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The Effect of Thinking Routines on 4th and 5th-grade Students' Sense of Agency

Cyrena Beaumont
St. Catherine University

Kelsey Martin
St. Catherine University

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Cyrena Beaumont and Kelsey Martin

Saint Catherine University

St. Paul, MN

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Abstract

This action research project has studied the effects of implementing Agency by Design thinking routines and makerspaces on the development of student agency. The study was conducted in two upper-elementary school classrooms: one fifth-grade suburban classroom in Florida, and one fourth- and fifth-grade rural, gifted and talented classroom in Minnesota. During the study, researchers collected baseline data from a pre-assessment related to student perceptions around their own sense of agency and sensitivity to design. This data was compared to the post-assessment data that was collected using the same survey at the end of the project. Throughout the study, students used sketchbooks to engage in the thinking routines of looking closely, exploring complexity, and finding opportunity. They then used their sketchbooks as inspiration as they participated in four separate makerspace experiences. After each makerspace experience, students assessed their projects for elements that would indicate that agency was present in their product. The compiled and coded data indicated that there was not a strong correlation between the implementation of the thinking routines and makerspace opportunities on the development of student agency. However, positive outcomes were present, and recommendations were made accordingly.

In an ever-evolving society where perspectives, priorities, and new technologies are in constant fluctuation, consumerism has grown (Bee-Gates, 2007; Hill, 2011). New technologies, and the services those technologies provide, have put the world at our fingertips. With a mere swipe or click, problems can be solved, and questions can be answered. In addition to convenience, these technological advances are increasingly efficient and affordable, resulting in an interconnected world that is accessible to most. Such liberties have shifted the upper- and middle-class American experience from one built on patience to one of instant gratification (Bee-Gates, 2007; Hill, 2011; Louv, 2005). Ideas and products are in constant interchange, creating a culture of growth and haste towards the newest updated version. Items that once were cheaper and more sensible to fix if broken have become more affordable and simpler to replace. This ease of access and affordability of merchandise and services for middle- and upper-class customers has fueled the concept of consumerism, the idea that purchasing goods and services is necessary to the success of the economy.

While adults watched this progression unfold, a majority of today's youth were born into it, offering concerns about the implications for our world's future tenants (Bee-Gates, 2007; Hill, 2011; Louv, 2005). Where children once used their imaginations to explore make-believe worlds, create games, and invent toys, digital technologies now do these things for them (Louv, 2005). We are beginning to see the impact of this transformation in childhood anxieties and identity concerns (Hill, 2011; Kazanjian & Choi, 2014). There is sufficient research suggesting that perseverance, risk taking, and sense of agency are at risk in today's youth (Bee-Gates, 2007; Hill, 2011; Louv, 2005). There is a need to seek solutions to these risks not only for the betterment of our children, but for the betterment of our world.

To address this concern, society has looked to schools, as it often does. To this end, strategies and programs have been implemented to guide students through the development of the skills for which they are predicted to be deficient. The purpose being to minimize the risks mentioned above. However, with the pressure of curriculum and testing requirements, such programs are typically pushed to the wayside by teachers and administrators. Additional research related to the effectiveness of these programs and strategies for their implementation is needed. Until successful reports from teachers and administrators are produced, such program implementations will not be a priority. Therefore, data must be collected on strategies that can reverse the negative ramifications of the consumerist society in which our youth are growing up.

Research suggests implementing makerspaces (spaces that are equipped with the tools and resources that enable problem-solving by creating and physically prototyping solutions) is one such solution to the consumerism response. By helping learners see the world as designed and alterable, the hope is that they are empowered with the skills to and understanding that they are capable of shaping the world. The literature suggests a positive correlation between student problem-solving through making and the development of the life-long habits of perseverance, risk taking, and sense of agency (Agency, 2015; Clapp et al., 2017; Tishman, 2008; Tishman, 2014). To encourage and support the implementation of makerspaces in the classroom, more documentation is needed related to beneficial outcomes of makerspace implementation.

Agency by Design is a research initiative developed to investigate maker-centered learning and develop resources to aid in its implementation (Agency, 2015; Clapp et al., 2017). The initiative is dedicated to providing information and research on effective implementation of makerspaces. The thinking routines associated with makerspaces as proposed by this initiative

suggest a clear formula for counteracting current student deficiencies as related to consumerism (Agency, 2015; Clapp et al., 2017). Therefore, the purpose of this action research project was to observe the effects of implementing the Agency by Design thinking routines (herein referred to solely as *thinking routines*) and makerspaces on students' sense of agency.

Review of Literature

In this literature review, theoretical support for developing agency in students within a maker-centered learning context will be developed. Then, a review of maker-centered learning and thinking routines within formal education will be conducted. Finally, a discussion, summarization, and evaluation of the findings will be provided.

Support for Developing a Sense of Agency Through Maker Empowerment

A sense of agency refers to the feeling of control one has to make choices, take action, and create change in one's life (Clapp et al., 2017; Moore, 2016). It is imperative for educators to encourage the development of agency in students for the sake of achieving the highest levels of student learning, cognitive functioning, and community involvement through problem-solving (Chu, Quek, Bhangaonkar, Ging, & Sridharamurthy, 2015; Clapp, Ross, Ryan, & Tishman, 2017). Individuals who exhibit a sense of agency are empowered to take problems into their own hands, take risks, and have an impact on the people, objects, and systems that surround them (Chu et al., 2017; Clapp et al., 2017; Moore, 2016). Within a maker-centered context, a sense of agency is a dispositional outcome, sometimes referred to as maker empowerment, or having a maker mindset (Chu et al., 2015; Clapp et al., 2017; Horton, 2017). In their book *Maker-Centered Learning: Empowering Young People to Shape their Worlds*, Clapp, Ross, Ryan, and Tishman (2017) define maker empowerment as "a sensitivity to the designed

dimension of objects and systems, along with the inclination and capacity to shape one's world through building, tinkering, re-designing, or hacking" (p. 103). Maker empowerment is a central value of maker-centered classrooms (Clapp et al., 2017).

Two of the most prominent educational theories to support the development of maker empowerment in students are Situated Learning Theory and the Theory of Constructivism. Situated Learning Theory distinguishes learning as situated rather than deliberate (Clancey, 1995; David, 2007). Authentic learning happens naturally when learners are provided authentic conditions for gaining that particular new knowledge (David, 2007; OTEC, 2007). Collaboration and social interaction are essential components to Situated Learning Theory as learners seek to discover, comprehend, and construct their experiences and knowledge within a space that is real to that field (Clancey, 1995; OTEC, 2007). Makerspaces are situated learning environments that provide the opportunity, but not necessarily the explicit instruction, for learners to explore and discover new knowledge.

