio of devices to students. This examination followed a qualitative case study design with a population of 27 fifth-grade students, the district technology teacher, a teacher librarian, and the three classroom teachers for the participating students. The researcher gathered data from two groups, students and teachers. Data from both groups was gathered through observations and focus groups. Student data collection also included the analysis of student products while lesson plan documentation was collected from teachers. The analysis of both data sets was completed by reviewing for themes. The researcher found that students reported easier collaboration due to availability of email and that students felt successful when they were able to
“choose their own research topic and form a question to drive the inquiry process” (Shekleton, 2015, p. 37). The study also found that once a topic has been identified, they need support and guidance in the selection of materials to support their inquiry and in the use of technology to share their learning.

Berrier and Stenstrom (2016) focused specifically on the need for collaboration in small group work, which is consistently expressed as a necessary 21st century skill, yet does not appear to have an impact on advancing student learning outcomes. The authors suggest that this lack of impact is due to a lack of generalizable steps, or a specified process, for students to follow when working in groups, so they set out to define these steps. They examined attempts to better direct students through tasks to improve their group work experience and achievement of student learning outcomes through the administration of a survey via Qualtrics to 75 college students in the School of Information at San Jose State University. One might think these students in particular would be accustomed to and adept at working in groups to collaborate on their student learning outcomes; however, the study found through a descriptive analysis that 45% of students lacked confidence in their capacity to work in groups and 40% did not think that the group work helped to improve the quality of the student learning. Thus, there is clearly a need for more direct instruction for student collaboration processes to positively influence student perceptions of group work.

These studies show the importance of student inquiry and awareness of procedural steps for students to follow. Inquiry has been shown to encourage student growth and increase motivation, but structure and support from teachers is still necessary.
Students have a clearly established need to be able to develop and pursue inquiry and to be able to collaborate with others in the pursuit of a goal, but are equally clearly lacking in having developed these skills in the upper grades. Having more direct instruction in collaboration would clarify the expectations and provide a better understanding of the structure needed to benefit more from constructionist and social learning.

**Design Thinking**

The recognition of high quality science education as critical to the environment and the economy coupled with sets of academic standards (AASL, ISTE, NGSS) which all require some level of inquiry learning led Olsen and Rule (2017) to look for research on elementary student use of high quality inquiry learning. They found little, so decided to do their own study to compare student learning, motivation, understanding, and creativity during an inquiry-based lesson set on models in two sixth-grade science classes. Their 38 students, 54% of whom qualified for free and reduced lunch, participated in the lessons, took pre- and post-tests, and responded to six repeated measures surveys designed to gauge student perceptions of enjoyment, motivation, learning, and creativity (for the lesson and for the student). Paired t-tests and Cohen’s d effects resulted in significant indications that all effects favored the more student-centered lessons. However, survey responses also indicated that as student-centeredness increased, it did reach a tipping point beyond which the positive perception declined, likely due to lack of direction and structure from the teacher. Overall, Olsen and Rule found higher levels of retention and enjoyment for student-centered lessons.
After conducting a literature review focused on how design thinking methodologies are being translated into education, Chon and Sim (2019) conducted a qualitative case study with a pilot group of undergraduate students at the School of Design Communication at LASALLE College of the Arts in Singapore to test design thinking as a clear structure for students to meet the challenges of collaboration. Students were taught a five-step process for design thinking, during which time they also kept journals and responded to a questionnaire with six open-ended questions. After evaluating the journals and questionnaire feedback from 67 students, the researchers found that design thinking indeed provided students with a relevant framework to reference in their collaboration, but that more testing in other disciplines should be done.

Van Gompel (2019) focused her research on finding connections between design thinking and 21st century skills such as collaboration, communication, critical thinking, and creativity. She recognized the limited availability of research and resources for promoting student inquiry and felt that design thinking could provide a flexible instructional strategy to better cultivate student abilities in these highly desirable 21st century skills. Her study attempted to explore the process and outcomes of using a design thinking process by answering the question, “How does design thinking foster 21st century skills?” (p. 58). This qualitative case study analyzed interviews, observations, field notes, and artifacts from the researcher’s interaction with 25 students in third-grade in a school in California. Data analysis consisted of using HyperRESEARCH to look for patterns. The study found that the highest improvement in students’ 21st century skills came in collaboration, with creativity being the next highest impact level. Students found
the design thinking process to be engaging, and it allowed them to participate in inquiry, information analysis, and product iteration successfully. Further research on design thinking integrated into the curriculum was recommended (p. 152).

These studies emphasize the need for design thinking to be taught as a process that students can then replicate for themselves. Students need both direct instruction and ongoing support to be successful. Design thinking encourages iteration and engagement with an emphasis on process.

**Makerspace Implementation**

Sheridan, et al. (2014) set out to discover how makerspaces function as learning environments because the explosion of makerspaces was well underway but little was still known about their content and processes. In their comparative case study of three makerspaces, their research questions investigated participation in makerspaces, use of resources in makerspaces, and arrangements for each space that connect with learning, teaching, or collaborating. To answer these questions, the researchers used purposive sampling to choose three different sites which self-identify as makerspaces but cater to different audiences in different spaces - one was a member-based space for adults, one was a museum-based space for family groups, and one was a community-based space for a neighborhood with limited economic resources. Data was analyzed using a priori concepts drawn from constructionism, communities of practice, and emergent topics in an ongoing process from September 2012 to August 2013 involving 150 hours of field observations, interviews, and artifact reviews. The study found the following
commonalities across each makerspace: a multidisciplinary approach, a flexible environment, and an emphasis on the process of making.

Beaumont and Martin (2019) studied 38 students in grades 4 and 5 using an experimental design that utilized student reflection, student work analysis, pre-student self-assessments, and post-student self-assessments. Their literature review suggested that due to a culture of consumerism, children were suffering from a lack of perseverance, risk taking, and sense of agency that could be mediated through the implementation of makerspaces to help them see that they are “capable of shaping” the world around them (p. 4). However, more documentation on the benefits of makerspaces is needed; thus, their experimental study focused on the effective implementation of makerspaces with an emphasis on thinking routines with the question, “What effect, if any, does implementing thinking routines and maker-centered learning environments have on student agency?” (p. 13). In their review of the literature, the researchers found that constructivist theory supports children’s development of agency by “identifying a problem and seeking to solve it through creation, collaboration, and reflection” (p. 7). Furthermore, an emphasis on teaching thinking routines may expedite participants’ abilities to create their own opportunities for reshaping their experiences, thus developing their sense of agency in any environment. After analyzing the reflections, work, and a pre- and post-self assessment from 38 gifted and talented students in grades 4 and 5, the researchers noted that the ambiguity involved in the makerspace implementation process poses a risk to the possible benefits. Thus, having a specified use of thinking routines in a makerspace
implementation would theoretically increase the benefits to agency, risk taking, and perseverance in students.

