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

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

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Abstract

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

The purpose of this qualitative case study was to examine whether makerspace or STEAM activities can support inquiry learning and meet specific American Association of School Library (AASL), Next Generation Science (NGSS) and Common Core Literacy (CCSS ELA) Standards. For purposes of this study, the three co-researchers were also focused on how this type of learning activity can support district initiatives in literacy, design thinking, novel engineering, STEAM and makerspace activities, as well as supporting specific district initiatives such as Lucy Calkins Units of Student in Reading and Project Lead the Way. The three co-researchers examined data from three different study sites. The data sources included lesson descriptions and reflections from the three teacher librarians (the co-researchers), 47 student work samples from 40 different students along with teacher librarian reflections on the student work, and three collaborating teachers' reflections about their students' experiences and learning that occurred as a result of these lessons. The data collected for this study indicates the majority of students who participated in the makerspace/STEAM activities met the identified standards from AASL, NGSS and CCSS ELA. The teacher librarians' reflections and lesson descriptions demonstrated a connection to district initiatives and collaborating teachers' reflections indicated that these lessons are engaging for students, encouraging them to consider personal interests and continue to learn about these and other related topics. When students are provided the opportunity to participate in hands-on learning activities that align with district initiatives, the overall results are positive.

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

A Graduate Research Project
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
Lisa Tegels
August 2020

This Project by: Lisa Tegels
Titled: Three Cases Of Makerspace Integration In School Library Programs In Conjunction With District Initiatives: STEAM, Design Thinking, And Literacy

has been approved as meeting the research requirement for the

Degree of Master of Arts.

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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 Kris Baldwin and Sara Pflughaupt.

The purpose of this qualitative case study was to examine whether makerspace or STEAM activities can support inquiry learning and meet specific American Association of School Library (AASL), Next Generation Science (NGSS) and Common Core Literacy (CCSS ELA) Standards. For purposes of this study, the three co-researchers were also focused on how this type of learning activity can support district initiatives in literacy, design thinking, novel engineering, STEAM and makerspace activities, as well as supporting specific district initiatives such as Lucy Calkins Units of Student in Reading and Project Lead the Way. The three co-researchers examined data from three different study sites. The data sources included lesson descriptions and reflections from the three teacher librarians (the co-researchers), 47 student work samples from 40 different students along with teacher librarian reflections on the student work, and three collaborating teachers' reflections about their students' experiences and learning that occurred as a result of these lessons. The data collected for this study indicates the majority of students who participated in the makerspace/STEAM activities met the identified standards from AASL, NGSS and CCSS ELA. The teacher librarians' reflections and lesson descriptions demonstrated a connection to district initiatives and collaborating teachers' reflections indicated that these lessons are engaging for students, encouraging them to consider personal interests and continue to learn about these and

other related topics. When students are provided the opportunity to participate in hands-on learning activities that align with district initiatives, the overall results are positive.

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CHAPTER 1

INTRODUCTION

As part of a focused initiative in one school district, a cart of makerspace and STEAM (Science, Technology, Engineering, Arts and Math) materials is provided to each elementary school, along with several training sessions for the school librarian provided by the staff of a local science center. The school librarian recognizes the potential of this opportunity and decides to provide students with makerspace and STEAM activities during regularly-scheduled library classes. The school librarian wonders if there is a way to show a direct correlation between makerspace or STEAM activities and alignment with American Association of Library (AASL) standards, Common Core Literacy (CCSS ELA) standards and Next Generation Science standards (NGSS) to show the value of makerspace activities as significant learning opportunities.

Justification

School librarians have long recognized the importance of connecting library resources with user-initiated and led learning (inquiry), which is one of the fundamental philosophies surrounding the development of 21st century skills (P21 Partnership for 21st Century Learning, 2020). Adopting a makerspace can give school libraries the opportunity to support creative thinking, encourage innovation, address 21st century learning and model implementation of standards in engineering, literacy and design, while integrating library standards.

Although one makerspace can look very different from another, depending on where the space is located and the users (Fontichiaro, 2016), the core tenets are self

directed learning based on student interest, a tolerance for failure and retrial, peer collaboration and skill sharing among experts and novices (Oliver, 2016). In a school makerspace, students create, explore, invent, tinker, and discover using a variety of tools or materials (Loertscher, 2012). In some makerspace areas students may have access to woodworking tools or sewing machines; in others, they may use Spheros, Ozobots, Makey Makeys or other electronic resources. Yet still other makerspace areas may provide KEVA planks or LEGO bricks for students to use in construction projects connected to Novel Engineering. The activities that take place in a makerspace are typically open-ended and student driven. Regardless of the materials available, within a makerspace, students are encouraged to explore creatively and take ownership of their learning (Kurti, 2014.)

Makerspace and STEAM have many things in common and the terms are, at times, used almost interchangeably. The STEAM movement encompasses learning that incorporates any combination of the subjects included in the acronym STEAM (science, technology, engineering, arts and mathematics) and has received attention as a way for students to engage in creative, imaginative and ingenious learning activities (Froschauer, 2016). Both makerspace and STEAM focus on the integration of cross-disciplinary student-led learning, and both can take place anywhere, not just in a designated makerspace area. Bowler (2014) attests to the underlying goal of a makerspace noting an emphasis on "innovation and creativity through the use of technology" (p. 59) and an intent "to offer a place where everything from STEM learning to critical expression to future start-ups can be nurtured" (p. 59). As makerspaces become more common in

school libraries, students can be empowered to explore their own interest areas through an interdisciplinary merging of making, STEAM, literacy, design thinking and inquiry. Providing the opportunity for exploration of interest areas allows for increased student voice and choice in the learning experience.

The AASL shares the common core belief that school libraries are a unique and critical part of a learning community (AASL, 2018) with the shared foundations that it is important for students to learn how to inquire, collaborate, and explore. It is important for teacher librarians to show a connection between makerspace, STEAM, literacy activities (as in novel engineering), design thinking, inquiry and educational standards such as those from NGSS, AASL and CCSS ELA. Demonstrating these connections to important standards reinforces the value of the school library program and can be a major point of advocacy for the school librarian.

Rationale

Makerspace, STEAM, novel engineering and design thinking have become relatively commonplace in schools, especially school libraries, and there is no doubt students enjoy the hands-on learning experiences. However, it is important that teacher librarians are able to show direct correlation between identified standards and the learning that is taking place through these activities.

Summary of Problem Statement

As new curriculums are adopted and teachers are expected to include additional content in the school day, finding time for activities such as makerspace and STEAM can be challenging. By determining the extent to which these activities align with NGSS, AASL and CCSS ELA standards, it may be possible to show that providing opportunities for students to participate in these types of hands-on learning activities is both engaging for students and meets these important standards.

