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Measuring the Effects of a Student Teaching-Based Unit on 3rd Graders' Perceptions of Engineers and Engineering

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Abstract

This paper explores previous findings on this topic and extends the level of research to lower grades of students. The research articles vary in finding for some upper elementary grade but eventually reach the same overall general consensus. Majority of researchers found that students do not have a clear understanding of what engineers are or what they do. They often confuse engineers with scientists, vocational workers, and train conductors. Of all the varying studies conducted on this subject, many researchers have used upper elementary aged students as subjects (4th and 5th grade). This project differs from them in the age of the subjects (3rd grade) and the process in conducting the research. Students are given a similar assessment as in other studies , called the Draw an Engineer Test (DAET), but they are also taught a week-long unit that focuses on the engineering practices laid out in the Next Generation Science Standards (NGSS) as well as a focus on engineers in general. The goal of this project is to exemplify the importance of including engineering in **all** elementary classrooms rather than just upper elementary classes.

Keywords: Engineering, Draw an Engineer Test (DAET), Next Generation Science Standards (NGSS), standards.

Importance of Science Education

Technology has become more prominent in society. An unfathomable collection of information is constantly at society's fingertips, and the information and amount of technologies continues to grow. Since society is becoming so dependent on technological innovation, the need for teaching Science, Technology, Engineering, and Mathematics (STEM) concepts in classrooms is increasing. However, there was a major decline in engineering enrollments in the 1990s (Colston, Thomas, Ley, Ivey, & Utley, 2017). This decline led to a smaller pool of prospective engineers, despite the growing enrollment of engineering majors in universities, to meet the excessive need for engineers. The following year saw a spike in engineering course enrollments, but research showed even with the rise in the choice of engineering as a career, the students studying to become engineers were still fulfilling the need for engineers in our society. There was debate about the effectiveness of mathematics and science instruction on a wide scale, ranging from elementary all the way to higher education in college. (Colston, Thomas, Ley, Ivey, & Utley, 2017). This research shows that STEM education during these years needed revision to improve the quality of the education students were receiving. Incorporating the newly adapted STEM concepts earlier during students' educational experiences, students will start out with these concepts under their belt and teachers can use the constructivists theory to build upon that knowledge as they grow in their education and give students a more rounded STEM education.

Research shows that students already have an indication of their future career by middle school (Colston, Thomas, Ley, Ivey, and Utley, 2017). If elementary students do not have exposure to the wide variety of engineering careers they could possibly have, they are less likely to pursue a career in engineering (Colston, Thomas, Ley, Ivey, and Utley, 2017; Duncan, Diefes-Dux, & Gentry, 2011). If students are less likely to pursue a career in engineering, the number of eligible engineers will decline, and society's need for professional engineers will never be met. Not only would incorporating these concepts in education help students better understand them, the newly adopted Next Generation Science Standards (NGSS) require teachers to do so.

The newly adopted Next Generation Science Standards (NGSS) are based on a text released by the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE) titled, *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press). The Next Generation Science Standards were drafted in 2011 and released and adopted in April 2013. These standards are vastly different from other standards. They were written and released publicly on two separate occasions for the public to comment on the standards and their merit. The NGSS were created based on a collaborative effort and underwent multiple revisions until their release in 2013. The release of these standards caused for a greater focus on STEM concepts in the classroom as the STEM concepts are directly woven into the standards themselves. (NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press). The standards themselves consist of the performance expectation, crosscutting concepts, science and engineering practices, disciplinary core ideas, and common core connections. The performance expectations state what the students should be able to do once they have mastered the standard and also includes a clarification statement for educators to fully understand what is expected of the students. The crosscutting concepts help students and educators explore the connections between the different domains of science. Science education can be divided into four domains: physical science, life science, earth and space science, and engineering design. The crosscutting concepts help students see the connections between the domains in this section by explaining how they are connected. The science and engineering practices sections describe how scientists investigate the world around them and how engineers design and build systems to solve a problem or meet a need. Students learn about these practices and they put them into practice as they are working on mastering the standards and the practices help give students a deeper understanding of core ideas and crosscutting concepts. The first section, the performance expectations, explain what students are expected to do upon mastering the standard. The next section, Disciplinary Core Ideas, defines the broader concepts at play within the standard that can be applied to other domains of science or other subjects as well. The final section, Common Core Connections, connects concepts in the standard to concepts in other common core standards such as math or language arts. For example, one of the common disciplinary core ideas is cause and effect which can be applied in science as well as in language arts. By incorporating these standards into the everyday classroom, students are given the opportunities and information they need to help them learn about STEM concepts and make connections between science domains and different subjects.

Research Questions

The research questions that drove this project are a) How do 3rd grade students in a general classroom perceive engineers and the field of engineering? and, b) How does a student teaching-based unit about engineering change 3rd graders' perceptions of engineers and engineering?

Background

The need for students to pursue careers in the engineering and science fields is rising, yet fewer students are choosing these careers. The No Child Left Behind Act and the increased use of standardized testing put such an emphasis on Language Arts and Mathematics fluency that science education is recent years has become less important in schools. Willingham (2009) found that only 5% of the allotted class time is dedicated to science in 3rd grade classrooms in the United States. The same study also found that a 47% of class time is dedicated to language arts in 3rd grade classrooms (Willingham, 2009). The emphasis of language arts and math in third grade classrooms leaves less time for science and social studies. This causes students to develop misconceptions to help them connect with the world around them and make sense of it. Research has shown that early exposure to STEM concepts can generate higher achievement scores, meaning integrating STEM concepts in classrooms with young learners is the most effective (Becker and Kyungsuk, 2011; Swift & Watkins, 2004). The ideal classroom allows time for all subjects and allows students to make connections in their learning every day.

The STEM initiative began in 1958 during the Space Race with Russia. The United States passed the National Defense Education Act which sought to increase a focus on Math and Science education (Epstein & Miller, 2011). A quality STEM education should improve their familiarity with technology and give them an understanding of how things work. The E in STEM is for Engineering, which promotes innovation and problem solving (Bybee, 2010). This study intends to emphasize the E in STEM and what it really means. Students in elementary grade levels are more inclined to tinker with things and take them apart. If schools start exposing students to STEM concepts early on, educators can maintain that natural spark as they progress through school and be more susceptible to pursuing an engineering career (Lachapelle and Cunningham, 2014). STEM education is a must at the elementary level to push future careers in engineering and science, but just integrating STEM education is not enough. The STEM education being integrated must be effective.

The best way to give students opportunities to experience what it's like to be an engineer, appropriate measures need to be taken in schools. One of the most important things is to have teachers well-versed in STEM education. It is important to give teachers professional development opportunities dealing with STEM (Stohlmann, Moore, & Roehrig, 2012). A helpful tool for teachers, designed and tested by researchers at the Museum of Science in Boston, is the Engineering is Elementary curriculum. Research of the effectiveness of the curriculum showed that students who participated in the study had a better understanding of engineering as involving design and teamwork rather than technical or construction jobs (Lachapelle & Cunningham, 2007). The developers of Engineering is Elementary curriculum wanted to create a tool for teachers to effectively teach engineering concepts to students. They created a program that provided curriculum for teachers to use and professional development workshops for teachers to better their skills in delivering the material. If the students are to receive education that betters their understanding of the world around them, the teachers must first be well equipped to deliver the material. The Engineering is Elementary curriculum helps guide teachers in the best practices for delivering the material with mentor texts and easy to follow instructions for projects. The goal of the curriculum was to correct misconceptions about engineers as well as misconceptions about technology.

Many students think technology is computers or electronics, but technology can be anything man-made that is meant to meet a need or want of society (Cunningham, 2009; Levin, & Barry, 1997). There is an activity that is part of the Engineering is Elementary curriculum in which students are exposed to different types of technology. Engineering is Elementary exposes students to the idea that technology is not always electrical and defines three different types of technologies engineers design: objects, systems, or processes. Although society has shifted to electronic and digital technologies as the main need, students must also understand that at one time a pencil was an object that served as a new technology that improved writing or a recipe for canning was a system that was a new technology that helped people can their crops to keep them longer. An understanding of both forms of technology, electronic and non-electronic, is essential for students to understand the concept of engineering. The Engineering is Elementary curriculum was written based on data collected from students using an effective data collecting tool to help the developers create the most successful curriculum for educating students about engineering.

The Draw an Engineer Test (DAET) has been administered to children at varying age levels in many different studies, one being the Engineering is Elementary curriculum designers. Majority of the studies were conducted on middle school students or upper elementary students (mostly fourth and fifth grade). The studies were conducted in different places and used different methods, but the research produced the similar results. Whether students participated in a summer engineering program (Oware, Capobianco, & Diefes-Dux, 2007) or the curriculum was integrated into the school (So Yoon, Lucietto, Capobianco, Dyehouse, & Diefes-Dux, 2014), the results showed improvement in student understanding of engineering. Some studies chose to measure the difference in the results based on the gender of students given the assessment (Hirsch, Berliner-Heyman, Cano, Carpinelli, & Kimmel, 2014). One study used the DAET to compare children of fourth and fifth grade's perceptions of engineers and technology. The study shows that fourth and fifth grade students have similar interest and perception of STEM careers; male and female students had similar perceptions of STEM jobs; and younger children have greater interest in STEM jobs, specifically math and science (Kurz, Yoder, & Ling Zu, 2015). The majority of the studies came to similar conclusions regarding how children perceive engineers (Capobianco, Diefes-dux, Mena, & Weller, 2011; Cunningham, Lachapelle, &

Lindgren-Streicher, 2005; Knight & Cunningham, 2004; Lachapelle, Phadnis, Hertel, Cunningham, 2012). The pre-assessment (DAET) results showed that students commonly associate engineering with construction work or vehicle mechanics and research showed that students do not associate a design process with engineering (Capobianco, Diefes-dux, Mena, & Weller, 2011). One study explains the extent of the misconceptions best when it said, "Children are more likely to think that engineers clean teeth than design ways to clean water!" (Cunningham, Lachapelle, & Lindgren-Streicher, 2005) Students showed no understanding of engineers or the profession. Students need to understand that engineering is a viable career choice for them, and they also need to understand what all the term engineering encompasses and what that career entails. While many of the studies have reached the same conclusion regarding students' perceptions of engineers, many different approaches for correcting these misconceptions have been suggested by different researchers. Some used the Engineering is Elementary curriculum as an intervention (Lachapelle & Cunningham, 2007), others were measuring the teachers' perceptions of teaching engineering and their comfort with teaching the subjects to gauge what teachers needed to best deliver the content (Hsu, Purzer, & Cardella, 2011; Estapa, & Tank, 2017; Duncan, Diefes-Dux, & Gentry, 2011; Dejarnette, 2018; Mendoza Diaz, Cox, & Adams, 2013). The Draw an Engineer Test (DAET) is a tested and proven method of data collection and is the chosen data collection instrument for this project as well.