The Theory of Constructivism, developed by independent contributions from John Dewey, Jerome Bruner, Jean Piaget, and Lev Vygotsky, states that learning by doing, collaborating, and reflecting on one’s own experience is the most natural and beneficial way to acquire information and engage in the process of thinking (Ackerman, 2001; Fosnot & Perry, 2005). Children who seek to solve problems through play, interaction, and creation develop new knowledge and schemas more quickly and more comprehensively than when they are simply told information (Fosnot & Perry, 2005). Learners begin to develop a sense of agency as they start to see themselves as producers within their society. As learners work through trial and error to fix and improve, they innately shape their knowledge and understanding of the world by

internalizing what they have learned to make this knowledge accessible for future situations (MakerEd, 2015). When the learner is the catalyst of their own learning, they will gain more than if they are the bystander to it (Clapp et al., 2017).

The Theory of Constructivism supports makerspace opportunities and agency development by validating the process of identifying a problem and seeking to solve it through creation, collaboration, and reflection. As learners engage in makerspaces, the outcomes should reflect an increased and deepened knowledge base as well as an expansion of thinking capabilities, resulting in a stronger sense of agency.

With the backing of prevailing educational theories including Situated Learning Theory and the Theory of Constructivism, a case for providing makerspace opportunities with the goal of increasing student agency becomes evident. To determine best practices for building maker empowerment and a sense of agency in a classroom setting, the remainder of this literature review will explore maker-centered learning and thinking routines.

Maker-Centered Learning

Makerspaces, also known as maker-centered learning environments, are becoming prevalent in a variety of settings, including libraries, museums, schools, and other community institutions (Clapp et al., 2017; Halverson & Sheridan, 2014; MakerEd, 2015; Patton & Knochel, 2017). Maker-centered learning in schools is defined as a learner-centered instructional approach that utilizes creation as a means to learn about and solve problems both individually and collectively (Clapp et al., 2017; Halverson & Sheridan, 2014; Han, Yoo, Zo, & Ciganek, 2017; Heroman, 2017; MakerEd, 2015; Taylor, 2016). A growing number of educators are exploring this trend by incorporating makerspaces into their classrooms and schools. Within a makerspace,

collaboration, creativity, and continuous improvement are fluid practices that students use as they plan, construct, and test their creations using open-ended materials and tools from multiple disciplines (Clapp et al., 2017; Halverson & Sheridan, 2014; Heroman, 2017; Patton & Knochel, 2017; Sierra, 2017; Tan, Barton, & Schenkel, 2018; Taylor, 2016). Maker-centered learning is not limited to a single content area but is used to enrich learning across a variety of academic disciplines (Marshall & Harron, 2018; Patton & Knochel, 2017).

Numerous professional studies and research discuss the benefits afforded to students through maker-centered learning activities. One of the more concrete benefits is the development of discipline-specific skills, especially STEM (science, technology, engineering, and math) skills (Clapp et al., 2017; Halverson & Sheridan, 2014; Heroman, 2017; MakerEd, 2015; Marshall & Harron, 2018; Patton & Knochel, 2017; Tan et al., 2018; Taylor, 2016). Within a maker-centered classroom, students learn to use, manage, and test familiar and foreign tools and technologies (Clapp et al., 2017; Heroman, 2017; MakerEd, 2015; Marshall & Harron, 2018; Tan et al., 2018). The tools they learn to use are diverse and help to break down any boundaries that may have been established around traditional gender roles (Baker & Alexander, 2018; Halverson & Sheridan, 2014; Marshall & Harron, 2018; Heroman, 2017).

While discipline-specific skills are crucial, the research also emphasizes the development of dispositional skills through maker-centered learning. Character traits such as perseverance, risk taking, and sense of agency are all developed through maker-centered learning (Agency, 2015; Clapp et al., 2017; Heroman, 2017; Marshall & Harron, 2018; Tan et al., 2018). The development of character is seen by practitioners as the primary learning outcome of a makerspace, while discipline-specific outcomes are secondary (Clapp et al., 2017). As students

gain confidence and competence in their ability to make things, they begin to view their role in the world from a new perspective; one of a maker, capable of taking charge, or becoming agents, of their own lives (Clapp et al., 2017; MakerEd, 2015; Marshall & Harron, 2018; Tan et al., 2018; Taylor, 2016). Students become problem-solvers and solution-seekers, growing more independent as they no longer feel the need to depend on teachers or other adults to determine and reach their goals (Clapp et al., 2017).

As students engage in maker-centered learning, another benefit becomes evident: the building of community (Clapp et al., 2017). Collaboration, co-inspiration, reflection, and sharing are key components of makerspaces that support the development and sustenance of a strong classroom community (Clapp et al., 2017; Heroman, 2017; MakerEd, 2015; Marshall & Harron, 2018; Patton & Knochel, 2017; Tan et al., 2018; Taylor, 2016). Respect for people and materials grows as learners spend time building relationships and taking responsibility for their actions while engaged in making (Clapp et al., 2017; Marshall & Harron, 2018). Students recognize the value of sharing materials and property and how communities can function positively and productively (Baker & Alexander, 2018; Clapp et al., 2017). Additionally, when work that students have created is displayed or used, a sense of pride and ownership contributes to a growing sense of community that results from a maker-centered learning environment (Baker & Alexander, 2018; Clapp et al., 2017; Patton & Knochel, 2017). Teachers, parents, and community partners volunteer their time and expertise to help and inspire students during makerspace work times (Baker & Alexander, 2018; Scheer, 2017; Tan et al., 2018), thus extending a community connection beyond the four walls of their classroom. The involvement of community members encourages maker empowerment by helping students see making as a

valuable endeavor. Furthermore, it expands their perspective as they begin to notice and act upon solving problems for the greater good. As this happens, their sense of agency toward their community grows (Clapp et al., 2017; Tan et al., 2018; Taylor, 2016).