Purpose

The purpose of this study is to describe the connection between makerspace activities taking place in a school library setting and NGSS and AASL standards.

Research Questions

1. How do makerspace/STEAM activities align with AASL standards?
2. How do makerspace/STEAM activities align with NGSS standards?

Assumptions and Limitations

This study assumes that students have access to makerspace/STEAM activities in a school library setting and that lessons are being designed that align with the AASL and NGSS standards. The scope of this research project is limited to three midwestern elementary school libraries and the student work that was completed in one year..

CHAPTER 2

LITERATURE REVIEW

The purpose of this research study is to determine to what extent the activities taking place in a makerspace environment enhance student learning and align with AASL, NGSS, and CCSS ELA standards. The three areas of prior research that inform this study are makerspace, inquiry and STEAM.

Makerspace

Hussain and Nisha (2017) conducted a study designed to understand the perception and overall usage of library makerspaces. Using an online survey and random sampling, a total of 470 completed questionnaires were used to calculate their final results. This study determined that all makerspaces were introduced within the past 10 years with the majority introduced since 2016. As expected, the makerspaces contain different tools and services. Almost half contain a computer workstation, some offered photo scanning opportunities and a few contained a 3D printer. More than 50% of respondents offered student workshops in their makerspace, while fewer (17%) provided a series of guided lessons that culminated in a final project. The majority of respondents viewed makerspace as valuable in helping students learn about local and global economies. Seventy percent of respondents indicated the makerspace was valuable or highly valuable to users overall. Researchers determined that by increasing awareness, the programs are more likely to be successful in the future.

Bieraugel and Neill (2017) examined whether learning spaces in libraries or elsewhere on school campuses fostered learning, creativity and innovation (key

components of makerspace and STEAM activities.) This study used Margaret Boden's definition of creativity which is "the ability to come up with ideas or artifacts that are new, surprising and valuable" (Bieraugel & Neill, 2017, p. 36) and defined innovation as the application of creativity for practical purposes. While this study focused on students in a college (undergraduate) setting, the results can be applied to all students, regardless of age or level of study. Results were gathered from 226 random students who were using one of eight pre-selected locations on campus, including a designated makerspace area. Results from this study showed that many different areas could be used to effectively explore, collaborate (this study calls it networking), and experiment. When a space was too busy or filled with materials, it could be challenging for learners to reflect on the learning that's taking place. Researchers recommended mindfulness of the need for students to have space to participate in different aspects of the learning process from observing, questioning, exploring, experimenting, networking (collaborating) and reflecting. This study showed that providing space for students to work together and separately can impact the level of learning that takes place.

In another research project, Li and Todd (2019) studied the opportunities and desired outcomes that impacted young people's desire to participate in makerspace activities hosted in the library. This study examined a public library makerspace and a public middle school makerspace in a somewhat rural area of New Jersey. These facilities were selected because of the diverse programming and the way they used space for their programming. In all, 21 participants were included in the qualitative study. Eighteen of the 21 participants described their desire to freely create and build something as a major

reason for their participation in the makerspace offerings. All 21 participants said they gained enjoyment and excitement through making and 14 reported that the makerspace gave them the opportunity to learn new technologies. The opportunity to be social and have fun were also noted as important. Overall, this study demonstrated that young people were interested in makerspace activities because they wanted to make, learn, hang out and engage with their personal interests, confirming the impact that increased voice and choice has in student learning and engagement.

Inquiry

Learning through inquiry has become more common as educational practices have moved away from rote memorization and evolved into more of a student-centered analytical thinking approach. Through inquiry learning, students come up with questions based on personal interest, curiosity or the topic at hand and use those questions to drive the learning process. Makerspace and STEAM activities fit well with inquiry as students typically engage with hands-on learning in these situations.

Garrison, FitzGerald and Sheerman (2019) examined the feasibility of helping learners become skilled at thinking creatively and critically while collaborating with others as they pursue learning and understanding. At the same time, ensuring that these learners are performing well on standardized tests. This study took place in Australia and the focus was how guided inquiry supports students' information literacy skills when engaged in a research project. The setting was a K-12 private suburban school with a strong history of using guided inquiry and the participants were 22 level 9 students (out of 100) who volunteered to participate. One of the areas students in this study found easy

was displaying curiosity. Participants especially noted that being allowed to choose their own research topic led to increased motivation and enthusiasm. This study noted an interesting dichotomy between students desiring the autonomy of completing the assignment their own way and wanting guidance from the instructor on how best to proceed. This study confirmed the challenge of balancing student voice and choice, while ensuring that specific standards were being met.

Bailey and Jacobsen (2019) conducted a research study to help better understand the role of librarians in embedded, collaborative teaching and to identify ways for faculty and librarians to improve collaborative teaching in order to integrate library instruction across a variety of subjects. This study took place at a private four-year liberal arts and science college in the midwest. The research team designed three different plans to include library instruction in an undergraduate writing course. In one plan, the librarian came into the class for one period (a one-shot session), in the second, the librarian was present for 10 classes as an observer and a support (present for 150 minutes of class time) and in the third design, the librarian attended all classes and taught two class periods. In the third design, the librarian also reviewed assignments and gave feedback to students. Data was collected from observations, notes, a student questionnaire, a faculty questionnaire, student interviews and a research summary. Based on the data collected, researchers felt that design 3 with the embedded librarian provided the best opportunity for just-in-time learning and gave students the opportunity to hear the same instructional material from a different perspective, which was beneficial. Further studies are warranted, but this researchers believe this study showed promising results.

The inquiry process has a lot of potential both for enriching the student learning experience and as a point of advocacy for school librarians. Stripling (2020) explained, "inquiry may be the school librarian's most important tool to accomplish a vision of student empowerment and learning" (p. 16). Rather than waiting to find time to sit down and plan collaborative units with classroom teachers, Stripling suggests that school librarians take on a proactive role to identify essential skills by analyzing school curriculum, identifying current projects and assignments and using test scores or other data points to identify areas for improvement. Once school librarians have put together a basic instructional plan, collaborative conversations can begin. By aligning skills taught in the library with those taught in the classroom, learning is more likely to be impactful and retained.

STEAM

Johnston (2018) conducted a study focused on teacher librarians who were employed by rural STEM schools in Alabama, Georgia and Louisiana to determine the knowledge, skills and abilities they felt were needed to be successful and to determine if these teacher librarians felt that they had been aptly prepared for this in their schooling. The researcher located twelve teacher librarians in Georgia, eight in Alabama and six in Louisiana who were willing to take part in the study. By traveling to each school, the researcher was able to complete face to face interviews with each participant and observe each school library first hand.

