The Impact of Developing a Maker Mindset in an Interdisciplinary Fifth Grade Classroom

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The Impact of Developing a Maker Mindset in an Interdisciplinary Fifth Grade Classroom

Submitted on August 7th, 2019
in fulfillment of final requirements for the MAED degree

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Acknowledgements

This journey would not have been possible without the support from our family, friends, and colleagues. To our families, thank you for always encouraging us in our personal and professional pursuits and always inspiring us to follow our dreams. We must also thank the wonderful educators that we have had the privilege to collaborate and work alongside the past few years. Each educator has given us time, energy, and expertise, that has made us become richer more well developed specialist teachers.
Abstract

This action research studied the impact of having a maker mindset on a unit of study in art and coding classrooms. This study was conducted with two fifth grade classrooms in a rural kindergarten through eighth grade charter school. Two specialist teachers, one from Art and one from Coding conducted the research over the period of four lessons each. Pre- and post-surveys were administered as well as student journaling, exit slips, and a final project rubric. The study revealed that a targeted unit of study on the maker mindset positively affected learner attitudes in all of the 12 qualities that construct a maker mindset. The data acquired through the research process informs educators’ practice to include explicit instruction to enhance a maker mindset.

Keywords: Makerspace, Maker Mindset, Makerspaces, Experiential Learning, Inquiry Method, Engineering Design Process
Any person may enter a classroom where students are applying a maker mindset, and it may look unfamiliar or be seamlessly integrated into the classroom. Through the classroom chaos and mess, you will start to see students who are working hard, thinking outside of the box, sketching, and bringing their designs to life. You will begin to hear students saying things like “I think I need to change my design” or, “Let me see how you have fixed that problem” Hearing those things are signs of a maker mindset in action. As students begin to use a maker mindset, they believe that they can shoot for the moon and accomplish anything as long as they keep believing that mistakes are proof that they are leaning. Students with a maker mindset possess the ability to make deep connections, take creative risks, think divergently, problem-solve, and have more engaged hands-on learning.

Specialist classes, such as art and coding, are essential to high quality, well-rounded education. The implementation of maker mindset could enhance educators’ abilities to respond to an increasingly complex and fast-moving world. Currently, there is a need for effective implementation of maker mindset in the specialist classroom to aid in student growth for the future. Therefore, the purpose of this action research study is to implement a maker mindset unit of study to determine its effects on student engagement and success, along with how maker mindset learning has an impact on the specialists’ classroom environment.

As art and coding specialist teachers, we have found that each class has its own set of challenges depending on the teaching style of the classroom teacher. Some classes are more reserved and not willing to open up while others are team players who step up right away. Students who use a maker mindset are more likely to be open to growth and seeing potential in all subjects. Our research investigates the effect of a unit of study explicitly designed to increase students’
development of a maker mindset. A maker mindset is defined as “an invitation to take ideas and turn them into various kinds of reality. It is the process of iterating over a project to improve it. It is a chance to participate in communities of makers of all ages by sharing your work and expertise. Making can be a compelling social experience, built around relationships (Dougherty, 2013, p.2).” A maker mindset is similar to a Growth Mindset but viewed through the lens of producing and sharing artifacts. A Growth Mindset is a belief that ability can be improved through personal learning and improving goals that can advance one's skills. (Dweck as cited in Degol, Wang, Zhang & Allerton, 2018).

Makerspaces have become a fixture in many communities spanning through schools, libraries, and community centers. Another way of defining a makerspace is a workspace for students to make, learn, explore, and share with both high and low tech tools. Makerspaces allow students to use a hands-on learning environment that fosters playful curiosity.

**Statement of the Problem**

When students are primarily taught using teacher-directed learning activities, they develop more skills in the area of compliance than they do in creativity and problem solving. Students are being taught in a teacher-centered method and are unable to problem solve and think creatively. Many advocates for maker centered learning argue that the traditional method of teaching STEM topics through textbook reading are boring and uninteresting to students. (Clapp, Ross, Ryan, Tishman, 2017) The revitalization of interest in hands-on authentic learning has guided us to wonder if the maker mindset is a valuable piece to student success. These topics have brought us to consider: What are the effects of a unit of study explicitly designed to engage the maker mindset with fifth grade students in an interdisciplinary classroom?
Theoretical Framework

Experiential learning theory was proposed by psychologist David Kolb in 1984. The theory states that knowledge is continuously gained through both personal and environmental experiences. Furthermore, the ability to reflect, make problem-solving decisions, and use analytic skills is obligatory for the learner. Experiential learning is only effective when a maker mindset is present.