While Taylor, Moore, Visser, & Drouillard (2018) focused specifically on the incorporation of computational thinking, an analogy can easily be drawn to the need for libraries to focus on teaching student inquiry through the use of makerspaces due to its similar emphasis on process. Taylor, et al. identified computational thinking (CT) as an essential skill that should be taught in libraries because libraries provide a natural space for developing lifelong learning skills. Computational thinking is defined by Braun & Visser (2017) as the abilities to “ask and answer questions using procedural thinking,” “define, model, and solve complex and ill-defined problems,” and “create personal meaning by processing information and creating connections to transform data into understanding” (p. 8). These abilities directly align with the makerspace characteristic of having an emphasis on process and with the inquiry learning expectation for students to generate their own questions and answers.

However, librarians tend to lack confidence in their ability to incorporate CT in their lessons in the same way they may not feel confident in their implementation of a makerspace. Taylor, et al. wondered how CT could be incorporated into the curriculum for future librarians, how doing so might change the course objectives, and how state standards and accreditation requirements impact their ability to include CT in library science coursework. After a directed content analysis of artifacts collected from six professors teaching library science courses in five different states, the researchers found that collaboration among professors helped them to identify ways to incorporate CT, that
CT fit with existing library science areas of focus, and that it can indeed be incorporated into library science coursework, albeit sometimes through a creative interpretation of the required standards. For example, one course titled “Electronic Resources for Youth” focused on coding and programming while another course titled “STEM and Youth Learning in the Library” focused more on state and national STEM standards. Both of these topics connect to computational thinking, but with slightly different contexts and perspectives (p. 16-17).

These studies show that makerspaces include multidisciplinary approaches, flexible environments, and an emphasis on process. While makerspaces vary in their specific goals, these areas of commonality may positively influence the use of inquiry and collaboration among students. However, ambiguity in the process poses a risk to the benefits of a makerspace. Thus, it is critical to provide students with a framework and mindset for inquiry learning, similar to those shown to be successful when teaching computational thinking.

Summary

A review of the literature provides an impetus to collect more information showing the value of makerspaces in supporting student learning, specifically as related to student inquiry, makerspace implementation, and design thinking.

Student inquiry appears to be a critical tool that must be taught for engaging students and promoting understanding of content. An emphasis on process can be seen throughout the research. Taylor, Moore, Visser, and Drouillard (2018) emphasized
specifically that student inquiry and design thinking in a makerspace can promote computational thinking, a key skill for STEAM, due to its emphasis on process.

When students learn to ask and answer their own questions through the cultivation of a specific design thinking model or structure, particularly one that emphasizes a culture of iteration, the benefits of a makerspace are amplified (Garrison, FitzGerald, & Sheerman, 2018; Shekleton, 2015; Van Gompel, 2019). However, ambiguity in the thinking process being taught poses a risk to these benefits (Beaumont and Martin, 2019); thus, it is critical to support student use of an inquiry or design thinking model through direct instruction with ongoing facilitation (Berrier and Stenstrom, 2016)

Makerspaces can provide the environment for student inquiry and design thinking as they tend to include flexible multidisciplinary learning with an emphasis on the process of making (Sheridan, et al., 2014; Chon and Sim, 2019). When students are given opportunities to complete student-centered lessons with necessary support from the teacher, retention and enjoyment increased (Olsen and Rule, 2017).

This study serves to expand the research on makerspace implementation to help fill the gap for teacher librarians concerning the benefits of makerspaces, whether they truly promote inquiry and design thinking, and how they might support district or building initiatives in an elementary school setting.
CHAPTER 3

METHODOLOGY

The need for creative thinkers who can problem-solve continues to grow. Students need to know how to identify problems, generate creative solutions, and communicate those ideas to others effectively. Acquiring these process skills in elementary school better prepares students for the various environments they will later experience in post-elementary school academics and in career settings. Makerspaces provide a safe environment in which students can practice their inquiry, design thinking, and literacy skills. The purpose of this mixed methods case study is to describe how makerspace projects can support the achievement of AASL standards through the use of design thinking and inquiry learning.

Research Design

This mixed methods study examined student work in grades 4 and 5 after students had participated in various makerspace projects: a novel engineering project, a station-based STEAM experience, and an interactive art project. The interactive art project specifically focused on the use of the engineering design thinking framework labeled ask, imagine, plan, create, and improve referenced by Novak (2019) and developed by the Engineering is Elementary program as a simplified approach better suited for young learners. A proposed alignment of the information search process (ISP) with the stages of guided inquiry design (GID) and traditional stages of design thinking with simplified terms for elementary students is shown in Table 1, with the first three columns taken from Garrison, Fitzgerald, and Sheerman (2018, p. 4). This alignment...
indicates the extent to which these various design thinking models all promote the same elements of process.

Table 1

*Design Thinking Process Stages*

<table>
<thead>
<tr>
<th>What students are doing</th>
<th>Stages of ISP</th>
<th>Stages of GID</th>
<th>Traditional stages of design thinking</th>
<th>Design process terms used in study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiating the project</td>
<td>Initiation</td>
<td>Open</td>
<td>Empathize</td>
<td>Ask</td>
</tr>
<tr>
<td>Selecting a topic</td>
<td>Selection</td>
<td>Immerse</td>
<td>Define</td>
<td>Imagine</td>
</tr>
<tr>
<td>Exploring information</td>
<td>Exploration</td>
<td>Explore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formulating a focus</td>
<td>Formulation</td>
<td>Identify</td>
<td>Ideate</td>
<td>Plan</td>
</tr>
<tr>
<td>Collecting information on focus and seeking meaning</td>
<td>Collection</td>
<td>Gather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparing to present</td>
<td>Presentation</td>
<td>Create and Share</td>
<td>Prototype</td>
<td>Create</td>
</tr>
<tr>
<td>Assessing the process</td>
<td>Assessment</td>
<td>Evaluate</td>
<td>Test</td>
<td>Improve</td>
</tr>
</tbody>
</table>

An emphasis on process can be found in the AASL standards, as well as in the 2010 Common Core State Standards for English Language Arts for Literacy in Reading Literature (CCSS.ELA-Literacy.RL) and the 2013 Next Generation Science Standards (NGSS). This common promotion of teaching process over product was included in the design of the rubric used to analyze student work as shown in Appendix A.

A mixed methods case study design with qualitative elements is appropriate for studying the influence of the makerspace participation on the achievement of AASL, CCSS.ELA-Literacy.RL, and NGSS standards and on the support of school goals because
it meets the criteria set forth by Wildemuth (2017) when considering a case study: the phenomenon is being studied in its natural environment with a focus on contemporary events and actions that can be directly observed while maintaining an emphasis on “how” and “why” these relationships are developed (p. 52).

Participants

The students in this study attended elementary school in one of three different districts housed in mid-sized Midwestern cities where the researchers were employed as teacher librarians at the time. For the purpose of comparison, the 40 participating students were assigned to subgroups labeled art, literacy, or STEAM based on the makerspace project in which they participated.