The 26 participant interviews shared similar experiences of making cross-curricular connections and the recognition that research skills can be applied in all subject areas

(Johnston, 2018). Most participants noted the importance of teaching students a thinking process similar to design thinking or the engineering process, inquiry based learning and computational thinking. Teaching students to locate and use quality digital information, teaching coding, training teachers in technology and STEM topics, designing a functional and welcoming environment were also topics mentioned by participants. None of the participants felt that their education program prepared them for these responsibilities.

Overall, this study found that teacher prep programs need to evolve and better prepare future teacher librarians for the expectations of today's responsibilities, including the foundational STEM topics of science, technology, engineering and mathematics. Educating teacher librarians about available resources, including Open Educational Resources (OER), and how they can best be used in the school setting were specifically mentioned, as well.

Recognizing the importance of digital resources in STEM education, Luetkemeyer and Mardis (2013) conducted a study that closely examined the Discovery Education Streaming to determine whether it could enhance school library collections. The rationale behind the study was the understanding that teacher librarians are the only educators typically asked to build and maintain a diverse, high quality library of both print and digital resources. Some districts were promoting the adoption of digital textbooks and despite the availability of OER resources (which are typically free or very low cost) many digital textbooks carry a relatively high price, which results in companies having a strong interest in acquiring subscribers.

Luetkemeyer and Mardis (2013) logged into Discovery Education Streaming over a three-day period and closely examined the offerings by grade level. Findings determined that Discovery Education Streaming appeared to be a better choice for grade 3 and higher, as the system had the most options available for upper elementary and middle grades. The majority of material was video clips, most from groups like NASA, Smithsonian, PBS and the Discovery Channel. While the quality of video was good and appeared reliable, the age of many of the clips was over the recommended threshold of seven years. In summary, the researcher determined that Discovery Education Streaming could be a valuable resource, but that it's important for teacher librarians to actively seek diverse and high quality STEM resources.

Mardis, ElBasri, Norton and Newsum (2012) synthesized current research and identified trends to watch related to school improvement in terms of STEM education, student engagement and 21st Century Skills. What they found was that the way in which digital media and technology were used differentiated between teaching and high quality teaching. Some of the challenges teachers faced were identifying high quality, affordable resources, organizing these resources so they could be used for future teaching, differentiating instruction, staying up to date on current trends and resources and finding enough time to do these things well. This article noted that while the Internet is a valuable source of a plethora of material, it can be, at times, a double-edged sword.

Factors identified as essential in providing a high quality education with regards to STEM and 21st century skills were the availability of high quality, agenda-neutral, free (or very low cost) materials, having on-site technical support, supportive administrators,

adequate bandwidth to be able to properly run the digital resources, a teacher librarian and respect for teachers' professional expertise. This article emphasized that in addition to adding curation tools to digital resources, consideration must be given to the essential conditions (price, available bandwidth, teacher comfort level, etc.) for changes to happen at the local level.

Summary

School libraries are uniquely positioned to offer students exposure to a variety of learning opportunities, including STEAM and makerspace activities, as well as to help classroom teachers integrate this type of learning into their lessons. The commonalities of these studies showed the importance of students being able to honor personal choice, connect with others and learn through doing. When students have the opportunity to engage with other learners and focus on topics that interest them, their learning is more impactful and they are more motivated to actively participate. It's also important that teachers and teacher librarians feel comfortable with technology, STEAM topics and available resources so that they can offer curate resources and quality learning experiences to their students. Based on the available research, this investigator believes it is important to determine to what extent the activities taking place in a makerspace environment enhance student learning and align with AASL, NGSS, CCSS ELA standards.

CHAPTER 3

METHODOLOGY

This qualitative case study was designed to describe how makerspace activities align with and support specific AASL, CCSS ELA, and NGSS standards.

Research Design

This study was developed using student work from three elementary schools located in the midwest. A qualitative case study was chosen because it "examines contemporary events in a natural setting" (Wildemuth, 2009, p. 59). Students in 4th and 5th grades participated in various makerspace-type activities: an interactive art project, a novel engineering project and STEAM/makerspace center activities.

The three data sources used in this study were student work samples, classroom teacher reflections and reflections from the three teacher librarian co-researchers. Student data was collected during the 2019-2020 school year at three different midwestern elementary schools. Researcher reflections and classroom teacher reflections were collected in the spring semester of 2020. Because of restrictions in place due to the Covid-19 health crisis, no additional student work was available.

The Art Project focused on design thinking which is based on the Engineering Design Process (EDP) framework from the Boston Museum of Science. In this specific project, the steps of the process: Ask, Imagine, Plan, Create and Improve are designed to help elementary students move through the guided inquiry process. Students were tasked with creating an interactive art design using graphite pencil and Makey Makey circuits that would include four quadrants.

The Literacy Project focused on the aspects of design, critical thinking, constraints and the connection to specific literacy standards through the use of the book *The Tiger Rising*. Students were encouraged to design and create a suitcase, similar to the main character in the story, in which they could place pieces of paper in which they had drawn or written down personal feelings that they might want to emotionally stuff away.

The STEAM Project was an eight-week unit where small groups of students would work at one STEAM station each week during their scheduled library class time. During this unit, all students would have the opportunity to experience each station which included a LEGO challenge, coding with Edison robots, completing OSMO activities, constructing a marble run, creating designs with Perler beads, coding Ollie robots, etc. However, because of Covid-19, the unit ended after the third week so each group of students only had the opportunity to visit three of the stations.

Participants

The student work samples used in this study were from students enrolled in one of three elementary schools where the researchers were employed as teacher librarians. Student work was selected for this research project based on level of completion at the time that schools transitioned to remote (online) learning. All of the students were either 4th or 5th graders and the projects analyzed were completed during library media class time. In total, there were 14 students in the art group (five 4th graders and nine 5th graders) who completed 14 projects, 12 students in the literacy group (all 4th graders) who completed 12 projects, and 14 students in the STEAM group (eleven 4th graders and three 5th graders) who completed a total of 21 projects. In addition, three collaborating

classroom teachers (one from each school) provided reflections on their own perceptions of the makerspace activities and its impact on the students. The three co-researchers provided lesson plans and personal reflections, as well.