Experiential learning is identified as an idealized, holistic, and recursive cycle of education (see Figure 1). The experiential learning cycle consists of four main parts for students: experiencing, reflecting, thinking, and acting (Peterson, DeCato, Kolb, 2015). There is the presentation of a messy problem, students defining the problem, compiling a knowledge base of what students know and do not know about the problem, developing possible solutions, evaluation of possible solutions and finally presenting findings (Larmer, 2015). Implementation of the inquiry method is a critical component to developing a maker mindset. In the case of younger students, teachers must model how to be an inquisitive thinker (Golding, 2013).

![Kolb's Cycle of Experiential Learning](Image by Karin Kirk)

*Figure 1. Kolb’s Cycle of Experiential Learning (Kirk, 2018)*
Experiential learning is characterized by the ability to be involved in vast experiences that focus on experimentation and observation. In this theory, learners are immersed in experiences that encourage multiple points of reflection. “When facilitating, educators help learners get in touch with their personal experience and reflect on it. They adopt a warm affirming style to draw out learners’ interests, intrinsic motivation, and self-knowledge (Kolb, Kolb, Passarelli, & Sharma, 2014, p. 220).” This quote best sums up the importance of creating an environment where students are the center of the learning experience and feel supported to take risks in learning. Teaching experientially means learning alongside students in authentic ways. Experiential learning is more than just walking beside our students; it includes reflection to make meaning of the experiences we have (Glazier, Bolick, & Stutts, 2017). When experiential learning is employed in classrooms, there is a lack of script and an abundance of working with what is happening in the “now.” Teachers give up their expert status to authentically join students in their experience and their learning. The aspect of experiential learning that impacts a maker mindset the most is the hands-on approach required within it. As students in experiential learning environments become experts--so do students within a maker mindset environment.

Teachers that utilize experiential learning have the responsibility to let students take control of their learning by setting a growth-promoting climate that is safe for all students to express themselves (Kolb, Kolb, Passarelli & Sharma, 2014). Teachers also have a responsibility to create a classroom climate that is non-judgemental and lets students practice their listening skills. In the experiential learning approach, students will feel valued and respected with all of their contributions. Teachers will see their role as a coach to help students develop
problem-solving and collaboration skills. Students will be expected to take initiative, make decisions, pose questions, investigate, collaborate, foster knowledge, experiment, and problem-solve with the aid of a teacher (Glazier, Bolick, Stutts, 2017).

When teachers use experiential learning, they will have an ability to stretch not only their student’s minds but also their own minds. Learning for both teachers and students will need to focus on the process more than the product. Conflicts during experimentation are inevitable but are beneficial to creative knowledge building. Reflection is a crucial element for both teachers and students because it allows each party to evaluate actions and experiences. Teachers need to make connecting and engaging students as their top priority. “Freedom of choice in the makerspace is a big part of the draw. Curiosity and a willingness to try are all anyone needs (Sierra, 2017, p.48).” Experiential learning’s contribution to the maker mindset grants authenticity to the practice of doing—and sophistication to the process of making mistakes.

Where experiential learning is characterized by four main points, experiencing, reflecting, thinking and acting. Maker mindset focuses on grit, creativity, and curiosity. Both frameworks allow students to develop problem-solving skills. Experiential learning is identified as a recursive cycle whereas the maker mindset is tasked with changing attitudes about creation. Within both, students are seen as inquisitive learners. Experiential learning is characterized by vast experiences in experimentation and observation whereas the maker mindset is focused on the process over the product. They both allow students to be immersed in an environment where multiple points of reflection are expected.

Our literature review provides a foundation for understanding how the maker mindset will be used in our classrooms. Learning more about how the inquiry-based method, which is a
form of experiential learning, along with the engineering design process plays a role in having a maker mindset. This allows teachers to integrate the maker mindset into their classroom more effectively. Emphasizing experiential learning along with the method and the engineering design process will allow a definition of maker mindset to come forward and set it apart from the others.

**Review of Literature**

This literature review seeks to create a distinction between a maker mindset and other educational frameworks. A clear definition of the maker mindset and connections both the inquiry method and engineering design process are outlined below.