Another important aspect of this research is the professional development aspect. This project will not focus on the professional development but there is research that supports the need for teachers to have access to appropriate resources to help them teach STEM concepts effectively (Lehman, WooRi Kim, & Harris, 2014; Bybee, Fortenberry, & Walker, 2005). One study found the professional development helped teachers identify STEM concepts but when they went back into their classrooms, they replicated the activities from the professional development rather than applying the principles and creating new challenges (Estapa & Tank, 2017). Teachers need the understanding of the engineering concepts to a degree in which they can create their own problems and activities for students to also understand the underlying concepts. If students don't understand the underlying concepts that connect the material, they will not see the purpose of the activities and, in turn, will not be fully engaged in them. Another study analyzed the level of comfort educators felt delivering the content in their classrooms (Hsu, Purzer & Cardella, 2011; Mendoza Diaz, Cox, & Adams, 2013). Both studies found that teachers found the content to be important and should be taught in schools, but they had low levels of confidence in their abilities to teach the content effectively. (Hsu, Purzer & Cardella, 2011; Mendoza Diaz, Cox, & Adams, 2013) The importance of this research shows that for teachers to effectively integrate STEM practices in their classrooms to better help students, they will need access to appropriate and effective professional development that assists them in knowing where to begin. If teachers feel confident in their abilities to deliver the content to students, then the education students receive becomes more enriching and beneficial.

Many studies have been conducted on the premise of the importance of integrating STEM concepts in elementary classrooms. As research clearly shows, younger students have more of an aptitude for STEM concepts and thrive in the Engineering challenges thanks to their natural inquiry predispositions. In fact, about 75% of children learn best through inquiry. Since majority of engineering challenges are inquiry based, a compelling argument can be made for implementing STEM concepts across subject areas (Dejarnette, 2018.) The Engineering Design Process and the Science and Engineering Practices laid out in the Next Generation Science Standards are two major components to effectively teach students about engineers and engineering. NGSS puts an emphasis on engineering concepts being taught at the elementary level, as early as kindergarten. The standards are what teachers are required by law to teach students. The emphasis put on engineering concepts in the standards proves their importance in students' science education. Since younger children have more of an aptitude for inquiry learning, the Engineering Design Process is an effective learning tool to help them understand the basic engineering principles (DiFrancesca, Lee, & McIntyre, 2014; NGSS Lead States, 2013). The Draw an Engineer Test (DAET) is a tool that has been adapted for many different studies depending on what researchers were targeting. The DAET has been proven as a legitimate research tool for measuring perspectives of children about engineers and engineering (Knight, & Cunningham, 2004; Lachapelle, Phadnis, Hertel, & Cunningham, 2012; Dyehouse, Weber, Kharchenko, Duncan, Strobel, & Diefes-Dux, 2011). The Draw an Engineer Test (DAET) is an adaptation of its predecessor, the Draw a Scientist Test (DAST)(Chambers, 1983). Both assessment tools were used to measure how students perceive scientists and engineers. Both assessments ask students to draw what they think a scientist (or an engineer) looks like and asked short answer questions about what tools they might use, what they might wear, etc. Many of the studies conducted in elementary schools were conducted on upper grades or even in middle school settings (Phelps, 2012). Younger students have the abilities to complete the activities with ease because of their natural curiosity. Waiting until they are older to introduce these concepts will not give them an effective understanding, they need to be introduced while they are young, and that information built upon as they continue in their educational careers.

Methodology

The purpose of this study was to expose third grade students to the multiple branches of engineering and monitor how their perceptions of engineers and engineering changes after being taught a unit that educates students about engineers and puts them through engineering tasks themselves. The unit and accompanying lesson plans are outlined in Appendices A-G. The goal was to get students interested in STEM concepts, focusing on the engineering aspect, and possibly start them on the right track to becoming engineers or, at the very least, exposing them to a possible career path. The significance of this project lies in the age group of the students being researched. There are few studies being conducted regarding engineering education in elementary schools on students below fourth grade. This project set out to show that younger children have the same misconceptions as the older children and need engineering education or STEM integrated in their curriculum to expose them to the engineering design process to help correct those misconceptions and even prevent them from occurring at all. This project also supports the recently adopted Next Generation Science Standards including engineering practices for primary grades. The engineering practices and engineering design process are two components this project utilized to help students better understand engineering. Third-grade students also have misconceptions about engineers, and they need access to the instruction about engineers and engineering. The broader implications of this project show that younger children also have the misconceptions and they need science education within their classrooms. Also, this project was designed to help students see themselves as engineers and show them that they have the capability to pursue that career if they choose.

The research methods for this project included administering the Draw an Engineer Test (DAET) to two different third grade classrooms. A copy of the DAET used for this study can be found in Appendix H. One administered to the experimental group as the pre-assessment to a student teaching-based unit plan, and one to a control group who did not participate in the unit plan or engineering challenges. The control group was only given the DAET twice with no unit plan or engineering challenges. The unit plan was designed to give students a well-rounded education about engineers and experience with the engineering practices that are laid out in the Next Generation Science Standards. The unit was written to be delivered during a six-day time span in which students spend the first day learning about the difference in a scientist and an engineer by reading Rosie Revere Engineer and Ada Twist Scientist, both by Andrea Beaty and looking at the different character traits the character possess and comparing them. (Beaty, 2013; Beaty, 2016For example, students saw that Rosie Revere builds things to solve a problem and Ada Twist was more concerned with answering questions. Students used these characters as examples of what real engineers and real scientists do. One of the most common misconceptions other studies found was that students often confuse the two. Students drew both engineers and scientists to look like a stereotype. Most students draw an older white male with white, crazy hair, huge thick glasses or goggles, a white lab coat, and working with test tubes or chemicals. Both of these books help students to see that is not always the case. Anyone can be a scientist or an engineer if they learn the practices and work for it. When students learn that anyone can be an engineer, the thought becomes less foreign to them and they can better understand what it means to be an engineer. Each day following, students were introduced to a different branch of engineering. There are four main branches of engineering: civil, mechanical, chemical, and electrical. Each day students participated in an engineering task that pertained to each branch. Students learned about each of the four branches and what an engineer who works within that branch would use as tools, or what type of technology they would create or maintain to help solve the problem or meet the need. The final day consisted of students creating posters about one of the four assigned branches and presenting them to the class. The unit is concluded by students reading career cards that describe engineering jobs and they had to sort the jobs into each of the four branches as groups. The four branches of engineering and their definitions are outlined in table 1 below.

Table 1

Branch of Engineering	Activity
Civil Engineering	Civil engineers build structures to solve a problem or meet a need. They can build structures such as pipelines, buildings, bridges, etc.
Mechanical Engineering	Mechanical engineers work with or create machines to help solve a problem or meet a need of society. Mechanical engineers can build items such as robots, satellites, roller coasters, vehicles, etc.
Electrical Engineering	Electrical engineers work with electricity in many different forms. Electrical engineers can build things such as cell phones, computers, space communications devices, etc.
Chemical Engineering	Chemical engineers use knowledge of chemicals and physics to solve problems relating to chemicals. Chemical engineers can do different jobs such as refining gasoline, creating new medicines or improving existing ones, purifying drinking water, etc.

Each day students learned something different about the engineering practices and they participated in the engineering design process to learn how engineers solve problems. The lessons were all structured similarly. The lessons opened with giving students a situation in which there was a problem they needed to solve, the class walked through the steps of the engineering design process with the students as they worked to solve the problem. The engineering design process used for this project is outlined in table 2. Students were then given their materials and they began building their designs. Students were asked to draw their own design first followed by working together in their groups to come up with one design. By drawing the designs first, students had to think about the materials they were given and how they could use them to create a solution that best solved the problem at hand. Students also learned through the engineering design process that the first time they try to solve a problem, their solution might not work, and it's okay if it doesn't work the first try. These lessons provided students with the knowledge that it's okay to fail and that's how learning happens, but it's also how their designs and solutions improve.

Table 2

Engineering Design Process

Process used by engineers to create products to solve problems

Step in the Process	What Students Do
Ask	Students spent the first part of the process defining the question or problem at hand and realizing what restraints they have on the project such as time, limited materials, etc. If they had already completed the process once and were circling back, then students must think about what didn't work for the design and how they can fix it in the next go around.
Imagine	Once students have identified the problem, they move on to the next phase in which they imagine the design. Students for this project

	drew and labelled how they would individually design the solution in their engineering notebooks.
Plan	After imagining their own designs, students then worked together in their groups and came up with one design for the group to create together. Students could have chosen one design to build or they could have combined multiple designs from their group to build.
Create	Once the groups had chosen the design for their solution, they then collected their materials and created the solutions they had drawn and labeled in their notebooks.
Test	After building the solutions, the students tested their solutions to see how they worked. How the students tested their models can mean different things depending on the problem they were trying to solve.
Improve	Once they have tested their designs, students reflected on how their solutions worked and ask themselves what they would do differently given the chance to try again. When students got the chance to try again, they took what they learned and started the process over again by editing what they had already created or starting from scratch and creating something new.

The data collection for this project occurred on two separate occasions. The first round of data collection occurred during the spring semester of 2019 and the second round occurred during the fall semester of 2019. The Draw an Engineer Test (DAET) was administered to students at the beginning of the unit as the pre-assessment, then students participated in the engineering challenges and then at the end of the unit, the students were given the DAET again at the end of the unit to see how their perceptions about engineers changed. The DAET assessments were scored using a checklist similar to one utilized in the original study. The checklist used can be found in Appendix I. The goal of the project is to see what stereotypes students draw initially and to hopefully correct those misconceptions through the unit plan and activities so that the second time they do the DAET, students include fewer, if any of the stereotypical character traits they drew in the beginning. The goal was for students to draw more accurate representations of engineers after participating in the engineering activities and walk away with a better understanding of what engineering is and what engineers really do.