Data Collection

Data for this research project was collected from three different sources: student work samples, teacher librarian reflections and classroom teachers' reflections. These three sources provided the opportunity to examine data obtained in different ways, reflecting Wildemuth's (2009) recommendation that data from artifacts or documents be analyzed in combination with data obtained from other methods (p. 161). The first data source was student work samples that were collected and organized into a common format to include a description of the assigned task, a photograph of the work (when available) and notes from each teacher librarian (co-researcher). Each teacher librarian also provided an assessment of the student work samples using a rubric adapted from Montgomery and Madden (2019) and aligned with AASL, NGSS, and CCSS ELA standards. The second data source was reflections of the three collaborating classroom teachers, whose students had participated in one of the makerspace activities. Each classroom teacher was emailed a brief questionnaire and responded via email. The third data source was the teacher librarians' lesson plans and reflections on their instructional activities. These reflections helped the co-researchers fully understand the structure of the lessons and activities happening at each location.

Data Analysis

The three co-researchers worked closely together, following Wildmuth's (2009) eight-step qualitative content analysis process in order to process the data equitably and consistently.

Step 1: Prepare the Data

The co-researchers met weekly to discuss the scope of the research project and to align the data into similar categories. Each teacher librarian wrote out her specific lesson plan and a brief reflection about the lesson. The three teacher librarians then shared their lesson plans, reflections and instructional materials with the other co-researchers. The responses to the collaborating teacher email questionnaire were collected and merged into one document. Student work was organized by using a standard template (Appendix A) which provided space for the teacher librarians to describe the student work and to note student comments or observations related to inquiry, collaboration, and creativity. The co-researchers designed the template to align with the categories shown in the rubric (Appendix B) which included design process, critical thinking/creativity, and constraints/criteria. At the top of each template was a brief description of the purpose and expected outcomes from that assignment. This design provided the teacher librarians with a standard format to use when organizing the student work and later, when scoring the work.

Step 2: Define the Units of Analysis

The co-researchers used the research questions which aligned with use of the design process, AASL Standards and the connections to their school initiatives. Keeping

these categories in the forefront, the researchers also examined the data for patterns that might emerge from the results.

Step 3: Develop Categories and a Coding Scheme

While Wildemuth (2009) recommends creating a coding manual to ensure consistency in coding, the three co-researchers for this project instead met weekly to carefully consider and discuss the categories and coding scheme that would best fit the project parameters. Scores were assigned according to the six categories of the scoring rubric: Design Thinking, Critical Thinking, Constraints and Criteria, Literacy- Identifying a Problem/Conflict; Literacy- Making a Plan Solving the Problem, Literacy- Summarizing/Sharing. Researchers agreed to assign scores of 3 (high), 2 (mid), or 1 (low) while working independently from one another. They agreed to compare scores after all scoring was completed.

Step 4: Test Coding Scheme on a Sample

In order to test the coding scheme, the co-researchers tested the code on a small number of student projects, then reconvened to compare the coding and discuss. After examining the results and clarifying several of the categories, the researchers determined that the planned coding scheme was appropriate and agreed to move ahead with coding all of the student work samples.

Step 5: Code all of the Text

After determining that the coding scheme was appropriate, the co-researchers then worked independently to score all 47 student work samples. Each researcher was careful during the coding process to ensure that each work sample was reviewed objectively and

consistently. In order to score student projects equitably, the researchers used both pictures and descriptions together, as much as possible. In cases where it was challenging to see evidence of some component in the picture, they referred to the written descriptions instead.

Step 6: Assess Coding Consistency

Once all scoring was completed, the complete collection of scores was compiled into a shared spreadsheet. At that point, the co-researchers analyzed the variance or similarity of their scores by highlighting any instances in which researcher scores varied more than one point, for example with scores that showed both a 1 and a 3 for the same item. Researchers then discussed the discrepancies greater than one in order to determine whether there was any error in understanding the student work sample, to question whether the criterion was applied consistently. If so, then the varied scores were kept. Most often the discrepancy derived from a lower score assigned by the researcher librarian who taught the students and felt the students didn't meet the criteria, whereas another researcher read the explanation in the description, and based on the written description determined that the student had met the criteria for the standard.

Step 7: Draw Conclusions from the Coded Data

Based on the compiled scores collected in the spreadsheet, the co-researchers each examined the data to determine whether the activities showed evidence of students meeting the identified standards. The researchers also looked for patterns within the data.

Step 8: Report Findings and Methods

The results of this qualitative research study were reported out through a thesis that each co-researcher prepared. Since qualitative data is typically interpretative (Wildemuth, 2009) the researchers made every attempt to balance both evidence and a clear description of the process.

Limitations

Due to Covid-19 related school closures, access to additional student work was not possible. Student work included in this study was limited to that which was most fully completed by the date that face-to-face instruction ended. Student work for the Art Project was limited to those students who attended a celebration held during the evening in February 2020. Each co-researcher chose a limited number of student work samples to use for this research study. The student work that was selected was based on the completeness of the project, the availability of photographic evidence and which projects the researchers could remember most clearly.

CHAPTER 4

FINDINGS

The purpose of this research study was to determine to what extent the activities taking place in a makerspace environment enhance student learning and align with American Association of Library (AASL) standards, Common Core Literacy standards and Next Generation Science Standards (NGSS.). Three co-researchers examined and analyzed three data sources: assessments of student work, reflections from the three teacher librarians and feedback from three collaborating teachers, obtained through an emailed questionnaire.

Observation and Reflection

The three co-researchers in this study, who are also teacher librarians, compiled descriptions of the lesson(s) taught and their reflections on the teaching experience. These lesson descriptions and reflections allowed the fellow researchers to more fully understand the lesson purposes and structure, since the artifacts provided were from the data available at the time, and may not have been fully complete. School closures due to Covid-19 did not allow for specially designed research projects to be implemented. From these observations and reflections, three main categories emerged: collaboration with other teachers, student reflection on learning and support for various district initiatives.

Collaboration with Other Teachers

Each teacher librarian noted the impact and importance of collaboration with classroom (or other) teachers when working with students. Interestingly, each teacher

librarian was the initiator of the collaborative conversation by reaching out to another teacher in their building.

Student Reflection on Learning

Providing the opportunity for students to reflect on their learning empowers them to consider what they learned that might have changed an opinion, what they learned to do differently the next time and what they learned that they did not previously know. As the teacher librarian for the Literacy Project noted, providing this reflection time for students helped "deepen their understanding of the themes, life lessons, and detailed explanations within the text." The teacher librarian for the STEAM Project explained that asking students to complete exit slips at the end of each class "helped students take their learning to a deeper level" and provided feedback about which centers students found to be most engaging and interactive, which is helpful for future lesson planning. The teacher librarian for the Art Project shared similar thoughts and encouraged her students to use notecards for planning and to review their ideas to determine which may have needed to be refined as they moved through the design process.