While maker empowerment is a primary benefit of maker-centered learning, an essential prerequisite to that empowerment is a sensitivity to the designed elements of the world (Clapp et al., 2017; Halverson & Sheridan, 2014; Somerville, 2016). Maker-centered learning experiences open students' minds to how humans have and still are shaping their environments through design and creation. The recognition of humans as creators encourages sensitivity to the many constructions found throughout our world (Agency, 2015; Clapp et al., 2017). Developing this awareness is a natural consequence of a maker-centered learning environment. Students begin to see design as a way they can both identify problems and create solutions (Agency, 2015; Clapp et al., 2017; Chu et al., 2017; Halverson & Sheridan, 2014). When students gain confidence in their ability to recognize problems and develop solutions, they begin to transition from passive consumers to active producers. Researchers claim this transformation to be the ultimate goal of instilling maker empowerment in students (Clapp et al., 2017; Marshall & Harron, 2018; Tan et al., 2018). A sensitivity to design coupled with a maker-centered learning environment encourage the development of empowered makers (Clapp et al., 2017; Somerville, 2016).

Thinking Routines

Is it possible, then, to speed up the acquisition of this sensitivity to design, and in so doing, also encourage the development of maker empowerment? Research is beginning to validate the contention that this can, in fact, be done through a variety of thinking routines (Agency, 2015; Clapp et al., 2017; Tishman, 2008; Tishman, 2014). The thinking routines

developed by the Agency by Design researchers from Project Zero stem from their Framework for Maker-Centered Learning, which includes looking closely, exploring complexity, and finding opportunity (Agency, 2015). All three components of this framework are interrelated. However, it is important to understand each of them on their own in order to fully comprehend how they work together to encourage the development of maker empowerment.

Looking closely, also known as slow looking, is the practice of mindful observation. Participants focus intently on an object or system to see it beyond its surface appearance. Not only are observations made, but as participants dig deeper into the nuances of the object, they begin to ask higher level questions and make inferences based on their own perspectives (Agency, 2015; Clapp et al., 2017; Tishman, 2014). Looking closely can be done with both seemingly simple objects, such as pencils and screws, as well as more complex technologies, such as computers and keyboards (Clapp et al., 2017). It can also be done with both simple and complex systems, such as restaurants and ecosystems (Tishman, 2014).

Exploring complexity is a thinking routine that relies very heavily on the previous routine. In order to uncover complexities in both objects and systems, it is necessary to first study them. In this way, looking closely and exploring complexity are interrelated thinking routines (Clapp et al., 2017). The natural questions that come out of looking closely, become the beginning stages of exploring the complexities within those objects or systems (Tishman, 2014). What begins to emerge from those complexities are questions about the different perspectives that were either included or excluded from the designs. This is naturally followed by questions regarding equity and privilege, as well as the interconnectedness of all objects and people within systems (Clapp et al., 2017; Tishman, 2008).

Finally, finding opportunity is the thinking routine most closely linked to the development of agency, as it is the thinking routine that necessitates action, and agency requires action (Clapp et al., 2017). In this routine, participants build upon the observations and curiosities they explored in the previous thinking routines to find opportunities to tinker, hack, redesign, fix, and/or create anew. Makerspaces provide these opportunities. However, the goal is for participants to begin to look beyond these defined makerspaces to create their own spaces and opportunities for making and reshaping their worlds (Clapp et al., 2017; Tishman, 2008).

Discussion

It is important to clarify that the research on the topics addressed in this literature review contains some gaps and contradictions. While incorporating a makerspace in a classroom has clear benefits, the ambiguity regarding the implementation process poses a risk to those benefits. If intentional and organized preparation methods are not prioritized, the posed benefits may not be reached. Regarding the thinking routines outlined here, it should be noted that there is limited research regarding their effectiveness in developing a sense of agency in participants. Educators are encouraged to exercise their professional knowledge and expand on their research base to determine if and how such systems should be implemented in their classrooms. The goal of implementation being to maximize student growth and achievement from an academic as well as social and emotional perspective. Upon further analysis of the literature, more research needs to be done to determine to what extent the implementation of thinking routines encourage the development of student agency. However, the research that is available indicates increased student agency could be achieved through developing a sensitivity to design with the implementation of thinking routines in a maker-centered learning environment.

Conclusion

The literature in this review provides evidence to support the use of thinking routines in a maker-centered learning environment to develop a sense of agency in students. Based on the research, there are several advantages to using thinking routines and makerspaces in a classroom including self-regulation, community awareness, and a sensitivity to design. Additionally, the literature, albeit limited, indicated a positive correlation between the use of makerspaces and thinking routines in students' development of agency. Therefore, the conclusions drawn from this literature review support the implementation of thinking routines within a maker-centered learning environment to achieve an improved sense of agency in students. To this end, the research question guiding this study was: What effect, if any, does implementing thinking routines and maker-centered learning environments have on student agency?

Methodology

The population for this action research study was 4th- and 5th-grade students in a gifted & talented classroom at an elementary school in a mid-sized, Midwestern town in the United States and a 5th-grade general education classroom at an elementary school in a mid-sized town in the Southeast in the United States. A total of two classes were studied during the 2018-19 school year. Thirty-eight students were involved in the study, of which 19 were female and 19 were male. This study used an experimental design that utilized student reflection, student work analysis, pre-student self-assessments, and post-student self-assessments in the interest of triangulation.

Before engaging in the makerspace experience, students completed a pre-assessment, answering questions in Likert-scale and multiple choice style format (See Appendix A). Results from the pre-assessment were stored for later analysis.

Following the pre-assessment, students partook in four makerspace activities involving the thinking routines. Each activity began with each student recording a problem that could be solved through creation in their sketchbooks (used solely for creative ideas and reflections). Once their problem was identified and approved by the teacher, students sketched and/or listed at least three ways the problem could be solved. Following the brainstorming of solutions, students chose one solution to create and sketched a more detailed design or list and identified the materials they planned to use. Students then used the classroom makerspace materials to create the solution to their identified problem.

When products were complete, students filled out a paper copy of a product rubric (See Appendix B). Product rubrics were used to gather information on the level of agency student products reflected. The rubrics contained categories related to the type of problem being solved, the intent of solving the problem, and the commonality of the solution(s) being sought. This data revealed the authenticity, purpose, and types of problems being solved along with patterns or common themes among individuals and groups of students in the problem-solving process. Students were to indicate if their product “definitely,” “somewhat,” or “not at all” sought to solve a problem in their life, their home, their classroom, their school, and/or their community. Students additionally reflected on the creation process by recording their thoughts in their sketchbooks. Thoughts included things they enjoyed during the activity, difficulties, and future goals/plans.