Results and Discussion

The data were collected in two classrooms, both containing twenty-two students each. The students were given permission and assent forms in order to use their DAET assessments for this study. For the experimental group, twelve of the twenty-two agreed for their assessments to be used as part of this study. For the control group, eleven of the twenty-two agreed for their assessments to be used as part of the study so the total sample for the first half of data collection is twenty-three students. Each class was given the DAET at the beginning of the same week on the same day. All students in the class were given the assessment but only the students who had permission forms from their parents and also signs assent forms to participate in the study. If the students had both forms signed and turned in, their DAETs were included in the data of the study. The students included in this round of data collection were at the end of their third-grade year, getting ready to move to fourth grade, having completed all the reading, math, science, and social studies for the year. Table 3 below shows the results of the pre and post assessments for both the experimental group and the control group in the first round of data collection.

Table 3

Spring 2019 Data

Comparison of Experimental and Control Group Data Spring 2019

Group	% Male	% Traditional Garb	% Science	% Vocational	% Train Conductor	% Actual Engineer
Experimental Pre	71.4 %	14.2 %	21.4 %	57.1 %	0%	7.1 %
Control Pre	90.9 %	9.0 %	9.0 %	90.9 %	0%	0 %
Experimental Post	81.8 %	0 %	0 %	9.0 %	0%	90.9 %
Control Post	91.6 %	33.3 %	25.0 %	58.3 %	0%	0 %

The data above were calculated based on the checklist used to assess the DAETs given to the students. The categories listed at the top of the graph are categories from the checklist used to analyze the assessments. The percentages were calculated based on how many DAETs from that group included the attribute compared to the total group. Both groups had some drastic changes in their percentages for certain attributes. Going into this project, the assumption was that the control groups drawings would essentially remain the same so the data wouldn't fluctuate much. This, however, was not the case. Initially, 90.9% of the control group drew their engineers as males. This was in keeping with the stereotype that most students draw when given the DAET. Students often think of engineering as a man's job and often draw male engineers. The experimental group had a lower percentage of students draw male engineers which went against initial assumptions. Still, majority of the students in the experimental group drew male engineers, which still keeps to students stereotypical perception of engineers. When students were given the assessment again, the numbers did change but in a different way than expected. The percentage of students in the control group who drew male engineers increased to 91.6%. At first it was surprising for the numbers to have increased for this group as the assumption was the numbers would stay the same, but the numbers remained high which is still consistent with past findings. The experimental group's drawings increased from 71.4% of the students drawing male engineers, to 81.8%. The students who received the engineering unit should have drawn fewer stereotypical male engineers. One of the things the lessons dwelled on was that anyone can be an engineer, no matter their gender, skin color, hair color, etc. Just because the number of students who drew males increased does not mean the lessons did not help the students understand what engineers really do or how they really look, rather students just chose to draw a male engineer. The data show that during the next round of data collection and teaching the unit, the importance that anyone can be an engineer should be emphasized more to better help students understand that not all engineers are males.

Another common misconception about engineers often involves students confusing engineers and scientists or seeing them as the same thing. This misconception is often reflected in the DAET drawings through what the table above labels as "traditional garb." The students draw the engineers wearing lab coats, googles or thick glasses, and crazy hair. The experimental group's data were as expected. The experimental group should have had some, if not all students were expected to draw traditional garb on their engineers because that was the expected stereotype. The percentage for the experimental group was unpredictably low when they initially drew their engineers. Only 14.2% of the students in the experimental group initially drew engineers that contained at least one piece of traditional garb. The expected percentage was much higher, but the fact remains that there were students who perceived engineers to have at least one or more of the pieces of traditional garb. The final DAET data for the experimental group aligned with expectations with 0% of the students drawing engineers with at least one piece of traditional garb. This was expected because the engineering unit should have provided students with enough imagery and knowledge to know that not all engineers look the same and they can be anyone. The control group's data were surprising for this category. The DAETs for the control group did have students draw their engineers with at least one piece of traditional garb, but the initial data only had 9% of the students include traditional garb in their drawings. This was surprising because the assumption was that most, if not all students had the same misconceptions about engineers and their appearance. The final drawings added to the surprise because the percentage of students who drew their engineer with at least one piece of traditional garb increased from 9% to 33.3%. Since these students did not receive the engineering unit, they had no reason to change their perceptions about engineers. It was interesting, though, that the percentage increased because since they received no new information about engineers, their drawings should have remained the same or at least similar. The data from the control group shows that without the education about engineers and experience with the engineering practices, students will develop misconceptions about them on their own. The leap from 9% to 33% in just one week was astonishing time for such widespread misconception among students.

The next category analyzed for the DAET assessments depended upon what the engineers in the pictures were doing. Another misconception that students often draw is the engineers as traditional scientists in a lab, the students in this study were no different. The experimental group initially had 21.4% of the students draw their engineers to look more like traditional scientists. This was a smaller percentage than anticipated but the final analysis of the experimental group revealed that only 9% of the students drew a traditional scientist instead of an engineer. After having the engineering unit and participating in the activities, the experimental group should have experienced a drop in their percentage. The control group had to opposite effect. Surprisingly enough, the initial analysis of the control group's drawings resulted in 0% of the students drawing their engineer to look more like a traditional scientist. This was surprising considering majority of the other studies conducted on the subject resulted in the students drawing a scientist rather than an engineer. The final analysis resulted in 25% of the students in the control group drawing their engineers to look like traditional scientists. The increase in the percentage shows how misguided the students in the control groups perceptions of engineers were. Students might have thought their original drawings were incorrect and chose to change how they drew their engineers, or they may have forgotten how they drew their engineer the first time and that resulted in an increase of students drawing traditional scientists rather than engineers. Whatever the case may be, the students who did not receive the engineering unit developed new misconceptions about engineers in only a week's time. Many students do not have consistent science/engineering education until the fourth grade when science is part of standardized testing. Students not only are introduced to new concepts, but fourth grade teachers often have to teach them the content but also reverse any misconceptions students may have developed the last four years of their education. Students need consistent science education that builds upon itself as they progress through school to minimize the misconceptions. When the Next Generation Science Standards (NGSS) are implemented properly, students experience science concepts and the knowledge part, but they also build problem solving skills related to the engineering practices woven into the standards. The students that did not draw their engineers as scientists drew one of two things: a vocational job that was not engineering, or they accurately depicted engineers in their drawings.

Another trend the DAET data showed was a large number of students drew people doing vocational jobs rather than engineers. In almost all of the drawings following this trend, students drew mechanics working on cars or trucks. Of the common misconceptions with this first round of data collection, drawing engineers as vocational careers was the most common. The control group had 90.9% of the students draw a vocational worker rather than an engineer. In fact, all of the students in this group drew mechanics rather than engineers. Their drawings included either a stick figure or a more detailed person working under a car lift with wrenches and grease all over them. The questions that accompanied their drawings were telling of their perceptions as well because the students who drew mechanics for their engineer answered that engineers "fix things." While engineers do fix their solutions through the engineering design process, their job does not revolve around fixing things that are broken. They only fix something that didn't work during their test phase. After having a week without engineering challenges or other exposure to engineering concepts, when given the DAET again, 58.3% of the students in the control group drew the mechanic or another vocational job instead of an engineer. Their percentage dropped but students still a little over half of the students had the same misconception. If the students had participated in the engineering challenges or they had participated in the engineering discussions of the experimental class, their percentage would not have been so high for this misconception.

Regarding the experimental group, the percentage of students who drew a vocational job was 57.1% initially. This was significantly lower than the control group's percentage, but it was also lower than anticipated. Upon looking at the control group, it was assumed the experimental group's percentage would be similar. The experimental group did not have as many students with this misconception. When students were given the DAET again at the end of the week after participating in the engineering unit and its challenges, only 9% of the students drew their engineer doing a vocational job rather than an engineering job. The percentage of students with this misconception dropped 48% after students had the learning experiences about engineering. This was the expected outcome that the students would learn about engineers and alter their perceptions about engineers and what they do. These data support the need for students to understand the engineering profession, otherwise they develop misconceptions to help themselves understand. The misconceptions students had about engineers are very common according to other studies conducted. The findings of this study were similar to those of other studies done on older students. There is one more aspect of the drawings the DAET data reflected and that was the percentage of students who accurately drew an engineer.

The goal of this study was to gauge common misconceptions students had about engineers and attempt to correct those misconceptions with the engineering unit to help students understand what engineers do. The final aspect of the drawings the DAET data reflected were those students who accurately depicted engineers in their drawings. The control group aligned with expectations upon analysis. Of the students in the control group, 0% of the students were able to accurately depict an engineer. The students in the control group all had misconceptions about engineers, which prevented them from truly depicting engineers in their DAET drawings. Upon receiving the DAET again a week later, the students in the control group were still unable to accurately depict an engineer, as 0% of the students in the control group drew an actual engineer in round two of the DAET administration. The experimental group had the opposite outcome. Initially, 7.1% of the students in the experimental group accurately depicted engineers in their drawings. This percentage was higher than anticipated because previous studies found that students often initially have a high rate of misconceptions, meaning very few students should have drawn their engineers accurately if any at all. The percentage was still low, keeping with expectations. After participating in the engineering unit for a week, students were given the DAET again and the results kept with expectations. The percentage of students who accurately represented engineers in their drawings should have risen significantly after being educated about engineers. The students kept with this expectation; the percentage increased from 7.1% to 90.9% by the end of the week. This rise in accurate engineer portrayal shows that in order for students to understand what engineers do, they must have effective education about the profession. If students continue in their education without science and engineering education, they may continue to develop misconceptions about engineering and other science concepts as well.

Table 4

Fall 2019 Data

Comparison of Experimental and Control Group Data Fall 2019

Group	% Male	% Traditional Garb	% Science	% Vocational	% Train Conductor	% Actual Engineer
Experimental Pre	81%	0%	0%	36%	36%	13%
Control Pre	80%	0%	0%	86%	0%	18%

Experimental Post	36%	0%	0%	0%	0%	100%
Control Post	87%	0%	0	69%	13%	19%

The same procedures were followed with the second groups of students in the following fall semester of 2019. The students were given the DAET the week before the engineering unit and on the last day of the engineering unit. The same analysis instrument was used as well to analyze the drawings and look for similarities and differences. The second group adds to the complexity and depth of the data because the data also compares end of the year 3rd graders (spring 2019) and beginning of the year 3rd graders (fall 2019).