Support of District Initiatives

In all three instances, the makerspace activities provided opportunities for students to delve more deeply into standards that aligned with district initiatives. The Art Project connected computer science and coding to the design thinking process, the Literacy Project was based on a mentor text from Lucy Calkins' Units of Study in Reading (UOS) program and the STEAM Project was initially developed through a partnership with a local science museum to support makerspace and STEAM activities.

Feedback from Collaborating Teachers

This researcher identified four main themes in the data collected from the collaborating teachers: student engagement, student interest and curiosity, encouragement of reading and the value of collaboration. The collaborating teacher data was solicited and collected via brief email questionnaire. One collaborating teacher responded from each of the art, literacy and STEAM locations.

Student Engagement

Active student engagement and overall enthusiasm was high, as noted by each of the three collaborating teachers. The collaborating teacher for the Art Project commented that "students were actively participating and taking risks" and that students "showed pride and excitement" when showing their learning to others. For the Literacy Project, the collaborating teacher noted that students were actively engaged and the collaborating teacher for the STEAM Project noticed "many excited comments" and that students were excited to see what activities would be available each week "that we don't always have time for in the regular classroom."

Student Curiosity and Interest

The makerspace activities supported student curiosity and helped pique student interest. The collaborating teacher for the Art Project noted, "students were excited and curious about combining technology and art," the collaborating teacher for the Literacy Project explained that the opportunity for students to share and explore personal interests "came into play during the conversation about what we all had inside of our suitcase" and the collaborating teacher for the STEAM Project noted that students were able to choose

topics of interest during their non-fiction unit of UOS that was "fueled by a connection to how things go together which was impressed upon them through the creative side of the makerspace activities."

Encouragement of Reading

Participating in makerspace activities appeared to have a positive impact on students' connections to reading material. The collaborating teacher in the Art Project said that students were encouraged to "search online and read more about interactive art and artists who use technology in their work." The collaborating teacher in the Literacy Project explained that the text to real world connection was a big takeaway from the project and that students took their own personal experiences to "connect to a deeper meaning within a text." The collaborating teacher for the STEAM Project explained that the makerspace activities "stirred interest" so that students were able to make personal connections that drove their reading selections. Additionally, she noted that the "makerspace activities encourage more reading both in fiction and non-fiction."

Value of Collaboration

Though there was not a question on the survey asking specifically about collaboration, each of the collaborating teachers mentioned it in their responses. As the collaborating teacher for the Art Project said, "the parallel teaching helped students reinforce the learning." The collaborating teacher in the Literacy Project noted that through the collaborative process, students were able to experience hands-on activities as well as explore meaningful content connected to what was happening in the classroom reading content. The collaborating teacher for the STEAM unit explained that the teacher

librarian "shared ideas with classroom teachers which helped us make connections on our digital libraries as well." These ideas were shared with classroom teachers on the days that their students had library class so the connection was immediate and there was no lapse from one experience to the other and a continuity of learning could easily be maintained. She further explained, "our world and the world of our future little humans we serve is changing and as much as I loved just sitting in the library and reading or hearing stories when I was my students' age, I know how important it is to expand young minds in many different ways to provide them with experiences that encourage them to keep learning and exploring the world around them that is more reachable now than ever."

Assessment of Student Work Samples

In order to evaluate the student work consistently, each of the 47 student work samples was examined and scored by the three co-researchers using a two-part rubric (see Appendix A) with the following categories in the first section: design process, critical/creative thinking, constraints and considerations. The second part of the rubric was designed to align more specifically with specific district initiatives. The teacher librarian for the Literacy focused project used the additional categories in the rubric to connect directly to literacy for her student work, while the teacher librarians for the Art and STEAM Projects aligned these additional categories with NGSS standards related to problem solving. All student work had previously been organized into a template formatted to align with the rubric. The majority of the STEAM student work samples included a student reflection. The Literacy student work samples did not show student

reflections, but the teacher librarian for the Literacy Project noted student reflections in her descriptions of the projects. The Art students had been asked to use a notecard for design purposes and while those were not available to the co-researchers, the teacher librarian for the Art Project noted that the notecards had been helpful to keep students focused and moving forward on the assigned task. Any available student reflections, whether available to the researchers or noted through the teacher librarian reflections, were taken into consideration during the scoring process.

Rubric Section 1

Design Process

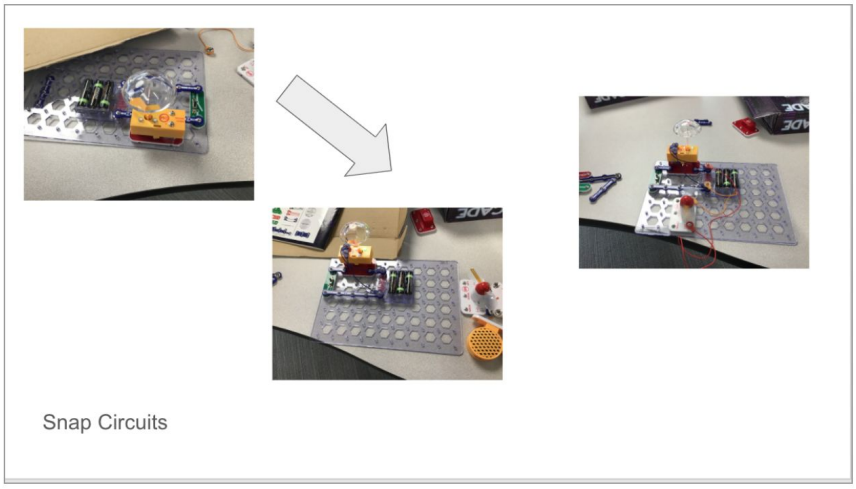
The first category used to evaluate the student work samples using the rubric adapted for this study (see Appendix B) was the design process. This category was based on AASL Standard V.A.3: "Engaging in Inquiry Based Processes for Personal Growth" (AASL, 2018). The Design Process is a creative problem solving framework that encourages learners to move through a series of steps as they move from a concept to a possible solution. Using a design process provides an opportunity for learners to meet this AASL Standard.

Examining scores from all three co-researchers, five of the 14 STEAM students received a score of 3 from each researcher (the highest score possible) and met AASL Standard V.A.3. Three of the 14 students who completed the Art Project received a score of 3 from all three researchers and five of the 12 students who completed the Literacy Project received a score of 3 from all three researchers and met AASL Standard V.A.3.