The exercise of completing the makerspace product, filling out the rubric, and reflecting on the process was followed on four separate occasions. Upon completion of the fourth makerspace activity, students were given a post-assessment identical to the pre-assessment given at the start of the study. The final data tool collected was a post-reflection utilizing online Google Forms in short-answer responses (See Appendix C). Questions were formulated in an attempt to generate further insights regarding the benefits and drawbacks of thinking routines and makerspace activities.

Data Analysis

The raw data from this study was in the form of short answer, multiple choice, rubric, and Likert-scale student responses and reflections, consisting of both quantitative and qualitative information. Of the data collected, researchers coded questions to isolate three major categories for best analysis and understanding of student changes in sense of agency: student self-perceptions, agency in product designs, and student reflections.

Student Self-Perceptions

The assessment taken before and after participating in makerspace activities using the thinking routines included questions regarding student perceptions of themselves as makers. For each question, researchers combined the two data sets and graphically displayed the pre- and post-assessment results side by side as pie charts to allow for clear comparison and analysis. Researchers sought significant increases, decreases, appearances, and/or disappearances of responses in the parallel data. Of the questions asked (See Appendix A), researchers grouped the questions into two categories: Likert-scale questions and multiple choice.

When analyzing the Likert-scale questions related to how students felt about making things, researchers looked at how the pre-assessment may have differed from the post-assessment data. Additionally, researchers noted responses that were not present in the pre-assessment but were in the post-assessment and vice versa. To better see the shifts and changes in perspectives, researchers opted to utilize a table to organize and display the data of the Likert-scale questions.

Multiple choice questions were displayed as pie charts to view changes in students' feelings about making and failure. The researchers looked for changes in attitude (i.e., students' tendency to be motivated by failure) for each of the questions before and after participating in the thinking routines and makerspace activities. Researchers also sought consistencies from pre- to post-assessment responses, potentially revealing the makerspace activities as having no impact on student perspectives regarding the relationship between failure and making.

Agency in Project Designs

At the conclusion of each makerspace project, students completed a product rubric on which they communicated whether their project sought to solve a problem in a variety of contexts. Data sets were displayed to compare product agency from the first makerspace activity to the fourth makerspace activity in a multi-bar graph. The bar graph represents the number of products created that students stated "definitely" sought to solve a problem in that context. Setting up the visual data in this way, the researchers easily identified trends and/or tendencies in product agency from project to project and overall.

Student Reflections

To interpret short-answer student reflections, researchers read through all responses and sought out common words, phrases, and perspectives in search of frequent themes. Researchers identified and coded specific categories for the reflective data collected. Upon identification of common themes, the researchers color-coded the data to organize it into categories. A bar graph was created to display the results.

Findings

The purpose of this study was to identify the effects of implementing thinking routines and makerspaces on 4th- and 5th-grade students' sense of agency. The research design utilized quantitative pre- and post-assessment self-reflections that were developed to address three aspects of agency: student self-perceptions, project purpose, and student reflection.

Quantitative: Student Self-Perceptions

The first question this study addressed was to what extent student self-perceptions of themselves as agents of their environment changed or developed when participating in the thinking routines and activities. To answer this question, students responded to a series of Likert-scale and multiple choice questions in a survey style format. Table 1 displays the three Likert-style question responses through the percentage shifts of student perspectives of themselves as makers.

The most notable changes in student perspectives from the beginning to end of the study were seen in Question 1 (See Appendix A). The percentage of students considering themselves makers increased from 68.7% to 80.4% from the pre- to post-assessment while the percentage of students who were neutral about feeling like makers decreased by 14.5%. While Question 1 reflected change in student perspectives, Questions 3 and 4 (See Appendix A) did not. While

there were some fluctuations in the data from Questions 3 and 4, evidence of a trend towards one side of the spectrum or the other was inconclusive.

This data suggests that engaging in Agency by Design strategies and makerspace activities did not have an impact on how often students think about how and why certain things are made or why procedures are in place nor how they could improve them. However, the data does show there may have been a positive effect on how students viewed themselves as makers.

Table 1

Percentage of Students with Particular Perspectives from Pre-assessment to Post-assessment

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Question 1	0%	2.5%	28.9%	37%	31.7%
Question 1	0%	5.3%	14.4%	49.9%	30.5%
Question 3	2.5%	13.4%	18.1%	42.2%	23.9%
Question 3	0%	3%	40.4%	45.3%	11.5%
Question 4	0%	10%	42.5%	36.7%	10.9%
Question 4	2.7%	14.1%	39%	30.2%	

Note: Highlighted rows denote pre-assessment results and non-highlighted rows denote post-assessment results, comparatively.

Note. Percentage of students' perspectives of themselves as makers (Question #1), how often they think about how and why certain things are made and what they could do to improve them (Question #3), and why certain systems, such as rules and procedures, are in place and how they could be improved (Question #4).

Figure 1 illustrates students' perspectives on how they react when something breaks. Also shown is a slight decrease in the number of students that try to fix something broken themselves from the pre- to post-assessment while there is a small increase in students who

would decide to use the broken item anyway. No students indicated that they would go to the store to buy something new on the pre-assessment, but a small percentage did on the post-assessment. While Figure 1 does not support an increase in student agency from pre- to post- study, it does show that a few students may have been frustrated enough by the Agency by Design thinking routines and activities, not wanting to fix or make things in the future.