The results from round two of data collection yielded some surprising results. A large percentage of students in the control group chose to draw their engineers as males. The pre-test resulted in 80% of the control group students drawing males. Upon administering the post assessment, the percentage increased to 87% of students in the control group drawing males. Reasoning behind the increase in percentage is unclear because students did not have any education pertaining to engineering so the percentage should have remained consistent. The experiment group aligned with expectations and previous studies. The pretest percentage of students who drew male engineers was 81% and according results of similar studies, the percentage of students who draw males should decrease because they should realize that anyone can be an engineer, not just males. The percentage did decrease after students participated in the engineering activities and class discussions during the engineering unit. The percentage decreased from 81% to 36% of the students drawing male engineers. The goal of the unit was to a) educate students about engineers and what they do and, b) help students realize they could become engineers when they grow up by helping them picture themselves as engineers. The goal is not to have 0% of students draw male engineers because there are male engineers in the field. The misconception that the majority of students have is that engineering is a primarily male occupation and females cannot be engineers. The data reflect that this group of students pictures themselves as engineers. Many of the drawings of the girls in the class depicted a female engineer doing a specific job. The boys in the class naturally drew male engineers to reflect themselves as engineers and what they would design and create. Both groups met expectations set by previous studies in this category based on their drawings. Other categories yielded different results than other studies as well as data collected in the previous semester.

The next two categories reflect a common misconception found in previous studies conducted on the topic of student perceptions of engineers. Students from the previous semester adhered to the misconception of engineers resembling "crazy scientists" by drawing goggles, lab coat, crazy hair, etc. They also drew stereotypical science objects in the background such as test tubes or chemicals. Neither the experiment and control group from the fall semester drew traditional garb or the science components in their drawings. Both groups of students shed light on a different misconception not previously seen in other studies. The misconception largely present with this control group was that engineers perform vocational jobs. The most common drawing among students was car mechanics. Students hear the word "engine" in *engineer* and they immediately think of the engine in a car. Using context clues, they draw car mechanics rather than accurately representing engineers. Many of the students in both the experiment and control groups drew car mechanics as engineers and in their questions, students also commonly responded that engineers "fix cars and other things." The control group had an initial percentage of 86% in the vocational category (car mechanics) and the post-test resulted in 69% of students drawing a vocational job rather than an engineer. The decrease in percentage does not meet expectations because if students in the control group were not exposed to accurate representations of engineers, their drawings of engineers should have remained the same or similar. Looking at the data, the students who changed their drawing chose to draw a different misconception instead.

The drawings should have stayed the same or been similar, but some students realized their first drawing was incorrect and changed to a different misconception or they kept the original. The initial data regarding the experiment group differed from expectations slightly but the end result adhered to results found in previous studies. The percentage resulting in the initial DAET assessment yielded 36% of the students in the experiment group drawing a car mechanic or other vocational job. After participated in a week full of engineering challenges and student-led discussions about engineers, the percentage fell to 0% of students drawing vocational workers rather than engineers. The unit and activities students participated in corrected the misconception that engineers are vocational workers. The students learned that engineers solve problems and design products to meet needs or wants of society rather than just fixing things that are broken.

Another misconception found in previous studies showed students often draw train conductors when asked to draw an engineer. The students from the previous semester did not draw train conductors when given their DAETs. Both the experiment group and control group contained students who depicted this misconception in their drawings. The control group initially had 0% of the student draw a train conductor but when administered the post DAET, the percentage increased to 13% of the students drawing train conductors. The students who changed their perceptions drew car mechanics during the first administration of the DAET then switched to train conductors when given the assessment a second time. This also caused the decline in the vocational section for the control group because the students who did not draw a car mechanic the second time drew either an actual representation of an engineer or a train conductor. It is unclear what prompted these students to change their perceptions, but the students had a different mental image of engineers when given the DAET a second time. The students in the experiment group had 36% of the students initially draw a train conductor on their test. This aligns with previous studies as one of the common misconceptions found among students. The percentage decreased to 0% when students were given the assessment a second time at the end of the week. The unit students participated in gave students the schema they needed to better understand the questions on the DAET and give accurate answers to better depict engineers. These results correlate with data collected in previous studies because the percentage decreased and by the end of the week, the misconceptions students previously had about engineers were replaced with accurate schema about the engineering occupation.

Another common misconception previous studies found were the number of students who were able to accurately depict engineers in their drawings. The control group adhered to expectations set by previous studies in this category. Based on previous studies, the results should reflect that most, if not all students have a misconception and very few, if any of the students could accurately depict engineers in their drawings. The post-test should also yield similar results since students received no formal education of engineers in their classrooms. The control group in this study had 18% of the students accurately depicting engineers in their drawings. This complies with expectations since the percentage is so small. The percentage increased to 19% when students were given the post DAET. The percentage was expected to stay the same, but it slightly increased. This complies with what previous studies found with their control groups because the percentage changes very little and misconceptions were still present in the post DAETs. The experiment group had ideal results in this category. The percentage of students who accurately depicted an engineer in their drawing was 18% for the pre DAET. This was a higher percentage than expected because most students should have misconceptions and students with no schema about engineers shouldn't be able to accurately depict an engineer in a drawing. The percentage was low initially so that matches what previous researchers found also. The percentage increased significantly when students were given the DAET at the end of the week. After participating in the engineering unit, the percentage of students that were able to accurately depict and engineer in their drawings increased to 100% of students. The engineering unit correct misconceptions of all the students in the experiment group and they may still have misconceptions about other concepts that deal with engineering, but they understand what engineers do and their misconceptions of what they look like were altered.

Conclusions and Implications

Based on the data presented above, three main conclusions can be drawn: students need opportunities to learn about engineers in elementary schools to correct misconceptions, build a foundation for a possible career path as they continue through school, and students who have identified learning or behavior disabilities become more engaged in the classroom. The students who participated in this study were in the third grade and had four previous years of school to build and exaggerate misconceptions they had with no opportunities to confront those misconceptions. The engineering challenges done during the unit put students in control of their learning and they were given the chance to explore and test different approaches to the same problem. Students also learned how important problem-solving skills are to society. Each day, students were presented with a different problem and were asked to create solutions to their given problem. None of the groups created the same design or approached the problem in the same way. The discussions between groups and presentations of designs was crucial to helping students see there is more than one way to approach a problem. Concepts from engineering can cross into other subjects as well such as the concept of problem-solving that is consistently weaved into math standards. Without engineering, students lose the opportunities to connect subjects through their learning.

As the data reflects, engineering education benefits students by correcting misconceptions and allows students to picture themselves as engineers, giving some a potential career path for when they graduate high school or college. There is a shortage of engineers in recent years, so it has become important for students to be exposed to the engineering profession early and continually build on the concepts as they progress in their learning each year. Since the standards have been re-written to incorporate engineering standards throughout science curriculum, it is now required by law that engineering is taught in schools. If students never have opportunities to confront their misconceptions, in any subject, they will continue using the misconceptions to explain the world around them and the longer the misconception resides in their minds, the harder it will be to correct later. That is why incorporating engineering concepts in elementary science curriculum is so important; to prevent misconceptions from arising and correct misconceptions students already have before they become engrained in the students' minds.

Finally, one of the major takeaways from this project was the engagement of the students who had identified learning or behavior disabilities. The engagement of these students provides a richness to teaching this content. The students who normally want nothing to do with school were taking leadership roles in their groups. The students were so engaged in the content and they rose to the challenges the engineering tasks provided. They were students that would normally be expected to struggle with content that is challenging but when given the chance to participate in activities that spark their interest, their demeanor changes completely. During the unit, the number of behavior instances in the classroom decreased significantly. The only behavior instances experience during the unit were social situations in which the students struggled to express their emotions and were upset about their design not being chosen or friction between them and another group member. Even though these instances were still present during the challenges, the students more susceptible to being redirected. The students were also given the chance to practice their social skills working in small groups. The engagement of the students with identified learning and behavioral disabilities was a major benefit of the engineering unit. The engineering concepts being integrated in the classroom will benefit all students but the students who seemed to get the most from the unit were the students who normally do not participate in school actively. The integration of engineering concepts in elementary classrooms is essential for all students to confront their misconceptions and correct them, be exposed to a possible career path for them, and engage all students in the content to help them learn.

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Appendix A

Six-Day Unit Plan Skeleton

Day	Targets	KCAS Standards	Student Engagement Practices	Assessments	Resources
1	I am learning to describe characters in a story. I am learning to explain how a character's actions add to the story. I am learning to compare and contrast characters in stories written by the same author.	• ELA.3.L.3: Describe characters in a story (e.g. their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events. • ELA.3.L.9 Compare and contrast by themes, settings, plots of stories written by the same author about the same or similar characters (e.g. books from a series)	The unit begins by giving the pre-assessment for the unit which is the Draw an Engineer Test. This will be given the week or a few days prior to the beginning of the unit for data analysis. During day 1 of the unit, students will be sitting in groups for discussion during this lesson. First students will be asked to draw a scientist in their notebooks and then draw an engineer. They will the share their drawings in their groups and looks for similarities and differences in their drawings. After students have had time to discuss their drawings, I will read *Rosie Revere Engineer* and *Ada Twist Scientist* by Andrea Beaty aloud to the students. As I read each story, students must write down characteristics of Rosie and Ada in their notebooks. After both books have been read, I will use think, pair, share. I will let students finish their thoughts individually, then share in their groups, then we will discuss as a class and create a Venn Diagram on the smart board to compare the	The pre-assessment for this lesson will be the Draw an Engineer Test (DAET) that will be used as the measurement tool for the research project. Students will draw a picture of what they think an engineer looks like and answer some questions about their drawing. Students will also draw what they think a scientist looks like in their engineering notebooks and answer questions about what they think they do. The formative assessment for this lesson will be Engineering Thought #1 in their notebooks. Students will first write down characteristics of Ada Twist from the book Ada Twist Scientist then they will do the same with Rosie Revere from the book Rosie Revere Engineer and they will work in a group to compare the	Engineering Notebooks for students Smart Board PowerPoint for discussion questions Draw an Engineer Test *Rosie Revere Engineer* by Andrea Beaty *Ada Twist Scientist* by Andrea Beaty

			characters. After comparing characters, we will shift the discussion to engineering and define engineering and talk specifically about what engineers do. After discussing engineers, students will complete Engineering Thought #1 which is an exit slip with three questions: 1. Name 2 character traits of a scientist. 2. Name 2 character traits of an engineer. 3. What is one main difference in a scientist and an engineer? Students will answer these questions in their notebooks to conclude the lesson.	characters. Next, we will create a list as a class with characteristics of a scientist vs. characteristics of an engineer. Students will have this list of characteristics to refer to as we continue with the engineering unit.	
2	I am learning to analyze a design solution that is meant to solve a given problem. I am learning compare my solutions to the problem to solutions my classmates create. I am learning to plan and carry out tests on my solution and identify what needs to be improved.	• 3-ESS3-1: Make a claim about the merit of a design solution that reduces the impact of a weather-related hazard. • 3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. • 3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • 3-5ETS1-3: Plan and carry out fair tests in	The lesson begins with students completing Engineering Thought #2 where they answer questions in their notebooks. The engineering branch for day 1 is Civil engineering so students will be building pipelines. We first discuss what a pipeline is and what it does so students have an idea of what they are building. Next, we walk through each stage of the engineering design process as students build their pipeline models: 1. Ask 2. Imagine 3. Plan 4. Create/Test 5. Improve	Students will be writing notes and drawing pictures in their engineering notebooks that will serve as the formative assessments. I will collect the notebooks each day and look over them during lunch/planning period and take note of misconceptions I am seeing to correct before the next challenge. Students will complete Engineering Thought #2 in their notebooks with the following	PowerPoint for discussion Paper cups Straws Tape Tea Towels