**The Inquiry Method**

Using inquiry as a teaching method puts the onus on students to ask questions, draw conclusions, and find evidence to support those conclusions. Teachers are not the gatekeepers to answers and information, it is up to the student to discover them through scaffolded learning activities (Jonassen, 2000). The instructional process involves engaging students in discovering problems as well as solving problems. Building on student interests that align with the curriculum and enabling student to student interaction is what creates meaning (Oppong-Nuako, Shore, Saunders-Stewart, & Gyles, 2015).

Teachers applying the inquiry method in their classrooms in a genuine and meaningful way to have a strong foundation for creating a meaningful makerspace for students. When teachers avoid taking on the role of “expert” and strive to not feel threatened when they don’t know the answer to a student question will help students to gain confidence and become experts themselves (Kurti, Kurti, & Fleming, 2014).
Teaching in a situation where questions do not have one correct answers create an intrinsic difficulty for the learner. where the learner is in some sense, lost, epitomizes the makerspace. Leading learners to the right answer do not help them learn how to continue. It may solve the immediate problem of moving them to a particular outcome, but does not by itself provide them with the ability, or the confidence, to find the way on their own (Burbles, 2000, p.184).

This passage speaks to the heart of why makerspaces have become a much-needed tool in the field of education. The process of coming to understand, rather than the funneling of “correct” answers is what gives the maker movement its power. In an era when almost any person anywhere can come up with an answer to a question via Google the importance of being able to apply knowledge and generate creative non-linear responses to problems has increasing significance in the valuable work that schools do in shaping students’ mental frameworks for approaching novel problems. In a makerspace, teachers are not concerned with the right answers, but the range of possibilities for students to be creative.

There is not a makerspace that will succeed and grow without a supportive environment (Kurti, Kurti, Fleming, 2014). A supportive environment will include participation that is collaborative for both the teacher and the students. Discovering what students need--rather than want--and determining if that will be integrated or separate from the existing curriculum are essential factors when outlining the components of a makerspace (Fontichiaro, 2016).

The inquiry method fits well within the constructs of the maker mindset we are exploring. Where the inquiry method teaches students through exploration and investigation, the maker mindset differs in that students conquer challenges through guidance from teachers. They
connect at the point where exploration is required for student learning. Within the inquiry method, everyone is seen as a learner wherein the maker mindset experts are integrated into the creating process. A support system is present in both methods but the roles are not the same. The inquiry method needs to be explicitly modeled to students whereas in the maker mindset students have an invitation to think broadly and become part of the maker community.

The Engineering Design Process

The engineering design process is a multi-step iterative process for design (see Figure 2). The relationship of the engineering design process to the maker mindset is that it can be a process students use for discovering problems, developing solutions and creating tangible results. The process is a multi-step endeavor focused on product development where the maker mindset is focused on character trait development (Dweck, 2010).
Establishing an environment where students can not only discover but also grow and hone their skills is essential when implementing a makerspace to develop the maker mindset. The engineering design process is a model for exploring a person's surroundings that fits well into the maker mindset.

The final and most crucial step is student buy-in (Kurti, Kurti, & Fleming, 2014). As a teacher guides students through the engineering design process, students can restructure the way they gain and understand information. This allows for student buy-in because it allows students to take ownership over the process of making. This in return builds a positive view of themselves and how they view their role in the world.
The way a student learns gives them an opportunity to benefit from different parts of the engineering design process. Different students will find different activities exciting and challenging. Activities like sketching, visualization, and journaling connect to the “detecting possible solutions” step of the engineering design process whereas brainstorming and questioning are an important aspect of “testing and evaluating solutions” (Safranj & Zivlak, 2018). Many of these activities are seen in an established makerspace. These makerspace environments are enhanced by working with other teachers and empower students to become confident leaders and problem solvers who shape their own learning (Smay & Walker, 2015). A makerspace allows students of multiple intelligences to participate and use their skills collaboratively to problem solve. Utilizing the engineering design process in a makerspace will enable students to use their sense of perception to create and manipulate different objects and ideas. As students’ perceptions are heightened, teachers will see an improvement in students’ ability to collaborate, solve problems, and use their imagination. Combining the engineering design process and a makerspace will allow students to think in a broader sense, use collaborative skills, and interact with materials and peers. Within this combination, teachers and students can view each idea as a valued contribution to be explored.