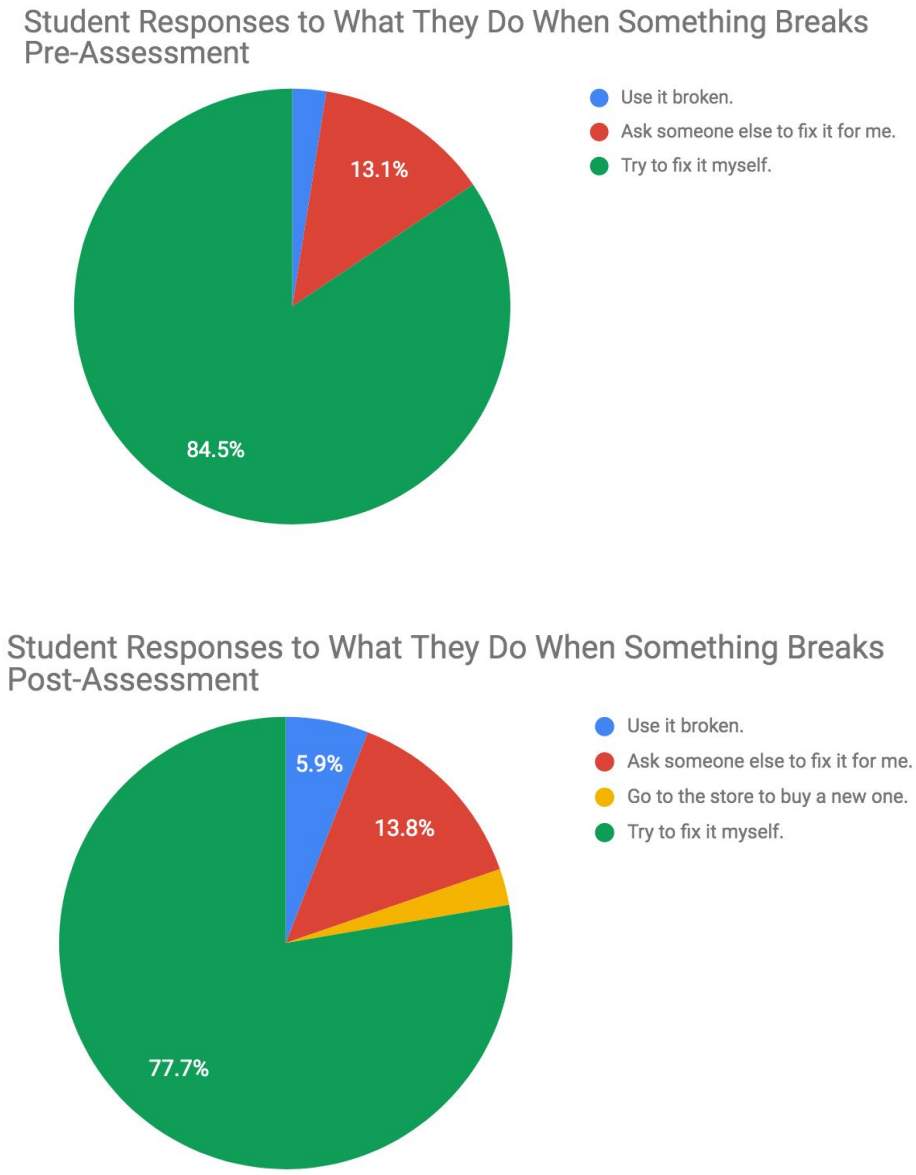


Figure 1. Student responses to what they do when something breaks from pre-(top) to post-(bottom) assessment.

Figure 2 shows an increase of 11.3% of students identifying with being motivated to work harder when something they do fails and conversely, a 14.2% decrease in those that take a break when something they do fails from pre- to post-assessment. Student agency begins with motivation, suggesting that this data supports the implementation of the Agency by Design thinking routines and activities as a means to develop a sense of agency in students. However, it is important to mention that engaging in the thinking routines and activities could also cause some students to get frustrated and give up, as indicated by the post-assessment results.

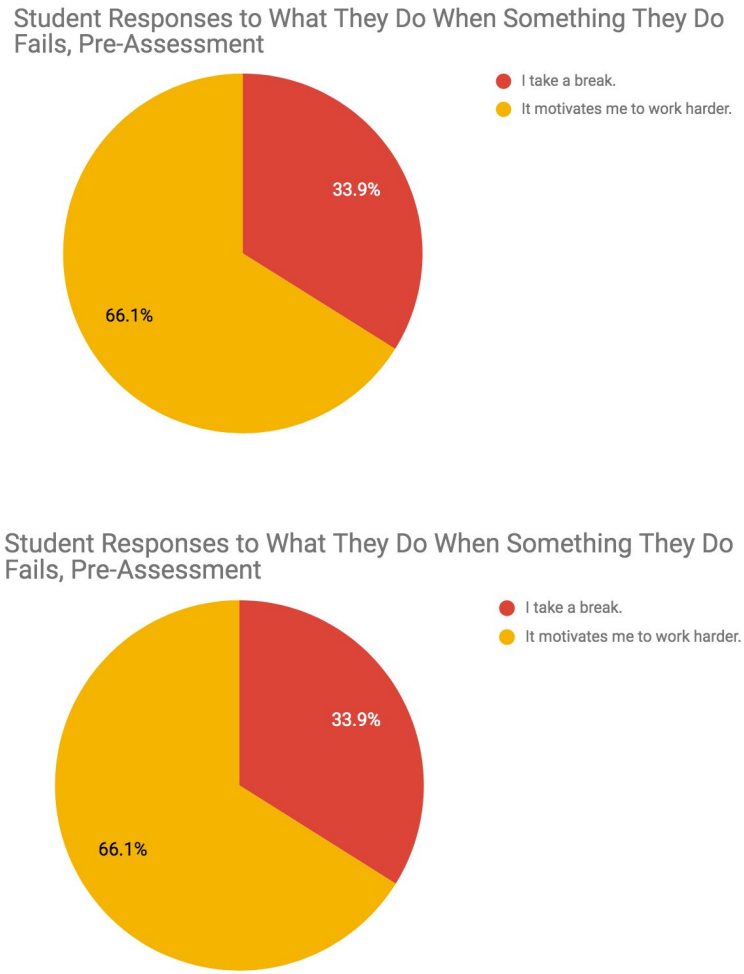
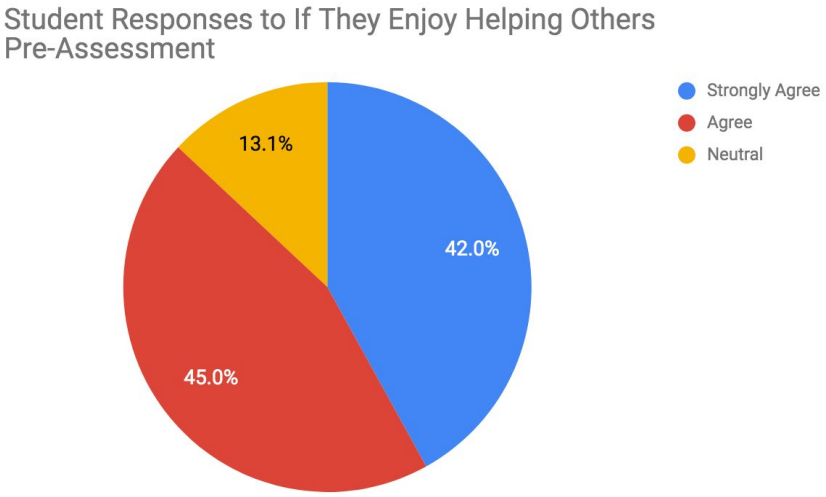


Figure 2. Student responses to what they do when something they do fails from pre- (top) to post- (bottom) assessment.