which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. • SEP 7: Engaging in Argument from Evidence • SEP 1: Asking and answering questions • SEP 3: Planning and carrying out investigations • SEP 6: Constructing explanations and designing solutions	At each stage, students will write ideas down in their notebooks individually, then discuss with their groups, and finalize one plan to start with. Think, Pair, Share will be a common strategy throughout this unit. After designing and testing the pipelines, we will come back together for some discussion about civil engineering. We will also discuss the engineering design process. What it is and why engineers use it. This will be the only day we discuss the process, but it will be emphasized throughout the unit as we are working through the engineering challenges. Students can take some notes in their engineering notebooks to keep for later in the week when we play Engineering Jeopardy on the last day as a review of what we learned. They will be allowed to use their notebooks to help them so I will recommend students take neat, legible notes that they can look back on during jeopardy!	questions to start the lesson: 1. Where on Earth can you find water? 2. Is water a solid, liquid, or gas? 3. How do you think the water gets to our faucets? I will also be walking around with a chart of our criteria for success rubric for working as a team. As students are working in their groups, I will put a check next to students who met the criteria for that day and a minus for the students who did not. At the end of the lesson, students will complete Engineering Thought #3 in their journals which consists of 4 questions: 1. How did my group's design work? (was it a success?) 2. What would you change about your design given more time or extra materials to use? 3. What is the engineering design process? 4. In your own word, describe

				what a civil engineer does?	
3	I am learning to design a solution to help solve a problem using materials that are available to me. I am learning to compare my solution to a problem to the solutions my classmates create. I am learning to test my solution and make notes about what I can change to make it better.	3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	Engage (3-4 minutes): For the engage, students will complete Engineering Thought # 4 in their journals. I will start by asking how many of them have ever ridden a roller coaster. Considering most of them are too short to ride roller coasters I will assume very few. I have a roller coaster simulation video we will watch. I will ask students to pay attention during the video and jot down some things they notice about how the roller coaster operates. When does is move slowly? When does it move quickly? Does the roller coaster move at the same speed the whole time? Explore (15-20 minutes): During the explore part of the lesson, students will be given pipe insulation, masking tape, various supports, a cup, and a small marble. Students will use these materials to create their own roller coaster. They will take that information and create a roller coaster using the materials. The marble must move throughout the whole roller coaster without flying off and land in the cup at the end.	Before the lesson begins, I will give students Engineering Thought #4 which are some discussion questions they will respond to in their engineering notebooks as a way to introduce the lesson. Engineering Thought #4 will have the following questions: 1. How many of you have ever ridden a roller coaster? 2. We are going to watch the following video of a roller coaster simulation. As you are watching, look for parts of the roller coaster where it seems to slow down and speed up. What do you notice as we ride the roller coaster? https://www.youtube.com/watch?v=2WaxrzSK5CI During the lesson, I will be walking around observing students writing in their notebooks and taking note of students who may not be understanding the content. I will be	• Pipe insulation • Marbles • Paper cup • Masking tape • Engineering journals • PowerPoint

Ask:
I will tell students they have been hired by King Island as roller coaster engineers to create a new roller coaster for the park. At first, I will tell them to experiment with hills and getting a feel for the materials. Then I will add requirements for their roller coaster. The park wants a new roller coaster with a hill and two loops.
Imagine
During the imagine stage, students will draw sketches of their roller coaster with labels of the materials. They will do this part independently and draw their own individual sketches first.
Plan:
During this stage, students will plan their investigation. Students will share their sketches and the group will choose a drawing and use it as a plan to create their roller coaster. Students will draw the final plan for their roller coaster in their notebooks and label the materials they need.
Create:
During the create stage, students will build their design. They will use the materials at their table to create the roller coaster their group decided on as a team. Before beginning this part of the lesson, we

collecting the notebooks after each lesson to read during planning period. Their engineering design process will be used as a formative assessment as well. I will write notes about what I see in the journals and jot down any misconceptions I see that may be forming in their answers to correct and reteach the next day at the beginning of the next challenge. I will also be walking around with a chart of our criteria for success rubric for working as a team and I will put a check next to students who met the criteria for that day and a minus for the students who did not.

At the end of the lesson, I will project 3 questions on the board pertaining to what we discussed in the lesson and students will respond in their engineering notebooks the exit slip will have the following questions on it:

will discuss what it means to work as a team. The students often have trouble working in groups so we will need to establish ground rules before breaking off into groups.

Test:
During the test phase, students will carry out the investigation by taking their small marble, placing it on the roller coaster, and the marble should continuously roll throughout the entire coaster without falling out. It should also drop in the cup placed at the end of the coaster. Students will be able to test their coaster before this test to make sure they are on the right track, but this is the "official" test that I will observe. I will have a checklist to grade their coasters.

Improve:
This is the reflection stage where students will think about their roller coasters. I will give them questions to think about such as:
1. Did our design work?
2. What didn't work?
3. What can we change to make it better?
4. Did my team work well together?

Explain:

1. How did my group's design work? (was it a success?)
2. What would you change about your design given more time or extra materials to use?
3. What is mechanical engineering?

			During the explain stage, we will talk about mechanical engineering. We will discuss this is what they do, they work on machines and technologies. I will have a PowerPoint that has images of mechanical engineers with some jobs that fit under that branch of engineering. Evaluate: The evaluate stage will complete Engineer Thought #5 with the following questions: 1. Did your roller coaster work? 2. What would you do differently, given more time or materials? 3. What is a mechanical engineer in your own words? 4. One super cool thing I learned today is…		
4	• I am learning to design a solution to help solve a problem using materials that are available to me. • I am learning to compare my solution to a problem to the solutions my	• 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. • 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model	**Engage (5-6 minutes):** For the engage part of the lesson, I will ask students to do a think pair share about the different types of electronic technologies they use in their everyday lives. This will serve as Engineer Thought #6 because they will write their ideas down in their notebooks during the think time. This will get students thinking about the technologies they use and open their eyes to the importance of	Before the lesson, I will have students answer the following questions in their notebooks as Engineering Thought #6: 1. Write a list of electronic technologies you use in your everyday life. 2. How often do you use	• Lightweight car • Propellers • 9 volt batteries • Wires • Tape • Engineering journals • Powerpoint

classmates create.

• I am learning to test my solution and make notes about what I can change to make it better.

or prototype that can be improved.

technology in our world. Technology is important to many cultures and will help all students relate to the lesson. I will have them independently list technologies they use, or they have seen used by others. Next, I will have students share out in their small groups about their technology usage lists. They can add things to their list their peers say that they didn't think of or didn't have time to write down. They should also use the share time to come up with 3-4 things they will share as a group. Finally, we will come together, and students will share out their group lists. I will have one or two from each group come up to the smart board and write their group's ideas. Students now realize how much technology we use, and they are thinking about how important technology is to our society.

Explore (15-20 minutes):
Ask:
For the ask stage, students will be given the task. For this engineering challenge, we will be building propeller cars. Students will be engineers for a new toy company called Silver Creek

technology?
3. How many minutes/hours a day do you think you use technology?

During the lesson, I will be walking around observing students writing in their notebooks and taking note of students who may not be understanding the content. I will be collecting the notebooks after each lesson to read during planning period. Their engineering design process will be used as a formative assessment as well. I will write notes about what I see in the journals and jot down any misconceptions I see that may be forming in their answers to correct and reteach the next day at the beginning of the next challenge. I will also be walking around with a chart of our criteria for success rubric for working as a team and I

Toys. They are tasked with creating a toy car that moves by propeller. They have to use a battery, the propeller, copper wires, and upcycles materials to create their car. They will have plastic containers, old CDs, bottle caps, tape, glue, and other materials to create their car. Students will write down some questions they have about the assignment they can ask before we begin.

Imagine:
During this stage, students will draw their own design of a car. I will show them the materials that are available for them to use. They must label their drawing with the materials they plan to use on their car. They will have to describe their design to their classmates so they must label it appropriately so they can explain their design to their group members.

Plan:
During the plan stage, students will share their designs in their group, and they will come up with a design as a group. They can choose one design from their group members or they can combine multiple designs to come up with one design for

will put a check next to students who met the criteria for that day and a minus for the students who did not.

At the end of the lesson, students will answer the following questions in their notebooks as Engineering Thought #7:

1. What does an electrical engineer do in your own words?
2. What tools might an electrical engineer use?
3. Electrical engineers focus on the transfer of ____________.
4. What do electrical engineers design/maintain?

their group car. They will have to draw the design in their notebooks for the car they plan to build.

Create:
During the create stage, students will get to come back to the container of materials and choose what they need to make their cars work. Their battery, motor propeller, and wires will be in a Ziploc bag, but the body and wheels will be at the student's digression in their design. They will grab their materials and they will have about 15 minutes to build their car. They can perform a mini-test to see how their car will work.

Test:
During this stage, students will test their car creations. We will clear a space in the classroom and each group will test their cars. WE will have a starting line and a finish line taped off from the back of the room to the front of the room. Their cars must move from the starting line to the finish line. We will also time the cars to see which group's moves the fastest.

Improve:
During the improve stage, students will reflect on the performance of their propeller car. They will write in their notebooks about how they felt their car did by answering the following questions:

1. Did our car work they way we thought it would?
2. How could I make it faster?
3. What materials would have worked better?

Explain (7-8 minutes):
During the explain stage, we will connect our activity to technologies we talked about at the beginning of the lesson. We will also talk about mechanical engineers and what they do. I will have a PowerPoint with slides about electrical engineers. We will talk about how the challenge they just completed is similar to what electrical engineers do. They use circuits and electricity to improve society by creating technologies that improve our world. We will talk about different jobs electrical engineers do and how they help make our world better.