Where the engineering design process allows teachers to understand student interests, the maker mindset invites students to create their own reality. While there are many varied activities in the engineering design process the maker mindset is more focused on the exploration and challenges specific to student interests. Each component highlights the process of iteration and encourages student learning in different ways. In our unit of study, students were expected to make multiple
attempts to create a working parallel circuit. Both frameworks require active engagement from multiple parties.

The overarching theme in the literature review is that students are equal partners in the learning process. Teachers do not have all the answers and encourage students to construct knowledge through trial and error. The review of the literature has guided us to focus on the Impact of Developing a Maker Mindset in an Interdisciplinary Fifth Grade Classroom for our research. We derived 12 maker mindset qualities from our literature review that were used during our unit of study (see Appendix A). The 12 maker mindset qualities are:

- I can learn from my mistakes.
- I can improve by working hard.
- I never give up when creating I always try my best.
- I will succeed if I try my best.
- The process if more important than the product.
- I can overcome challenges if I put in the effort.
- I can train my brain.
- I should not give up when creating.
- Feedback is always helpful when doing a project.
- I am a creative risk-taker.
- 12) Setting a goal will help me achieve my dreams.

Thus, these 12 qualities were used to see the impact of developing a maker mindset in an interdisciplinary fifth grade classroom.
Methodology

This study included an experimental research design method with a teacher and student journaling, pre-post-surveys, daily exit slips, and a rubric used to assess a final student project. The research took place in a small rural charter school in the midwest and conducted in two fifth grade classrooms. Classroom “A” is a class of 21 students in which 86% of the students are classified as White/Caucasian, and 14% of the students are classified as Hispanic. Classroom “A” is identified as having 14% of the students receiving special education services. Classroom Teacher “A” identified as having six years of teaching experience with an emphasis on responsive classroom and outdoor education. Classroom “B” is a class of 21 students. 90% of the students are classified as White/Caucasian, 9% Hispanic, and 1% two or more ethnicities. In classroom “B,” there are not any special education students. Classroom teacher “B” has identified as having four years of teaching experience. Classroom “A” had ten males and 11 females while classroom “B” had nine males and 12 females.

Pre-post-surveys used the Likert scale that consisted of twelve questions (see Appendix A) that were extrapolated from the literature review regarding growth mindset, the engineering design process, and inquiry-based teaching methods. The pre-post-surveys were given in the art classroom. Exit slips (see Appendix C) were collected at the end of each lesson for students to reflect on their outcomes. Lastly, the final work rubric (see Appendix D) was used to evaluate student learning.

First, students were given the pre-survey (see Appendix A). Students were given a piece of paper with the twelve questions and circled their rating for each question. Then each student completed the eight lessons in the unit. During each lesson, students completed a journal entry
about vocabulary and accomplishments for that lesson (see Appendix B). In addition to the journal entries, students completed exit slips at the end of each lesson in the unit. The exit slips asked students about keywords used, accomplishments, preventions, and changes for that completed lesson (see Appendix C). After the unit was complete, students were given the post-survey (see Appendix A); where they circled their rating for each of the 12 maker mindset questions. Finally, the completed projects were graded against a rubric that students were presented with during the second week of the unit of study (see Appendix D).

**Analysis of Data**

The raw data for the pre-post-surveys were in the form of Likert scales, where students selected their responses. A team comprised of two researchers systematically sorted the total number for each category. These categories were comprised of a scale from 1-5, (see Appendix X). These category totals were placed in graphs for each maker mindset question. This data showed trends based on each specific question. Afterward, each pre-post-survey was labeled with the student's discrete identification code. Tables were formed using the combined scores for the pre-post-surveys data to establish individual student gain scores.

The raw data for the exit slips included one section for each of the four days of the unit. Again, a team of two researchers sorted through and coded each students’ accomplishment data. Total percentages were placed into graphs that indicate what days information will need more reteaching.

The raw data for reflections were included inside of the learning journal as well. A team of coders sorted through each students’ outcomes of the day. This data was coded by separating each of the four days and recorded on a bubble chart. This data showed what students would
change next time to be more successful. These changes were taken into account when teaching subsequent lessons throughout the unit.

The raw data for the final assessment was a scale that two teachers filled out for each student on a 1-3 scale; (1) Does not meet the standard, (2) Approaching the standard, (3) Meets the standard. The 1-3 scaled grade was added up for each student based on six key elements from the unit. These totals were converted into percentages and compared against their gain score percentages for each student.