There was a slight decrease (1.6%) in both students who agree and students who strongly agree that they like helping others from the beginning to end of the study (See Figure 3). The decrease conversely related to the increase (1.5%) of students who felt neutral about helping others, and no students disagreed or strongly disagreed that they liked helping others. The results indicate that student engagement in sketchbook thinking routines and makerspace activities did not impact how students felt about helping others.



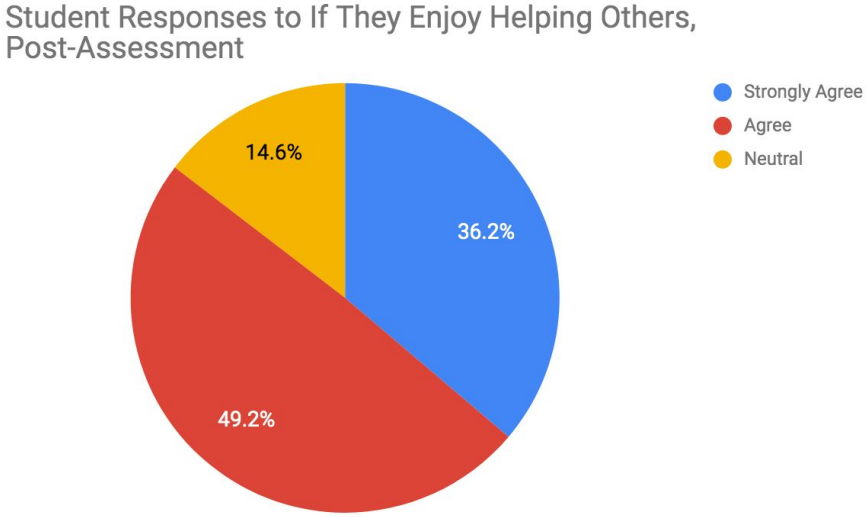
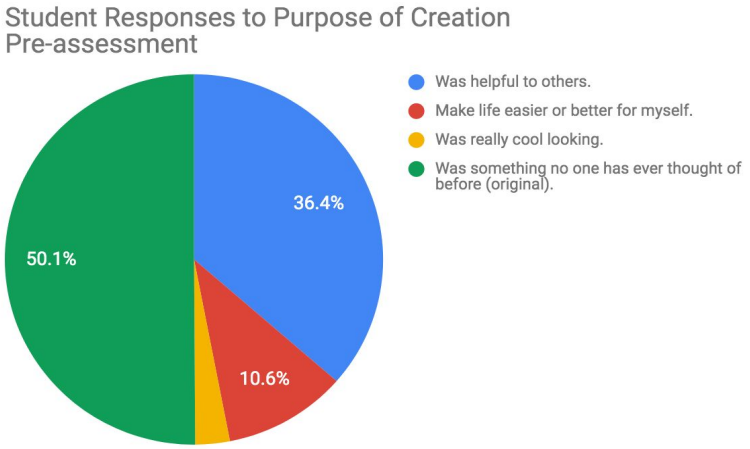


Figure 3. Student responses to if they like helping others from pre- (top) to post-(bottom) assessment data.

More students felt it was important that their creation "was helpful to others" after participating in the Agency by Design thinking routines and activities, while fewer students felt it was important that their creation was original (See Figure 4). Additionally, there was an increase (5.5%) of students who thought it was most important that their creations looked cool. An increase in student agency is connected to the desire to create products that are helpful to others. Therefore, the data in this figure indicates that the implementation of this study slightly increased student agency.



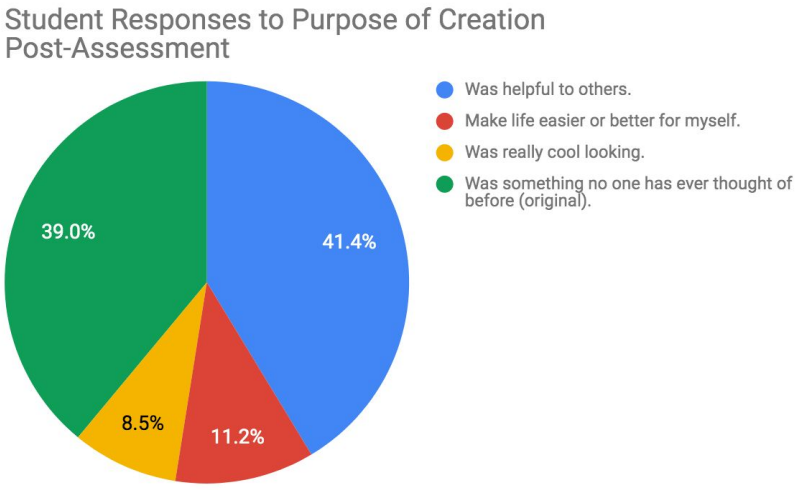


Figure 4. Student responses to what would be most important that their creation did or was from pre- (top) to post- (bottom) assessment.

Agency in Project Designs

This study examined whether students were able to demonstrate agency by identifying the context in which each of their products attempted to solve a problem. Upon completion of each makerspace creation, students filled out a rubric to indicate in which environmental context their product attempted to solve a problem. When comparing the first project to the last, there was an increase in the number of products that demonstrated agency in all contexts except agency in the community (See Figure 5). Students created an increasing amount of products that met various levels of agency, indicating that the more sketchbook thinking routines and makerspace activities students participated in, the more agency their products were likely to show. It should be noted that in one of the two study classrooms, the first makerspace project was introduced when students were learning about the water cycle with a focus on water conservation and environmental awareness. This could be responsible for the higher number of students creating a product that solved a problem in the community compared to the other projects.