The art group had nine fifth-grade and five fourth-grade students for a group total of 14 participants in the art group. In the literacy group, there were 12 participants who were all in fourth grade. The STEAM group consisted of three students in grade five and eleven students in grade four. These 14 students provided 21 data samples. All together, there were 12 students in grade five and 28 students in grade four who served as participants for the research. These students were selected for inclusion in the study based on their completion of a makerspace project in their respective elementary school during library media time prior to the closing of schools in spring 2020 due to the COVID 19 pandemic.

Students in the art project K-5 elementary school had not really used the makerspace or engaged in design thinking since the beginning of the 2019-20 school year. In past years, at least some students from each grade level participated in various
teacher-directed activities using the makerspace. In first grade, students created a marble run from recycled materials. In second grade, they built a cardboard arcade and made circuit cards (greeting cards with LED light bulbs). Third-grade students created simple machines to create a chain reaction (aka Rube Goldberg structures). In fourth grade students created circuits with Little Bits, Makey Makey, or Snap Circuits. Fifth-grade students were then given the opportunity to choose an activity using TinkerCAD, engineering, cardboard construction, animation, movie production, gaming, or public service announcements.

These projects were completed in the library makerspace under the direction of the teacher librarian at the time who was not the researcher. Some projects were completed in collaboration with classroom teachers while others were small group activities that did not ensure whole classes participation. No records are available regarding individual student participation in these various experiences. In addition, there is not a systemic, building-wide plan or expectation in place for how and when students will use the available makerspace resources.

In the early part of 2020, students from the art group participated in a teacher-directed interactive art activity that referenced the engineering design process. In this collaborative project, students were given direct instruction by the art teacher and the technology teacher librarian during art and media class respectively. Students then chose their own specific subject matter to use in creating their project which was an interactive artwork where they used graphite pencils, Scratch coding, and Makey Makey circuit
boards to create a piece of art that would make sound when touched. Some direct instruction about the design process was included in the project implementation.

For the literacy group, students in fourth grade were engaged in a novel engineering project in the fall of 2019 as a collaboration between the classroom teachers and the teacher librarian. Students read the book *The Tiger Rising* in which one of the characters utilizes the metaphor of putting their feelings into a suitcase. After reading and discussing the novel in their classrooms, students went to the makerspace to create their own suitcases and share their feelings as a group. This provided a social and emotional learning experience in addition to a making experience related to the literature, thus providing a specific literacy connection with the process of making.

The STEAM group engaged in a series of eight makerspace stations over the course of a semester in 2019 where the students chose three stations to complete and then shared a short reflection about each station as an exit slip for the class period. The stations offered a variety of different making opportunities such as using an Osmo, building with LEGO, using Sphero to program an Ollie, creating a marble run, designing with Perler beads, and coding with an Edison robot. Participation in these activities emphasized a growth mindset.

All of the data collected were a normal part of the activities in students’ library media classes. Because students do not receive a grade in media center, there is no obligation for them to complete any of the activities beyond the expectation that they participate in media center class. To this effect and to fulfill the guidance of the University of Northern Iowa Institutional Research Board (IRB), the researchers used
parental notification to describe that the project was a part of normal classroom activities. The Letter of Parent Notification that met the criteria specified by the IRB is in Appendix B.

**Procedures**

Data for this research study was collected by each teacher librarian in their own building. Teacher librarians wrote descriptions of their lesson implementation, collected and categorized student artifacts, then shared those artifacts for evaluation by the other two researchers using a standards-aligned rubric. A questionnaire was used to collect reflective feedback from the collaborating teachers from each project group as shared in Appendix C.

Students in the art group had daily access to Chromebooks and regularly used G-suite resources to interact with online resources. Students in the STEAM group also used Google docs to record their exit ticket reflections. Digital technology was not a part of the literacy group project so computer use was not relevant to the project. Students in the art and literacy groups have media class every four days whereas the STEAM students are on a six day cycle.

**Data Sources**

Data for this mixed methods case study was gathered through artifacts from students, lesson descriptions and reflections from the teacher librarians, and responses to a questionnaire from collaborating teachers.

Student artifact data included images of student work with observation notes from each researcher (see Appendix D) about the students’ use of design thinking and
engagement in process strategies. Artifacts were collected from students who had completed makerspace projects earlier in the year. Since not all students in the population completed these projects, the sample represented those submissions that would have a tendency to score higher in regular scoring or grading.

The researchers assessed completed student projects using a rubric focused on the design process, critical thinking, the use of constraints and criteria, and literacy as related to problem solving (see Appendix A). This rubric featured descriptions adapted from Montgomery and Madden (2019) who emphasized the integration of the engineering design process with literacy development. All of the language was adjusted to fit a third-person point of view. In addition, the critical thinking descriptors were adjusted to remove the element of argumentation since this was not addressed in any of the makerspace projects. The constraints wording was also adjusted for individual student work rather than group processes. Other categories from the original Madden and Montgomery (2019) rubric were not used because they focused on areas such as group collaboration that could not be evaluated with the available data.

Lesson descriptions and reflections were provided by each researcher who served as a participant observer for their group. Finally, a short questionnaire was sent to the collaborating teachers (classroom or other non-library teachers) whose students had participated in the projects. The questionnaire can be found in Appendix C.

**Data Analysis**

Data was analyzed by each researcher individually with weekly group meetings to discuss the process and results. Each project had a slightly different focus (design
thinking, growth mindset, novel engineering) but they all related to the AASL standards as well as the NGSS and CCSS.ELA-Literacy.RL standards. The specific standards from each organization that were focused on for this study can be found in Appendix E. Their varying implementations provided a more well-rounded sampling of student artifacts.

The qualitative analysis of content followed the procedures defined in Wildemuth (2017) in the review of three data sets: teacher librarian lesson descriptions, student artifacts and rubric scores from three makerspace projects, and collaborating teacher questionnaire responses.

**Step 1: Prepare the Data**

To prepare the lesson description data, the teacher librarians wrote out their lesson plans, including a short reflection for the lesson implementation, and shared these descriptions, along with instructional materials used in the lesson, with the other researchers.

Responses gathered from the collaborating teachers were prepared by compiling them into a single document organized by question. This allowed the researchers to more easily observe patterns in the data from the three different sources.

Preparation of the student artifacts began with a standard template (Appendix D) for the teacher librarians to use in describing the student work and noting student comments related to inquiry and collaboration. The template was created based on themes that existed in the rubric as related to the engineering design process with an emphasis on problem solving. Those themes were design process, critical thinking/creativity, and constraints/criteria. Information was also included at the
beginning of the template documents regarding the basic expectations for the project so that the researchers could reference that without having to always refer back to the full lesson plan descriptions from the teacher librarians. Structuring the data using this template helped to provide the teacher librarians with a uniform set of questions to answer and to later develop a coding scheme for analyzing the data. Images of student work from their makerspace projects with direct quotes from students as transcribed by the researchers were included when available as shown in Figure 1.