Maker Mindset Development based on Individual Questions

The purpose of this study was to identify the growth of 12 different qualities that make up the maker mindset. The research design was descriptive and a survey that utilizes a series of Likert scale questions were used to gather the information for each fifth-grade classroom.
Figure 3.1 shows the pre-post-survey data for question one on the maker mindset survey. Within this question, it is seen that “sometimes true” was the most popular answer in both the pre-post-survey. There is an upward spike on the post-survey in the rating of “Always true”.

*Figure 3.1. I can learn from my mistakes (side by side comparison of pre-post-survey results)*
Figure 3.2 shows the pre-post-survey data for question two on the maker mindset survey. Students fall primarily in the category of sometimes true or always true on the post-survey.

Figure 3.2. I can improve by working hard (side by side comparison of pre-post-survey results)
The results of Figure 3.3 indicate a 14% overall increase in the categories of sometimes true and always true.

*Figure 3.3. I never give up when creating (side by side comparison of pre-post-survey results)*
Figure 3.4 shows the upward growth of the maker mindset quality of “I always try my best”. Given that 42 students participated in the unit of study, the graph depicts ten students moving to the sometimes true or always true part of the graph.

*Figure 3.4. I always try my best (side by side comparison of pre-post-survey results)*
The results of Figure 3.5 shows the maker mindset quality of “I will succeed if I try my best”. Students responding “Always True” to the prompt jumped from 11 to 24, more than doubling the initial response. There was also a decrease in students responding that it is sometimes false that they will succeed if they try their best, going from four “Sometimes False” to zero.

*Figure 3.5. I will succeed if I try my best (side by side comparison of pre-post-survey results)*
Within the outcome from Figure 3.6, it is shown that the unit of study taught did not show much movement on either the false or true side of the spectrum. Most students stayed or only moved a small amount in the category of “the process is more important than the product”.

*Figure 3.6. The process is more important than the final product (side by side comparison of pre-post-survey results)*
Figure 3.7 indicates 7% of students believed they could never overcome challenges if they put in effort and that decreased to 0% of students.

*Figure 3.7. I can overcome challenges if I put in effort (side by side comparison of pre-post-survey results)*
Results of Figure 3.8 show significant gains in students’ belief that they are able to train their brain. This increase of 60% indicates a shift in students perceptions in how their actions can impact their learning.

Figure 3.8. I can train my brain (side by side comparison of pre-post-survey results)
Figure 3.9 Shows the students responses to the quality of “I should not give up during creation”. There was a 14% increase in student perception that they should not give up while they are working to complete a task.
Figure 3.9. I should not give up during creation (side by side comparison of pre-post-survey results)
Figure 3.10 indicates a significant increase in students' ability to view feedback as a critical part of the maker process. The largest increase was from neutral and sometimes true to always true.

*Figure 3.10. Feedback is always helpful when doing a project (side by side comparison of pre-post-survey results)*
Figure 3.11 shows a significant decrease in the number of students who considered themselves as never taking creative risks, changing from 10% of participants to 0% of participants, as well as an increase of 12% of students reporting they are always creative risk-takers.

*Figure 3.11. I am a creative risk taker (side by side comparison of pre-post-survey results)*
Figure 3.12 The largest increase in students belief that setting goals help them achieve their dreams was from the neutral category to the sometimes true category with a 60% increase of students in the answering “neutral” to the post-survey answering “sometimes true”.

Figure 3.12. Setting a goal will help me achieve my dreams (side by side comparison of pre-post-survey results)

Maker Mindset Development by Gain Score

The purpose of this study was to identify the gains that each individual student made during the maker mindset unit of study. The research design was descriptive and a survey that utilizes a series of rated questions were used to gather the information for each student.

Figure 4 shows gain score percentage and rubric score percentage for Class A. On the initial survey; it is determined that the average gain score is 11%. Students A3 and A21 had the
most gains in Class A. On the final survey, the table shows that the average gain score was 11%.
The table shows that student A1 had the lowest post-survey score of -41%. Within the gain score
column for Class A, it is shown that 17 out of the 21 students did make gains in the development
of maker mindset.

Figure 4. Class A Gain Scores.