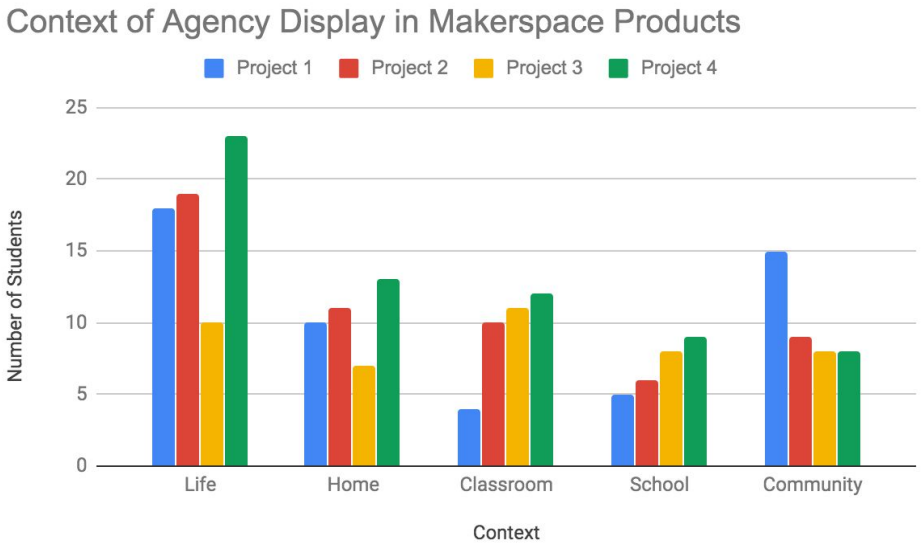


Figure 5. Student product evaluations based on agency.

Student Reflections

The final piece of data collected from this study addressed student perspectives in participation in the makerspace process, following the Agency by Design thinking routines through sketchbook entries. Students were asked to reflect on the benefits, drawbacks, and other insights from engaging in and utilizing a sketchbook in order to problem solve and create solutions through making.

All student input reflected more positive feedback than negative feedback regarding the use of sketchbooks and participating in makerspaces. Seven categories were identified by the researchers when evaluating the reflections (See Figure 6). Several categories reflected benefits of using makerspaces and sketchbooks, including the development of problem-solving skills, enjoyment, ability to express oneself, teamwork development, helping others, and inspires creativity. There was one student that provided negative feedback related to the Agency by Design thinking routines and activities. While not all categories reflected the development of student agency, researchers felt all categories were necessary to report in the findings in order for

comprehensive conclusions to be drawn from the study. Categories that are connected to agency development included “problem-solving”, “helping others”, and “teamwork”. Many students freely wrote about these three distinct areas as being direct benefits of makerspaces, so it can be noted that the implementation of makerspaces and sketchbook thinking routines positively correlated with students’ agency development.

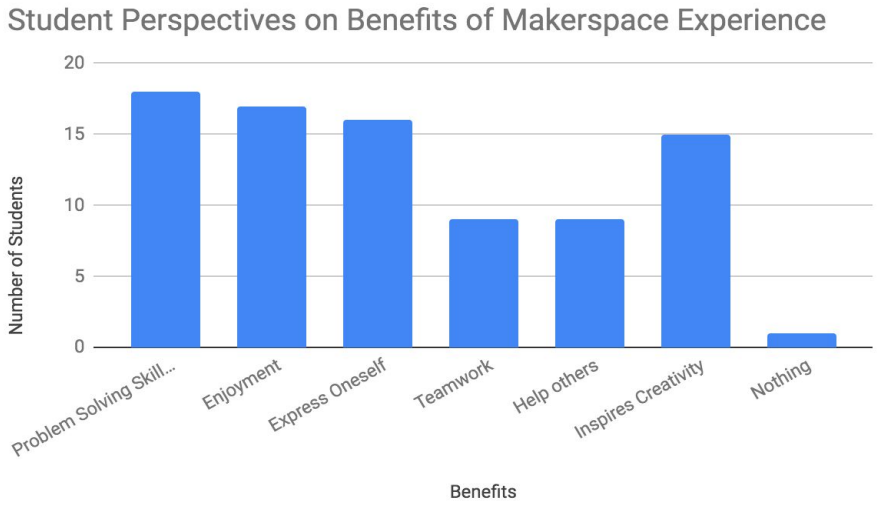


Figure 7. Categories developed from student reflections on the benefits of makerspaces.

Discussion

The purpose of this study was to observe the effects, if any, implementing Agency by Design thinking routines and activities had on 4th- and 5th-grade students’ sense of agency, specifically through the use of sketchbooks and makerspaces. Despite some benefits, changes in students’ sense of agency were not apparent. While there were slight shifts in student mindsets during the study in multiple categories (e.g., how often they think about improving products and systems, how they respond when something breaks, and how much they like helping others), most of these changes were small. However, there was an increase in the number of students who viewed themselves as makers after Agency by Design strategies and makerspace activities were

implemented. This reveals the curriculum was successful in helping students to view themselves as makers.

By the end of the study, nearly all students found something worthwhile in the Agency by Design thinking routines and activities. Creative inspiration, freedom to express oneself, enjoyment, team building, and problem-solving skills were some of the positive things students associated with the curriculum. Over half of the students indicated that utilizing sketchbooks and makerspaces changed them. Therefore, while the study did not result in students viewing themselves as agents, it did provide insight into other benefits of implementing the Agency by Design process.

Despite the inconclusiveness of the study, it did reveal steps that would be useful to take moving forward. Makerspaces may need to be adjusted to accommodate the age of students participating in them. In working with this study's targeted population, the researchers felt that a more structured and intentional approach would have been beneficial in promoting agency development. An inference the researchers made was that the targeted population would have benefitted from parameters set up to challenge their minds, and to think more outside of themselves. However, younger populations might be challenged by the simple task of brainstorming and creating.

Throughout this process, the researchers were apprehensive about the amount of time dedicated to each of the makerspace projects. Each of these projects took time away from other curricular goals. From the researchers' perspective, the cost to benefit ratio did not favor the implementation of regular makerspace activities unless connected intentionally to the standardized curriculum. However, the thinking routines and activities alone were not nearly as

time-consuming as the makerspace projects. Therefore, additional research is suggested to look at the benefits of thinking routines and activities without the makerspace experience tied to it.

Finally, student agency development may take longer than the study lasted. Since the findings showed that students increasingly viewed themselves as makers and found benefits in their participation in this study, these may be precursors to deeper agency development. Additionally, the regular practice with thinking routines and activities may have made the little time students take to think about design and the design process in their everyday lives more apparent. This attention is a positive consequence, however, it may have affected how students rated themselves on the post-assessment. More longevity and regularity with the routines and activities could potentially result in more confidence in proclaiming their behaviors and designs as agentic.