One student project that received a perfect score in the Design Process category was STEAM Student 8. This project involved creating an electrical circuit using a Snap Circuit set (Figure 1.) While each Snap Circuit set comes with an instructional booklet filled with examples of working circuits that students can recreate, STEAM Student 8 chose not to look at the booklet at all. After examining all of the available components, this student realized he would need to have a power source (battery), kit pieces to create a circuit and then a feature piece that would do something to show that the circuit was working (either sound, light or movement.) Through trial and error, this student was able to create a circuit that lit up. He took photos of his work process and included that to show his work.

Figure 1

STEAM Student 8 project sample

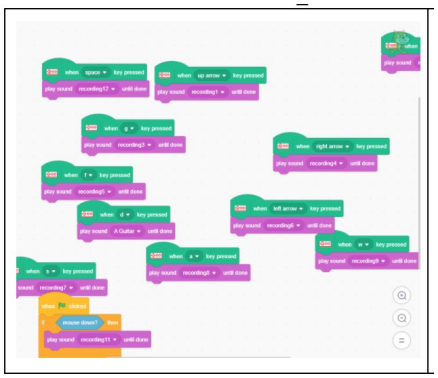


Art Student 11 also received a perfect score of 3 from all three co-researchers. This student (Figure 2) chose to include six Makey-Makey connections as part of the project, rather than using only the required four. The teacher was not familiar with

creating six circuits, so Art Student 11 took the initiative to research this challenge and come up with some possible solutions. In addition, Art Student 11 decided to include if-then statements in the coding, which was a more complex task than had been assigned and was interested in learning about how to find or generate sounds that weren't readily available.

Figure 2

Art Student 11 Project Sample



Literacy Student 8 (Figure 3) also received scores of all 3s from the three co-researchers. This student used the design process to create a suitcase that was sturdy and had a separate handle constructed of popsicle sticks and duct tape. Literacy Student 8 had a plan for the project from the beginning so knew to leave an opening so that items could be placed inside the suitcase. Some other students forgot about that part of the assignment. This student also wrote down personal feelings to place inside the suitcase and shared those feelings during the group discussion.

Figure 3

Literacy Student 8 Project Sample

Critical/Creative Thinking

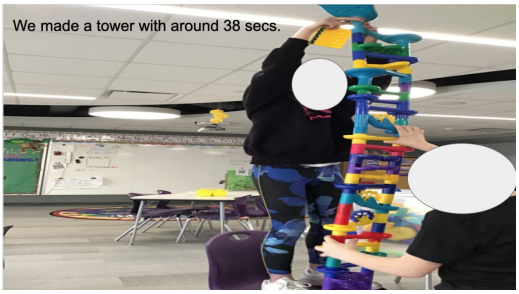
In the Critical/Creative Thinking category, the co-researchers were looking to see if students asked relevant and thoughtful questions and if students constructed ideas by consolidating other perspectives. These considerations align with AASL Standards V.B.1 which is "Problem solving through cycles of design, implementation, and reflection" (AASL, 2018), and AASL V.C.1 which is, "Expressing curiosity about a topic of personal interest or curricular relevance" (AASL, 2018). Five of the 14 STEAM students received the highest possible score of 3 from all three co-researchers, Four of the 14 art students received a score of 3 from the three co-researchers and five of the 12 Art students received a score of 3 from all of the co-researchers.

In the STEAM activity, students were tasked with creating a marble run that would take at least 25 seconds to travel from start to finish. STEAM Student 7 received a score of 3 from all three co-researchers (Figure 4). This student worked with other members of his group to construct a marble run that took 38 seconds to complete. During the

construction process, STEAM Student 7 worked collaboratively with the other members of his group, discussing which pieces would fit well together to help meet their goal.

Figure 4

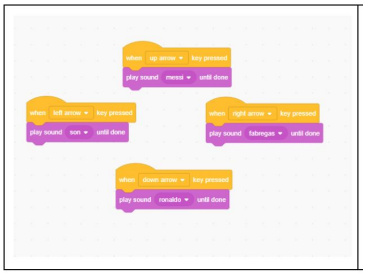
STEAM Student 7 Project Sample



Art Student 13 was determined to use specific sounds with his project and asked for assistance in finding different soccer-related sounds (Figure 5). He was unsuccessful in finding one specific sound, a whoosh to symbolize a goal, so the student researched and found a way to record his own sound clip to accompany his project. Although a photo of the artwork is not available to show, Art Student 13 spent time creating four different logos to represent four different soccer teams, which he chose for the sections of the four quadrants in his project. Through questioning, research, trial and error, the student was successful in completing the project.

Figure 5

Art Student 13 Project Sample



Among the Literacy work samples, Literacy Student 6 successfully created their designed idea, a suitcase with a long handle (Figure 6.) The challenges this student faced included finding materials to allow the handle to be long, yet sturdy enough to support the suitcase and finding a way for the suitcase to open and close. By experimenting with different ideas and designs, Literacy Student 6 was ultimately able to find a creative option of a side opening for the suitcase. Popsicle sticks, a clothespin, a drinking straw and tape were combined to create the handle.

Figure 6

Literacy Student 6 Project Sample

Constraints and Considerations

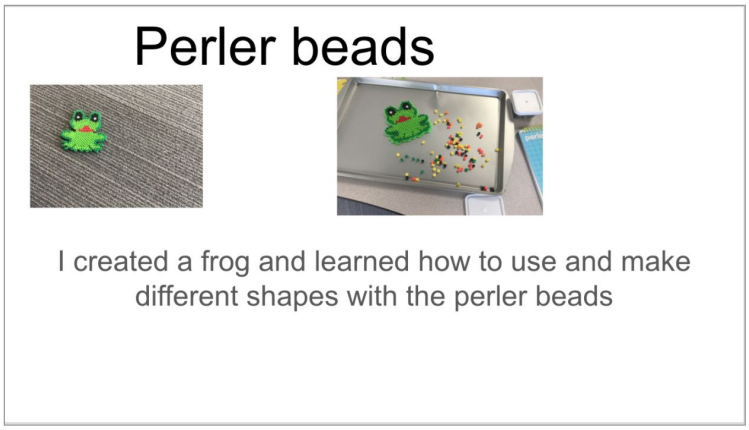
The third area of review was Constraints and Criteria which looked at whether the student was able to work successfully within the constraints of the assignment, making adjustments and adaptations as needed to use available resources. This area aligns with the AASL Standard Explore V.D.1 which specifically says, “Learners develop through experience and reflection by iteratively responding to challenges” (AASL, 2018). Eight

of the 14 STEAM students received a score of 3 (the highest possible score) in this category from all three co-researchers. Three of the 14 Art Students received a 3 from all three co-researchers and five of the 12 Literacy Students received a score of 3 from all three co-researchers.