Figure 5 shows gain score percentage and rubric score percentage for class B. On the
initial survey it is determined that the average gain score is 17%. Student B12 had the highest
gain at 175%, while student B8 had the lowest score at -12%. On the final survey, the table
shows that the average gain score was 17%. Within the gain score column for Class B, it is
shown that 16 out of the 21 students did make gains in the development of maker mindset.
There is no correlation between a higher gain score with a higher rubric score. There are examples of students who showed negative growth and still performed well on the project overall. Likewise, there are students who indicated high gains in their maker mindset but did not score high on their project.

Maker Mindset Exit Slips

The purpose of this study was to identify the pieces of each lesson in the unit of study that would need to be retaught. The research design was descriptive and a survey that utilizes a yes or no question was used to gather the information for each day during the unit of study.

Figures 6.1 and 6.2 represent the first of the four lessons. Art students who indicated they did complete what they expect to were 91% and 74%, of Coding students indicated they had
accomplished what was expected. In coding, more review was needed in TinkerCAD for students to complete their task for day one.

*Figure 6.1. Art Lesson 1: Did you accomplish what you expected to?*

*Figure 6.2. Coding Lesson 1: Did you accomplish what you expected to?*
Figures 6.3 and 6.4 indicate the same number of students accomplished what they expected to in week two in Art and Coding. More review on circuits was needed in Art while more review on 3D shapes was necessary for Coding.

**Figure 6.3.** Art Lesson 2: Did you accomplish what you expected to?

**Figure 6.4.** Coding Lesson 2: Did you accomplish what you expected to?
Figures 6.5 and 6.6 depict Art needing more review than Coding in the following lesson. Art students required more review of parallel circuits while the bulk of students in coding were able to accomplish what they expected to.

*Figure 6.5. Art Lesson 3: Did you accomplish what you expected to?*

*Figure 6.6. Coding Lesson 3: Did you accomplish what you expected?*
Figures 6.7 and 6.8 show a two percent difference in expected outcomes between Art and Coding. Being the final week, some students that did not accomplish what they expected to were pulled out of their general education classes to complete the project.

*Figure 6.7. Art Lesson 4: Did you accomplish what you expected?*

*Figure 6.8. Coding Lesson 4: Did you accomplish what you expected?*
Maker Mindset Journaling

The purpose of this study was to identify changes that were implemented during the planning and execution in each lesson of the unit of study. The research design was descriptive and a survey that utilizes a series of open-ended questions were used to gather the information for each lesson during the unit of study.

The data displayed in Figure 7 shows the seven most prevalent answers students gave on the changes they would make during the unit of study. Time management was the most common answer during the unit of study with 38%. Try again was the least common response with 10%.

![Figure 7. Student Feedback on Changes](image)

The data we collected over the course of eight lessons between two specialists have informed our practice and provided insight into both teaching methods and learner outcomes that will guide us well into the future. In the following section, the application of all the data is
mapped out in a succinct way that explains how to teach a successful unit of study to promote a maker mindset.

**Findings**

Within our project, we see clear parallels between our unit of study and developing a maker mindset. The pre-post-survey results provided us with information on the development of the 12 maker mindset qualities. Within the 12 qualities of maker mindset, our data shows a growth in all of them. Thus, our unit of study did have a positive effect on learners developing a maker mindset. The gain scores provided us with information on correlations between rubric score and maker mindset development. Figures 4 and 5 show that there was no correlation between having a higher rubric score and developing a maker mindset. We were surprised to see that one student had a 175% gain in their maker mindset development because it is a significant deviation from the average score. The exit slips provided us with information on how we could improve our teaching and what information needed to be reviewed, next class. We saw the most need for review on the last day of the unit. The information obtained leads us to conclude more time is necessary and we believe two days will be needed if replicating the study. The journaling provided us with feedback on what changes students would make. Student journaling did not indicate an issue students had with material specific to the lesson but rather overall classroom expectations and time management on the part of the student. There were very few items that could be modified in relation to the material being taught. Overall our data show a positive growth in maker mindset development for fifth-grade learners in an interdisciplinary classroom.

**Action Plan**
The culmination of our research shows that students in our two fifth grade classrooms possess the ability to acquire a maker mindset based on a specific unit of study.

To further develop a maker mindset that is transferable from subject to subject, we would need to implement several interdisciplinary units of study throughout the year. These units of study could be combined with other specialists or classroom teachers. Further research on the strategies that would improve the application of the 12 qualities that make up maker mindset would improve instruction and increase the maker mindset. Students may be able to better articulate the thinking aligned with the growth of a maker mindset.