The researchers conclude that incorporating thinking routines in the classroom is beneficial, albeit with slight adjustments. Necessary adjustments would include setting parameters on the problems students are seeking to solve based on age and development, incorporating makerspaces and sketchbook use into curricula, and using these activities throughout the school year with a capstone makerspace project at the end of each semester or year. For instance, when teaching the water cycle, students might be directed to identify a problem that has to do with water or resource use. Similar parameters can be set up for other standards/curriculum. Pre- and post-assessments and reflections should be implemented to monitor the effectiveness of the implementation. By incorporating makerspaces and sketchbook use into curricula, these routines could happen more frequently, thus may produce more conclusive data on the benefits and changes in student perspectives. An end-of-year capstone

makerspace project would take less time away from the standardized curricula for makerspace projects, while still yielding the benefits of the thinking routines and activities.

In a world inundated with new ideas to be implemented in classrooms for not only the sake of academic growth but social growth as well, teachers must communicate and share their findings and insights among the teaching community. Agency by Design strategies are one such idea that has grown in popularity in recent years, and despite the overwhelming push to implement this curriculum among sources, it is crucial that educators evaluate the curriculum from every angle. This study showed that implementing the Agency by Design strategies has beneficial outcomes, but the time and resources required for thorough implementation may not always be in a classroom teacher's best interest. However, elements of the Agency by Design strategies can and should be considered by all educators so that today's children can develop the necessary skills for the 21st century. By tapping into student creativity, educators can utilize elements of the Agency by Design strategies so that students become informed and passionate citizens, cognizant of not only how they can be agents in their own lives, but to help others as well. In a world growing in diversity and number, the best we can do for our youth is to prepare them to understand and care for things beyond themselves.

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Appendix A

Maker Empowerment Assessment

1. **I consider myself to be a maker.**
   Mark only one oval.
   - ◯ Strongly Agree
   - ◯ Agree
   - ◯ Neutral
   - ◯ Disagree
   - ◯ Strongly Disagree

2. **What does being a maker mean to you?**

3. **I often think about how and why certain things are made and what I could do to improve them.**
   Mark only one oval.
   - ◯ Strongly Disagree
   - ◯ Disagree
   - ◯ Neutral
   - ◯ Agree
   - ◯ Strongly Agree

4. **I often think about why certain systems, such as rules and procedures, are in place and how they could be improved.**
   Mark only one oval.
   - ◯ Strongly disagree
   - ◯ Disagree
   - ◯ Neutral
   - ◯ Agree
   - ◯ Strongly agree

5. **When something breaks I usually...**
   Mark only one oval.
   - ◯ use it broken.
   - ◯ ask someone else to fix it for me.
   - ◯ go to the store to buy a new one.
   - ◯ try to fix it myself.

6. **Check the appropriate box that describes how you feel about making things.**
Check all that apply.

	I do not feel this way at all	I only feel this way a little bit	I sometimes feel this way	I feel this way most of the time	I always feel this way
Empowered - I feel confident in my ability to change things in my life through making.	☐	☐	☐	☐	☐
Neutral - I don't feel strongly about making things, but I will if it's expected of me.	☐	☐	☐	☐	☐
Excited- I love to make things!	☐	☐	☐	☐	☐
Overwhelmed - I have a hard time getting excited about making things because it seems like so much work.	☐	☐	☐	☐	☐
Frustrated - Making things never goes my way, so I get upset and don't want to keep trying.	☐	☐	☐	☐	☐
Proud - I get really excited about showing and sharing what I've made with others.	☐	☐	☐	☐	☐

7. **I like helping others...**
Mark only one oval.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

8. **If I created something, it would be most important to me that it...**
Mark only one oval.

- ◯ was helpful to others
- ◯ made life easier or better for myself
- ◯ was really cool looking
- ◯ was something no one has ever thought of before (original)

9. **When something I do fails...**
Mark only one oval.

- ◯ I give up
- ◯ I take a break
- ◯ It motivates me to work harder

10. **How likely would you be to accept feedback from the following people regarding something you made? 1 = unlikely 5 = very likely**
Check all that apply.

	1	2	3	4	5
Classroom teacher	☐	☐	☐	☐	☐
Peer	☐	☐	☐	☐	☐
Parent	☐	☐	☐	☐	☐
Sibling	☐	☐	☐	☐	☐
Other teacher	☐	☐	☐	☐	☐
Community member	☐	☐	☐	☐	☐

11. **How likely are you to give suggestions to others?**
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Sometimes I give too much feedback

12. **How likely are you to accept suggestions from others?**
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	I often ask others for suggestions

Appendix B

Makerspace Product Checklist

	1	2	3
Product Agency	Product attempts to or does solve a problem in the student's life.	Product attempts to or does solve a problem in 2 of the following: ● student's own life ● student's home ● student's classroom ● student's school ● larger community	Product attempts to or does solve a problem in 3 or more of the following: ● student's own life ● student's home ● student's classroom ● student's school ● larger community
Product Creativity	Product is entirely based on something that I've seen before.	Product is partially based on something I've seen before, but I've added some new elements.	Product is completely new, I've never seen anything like it before.
Product Value - Circle appropriate descriptor(s)			
Efficient	Product does not make something: ● Work with less effort ● Less wasteful	Product slightly makes something: ● Work with less effort ● Less wasteful	Product really makes something: ● Work with less effort ● Less wasteful
Ethical	Student's project seeks to fulfill their own need(s).	Students project seeks to fulfill the unique need(s) of one person in their life.	Student sought to fulfill the need(s) of a particular group of people. Product seeks to improve the lives of others.
Effective	Product does not make something more successful.	Product makes something slightly more successful.	Product makes something much more successful.
Beautiful	Product does not make something more visually appealing.	Product makes something slightly more visually appealing.	Product makes something much more visually appealing.

Appendix C
Makerspace Student Reflection

1. **What do you find valuable about having time in the makerspace?**

2. **What have you learned from your time in the makerspace?**

3. **Do you think makerspaces belong in schools? Why or why not?**

4. **How could we improve the makerspace experience?**

5. **Has the makerspace experience changed you in any way? If so, how have you changed?**

6. **What do you find valuable about having time in the makerspace?**

7. **Has your time in the makerspace at school helped encourage you to engage in activities like this at home? If so, what have you done at home related to this makerspace?**

8. **What did you find valuable about working in your sketchbook?**

9. **What do you find valuable about having time in the makerspace?**