			Evaluate (5-6 minutes): For the evaluate stage, students will complete Engineering Thought #7 about electrical engineering with the following questions on it: 1. What does an electrical engineer do in your own words? 2. What tools might an electrical engineer use? 3. Electrical engineers focus on the transfer of ___________. 4. What do electrical engineers design/maintain?		
5	• I am learning to design a solution to help solve a problem using materials that are available to me. • I am learning to compare my solution to a problem to the solutions my classmates create.	• 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. • 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	**Engage (4-5 mins):** For the engage part, I will ask students to respond to the following questions in their engineering notebooks as Engineering Thought #8: 1. How much water do you think you use? 2. Is water important to our world? 3. What do we use water for? **Explore:** <u>Ask:</u> The students will be tasked with creating their own water filtration systems. They		• river rocks • coffee filters • cheesecloth • sand • cotton balls • two-liter bottle • measuring cup • potting soil • clarity testing machine • water droppers • masking tape • engineering journals • 200mL water

• I am learning to test my solution and make notes about what I can change to make it better.

work at the Madison County Utilities and they need their group of engineers to create a water filtration system that gets the clearest water. I will give students river rocks, coffee filters, cheesecloth, sand, cotton balls, and a two-liter bottle to make a water filtration system. We will put some potting soil in 200 mL of water and put it through their water filters. Whichever teams has the clearest water will "get the job."

Imagine:
During the imagine stage, students will draw their own representations of what their model filtration system will look like. They must label what materials they plan to use and what order they plan to put them in. They will have to explain their design to their group partners so they will need to have an understanding of their design to explain to their partners when they share.

Plan:
During the plan stage, students will share their designs in their groups. The students will share their ideas and talk about what materials they think will work best and why. They will

draw a water filtration design in their notebooks for their group. They can take ideas from each person or use one person's design if they all think it will work best. They will draw the final design in their notebooks for their team's model.

Create:
During the create stage, students will collect the materials they need to create their team's design. They will collect their materials from a table in the room where I will have everything set up. They will collect their materials and bring it back to their table for their groups the start building. They will have time to build their model before we test it out officially.

Test:
During the test phase, we will pour 200 mL of dirty water into the filtration system. We will let them drip while we do the explain part of the lesson and come back at the end to test them. I will put a sample into a machine and test the clarity of the water. Students will write down the clarity of their samples in their notebooks.

Improve:

During the improve stage, students will reflect on their design in their notebooks. They will answer the following questions as a reflection:

1. What could we add/take away to improve clarity?
2. Did another group's design work better? Why/why not?
3. Are there other materials not offered that I could use to improve my design?
4. How could I make the water clearer?

Explain:
During the explain stage, we will talk about chemical engineers. We will define what a chemical engineer is and what they do. I will have pictures of chemical engineers and we will talk about the different contributions they make in our society such as

- Design environmentally friendly cleaning products
- Develop chemotherapy that has fewer side effects

			• Turn seawater into drinking water • Develop ways of mass-producing vaccines to ward off epidemics • Reduce pollution by developing cleaner sources of energy **Evaluate:** Students will answer the following questions in their notebooks as Engineering Thought #9: 1. What is chemical engineering in your own words? 2. What do chemical engineers do? 3. What tools do they work with? 4. Name one job a chemical engineer might do.		
6	• I am learning about the four branches of engineering. • I am learning to sort engineering jobs into one of the four main branches of engineering.		**Engage (5-6 mins):** For the engage stage, I will have students do the final engineering thought, Engineering Thought #10, where they choose one of the branches of engineering, they found the most interesting or the challenge they loved the most and why. This will get them thinking about each of the activities and what each of the branches does.	During the lesson I will be walking around listening and observing the discussion and group work taking place among students. I will have my roster and put a participation check next to students who are doing well and a minus next to students who did not participate well in the lesson. Students will also	• Sort an Engineer Cards • Chart to sort engineer cards • Engineering Jeopardy PPT • PowerPoint • Engineering Journals • Draw an Engineer Test

Explore (15-20 minutes): During the Explore stage, students will be tasked with becoming an expert on one of the four branches of engineering we talked about in class. I will have students draw them from an envelope, so the selection is random. Students will then use the iPads and chrome books to research the branch they got with jobs, tools, and other important things about the branch they get. Next, students will be doing their research about their branch. They will write down in their notebooks some facts about the branch they get. This will be a layout for the informational poster they will create about their branch. After researching their branch, students will draw a sketch of their informational poster in their notebooks to lay out the poster before they create it. They will decide as a group what information should be on the poster and what information they should leave off. Finally, the groups will create their poster. Based on previous experience with this group, I will assign jobs within the groups to keep arguments from	have their engineering journal for me to flip through during planning and lunch time and their Draw an Engineer Test will be part of the summative assessment for the unit. Students will also be assessed summatively with the engineering Jeopardy game I created to sum up the week and see how much students learned about the four branches.

breaking out. Each group will have an artist, 2 writers, and 2 readers. The writers and readers will work together to get the information from their books onto the poster. The artist is in charge of drawing any pictures they choose to put on the poster.

Explain (5-7 minutes):
During the explain part of the lesson, each group will present their posters to the class. They will teach their classmates about their branch of engineering. This will work as a refresher since we had been learning about the branches in the previous lesson. They will need this information to complete the extend activity. We will also have students in the audience ask questions about the posters and they have to be able to answer questions about their branch of engineering. I will have students jot down some notes about each branch in their notebooks as each group presents so they can use that information during the extend activity.

Elaborate (10-15 minutes):
During the elaborate stage, we will play a

game called Engineer Sort. I will start by sorting students into four groups. We will jigsaw the groups from the explore stage. Each group will have at least one person who was an expert in each branch. So, each group will have someone from the mechanical, chemical, civil, and electrical engineer group. This will be a game in which students have a poster with each of the 4 branches written on it. The students will have an envelope full of different engineering jobs. They will pull them out and sort them based on the branch that job fits under.

Evaluate:
The evaluate part of the lesson will be me giving students the Draw an Engineer Test again to measure their change in perceptions about engineering after participating in the challenges.

Appendix B

Source of Evidence 1: KTIP Lesson Plan: Day 1 Engineer V. Scientist

1. **Learning Target(s)/Objectives (1C)**

   a. Current lesson's learning target(s)/objective(s)

   Standard(s):

   ELA.3.L.3: Describe characters in a story (e.g. their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events.

   ELA.3.L.9 Compare and contrast by themes, settings, plots of stories written by the same author about the same or similar characters (e.g. books from a series)

   Learning Objective:

   - I am learning to describe characters in a story.
   - I am learning to explain how a character's actions add to the story.
   - I am learning to compare and contrast characters in a story.

   b. Next lesson's learning targets/objectives.

   Standard(s):

   3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

   3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

   Learning Objective:

   - I am learning compare my solutions to the problem to solutions my classmates create.
   - I am learning to plan and carry out tests on my solution and identify what needs to be improved.

2. **Students' Baseline Knowledge and Skills (1B, 1F)**

The pre-assessment for this lesson will be the Draw an Engineer Test (DAET) that serves as the pre-assessment for the unit. Students will be given the assessment a few days prior to the start of the unit for data collection to assess misconceptions before beginning the unit. The pre-assessment for this lesson will be a simple drawing exercise students will be asked to complete. I will ask students to draw what they think a scientist looks like in their notebooks and name 2 character traits of a scientist. Then I will ask students to turn the page and draw an engineer and list 2 character traits of an engineer. I will be walking around as students are drawing and taking note of students who have misconceptions and creating a list of misconceptions I am commonly seeing.

3. Formative Assessment (1F)

The formative assessments for this lesson are the notes students take in their notebooks. As I read the stories, students must write down character traits they observe about each character in each story. They will create a three-chart in their notebooks with Ada Twist on one side and Rosie Revere on the other. In the middle, they will come up with similarities between the two characters and they will compare the similarities and differences. After they have individually written down their ideas, students will then talk in their groups about the traits they came up with and then students will share out in whole group discussion and we will fill out a three-chart on the board as a class.

4. Resources (1D)

Resources for the lesson are as follows:

Rosie Revere Engineer book by Andrea Beaty

Ada Twist Scientist book by Andrea Beaty

Engineering Journal

PowerPoint with discussion questions

Cooperating Teacher

Smart Board and markers

5. Lesson Procedures (1A, 1E)

Describe the sequence of strategies/activities and/or assessments will be used to scaffold instruction, engage your students. facilitate attainment of the lesson objective(s), and promote higher order thinking. Within this sequence, be sure to describe how the instruction will be differentiated to meet your students' needs, interests, and abilities.

Engage (4-5 minutes):

- I will begin by telling students to open their notebooks to the first page. On the first page, I will ask students to draw what they think a scientist looks like and write a list of 2 character traits about what they draw. I will give students about 2-3 minutes to draw their picture.
- Once they have drawn their scientists, I will have a few students share their ideas on the document camera. We will talk about similarities and differences students see in the drawings of the scientists.
- Next, I will have them turn the page and draw what they think an engineer should look like. I will also have them list 2 things about the engineer. I will give them a minute or two to draw their picture and then we will share on the document camera again. This time, we will point out differences and similarities in the engineer drawings.
- Then we will talk about differences we see in the scientist drawings and the engineer drawings so we have a good idea of what students originally think about scientists and engineers before reading the stories.

Explore (15-20 minutes):

- Next, I will have students turn to the next page in their notebooks and title it Ada Twist (I will write the name on the board so students can see how to spell it.) I will tell students that I brought two friends with me who have very important jobs. I want them to think about each friend and what makes them good at what they do.
- I will begin by reading Ada Twist Scientist. As I read the story, I will have students write down character traits about Ada Twist that makes her a good scientist. What does she do? What does she not do?
- I will read the story and let students jot down ideas as I read. I will model expressive reading and questioning strategies as I read the story.
  When I finish reading Ada Twist, I will then tell students to turn the page in their notebooks and title that page Rosie Revere. I will instruct them to do the same thing as when I read Ada Twist, write down some ideas about what makes Rosie a good engineer.

Explain (8-10 minutes):

- For the explain part, we will do the pair share part where students talk in their groups about the characteristics, they wrote down for Ada Twist first then Rosie Revere.
- As students talk, I will be walking around listening to their conversations and observing in their journals what they wrote down.
- I will encourage students to think about similarities between the two also. They do have similarities, but we will focus on the differences, but it is also important to see how they are similar fields.
- After student share about Ada Twist and Rosie Revere, we will create a list on the smart board in the form of a Three-chart (a T-chart with three columns instead of two).