**Step 2: Define the Unit of Analysis**

In defining the unit of analysis for the three data sources, the researchers looked to their questions, which focused on the use of the design process, the promotion of AASL standards, and the support of local school initiatives, also referred to as district or building goals. While the researchers began their analysis with these themes in mind, they were also cognizant of recognizing patterns which grew out of the data.

**Step 3: Develop Categories and Coding Scheme**

In this way the categories for analysis grew both inductively and deductively from the data. According to Wildemuth (2017, p. 321), “inductive analysis is particularly appropriate for studies that intend to develop theory, rather than those that intend to describe a particular phenomenon.” The researchers in this study did not develop a coding manual as is recommended when multiple coders are involved; however, they did meet weekly to discuss questions about the coding and scoring processes once the analysis was underway.
Step 4: Test the Coding Scheme

The next step in the process as described by Wildemuth (2017) was to test the coding scheme on a sample of text. In this case, the teacher librarian lesson descriptions and collaborating teacher questionnaire responses were fairly straightforward so most of
the next few steps in the content analysis process were focused on the scoring of the student artifacts.

To apply the rubric to a sampling of student artifacts, the teacher librarians first each scored the artifacts from their own group. While the researchers did not set forth a specific coding structure, they did rely on the themes identified in the rubric when looking for patterns in the data.

During this testing of the coding scheme, or rubric scoring in this case, the researchers found that not every artifact included a specific student description. The researchers made an adjustment to the rubric based on the lack of direct student descriptions for their samples. When scoring, the researchers focused on the images provided of the artifacts when direct student quotes were unavailable or on the description from the teacher librarian if images were unavailable as shown in Figure 2.

Whether to include the more literacy-specific characteristics from the rubric was another point of discussion for the researchers since two of the projects did not specifically connect to literature or reading. In the end, the researchers decided to include some literacy skills to better illustrate the connection between makerspace projects and reading as well as to make possible better comparisons among projects that did or did not specifically align to literacy standards. As such, the rubric was expanded to include more literacy skills based on the CCSS.ELA-Literacy.RL standards with process descriptions aligned from the NGSS standards.
Step 5: Apply the Coding Scheme

Once a finalized version of the rubric and student artifacts was agreed upon, the researchers continued to score the remaining student data from the other two researchers.
Scores of 3 (high), 2 (mid), or 1 (low) were assigned independently from one another and the researchers compared scores only after all scoring was completed.

While scoring, pictures and descriptions were used together when possible to give the most well-rounded representation of the student project, with emphasis given to textual descriptions in most categories with one exception. The art group teacher librarian noted that when scoring the Literacy 3 category, they relied more on the image for the art students, the image and the literacy description together for the literacy students, and more on the student quotes for the STEAM students.

**Step 6: Assess Coding Consistency**

Coding consistency seemed evident for the researchers when looking at the deductive categories of design process, critical thinking/creativity, and constraints/criteria, but there was greater variation in the inductive categories developed by each researcher due to the perspectives from which each teacher librarian was approaching the data. For example, the literacy group teacher librarian found patterns emerging from the data focused more on literacy while the STEAM group teacher librarian tended to recognize more growth mindset and engineering-related themes.

The greatest amount of discussion for coding consistency took place for the student artifacts and rubric scores. When the individual scoring was completed, scores were combined into a joint spreadsheet for comparison of inter-rater reliability, and the researchers analyzed the variance or similarity of their scores by highlighting instances with more than a one point difference for the same item. Researchers discussed these discrepancies to determine any error in understanding the student work sample and to
question whether the criterion was applied consistently. If consistency was found, then the varied scores were kept.

Most often a discrepancy derived from a lower score assigned by the researcher who taught the students and felt the students did not meet the expected criteria, whereas another researcher relying solely on the artifact evidence granted a higher score. Also, as noted by Wildemuth (2017), “human coders are subject to fatigue and are likely to make more mistakes as the coding proceeds.” (p. 322) so it is possible that coding fatigue may have influenced some of the discrepancies. The researchers found only a few instances, though, where scoring seemed inconsistent so they made adjustments to those scores during a joint review session to better reflect their verbally agreed upon perspective.

**Step 7: Draw Conclusions from the Coded Data**

As the researchers completed their analysis of the three data sets, they continued to meet weekly to discuss their findings and share the various themes that they were finding in the data or to confer about possible connections in the patterns found.

**Step 8: Report Your Findings**

Finally, each researcher wrote a thesis to share their version of the study progression and the patterns, themes, and categories found in the analysis process. This was a most interesting part of the research process, as despite sharing the same data, each researcher drew their own independent conclusions with reference to their unique context and interests as described in step 6 of the content analysis process.
Limitations

This study was limited by the use of existing student project data as school closures due to the novel coronavirus (COVID-19) prevented the collection of new data as was originally intended for this study. Likewise, the sampling of student projects for inclusion in the study was limited to those items available to the researchers at the time of the school closures.

The art data available could also be categorized as higher scoring work than would have been collected if the full sample had been available since it was limited to those 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 literacy data provides a good representation of the range of student work that was completed, but the 12 samples that are used in this study were selected because they were photographed and because the researcher could remember the most about these specific projects.

It is also important to note that this researcher holds a positive bias for the use of design thinking based instruction.
CHAPTER 4

FINDINGS

This descriptive case study used a mixed methods analysis method to review three makerspace projects for their promotion of student inquiry and design thinking to support AASL standards and local school initiatives.

Data for this study was collected from three datasets labeled as art, literacy, and STEAM. There were 14 students in the art group, 12 students in the literacy group, and the STEAM group consisted of 14 students who provided 21 data samples. Data about all three sets was collected through participant observation and reflection, collaborating teacher questionnaires, and evaluation of student artifacts.

Participant Observation and Reflection

Each of the teacher librarians, who were also the researchers for this study, wrote a description and reflection of the lesson or unit utilized in their makerspace for the projects included in the study. It was helpful for the research partners to be able to better understand how the lesson was structured and what the original goals were since the student artifacts were collected from previously available data, not from specially designed projects intended for research. Three themes emerged from this descriptive data: support for district initiatives, student reflection on their learning, and collaboration with classroom or other teachers.

Support for District Initiatives

The first commonality noted in the descriptions is that these projects were designed to meet or support the needs of content area instruction, not specifically to
promote “Makerspace” or “library” skills. For example, the literacy project amplified classroom learning that was designed from a mentor text as part of the Lucy Calkins Reading Units of Study literacy program in the district. The art project included some computer science related coding curriculum, but the main focus was on the creation of an interactive piece of art through design thinking to promote visual art standards and a district equity goal. The STEAM project emerged from a district Makerspace focus as a follow on from a partnership with a regional science museum with an emphasis on developing a growth mindset in learners.