We intend to continue to incorporate maker mindset activities into our classrooms and integrate activities that include collaboration, a wider range of grades, and span more time. Collaboration is at the top of our list because teachers should work together to include the maker mindset within many different aspects of each day. We also plan to have several activities throughout the year that we will work together as specialists again. Allowing students more time will allow them to plan, build, reiterate, and reflect. We see the greatest potential in developing a maker mindset, in the students’ reflections and use of a variety of teaching strategies through many class hours. We plan to include a variety of grades into this study because of the ability in our schedules to add middle school students. Reevaluation of all students maker mindset will occur at the end of each school year.

Hands-on, reflecting experiences push students’ thinking out of the box and expand strategies they are used each day when playing or learning. If all classrooms had a makerspace, there would be greater potential for developing a maker mindset. As specialist teachers, we plan to introduce two carts with different materials and information on the maker mindset into each
building at our school. We believe that if teachers have materials and information, more teachers will be able to integrate the Makerspace cart and mindset into their classrooms. We both believe that if students have multiple experiences using the maker mindset qualities, the overall growth for each student would improve exponentially each school year. Further, long term research would have to be conducted to determine if this perceived outcome would be attainable and impactful for all students. There are many topics for further investigation. Some of the topics include the following:

1. Do the qualities listed in the maker mindset pre-post-survey accurately depict the current definition of a maker mindset? Do new items need to be added or taken away based on current research?

2. Do the strategies we focused on for each lesson actually foster a maker mindset or are there other activities that could be used?

3. Do different classrooms need different types of instruction in the maker mindset qualities?

4. Do different groups of students (i.e. special education) need different types of instruction to develop certain areas of a maker mindset.

5. Are there specific activities for each grade level that have been proven to develop a maker mindset?

Maker mindset and makerspaces are a relatively new topic of study. There is much more research that could be developing daily. Future research may provide additional insight into the benefits of having makerspace activities and connect these to developing a maker mindset. Furthermore, identifying a tool, or specific resources to teach each quality of maker mindset in
students may be increasingly important with the rise in the maker revolution, to determine students' academic, personal, or professional successes.
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**Appendix A**

Maker Mindset

Circle a number on a scale of 1-5.
THE IMPACT OF DEVELOPING A MAKER MINDSET

1 = always false 2 = sometimes false
3 = neutral
4 = sometimes true 5 = always true

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<table>
<thead>
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<tbody>
<tr>
<td>1</td>
<td>I can learn from my mistakes.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2</td>
<td>I can improve by working hard.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3</td>
<td>I never give up when creating.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4</td>
<td>I always try my best.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5</td>
<td>I will succeed if I try my best.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6</td>
<td>The process is more important than the final product.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>7</td>
<td>I can overcome challenges if I put in effort.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>8</td>
<td>I can train my brain.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>9</td>
<td>I should not give up during creation.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>10</td>
<td>Feedback is always helpful when doing a project.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>11</td>
<td>I am a creative risk taker.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>12</td>
<td>Setting a goal will help me achieve my dreams.</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

*Items 2,3,7, and 10 are taken from Carol S. Dweck.*

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Appendix B

Maker Mindset Coding Day #1

Goal of the day: Log into TinkerCAD, Complete first tutorial

Planned outline of the day:
Discuss Maker Mindset
Watch 3D Printing Video
Complete TinkerCAD tutorial

Outcome of the day:

Key Words:
Additive Manufacturing:
Filament:
Ink
Laser:
## Maker Mindset Coding Day #2

### Goal of the day:
Create 3D model of game dice, review TinkerCAD vocabulary

### Planned outline of the day:
- Learn TinkerCAD Specific vocabulary
- Make 3D game dice
- View the object on different plains in TinkerCAD

### Outcome of the day:

### Key Words:
- Plain
- Group
- Ungroup
Maker Mindset Coding Day #3

Goal of the day: Copy and Paste Objects, Manipulate sizes by typing values

Planned outline of the day:
- Watch video on high-interest 3D Print projects
- Have students create size specific objects
- Create copies of objects in the 3D Plain

Outcome of the day:

Key Words:
- Copy
- Paste
- Uniform
- Group
Maker Mindset Coding Day #4

Goal of the day: Create 3D Constellation

Planned outline of the day:
Create a 3D Constellation meeting requirements in rubric
Export design and email it to Ms. Wells

Outcome of the day:

Key Words:
Export
Constellation
Maker Mindset Art Day #1

Goal of the day: Background painting of the sky

Planned outline of the day:

- Review of Maker Mindset
- Introduction to watercolor resist techniques
  - Salt
  - Oil Pastel
  - Plastic wrap
- Review Constellations & the Solar System
- Demo Painting techniques
- Painting time
- Journal & Exit Slip

Outcome of the day:

Key Words:
- Resist
- Solar System
- Maker Mindset
- Constellation
- Wet on wet watercolor
- Creation
- Astronomy
Maker Mindset Art Day #2

Goal of the day: Circuit review and exploration

<table>
<thead>
<tr>
<th>Planned outline of the day:</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Review circuits &amp; materials</td>
</tr>
<tr>
<td>● Circuit Demo</td>
</tr>
<tr>
<td>● Circuit exploration time</td>
</tr>
<tr>
<td>● Preview for card making</td>
</tr>
<tr>
<td>● Journal &amp; exit slip</td>
</tr>
</tbody>
</table>

Outcome of the day:

Key Words:
- Open Vs. Closed Circuit
- Electrical Energy
- Conductor
- Electricity
- Current
- Exploration
Maker Mindset Art Day #3

Goal of the day: Card Design with LED

Planned outline of the day:

- Review circuits
- Think-pair-share: Card designer
- LED Card intro
- Card Creation work time
- Journal & exit slip
- Preview next time

Outcome of the day:

Key Words:
- Circuit
- Imagine
- LED Lights
- Copper tape
- Battery
- Problem-solving
Goal of the day: 3D printed LED Constellation Construction

Planned outline of the day:

- Overview Constellation Construction
- Pass out materials
  - Resist Painting
  - LED Lights
  - Copper Tape
  - Battery
  - 3D print
- Demo Assembly
- Assembly Work Time
- Journal & Exit slip
- Post Survey
- Maitre-D

Outcome of the day:

Key Words:
- Collaboration
- Integration
- Plan
- Circuit
- Filament
### Appendix C

Exit Slip - Maker Mindset

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did you accomplish today?</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you accomplish what you expected to?</td>
<td></td>
</tr>
<tr>
<td>Yes or No</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>What prevented you from completing what you wanted to?</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>What will you change next time to be more successful?</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>What is a keyword that you used today?</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix D

Student ID: _________________________________

<table>
<thead>
<tr>
<th>Final Unit Criteria</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ports for LED’s</td>
<td>Constellation contains at least 3 ports for LEDs</td>
<td>Constellation contains 2 ports for LED’s</td>
<td>Constellation contains 1 or no ports for LED’s</td>
</tr>
<tr>
<td>Number of lights</td>
<td>At least 3 lights that are on at the same time</td>
<td>2 lights that are on at the same time</td>
<td>1 or no lights on at the same time</td>
</tr>
<tr>
<td>Size of Constellation</td>
<td>At least 6” wide</td>
<td>4”-6” wide</td>
<td>Less than 4” wide</td>
</tr>
<tr>
<td>Uniqueness</td>
<td>Constellation is completely unique, unlike any other constellation</td>
<td>Constellation follows similar patterns of known constellations</td>
<td>Constellation is a copy of an existing constellation</td>
</tr>
<tr>
<td>Watercolor painting</td>
<td>Student used a resist technique in their watercolor background</td>
<td>Student used a non-resist watercolor technique</td>
<td>Student did not use watercolor</td>
</tr>
<tr>
<td>Reflection Sheet</td>
<td>Student completed all exit slips</td>
<td>Student completed at least 50% of exit slips</td>
<td>Student completed less than 50% of exit slips</td>
</tr>
</tbody>
</table>
Appendix E

Replication Note to Educators:

Student’s were introduced to TinkerCAD in the coding classroom and were tasked with creating a simple design using 3D shapes. In the Art classroom, students were introduced to the solar system and what a constellation is. Each student painted the background for their constellation design using watercolor paint and a resist technique. Students began creating designs in TinkerCAD using uniform shapes and sizes that group together meeting specific size requirements. Students reviewed and explored parallel circuits in the art room using copper tape and LEDs, then designed their constellations within the given parameters. Those drawings were translated into 3D CAD designs in Coding class which in return were printed on a 3D printer. After all of the prints were completed students mounted their design to the background they had painted in art. Their constellation was then wired to create a parallel circuit using led lights, copper tape, and button batteries.