Extend/Elaborate (7-8 minutes):

- For the elaborate part of the lesson, we will refer back to the drawings students did during the engage part of the lesson.
- I will ask students to look back at the drawings they completed at the beginning of the lesson and the character traits they wrote down about both. I will ask students if their opinions have changed after reading the books. Would you change your character traits? Would they stay the same? Would you add anything to your drawing?

- Students will directly confront their misconceptions and we will talk about misconceptions they previously had about engineers and scientists.
- Next, we will focus on engineers and define engineering and talk about, broadly, what an engineer does. This is where we will define what engineers are and what the field of engineering is all about.

Evaluate (2-3 minutes):

- The formative assessment for this lesson will be the three-charts students create in their engineering journals and I will do the first "exit slip" that I will call Engineering Thoughts for this unit. I will have the students respond to a question in their notebooks.
- Today will be Engineering Thought #1. The questions will be:

1. Name 2 characteristics of a scientist.
2. Name 2 characteristics of an engineer.
3. What is one main difference in a scientist and an engineer?

Appendix C

Source of Evidence 1: KTIP Lesson Plan: Day 2 Civil Engineering

1. **Learning Target(s)/Objectives (1C)**

c. Previous lesson's learning targets/objectives (Connect each target/objective to the appropriate state curriculum/content area standards.)

Standard(s):

ELA.3.L.3: Describe characters in a story (e.g. their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events.

ELA.3.L.9 Compare and contrast by themes, settings, plots of stories written by the same author about the same or similar characters (e.g. books from a series)

Learning Targets:

- I am learning to describe characters in a story.
- I am learning to explain how a character's actions add to the story.
- I am learning to compare and contrast characters in a story.

d. Current lesson's learning target(s)/objective(s) (Connect each target/objective to the appropriate state curriculum/content area standards)

Standard(s):

3-ESS3-1: Make a claim about the merit of a design solution that reduces the impact of a weather-related hazard.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Learning Targets:

- I am learning compare my solutions to the problem to solutions my classmates create.
- I am learning to plan and carry out tests on my solution and identify what needs to be improved.

e. Next lesson's learning targets/objectives. (Connect each target/objective to the appropriate state curriculum/content area standards)

Standard(s):

3-ESS3-1: Make a claim about the merit of a design solution that reduces the impact of a weather-related hazard.

3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Learning Targets:

- I am learning to analyze a design solution that meets certain criteria.
- I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- I am learning to plan and carry out fair tests on a model and identify things that can be improved.

2. Students' Baseline Knowledge and Skills (1B, 1F)

For the pre-assessment in this lesson, I will be giving students a small opener to answer in their engineering notebooks, called Engineering Thought #2. They will write their answers in the notebooks for me to look at during notebook checks and as I walk around. I will have the questions posted on the document camera and students will right their answer in the book. The following questions will be on the pre-assessment:

1. Where on Earth can you find water?
2. Is water a solid, liquid, or gas?
3. How do you think the water gets to our faucets?

3. Formative Assessment (1F)

a. During the lesson

During the lesson, I will be walking around observing students writing in their notebooks and taking note of students who may not be understanding the content. I will be collecting the notebooks after each lesson to read during planning period. I will write take notes about what I see in the journals and jot down any misconceptions I see that may be forming in their answers to correct and reteach the next day at the beginning of the next challenge. I will also be walking around with a chart of our criteria for success rubric for working as a team and I will put a check next to students who met the criteria for that day and a minus for the students who did not.

b. End of lesson (formative/summative)

At the end of the lesson, students will be answer 4 questions in their engineering notebooks as Engineering Thought #3. Engineering Thought #3 will have the following questions on it:

1. How did my group's design work? (was it a success?)
2. What would you change about your design given more time or extra materials to use?
3. What is the engineering design process?
4. In your own word, describe what a civil engineer does?

4. Resources (1D)

- Straws
- Styrofoam cups
- Tape
- Engineering notebooks
- Pencils
- Exit slip sheet
- Towels
- Pitcher of water
- Cooperating Teacher

5. Lesson Procedures (1A, 1E)

Describe the sequence of strategies/activities and/or assessments will be used to scaffold instruction, engage your students. facilitate attainment of the lesson objective(s), and promote higher order thinking. Within this sequence, be sure to describe how the instruction will be differentiated to meet your students' needs, interests, and abilities.

Engage:

During the engage stage, we will be connecting what they learned in second grade to what they will be learning during this lesson. I will have an opener with questions that will help students bridge what they learned in second grade to what they will be learning during this lesson. The questions will be posted on the board in my power point and students will write their answers in their engineering notebooks. I will be able to look at their previous ideas before beginning the lesson then how their views change after the lesson. The following questions will be part of my pre-assessment:

1. Where on Earth can you find water?
2. Is water a solid, liquid, or gas?
3. Where does out water we use come from?
4. How do you think the water gets to our faucets?
5. Who is in charge of making sure our water gets where it needs to go?

Students will answer these questions before we begin the lesson.

Next, I will give students the short readings about what pipelines and some examples of real pipelines developed by engineers. Students will read the examples silently before we discuss them. I will use this resource to guide students' thinking as they begin designing their pipelines and give them context for how important pipelines are to our society.

1. What is a pipeline?
2. What do pipelines do?
3. If you were tasked with making a pipeline, how would you do it?
4. What materials might you need to create a pipeline?

Explore:

Ask:

- A village in South Africa only has access to water by walking for miles to fill up jugs and containers to bring back to the village. For the village to sustain their people, they need better access to water. You and your teammates are civil engineers, tasked with creating a pipeline to deliver water from the lake to a reservoir in the center of the village. Students will be working to answer the following question:
- How can I use materials to create a pipeline to get water from the lake to the village?

Research:

- Students will refer to their example sheet and discuss in their groups what they need to consider when building their pipelines.
- They will write down some notes in their notebooks about things they need to consider when creating their own pipeline.
- Students will make a list of the materials their groups need to build their pipeline.

Imagine:

- During this stage, students will have a few minutes to discuss in their groups about what they want to do as a group to create their design. Students will discuss some things they want to keep in mind as they begin creating their pipeline. They can also discuss some things to avoid when creating their pipeline.

Plan:

- During this stage, students will each draw their own design in their notebooks. They must label their design with the materials and list what materials the plan to use. Their drawing should be big and elaborate, as much detail as they can get so it is clear what their intention is behind the design. They will also be aware that they will need to explain their design to their group so they need to have a good idea of what their design should look like so they can explain it to their peers.

Create:

- During this stage, students will select one design, or combine ideas of multiple, to create their pipeline as a group. Students will get 10 straws, 24 inches of tape, a towel, two cups, and a stand made of popsicle sticks to put their lake cup on. Students will have to create a pipeline using the straws to connect the lake cup with the cup for the village. Students will initially just have to connect the two cups but when we do round 2, students will have a challenge to complete.

Test:

- During the test phase, we will pour water into the lake cup and see how well the design works. Students will watch for flaws in the design to fix for the next round, take note in their notebooks and make edits in their design for round two.

Improve:

- The improve stage will simply be students taking the ideas they jotted down in their notebooks about what didn't work and applying that in a new design with a twist. The second time around, students will have to overcome a slight hill and the water must still flow from one cup to the other.

Explain:

During this stage, students will reflect in their journals about their designs by answering the following questions in their notebooks:

1. What challenges did you face when creating your pipeline?
2. Did you find you needed to rework your original plan when you began building the real pipeline? If so, how did your pipeline change?
3. Which pipeline developed by another "engineering" team did you think worked best? Why?
4. Did you find that there were many ways to solve this challenge? If so, what does that tell you about the engineering designs of real pipelines?
5. How do you think engineers working on the Alaskan Pipeline attempted to avoid negative environmental impact in Alaska? Did they succeed?

Elaborate (8-10 minutes):

The elaborate stage will occur later in the week at the end of the unit when we play Engineering Jeopardy as a review of each branch of engineering and the engineering design process we have been learning about all week.

Evaluate:

During the evaluate stage, I will take up the students' notebooks for the day and look over their notes, designs, and answers to the questions posed at the beginning. The final assessment will be the exit slip I give students with 5 questions on it for them to answer about what we learned for the day. The exit slip will have the following questions on it:

1. How did my group's design work? (was it a success?)
2. What would you change about your design given more time or extra materials to use?
3. Where does our water come from?
4. Who makes sure we get water to our faucets?
5. What is civil engineering?

Appendix D

Source of Evidence 1: KTIP Lesson Plan: Day 3 Mechanical Engineering

1. **Learning Target(s)/Objectives (1C)**
   f. Previous lesson's learning targets/objectives (Connect each target/objective to the appropriate state curriculum/content area standards.)

   Standard(s):

   3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

   3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

   3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

   Learning Targets:

   - I am learning to analyze a design solution that meets certain criteria.
   - I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
   - I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
   - I am learning to plan and carry out fair tests on a model and identify things that can be improved.

   g. Current lesson's learning target(s)/objective(s) (Connect each target/objective to the appropriate state curriculum/content area standards)

   Standard(s):

   3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

   3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

   3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
   Learning Targets:

   - I am learning to analyze a design solution that meets certain criteria.
   - I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
   - I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

- I am learning to plan and carry out fair tests on a model and identify things that can be improved.

h. Next lesson's learning targets/objectives. (Connect each target/objective to the appropriate state curriculum/content area standards)

Standard(s):

3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Learning Targets:

- I am learning to analyze a design solution that meets certain criteria.
- I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- I am learning to plan and carry out fair tests on a model and identify things that can be improved.

2. Students' Baseline Knowledge and Skills (1B, 1F)

Describe and include the pre-assessment(s) used to establish students' baseline knowledge and skills for this lesson.

Students' baseline knowledge will be assessed through previous engineering challenges, the Draw an Engineer Test given at the beginning of the unit, and Engineering Thought #4, which assesses their previous experiences with roller coasters and machines. Many of the students have never ridden a roller coaster and many have never even seen one in person, so I have a virtual roller coaster ride (Youtube video) we will watch and students will answer questions/write down observations as we watch. The following questions make up Engineering Thought #4:

- How many of you have ever ridden a roller coaster?
- We are going to watch the following video of a roller coaster simulation. As you are watching, look for parts of the roller coaster where it seems to slow down and speed up. What do you notice as we ride the roller coaster?

3. Formative Assessment (1F)

Describe and include the formative assessment(s) to be used to measure student progress during this lesson.