Student Reflections on Their Learning

The reflective data from the teacher librarians emphasized the importance of including time for students to reflect on their own learning as part of their projects. The STEAM teacher librarian “started having students fill out exit slips at the end of each class period, telling me...something they learned and something they wanted to learn more about.” This provided valuable feedback for the station effectiveness, but also gave the teacher librarian a better awareness of the level of student understanding related to the concepts being reinforced. As the teacher librarian stated, “this reflection time helps them [the students] take their learning to a deeper level and can contribute to students developing a growth mindset.”

As the literacy teacher librarian said, “this activity helped to make this abstract idea from the text more concrete,” a feeling that was echoed in the art project where the teacher librarian found that when students had to create notecards explaining their work, the stage at which the students were in the creative process became much more evident.
The art project was also cut short due to school scheduling changes which prevented students from completing the reflections they were originally supposed to have written, and not having that data meant not knowing the extent to which student understanding was achieved.

**Collaboration with Classroom or Other Teachers**

Every teacher librarian noted their collaborative role, including their responsibility for initiating the collaboration. They reached out to the classroom or other content area teachers and found ways to support the learning being done in the other classrooms. Without the teacher librarians, these makerspace projects would likely not have happened, and students would have had fewer opportunities to practice content area skills. Students would have missed a chance to, as noted by one of the collaborating teachers, “make personal connections to the characters in the book and deepen their understanding of the themes, life lessons, and detailed explanations within the text.” As discussed earlier, these collaborations served to provide even more support for local school district initiatives that ranged from a STEAM focus to literacy to equity, whether the makerspace project lasted for two class meetings or eight.

**Collaborating Teacher Questionnaires**

There were four themes identified by the researcher from the collaborating teacher data: student engagement, personal curiosity and inquiry for individual growth, diverse reading, and the importance of collaboration. Collaborating teachers are referenced in this section by the group with which they worked (art, literacy, STEAM) rather than their actual titles.
Student Engagement

Student engagement was noted by all three teachers as high. The art teacher rated student engagement as “over 50%” and the literacy teacher noted, “Throughout this whole process, students were actively engaged in the makerspace project.” The STEAM teacher specifically recalled the “excited comments students make” prior to library media class and the art teacher included that, “students showed pride and excitement to demonstrate their projects.”

Personal Curiosity and Inquiry for Individual Growth

Teachers also noticed students showing personal curiosity as part of the makerspace project experiences. The art teacher said, “Students connected their personal interests shown through the subject matter/theme and sounds they chose.” The STEAM teacher added, “Students were able to choose topics of interest during non-fiction units of study that were often fueled by a connection to how things ‘go together’.” The literacy teacher mentioned that students “showed curiosity about how the book related to them” which helped the students reach a deeper level of understanding of the text. As an extension of this personal curiosity, the literacy teacher also shared that “Students were persistent in creating a suitcase that was unique to them…” and that “facilitation lead to self direction and creative inquiry.”

Diverse Reading

Makerspace project participation also appeared to influence reading selection as the STEAM teacher discussed how “Maker Space activities encourage more reading both in fiction and non-fiction” and 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.”

**Importance of Collaboration**

Probably the most notable theme, though, was that of the importance of the collaboration between the teacher librarian and the collaborating teachers. Even though no question was asked specific to collaboration, every one of the collaborating teachers commented on it. The art teacher said, “The parallel teaching helped students reinforce the learning since they were receiving twice a week (Media and Art).” The literacy teacher stated, “I was so happy to have had the opportunity to collaborate/co-teach with you. I was so impressed by your ideas, and how you could facilitate not only hands-on activities, but meaningful content that connected to work we were doing in our reading content area.” The STEAM teacher emphasized that these collaborations might not have happened without the impetus of the teacher librarian, stating how the teacher librarian, “shared ideas with the classroom teachers which helped us make the connections on our digital libraries as well.”

**Evaluation of Student Artifacts**

An evaluation of the 47 student projects from 40 students was conducted by the three co-researchers for this study using a rubric designed to gauge whether, through their participation in the makerspace projects, students were meeting the AASL standards as shown in Appendix E. Multiple coders assigned ratings to student work according to six categories: use of a design process, demonstration of critical thinking, adherence to constraints and criteria, problem identification, problem solving, and process sharing.
These ratings, or scores, were then analyzed for the level of reliability among the researcher scores, how well the student met the standards through the six categories, and evidence of relationships between the criteria areas.

**Inter-rater Reliability**

The level of inter-rater reliability was 62% overall and a combination of means showed score agreement for art at 8.75 out of 14, literacy at 8.30 out of 12, and STEAM at 11.67 out of 21 projects. As was noted in Chapter 3, the raters tended to find that they were more critical of the student work provided by their own group. Furthermore, the use of a three-point scale did not allow for a great level of differentiation in scoring and there was no training for the co-researchers in using the rubric prior to implementation. Thus, there seemed to be overall a high level of agreement in the scoring outcomes.

**Standards Assessed in the Rubric**

The six categories for the rubric scoring were selected for their connection to the AASL (2018) standards specifically relating to inquiry and engineering. These six categories were chosen for their representation of selected standards from AASL, CCSS ELA, and NGSS. The researchers suggest that meeting the rubric criteria thus is equivalent to having met the standard(s) associated with that rubric criteria as further explained in the following paragraphs.

The rubric can be further broken down into two main sections - the first section has an emphasis on using a design thinking approach while the second section delves into the problem solving process and connection to literacy as evidenced through reading
widely and deeply in multiple formats. The specific standards represented in each rubric category are explained next and are listed in Appendix E.

**Design Thinking**

In the design thinking section, the first category is the design process which aligns with AASL Explore standard A.3 in encouraging learners to engage in inquiry-based processes for personal growth. The second category addresses two AASL Explore standards to emphasize critical thinking: V.B.1 “Problem solving through cycles of design, implementation, and reflection,” and V.C.1 “Expressing curiosity about a topic of personal interest or curricular relevance.” Category three focused on AASL standard V.D.1 to show if students are “iteratively responding to challenges” as they go through the design process, specifically in relation to meeting the makerspace project criteria while staying within the project constraints.

**Problem Solving**

The problem solving section of the rubric was commonly referred to by the researchers as the “literacy” section due to its overt connection to AASL standard V.A.1 encouraging students to read “widely and deeply in multiple formats” while also “writing and creating for a variety of purposes” (p. 104). In addition, the three categories in this section show alignment with both the English language arts (CCSS ELA) and science (NGSS) standards. These connections among the multiple standard groups reinforce the idea that when makerspace projects meet the AASL standards, they also support other content area standards, or local school district initiatives originating from the standards.
The first category in the problem solving section, category four, emphasized the identification of the problem or conflict. For CCSS ELA RL.5.2, this meant the student was able to identify conflict in a novel while for NGSS 3-PS2-4 it meant that students were able to identify both the problem and an appropriate solution. Category five followed the next step in problem solving - making a plan. For CCSS ELA RL.4.3 that looked like students who can adopt a character’s situation and explain logical steps for them to take while for NGSS 5-ESS3-1 it looked like students who could assess a situation and logically solve the problem. Finally, the sixth and last category looked to students’ abilities to explain and describe their work. For CCSS ELA RL.4.2 that meant students could summarize the text including key details. For NGSS 3-LS3-2 and 3-LS4-2, it meant students were able to describe their overall design process upon completion of their project work. All of the standards represented in the rubric are listed in full in Appendix E.