STEAM Student 13 worked successfully within the constraints of time and supplies to create a unique Perler bead design (Figure 7) that wasn't shown in any of the idea books. After looking at the available baseplates, she chose one (not her first choice) then examined the available bead colors to help in her decision making process. After a brief time of investigation, the student began to work and was able to complete her design within the allotted 40-minute class period.

Figure 7

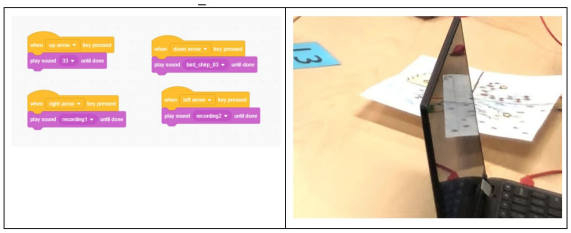
STEAM Student 13 Project Sample



Art Student 3 demonstrated this standard through their use of a tree design (Figure 8) to represent the four seasons to fit within the four quadrants, using brass fasteners as electrical conductors to connect with the alligator clips and recording their own sounds to use in place of the sounds available in the sound library.

Figure 8

Art Student 3 Project Sample



Literacy Student 4 worked successfully through the constraints to construct a traditional style suitcase (Figure 9) with a fold over top that allowed items to be inserted into the suitcase. This student took some time to experiment with different materials before selecting those that would work best for the assignment. Literacy Student 4 used drinking straws and tape to construct a functional handle and also used a straw as a catch to help keep the lid closed.

Figure 9

Literacy Student 4 Project Sample

Rubric Section 2

Identifying Problem/Conflict

In the student rubric, this category is shown as Literacy 1. The standard aligned with this category is NGSS, 3-PS2-4 which is, " define a simple problem that can be

solved through the development of a new or improved object or tool" (NGSS Lead States, 2013). For this portion of the rubric, a score of 3 (highest) was given if the student was able to correctly identify the problem and determine an appropriate solution. 12 of the 14 STEAM students met this standard with a score of 3, while 11 of the 14 Art students met the standard with the highest possible score and 11 of the 12 Literacy students met the standard with a score of 3, as well.

Making a Plan/Solving the Problem

The category of Literacy 2 represents NGSS standard 5-ESS3-1 which reads, "obtain and combine information from books and/or other reliable media to explain phenomena or or solutions to a design problem" (NGSS Lead States, 2013). For scoring purposes, the co-researchers determined whether the students had logically and appropriately solved the problem at hand. Five of the 14 STEAM students met this standard with the highest score of 3. Six of the 14 Art students met the standard with a score of 3 and 10 of the 12 Literacy students received the highest possible score of 3.

Summarizing/Sharing

On the rubric, this category is shown as Literacy 3. This standard aligns with NGSS 3-LS3-2, 3-LS4-2 and reads, "use evidence (e.g. observations, patterns) to support an explanation" (NGSS Lead States, 2013). The co-researchers considered whether students appropriately described their design process including the problem and the solution when scoring student work. Two of the STEAM students received the highest possible score of 3 in this category. Four of the 14 Art students received a score of 3 in

this category and 3 of the 12 Literacy students received the highest possible score of 3. This category showed the lowest scores overall.

Table 1

Number of Students Who Met the Standard

	STEAM	Art	Literacy	All
Section 1				
Design Thinking	9 (64%)	4 (29%)	10 (83%)	23 (59%)
Critical Thinking	10 (71%)	7 (50%)	8 (67%)	25 (63%)
Constraints/Criteria	13 (93%)	5 (36%)	9 (75%)	27 (68%)
Section 2				
Literacy 1: Identifying the Problem	12 (86%)	11 (79%)	11 (92%)	34 (85%)
Literacy 2: Problem Solving	12 (86%)	6 (43%)	10 (83%)	28 (71%)
Literacy 3: Summarizing/Sharing	2 (14%)	4 (29%)	3 (25%)	9 (23%)

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this qualitative case study was to examine whether makerspace or STEAM activities can support inquiry learning and meet specific AASL, NGSS and Common Core Literacy Standards. For purposes of this study, the three co-researchers were also focused on how this type of learning activity can support district initiatives in literacy, design thinking, novel engineering, STEAM and makerspace activities, as well as supporting specific district initiatives such as Lucy Calkins Units of Student in Reading and Project Lead the Way.

The three co-researchers examined data from three different study sites. The data sources included lesson descriptions and reflections from the three teacher librarians (the co-researchers), 47 student work samples from 40 different students along with teacher librarian reflections on the student work, and collaborating teachers' reflections about their students' experiences and learning that occurred as a result of these lessons.

The data collected for this study indicates that most of the students who participated in the makerspace/STEAM activities met the identified standards from AASL, NGSS and CCSS ELA. The teacher librarians' reflections and lesson descriptions demonstrated a connection to district initiatives and collaborating teachers' reflections indicated that these lessons are engaging for students, encouraging them to consider personal interests and continue to learn about these and other related topics. When students are provided the opportunity to participate in hands-on learning activities that align with district initiatives, the overall results are positive.

Conclusions

This qualitative case study provided the three co-researchers the opportunity to examine previously completed makerspace projects in order to determine whether they were supporting student learning and district initiatives. Specifically, this researcher sought answers to the questions of how makerspace/STEAM activities align with AASL and NGSS standards.

Collaboration is a theme that surfaced frequently during this study. Makerspace activities themselves often involve peer collaboration (Oliver, 2016) and that same theme was reflected in the questionnaire responses from the collaborating teachers, as well as the co-researchers of this study. Collaboration allows both teacher librarians and other teachers to have a stronger impact on student learning by aligning vocabulary, expectations, and teaching focus. The teacher librarian for the Art Project explained, "doing this collaborative project helped students to get more in-depth with their understanding of the art concepts and the technology concepts while working on a single project." Because each teacher librarian was the one responsible for initiating the collaborative conversation with the classroom teacher in her school, it is likely that without the influence of the teacher librarians, students would not have had the opportunity to participate in the makerspace activities described in this study. This co-researcher also notes that working in collaboration with the other two teacher librarians during this study deepened my thinking and pushed me to consider data from other perspectives than I might have done if working independently, essentially heightening my sense of efficacy.