**Student Artifacts**

In general, the student artifacts demonstrated that a majority of students met each of the standards for the six areas evaluated using the rubric. For the purpose of this study, a standard was considered to be “met” if at least two of the three raters scored the artifact at a level 3. Table 2 shows the results for the number of students who met the standard in each category. See Appendix A for standards alignment for each rubric category.

The most frequently meeting standards were AASL V.A.1, ELA RL.4.3, and NGSS 3-PS2-4 with 85% of students demonstrating their ability to define problems and determine possible solutions. That percentage dropped slightly to 71% when it came to
synthesizing the necessary information to actually solve the problem. Within the project groups, literacy students had the strongest showing with 92% meeting the standard, then STEAM students at 86% and art students at 79%.

Students had a solid showing for exhibiting personal curiosity and inquiry for personal growth as related to the AASL standard V.D.3 with an overall rate of 68% for adhering to the project constraints and criteria. In the project area groups, STEAM students ranked the highest with 93% meeting the standard, followed by literacy with 75%. Most of the art students did not meet this standard, with only 36% showing proficiency.

Table 2

*Number of Students Who Met the Standard*

<table>
<thead>
<tr>
<th></th>
<th>Art</th>
<th>Literacy</th>
<th>STEAM</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Thinking Section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Process</td>
<td>4 (29%)</td>
<td>10 (83%)</td>
<td>9 (64%)</td>
<td>23 (59%)</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>7 (50%)</td>
<td>8 (67%)</td>
<td>10 (71%)</td>
<td>25 (63%)</td>
</tr>
<tr>
<td>Constraints and Criteria</td>
<td>5 (36%)</td>
<td>9 (75%)</td>
<td>13 (93%)</td>
<td>27 (68%)</td>
</tr>
<tr>
<td><strong>Problem Solving Section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literacy 1: Identifying Problem</td>
<td>11 (79%)</td>
<td>11 (92%)</td>
<td>12 (86%)</td>
<td>34 (85%)</td>
</tr>
<tr>
<td>Literacy 2: Problem Solving</td>
<td>6 (43%)</td>
<td>10 (83%)</td>
<td>12 (86%)</td>
<td>28 (71%)</td>
</tr>
<tr>
<td>Literacy 3: Summarizing / Sharing</td>
<td>4 (29%)</td>
<td>3 (25%)</td>
<td>2 (14%)</td>
<td>9 (23%)</td>
</tr>
</tbody>
</table>
The standards least met by students in the makerspace projects were CCSS ELA RL.4.2, NGSS 3-LS3-2, and NGSS 3-LS4-2 for summarizing and/or sharing their process. Only 23% of students met the standard overall, as shown in the project groups with 29% of art students, 25% of literacy students, and 14% of STEAM students.

Evidence of relationships

Disaggregating the artifact scores as shown in Figure 3 further showed that students in the STEAM based project really excelled in identifying the conflict or problem, but struggled with summarizing and sharing their process. Art project students seemed to follow more of a bell curve in their scores with a majority of students scoring in the mid-level range for all six categories. Literacy project students performed very well in both identifying the conflict or problem and engaging in the problem solving process, but like the STEAM students had lower scores in the summarizing and sharing category. In disaggregating the standards, students were categorized as high, medium, or low in terms of the level to which they were able to meet the standard as demonstrated through their makerspace project in this study. High scoring students had all level 3 scores. Medium scoring students received at least one 3 but also one or more scores of 2. Low scoring students received no 3 scores - only scores of 2 and 1. Most students received at least one score of 2 with very few students receiving scores of only 1 from all three evaluators. The fact that the student artifacts skew slightly higher is likely connected to the sampling limitations.
A good example of a student who received the highest possible score in both sections is Art Student 11 as shown in Figure 2. This student was able to stay within the project constraints while going beyond the criteria to satisfy their own personal curiosity. When the student wanted to do more than the teacher librarian was able to assist with them doing, they did their own research and used, “different but effective codes and was working on connecting them into an if/then statement which is more advanced than anything we had worked on in class” as stated in the teacher librarian reflections.

Another student with perfect scores in the design thinking section was STEAM Student 8, who also chose not to follow the directions to the letter but, “to create a design of his own” according to the teacher librarian, who went on to share that this student “also showed his creation process stages, so that the learning outcomes were evident.”
Literacy Student 8 had perfect scores in the design thinking categories and their work echoed the art student’s persistence and determination. According to the teacher librarian, “this student had a plan from the beginning” and worked with the available materials to make their plan happen.

Literacy Student 10 had the highest score from that group in the problem solving section, particularly in the summarizing and sharing category. The student stated in video footage from the project, “Like *The Tiger Rising*, we are writing down our feelings and we are putting it in our box,” which shows the depth of critical thinking the student reached in addition to their ability to explain what they did. STEAM Student 13 was likewise able to summarize their process in stating, “I practiced subtraction when giving the people change after they gave me extra money for the pizza.” This student had the highest problem solving score for the STEAM group and the teacher librarian stated that for this student there is also, “evidence that the student was using her critical thinking skills in order to infer what toppings the customer preferred and to be able to make proper change.”

On the opposite end of the spectrum, Art Student 2 scored the lowest in both the design thinking and problem solving sections. This student followed directions well but did not show any creativity in their design and incorrectly applied the coding aspect of the project as can be seen in Figure 1. When faced with difficulty, the student persisted in their original plan, but unlike the students who scored high due to their determination to make their plan work, Art Student 2 was unable to find a solution to the challenge. So
while the student was able to complete the project, there was not evidence of advanced critical thinking or problem solving skills in their work.

In a related scenario, Literacy Student 5 started with a design in mind and “worked hard on each step until they felt that their project was complete.” However, the student forgot part of the directions and had to implement a last minute fix to complete the project. Another student with low design thinking scores, STEAM Student 5-2, similarly followed the directions step by step but was unable to demonstrate his problem solving skills. However, this student had two project submissions and scored slightly higher in the completion of a separate makerspace project that better allowed for the student to explain their process.

Students who scored low in the problem solving section included STEAM student 11 who despite being “quite resourceful in trying to problem solve” was unable to explain her process, saying only that “I tried to solve the rubik’s cube, used string for string tricks, and used the puzzibits,” and Literacy Student 4 who “struggled to connect with the main character in The Tiger Rising and couldn’t think of anything to write down to put inside their suitcase.” Later this student was able to get some ideas from classmates to complete the project.

These student examples illustrated the complexity of thinking required of students in three fairly standard makerspace projects. In each of the examples, students were asked to be creative, to generate and follow a plan of action, and to be persistent in achieving the goals of the project. In the more successful projects, based on the artifact rubric scores, students used their creativity to seek out workable solutions, and either developed
plans that they were able to follow through to fruition or relied on their determination to make the plan work in order to effect a positive outcome. Less successful students showed a lack of creativity in that they were either unable to develop their own unique plan or persisted in a plan that was not going to work and they were not able to make effective adaptations.
CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

The purpose of this mixed methods case study was to find out how makerspace use might influence an inquiry-based focus in student learning through the use of design thinking. The researchers were interested in how makerspaces support the National School Library Standards and local school district goals which are often used to determine student achievement and success. Finally, this study investigated literacy, critical thinking, and inquiry-based processes that would encourage having a makerspace in an elementary school library.

Data was collected from 40 students through 47 student artifacts with descriptions and reflection from the teacher librarian participant observers and 3 questionnaires from the collaborating classroom teachers. Student artifact data showed that a majority of students (mean=61%) who participated in the makerspace projects met standards from AASL, CCSS ELA, and NGSS that were addressed in the study. The teacher librarian descriptions and reflections indicated that makerspaces provided support for district initiatives as well as the need for more student reflection time. According to the collaborating teachers, students showed personal curiosity, engaged in inquiry for individual growth, and were likely to engage in more diverse reading due to their makerspace projects.

Conclusions

This study afforded the researchers an opportunity to review existing makerspace projects for the promotion of inquiry and design thinking within the context of existing
makerspace units and to analyze student work. This resulted in three conclusions. First, students who engage in inquiry processes tend to have increased motivation and student growth (Garrison, 2018; Shekleton, 2015). Students in this study reflected these higher levels of engagement and inquiry in their collaborating teacher observations and artifact rubric scores. This information suggests that students should be provided with more opportunities to engage in inquiry and that makerspaces provide an environment that is conducive to this kind of student-centered inquiry learning.

Second, Chon and Sim (2019) and Van Gompel (2019) found that having a framework to support design thinking resulted in greater student success. This was echoed in the findings of the current study through the student artifacts and teacher librarian reflections. Students scored very well on the design process category, but did not do as well in the sharing process. It was noted that the reflection and sharing part of the project implementation was often missing or cut short due to a lack of time. Thus, makerspace project designers would be remiss if they did not incorporate more reflection time into their projects.

And third, makerspaces are clearly not just a fun new trend for school libraries. They provide students with time to practice inquiry through design thinking processes, and in doing so, they provide support for meeting not only school library standards, but also a number of content area standards in English language arts and science. Schools should consider how the inclusion of makerspaces that include specific instruction for design thinking, that offer time for student-centered inquiry, that include reflection as part of the makerspace project, and that encourage collaboration between teacher librarians
and other teachers would help to ensure that all students could meet their expected standards.

Meeting these standards helps to promote district initiatives such as improving student literacy and making schools more equitable learning environments by providing all students with access to the time and resources to practice those skills that will help them to be successful in meeting district goals like improving literacy and critical thinking skills.

**Research Question One - Inquiry and Design Thinking**

Research question one asked how makerspaces might promote AASL standards through inquiry and design thinking. Themes pertaining to this question that became evident through the data analysis were student engagement and personal curiosity, student reflection on their learning, and student planning and persistence. Student engagement and personal curiosity are key to inquiry and the makerspace projects in this study promoted both. According to the collaborating teachers, students showed personal curiosity and engaged in inquiry for individual growth. This connection between personal curiosity and content area goals has been promoted in the research as the “third space” which supports student creativity (Kuhlthau, et al., 2015, p. 10; Shekleton, et al., 2015, p.12).

The student artifact data showed that most students who participated in the makerspace projects met the standards from AASL, CCSS, and NGSS addressed in the study. Students who had more than one project completed were also more likely to have met more of the standards providing an argument for the inclusion of multiple
makerspace projects, either over time or through a station approach. This willingness to engage in product iteration (Van Gompel, 2019) helped students to be more successful in meeting the standard.

Observations from the teacher librarian researchers also provide a rationale for including more time for students to reflect on their learning. A lack of this provision in the makerspace projects for this study resulted in much lower scores for students in the area of summarizing or explaining their process work.

Finally, the data indicated that students were more likely to meet the standards when they engaged in planning and were persistent in bringing their vision to completion, a process termed academic tenacity by Carello (2017). Collaborating teachers pointed out that students were highly motivated to participate in makerspace projects. This motivation could also be responsible for the likelihood of students to do more research and reading of diverse texts, which leads to the second research question.

**Research Question Two - Literacy and Critical Thinking**

Research question two asked to what extent participation in a makerspace might support district and building goals related to literacy and critical thinking. Themes related to this question included diverse reading by students, collaboration by teachers, and creativity. The teacher librarian descriptions and reflections indicated that makerspaces did indeed provide support for district initiatives, including promoting literacy skills through the reading of diverse texts for a variety of purposes, as noted in the National School Library Standards (AASL, 2018). This may have been made possible by the
students’ overwhelming ability to identify the problem they wanted or needed to address which was shown by Beaumont et al. (2017) to be a critical factor.

The importance and benefits of collaboration were noted by both the teacher librarians and the collaborating teachers. The collaborating teachers also spoke to a high level of student engagement with the makerspace projects. Finally, they noted that students were likely to engage in more diverse reading due to their makerspace projects.

Creativity was not a topic of direct interest at the outset of the study; however, the ability of students to be critical thinkers could often be connected to their ability to consider information outside of that which was provided by the instructors.

**Recommendations**

This study was based on existing student data selected for its availability after COVID-19 forced the early closure of schools and prevented the collection of original data as intended for study. A replication of the study using the original plan to provide students with a choice inquiry-based makerspace project would provide even more data to support the level to which makerspaces might be valuable components of elementary school libraries. Using a rubric specifically designed for each of the student projects to be assessed would also provide better validity in knowing that meeting the rubric expectations directly aligns with the specific school library or content area standard as related to local school district initiatives. The researchers also recognized the extent to which promoting literacy and promoting problem solving appeared to be interwoven through the AASL, CCSS, and NGSS standards. This relationship would be worthy of additional study.
In addition, the study indicates that having more dedicated and intentional collaboration with classroom teachers could have an increased impact on the achievement of content areas standards and district initiatives. While collaboration was not a focus for the study, the data collected showed the impactfulness of having these additional learning opportunities for both students and teachers. Likewise, creativity and persistence were themes that arose from the data for which having more research regarding the impact of makerspaces on those traits in students could be very beneficial.