Based on the data collected, it's clear that makerspace activities can and do align with a variety of learning standards, whether it's AASL's Explore V.D.1. of working within constraints and criteria, NGSS's 5-ESS3-1 which is collecting and combining reliable information in order to explain a problem or come up with a solution, or one of the other standards addressed in this research paper. Makerspace activities provide opportunities for students to participate in highly engaging, hands-on learning. Much of the previous research has focused on makerspace as a separate experience, something students work on independently of the standard curriculum materials they are learning from in their classrooms, or as Fontichiaro (2019) describes, makerspace activities are offered as stand alone "stars" (p. 43) rather than constellations which are connected. However, this researcher believes that with more intentional focus during lesson development, makerspace activities could become part of the curriculum, supporting learning in ways that encourage students to hone their inquiry and problem solving skills. This could be especially beneficial for schools and districts with limited resources that might not be able to purchase packaged curriculum such as Project Lead the Way.

Recommendations

An important piece of inquiry is reflection, which allows learners to improve upon their work by making enhancements and changes. As shown in the data collected through this research project, the area involving summarizing and sharing was the lowest-scoring category for student work. Using reflection during the inquiry process allows students to learn about themselves as a learner and how they learn. Both of these are important for students to understand as they move toward becoming lifelong learners

(Maniotes, 2019). Reflections also help provide accountability for student learning. When students know that a reflection will be collected at the completion of the lesson or end of the work time, they are aware that they will be accountable for their time. Collecting artifacts (student reflections, examples of student work, teacher reflections, etc.) can also be used to support makerspace initiatives when communicating with administrators and decision makers (Fontichiaro, 2018). Knowing the importance of student reflection, intentionally providing ample opportunity for student reflection to occur supports and enhances the makerspace learning experiences.

The majority of students whose work was used in this research were those who had completed the assigned tasks in a timely manner, as assigned. Some of these early finishers are the exemplary students who go above and beyond assignments to complete their work by working efficiently and effectively. Others may have had previous exposure to makerspace type activities, so it may not have been a completely new experience for them. Students who might not have had the opportunity to participate in this type of learning previously may need some extra time to develop a comfort level with hands-on learning and exploration. In these situations, the teacher librarian can help support students by giving them time to experiment with the materials before launching the lesson objectives, because the value of this type of learning is high. Bowler (2014) explains that opportunities facilitate confidence, "Creative confidence comes when people are given the opportunity to think like a designer" (p. 60).

Because of the impact of Covid-19, several of the projects used in this study were not completed as fully as they were intended. This was due to the limitation on planning

and implementing student projects in another semester. Future researchers could replicate this study while allowing for enough time for also analyzing the work of those students who need more time to finish and as such could provide greater understanding of instruction that would facilitate all students in this area. Future researchers could focus on the benefits of collaborative teaching, the impact of collaborative teaching on teacher efficacy, on the connections between AASL, CCSS ESL and NGSS standards as well as replicating this study with projects that are intentionally designed to connect with all of these standards.

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APPENDIX A

OBSERVATION NOTES OF STUDENT WORK SAMPLES

Student #_____

Place Image of Student Work here	
What I observed and remember about this student's process and product as related to:	
Design Process:	Was there evidence of the student utilizing the design process? Did the student complete each step before moving on to the next? Was the product tested and revised to achieve success? Did the student share information regarding the evolution of the product?
Critical Thinking:	Did the student ask relevant and thoughtful questions? Did the student construct ideas by consolidating perspectives?
Constraints & Criteria:	Did the student work within the constraints and follow the criteria for the activity? Did the student make any adjustments due to the resources available?

APPENDIX B

STUDENT RUBRIC

Adapted from Montgomery and Madden (2019)

Student # _____

	3	2	1	N/A
Design Process (AASL, 2018. Explore. V.A.3)	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.	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 engineering design process was not followed.	No Evidence Available
Critical Thinking (AASL, 2018. Explore. V.B.1) (AASL, 2018. Explore. V.C.1)	The student asked relevant and thoughtful questions to develop ideas and applied them in many ways. The student constructed ideas by consolidating perspectives.	The student asked relevant and thoughtful questions. The student constructed a single idea.	The student did not ask relevant and thoughtful questions. The student essentially recreated a model/followed directions.	No Evidence Available
Constraints & Criteria (AASL, 2018. Explore. V.D.1)	The student worked within the constraints and criteria and they considered and adjusted for the constraints and criteria of the resources available at school.	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.	The student did not work within the constraints and criteria or the constraints and criteria of the resources available at school.	No Evidence Available
Reading widely and deeply in multiple formats and writing and creating for a variety of purposes. (AASL, 2018. Explore. V.A.1)				
Literacy 1 (ELA RL.5.2)	The student correctly identified several conflicts in my novel. The student evaluated the different conflicts and thought about	The student correctly identified several conflicts in my novel.	The student could not identify the conflicts in my novel.	No Evidence Availabl e

(NGSS, 3-PS2-4)	which one my character would benefit most from solving. The student identified the problem and was able to determine an appropriate solution.	The student correctly identified the problem.	The student could not identify the problem.	
Literacy 2 (ELA RL.4.3) (NGSS, 5-ESS3-1)	The student explained characteristics, mood, and features of the setting and characters. The student thought from the character's point of view and what would be a logical step for him or her within the time and place of the book. The student also thought about how the setting affects the character's actions and decisions. The student was able to identify an appropriate and logical solution.	The student explained characteristics, mood, and features of the setting and characters. The student was able to identify an appropriate solution.	The student could not explain characteristics, mood, and features of the setting and characters. The student could not solve the problem.	No Evidence Available
Literacy 3 (ELA RL.4.2) (NGSS, 3-LS3-2) (NGSS, 3-LS4-2)	The student accurately summarized the text by stating the main points and a few key supporting details that connect to the theme and plot of the story. The student mentioned the main characters, setting, and conflict and solutions. The student appropriately described their design including the problem and solution.	The student accurately summarized the text by stating the main points and a few key supporting details that connect to the theme and plot of the story. The student briefly described their design, but did not include all elements.	The student retold the story instead of summarizing or the student did not state the main points or key details. The student did not describe their design.	No Evidence Available

APPENDIX C

COLLABORATING TEACHER QUESTIONNAIRE

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

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

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

APPENDIX D

COMPILATION OF STUDENT SCORES

	% of students who met standard			
	Art (14)	Literacy (12)	STEAM (14)	ALL
Design Process	**29%**	**83%**	**64%**	**59%**
Critical Thinking	**50%**	**67%**	**71%**	**63%**
Constraints, Criteria, & Conclusions	**36%**	**75%**	**93%**	**68%**
Literacy 1: ID Conflict	**79%**	**92%**	**86%**	**85%**
Literacy 2: Problem Solving	**43%**	**83%**	**86%**	**71%**
Literacy 3: Summarizing & Sharing	**29%**	**25%**	**14%**	**23%**