Finally, further research could help to better define the impact of students working together in groups, as was the initial intent of this study, compared with students working individually, which was the case for most of the makerspace projects featured in this research. If collaboration showed that much benefit for the adults, it would be helpful to know how much more impactful the makerspace environment could be with student collaboration included as part of the design.
REFERENCES


McKinnon, F. R. (2019). The effects of STEM education on elementary student achievement [ProQuest Information & Learning]. In Dissertation Abstracts International Section A: Humanities and Social Sciences (Vol. 80, Issue 6–A(E)).


http://par.nsf.gov/biblio/10073117
APPENDIX A
STUDENT ARTIFACT RUBRIC

Adapted from Montgomery and Madden (2019) and modified to include alignment with AASL (2018), CCSS.ELA-Literacy.RL (2010), and NGSS (2013) standards.

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>NA</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 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 V.B.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AASL V.C.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Constraints and 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 V.D.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literacy 1</td>
<td>The student correctly identified several conflicts in my novel. The student evaluated the different conflicts and thought about which one my character would benefit most from solving. Student correctly identified the problem and was able to determine an appropriate solution.</td>
<td>The student correctly identified several conflicts in my novel. Student correctly identified the problem.</td>
<td>The student could not identify the conflicts in my novel. The student was not able to correctly identify the problem.</td>
<td>No Evidence Available</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Literacy 2</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. Student was able to appropriately and logically solve the problem.</td>
<td>The student explained characteristics, mood, and features of the setting and characters. Student was able to identify an appropriate and logical solution.</td>
<td>The student could not explain characteristics, mood, and features of the setting and characters. Student could not solve the problem.</td>
<td>No evidence available</td>
</tr>
<tr>
<td>Literacy 3</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. Student appropriately described their design process including 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. Student briefly described their design process but did not include all elements.</td>
<td>The student retold the story instead of summarizing or the student did not state the main points or key details. Student did not describe their design process or solution.</td>
<td>No Evidence Available</td>
</tr>
</tbody>
</table>
APPENDIX B

PARENTAL NOTIFICATION LETTER

My name is Kris Baldwin. I am the Technology Teacher Librarian for _______ Elementary in the ____ Community School District. I am in the process of finishing my master’s degree in School Library Studies at the University of Northern Iowa. One of my degree requirements is to conduct a research study.

My goal in this research study is to determine to what extent participation in a makerspace project impacts students’ use of a design thinking process. As a part of this study, I will observe students involved in a genius hour project, where they develop a proposal for a makerspace project and complete that project during media center time.

As the students work through this process they will complete a design thinking project plan which will be used to guide their designs. Next, the students will work in the makerspace to create a product. When the project is completed, students will present their products to each other, and discuss if their creations were successful or needed more work.

Using the students’ project plan, their rubric of self assessment, and my observations of their work, I will conclude the unit with a focus group conversation for students to reflect and comment on their experience. The focus group will be recorded and later transcribed.

These activities are a normal part of class and involve all students, however, providing me with permission to use the data from my notes, observations, and assessment of projects is voluntary. Risks are minimal, and there will be no compensation for students’ time.

My research will be submitted to the Department of Curriculum and Instruction as part of the requirements for the degree of MA in School Library Studies. Results and findings will be shared with other school librarians and may be published in a journal or presented at conferences. If you have questions about this study, or if you would prefer that I not include data from my notes and assessments of your child please contact me at baldwkaa@uni.edu. You may also contact my faculty advisor, Dr. Karla Krueger at karla.krueger@uni.edu. If you have questions about the rights of research participants, please contact the UNI IRB Administrator at anita.gordon@uni.edu.
APPENDIX C

COLLABORATING TEACHER QUESTIONS

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)
APPENDIX D

TEMPLATE FOR OBSERVATIONS - REFLECTIONS ON STUDENT WORK

Completed by the teacher librarian for each student project in their designated group.

**Reflection/Observation for:**

What I observed and remember about this student’s process and product as related to

<table>
<thead>
<tr>
<th>Design Process:</th>
<th>Was there evidence of the student utilizing the design process?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Did they complete each step before moving on to the next step?</td>
</tr>
<tr>
<td></td>
<td>(planning and designing, adapting as encountered challenges)</td>
</tr>
<tr>
<td></td>
<td>Was the product tested and revised to achieve success? Did the</td>
</tr>
<tr>
<td></td>
<td>student share information regarding the evolution of the product?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Critical Thinking/ Creativity:</th>
<th>In what ways did the student construct arguments by considering multiple perspectives?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Did they ask relevant and thoughtful questions to develop ideas and apply them in multiple ways?</td>
</tr>
<tr>
<td></td>
<td>Was it possible to see the student evaluate and combine ideas to support decisions?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraints/ Criteria:</th>
<th>How well did the student work within the constraints and follow the criteria for the project?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Did you notice any adjustments the student made due to the available resources?</td>
</tr>
</tbody>
</table>

A final row for Literacy was added by the literacy teacher librarian after the rubric was updated to include all six categories, but was not used by the art and STEAM teacher librarians.
APPENDIX E

AASL, CCSS, AND NGSS STANDARDS ADDRESSED IN STUDY

Rubric alignments are noted in parentheses at the end of each standard.

National School Library Standards, Explore, AASL, 2018

Learners develop and satisfy personal curiosity by:
V.A.1 - Reading widely and deeply in multiple formats and writing and creating for a variety of purposes. (Literacy 1, 2, and 3)

V.A.3 - Engaging in inquiry-based processes for personal growth. (Design process)

Learners construct new knowledge by:
V.B.1 - Problem solving through cycles of design, implementation, and reflection. (Critical thinking)

Learners engage with the learning community by:
V.C.1 - Expressing curiosity about a topic of personal interest or curricular relevance. (Critical thinking)

Learners develop through experience and reflection by:
V.D.1 - Iteratively responding to challenges. (Constraints and Criteria)

English Language Arts for Literacy in Reading Literature, CCSS, 2010

4.2 - Determine a theme of a story, drama, or poem from details in the text; summarize the text. (Literacy 3)

4.3 - 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). (Literacy 2)

5.2 - 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; summarize the text. (Literacy 1)

2013 Next Generation Science Standards, Appendix F - Science and Engineering Practices in the NGSS

Developed by National Research Council (NRC), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS)

Practice # 1 - Asking Questions and Defining Problems
Asking questions and defining problems in grades 3-5 builds on grades K-2 experiences and progresses to specifying qualitative relationships.
3-PS2-4 Define a simple design problem that can be solved through the development of a new or improved object or tool. (Literacy 1)

**Practice # 6 - Constructing Explanations and Designing Solutions**
Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

3-LS3-2 and 3-LS4-2 Use evidence (e.g., observations, patterns) to support an explanation. (Literacy 3)

**Practice #8 - Obtaining, Evaluating, and Communicating Information**
Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

5-ESS3-1 Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (Literacy 2)