Before: before the lesson begins, students will complete Engineering Thought #4 in their engineering notebooks. The questions will get students thinking about personal experiences so they can connect with the material and concepts we will be discussing that day. The following questions will make up Engineering Thought #4:

- How many of you have ever ridden a roller coaster?
- We are going to watch the following video of a roller coaster simulation. As you are watching, look for parts of the roller coaster where it seems to slow down and speed up. What do you notice as we ride the roller coaster?

During: During the challenge, I will be walking around with a roster and if students are working well in their groups, I will put a check next to their name and if students are not participating the way they should be in the group challenges, I will put a minus and the students with a minus next to their name will earn a discussion with me after class to discuss why they were not participating or exhibiting bad group work behavior.

After: After the lesson, students will respond to questions in their engineering journals that sum up the information we discussed during the lesson. These questions will be Engineering Thought #5 and will have the following questions for students to answer:

1. Did your roller coaster work?

2. What would you do differently, given more time or materials?

3. What is a mechanical engineer in your own words?

4. One super cool thing I learned today is…

4. Resources (1D)

Identify the resources and assistance available to support your instruction and facilitate students' learning. This includes links to technology, homework, exit or bell ringer slips, readings, etc. Be specific if there is an aide in the classroom and their role.

- Engineering Journals
- Roller Coaster Video Link
- Pipe insulation
- Marbles (1 per engineering group)
- Cups (1 per engineering group)
- Masking tape (1 long strand per group)
- PowerPoint with discussion questions/information

5. **Lesson Procedures (1A, 1E)**
   Describe the sequence of strategies/activities and/or assessments will be used to scaffold instruction, engage your students. facilitate attainment of the lesson objective(s), and promote higher order thinking. Within this sequence, be sure to describe how the instruction will be differentiated to meet your students' needs, interests, and abilities.

Day 3: Mechanical Engineering

Engage (3-4 minutes):

For the engage, students will complete Engineering Thought # 4 in their journals. I will start by asking how many of them have ever ridden a roller coaster. Considering most of them are too short to ride roller coasters I will assume very few. I have a roller coaster simulation video we will watch. (link: https://www.youtube.com/watch?v=2WaxrzSK5CI) I will ask students to pay attention during the video and jot down some things they notice about how the roller coaster operates. When does is move slowly? When does it move quickly? Does the roller coaster move at the same speed the whole time?

Explore (15-20 minutes):

During the explore part of the lesson, students will be given pipe insulation, masking tape, various supports, a cup, and a small marble. Students will use these materials to create their own roller coaster. They will take that information and create a roller coaster using the materials. The marble must move throughout the whole roller coaster without flying off and land in the cup at the end.

Ask:

I will tell students they have been hired by King Island as roller coaster engineers to create a new roller coaster for the park. At first, I will tell them to experiment with hills and getting a feel for the materials. Then I will add requirements for their roller coaster. The park wants a new roller coaster with a hill and two loops.

Imagine

During the imagine stage, students will draw sketches of their roller coaster with labels of the materials. They will do this part independently and draw their own individual sketches first. They will be required to label their drawing with the materials they plan on using and how they plan on using each material. They should also create a list of materials out to the side they think they will need to complete the task at hand.

Plan:

During this stage, students will plan their investigation. Students will share their sketches and the group will choose a drawing and use it as a plan to create their roller coaster. Students will draw the final plan for their roller coaster in their notebooks and label the materials they need (similarly to how they labeled their personal drawings).

Create:

During the create stage, students will build their design. They will use the materials at their table to create the roller coaster their group decided on as a team. Before beginning this part of the lesson, we will discuss what it means to work as a team. The students often have trouble working in groups so we will need to establish ground rules before breaking off into groups. We will review group work etiquette and manners before building and I will remind students that I will be walking around looking for the team who works together the best during the challenge.

Test:

During the test phase, students will carry out the investigation by taking their small marble, placing it on the roller coaster, and the marble should continuously roll throughout the entire coaster without falling out. It should also drop in the cup placed at the end of the coaster. Students will be able to test their coaster before this test to make sure they are on the right track, but this is the "official" test that I will observe. I will have a checklist to grade their coasters.

Improve:

This is the reflection stage where students will think about their roller coasters. I will give them questions to think about. Students will respond to the following questions in their engineering notebooks to reflect on their design:

1. Did our design work?
2. What didn't work?
3. What can we change to make it better?
4. Did my team work well together?

Explain:

During the explain stage, we will talk about mechanical engineering. We will discuss this is what they do, they work on machines and technologies. I will have a PowerPoint that has images of mechanical engineers with some jobs that fit under that branch of engineering. We will discuss the different jobs of mechanical engineers and students may take notes in their journals that they will be able to use during engineering Jeopardy at the end of the week.

Elaborate:

The elaborate stage will take place at the end of the week when we play Engineering Jeopardy to conclude the lesson and reinforce concepts students have been working on all week.

Evaluate:

The evaluate stage will complete Engineer Thought #5 with the following questions:

1. Did your roller coaster work?
2. What would you do differently, given more time or materials?
3. What is a mechanical engineer in your own words?
4. One super cool thing I learned today is…

Appendix E

Source of Evidence 1: KTIP Lesson Plan: Day 4 Electrical Engineering

1. **Learning Target(s)/Objectives (1C)**

   i. Previous lesson's learning targets/objectives (Connect each target/objective to the appropriate state curriculum/content area standards.)

   Standard(s):

   3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

   3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

   3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

   Learning Targets:

   - I am learning to analyze a design solution that meets certain criteria.
   - I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
   - I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
   - I am learning to plan and carry out fair tests on a model and identify things that can be improved.

   j. Current lesson's learning target(s)/objective(s) (Connect each target/objective to the appropriate state curriculum/content area standards)

   Standard(s):

   3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

   3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

   3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

   Learning Targets:

   - I am learning to analyze a design solution that meets certain criteria.
   - I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
   - I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
   - I am learning to plan and carry out fair tests on a model and identify things that can be

improved.

k. Next lesson's learning targets/objectives. (Connect each target/objective to the appropriate state curriculum/content area standards)

Standard(s):

3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Learning Targets:

- I am learning to analyze a design solution that meets certain criteria.
- I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- I am learning to plan and carry out fair tests on a model and identify things that can be improved.

2. Students' Baseline Knowledge and Skills (1B, 1F)
Describe and include the pre-assessment(s) used to establish students' baseline knowledge and skills for this lesson.

Student's baseline knowledge will be assessed with the Engineering Thought #6, the Draw an Engineer Test given at the beginning of the unit, and observations from previous challenges. Engineering Thought #6 will ask students the following questions to assess their value of technology to connect with what electrical engineers do:

- Write a list of **electronic technologies** you use in your everyday life.
- How **often** do you use technology?
- How many **minutes/hours** a day do you think you use technology?

3. Formative Assessment (1F)
Describe and include the formative assessment(s) to be used to measure student progress during this lesson.

Before: Engineering Thought #6 will be the pre-assessment to gauge student's use of electronic technology and help them visualize things electrical engineers might create/improve.

During: During the lesson I will be walking around looking to see if students are working well in their groups and if they are, they will get a check. If not, they will get a minus and we will have a discussion about their behavior/lack of participation.

After: Engineering Thought #7 will be the final assessment for this lesson. Students will respond to the following questions in their notebooks:

- 1. What does an electrical engineer do in your own words?
- 2. What tools might an electrical engineer use?
- 3. Electrical engineers focus on the transfer of _____________.
- 4. What do electrical engineers design/maintain?

4. Resources (1D)

Identify the resources and assistance available to support your instruction and facilitate students' learning. This includes links to technology, homework, exit or bell ringer slips, readings, etc. Be specific if there is an aide in the classroom and their role.

- PowerPoint
- Lightweight cars
- Propellers
- 9-Volt batteries
- Engineering Notebooks
- Smart Board
- Wires
- Masking Tape

5. Lesson Procedures (1A, 1E)

Describe the sequence of strategies/activities and/or assessments will be used to scaffold instruction, engage your students. facilitate attainment of the lesson objective(s), and promote higher order thinking. Within this sequence, be sure to describe how the instruction will be differentiated to meet your students' needs, interests, and abilities.

Day 4: Electrical Engineering

Engage (5-6 minutes):

For the engage part of the lesson, I will ask students to do a think pair share about the different types of electronic technologies they use in their everyday lives. This will serve as Engineer Thought #6 because they will write their ideas down in their notebooks during the think time. This will get students thinking about the technologies they use and open their eyes to the importance of technology in our world. Technology is important to many cultures and will help all students relate to the lesson. I will have them independently list technologies they use, or they have seen used by others. Next, I will have students share out in their small groups about their technology usage lists. They can add things to their list their peers say that they didn't think of or didn't have time to write down. They should also use the share time to come up with 3-4 things they will share as a group. Finally, we will come together, and students will share out their group lists. I will have one or two from each group come up to the smart board and write their group's ideas. Students now realize how much technology we use, and they are thinking about how important technology is to our society.

Explore (15-20 minutes):

Ask:

For the ask stage, students will be given the task. For this engineering challenge, we will be building propeller cars. Students will be engineers for a new toy company called Silver Creek Toys. They are tasked with creating a toy car that moves by propeller. They have to use a battery, the propeller, copper wires, and upcycles materials to create their car. They will have plastic containers, old CDs, bottle caps, tape, glue, and other materials to create their car. Students will write down some questions they have about the assignment they can ask before we begin.

Imagine:

During this stage, students will draw their own design of a car. I will show them the materials that are available for them to use. They must label their drawing with the materials they plan to use on their car. They will have to describe their design to their classmates so they must label it appropriately so they can explain their design to their group members.

Plan:

During the plan stage, students will share their designs in their group, and they will come up with a design as a group. They can choose one design from their group members or they can combine multiple designs to come up with one design for their group car. They will have to draw the design in their notebooks for the car they plan to build.

Create:

During the create stage, students will get to come back to the container of materials and choose what they need to make their cars work. Their battery, motor propeller, and wires will be in a Ziploc bag, but the body and wheels will be at the student's digression in their design. They will grab their materials and they will have about 15 minutes to build their car. They can perform a mini-test to see how their car will work.

Test:

During this stage, students will test their car creations. We will clear a space in the classroom and each group will test their cars. WE will have a starting line and a finish line taped off from the back of the room to the front of the room. Their cars must move from the starting line to the finish line. We will also time the cars to see which group's moves the fastest.

Improve:

During the improve stage, students will reflect on the performance of their propeller car. They will write in their notebooks about how they felt their car did by answering the following questions:

4. Did our car work they way we thought it would?
5. How could I make it faster?
6. What materials would have worked better?

Explain (7-8 minutes):

During the explain stage, we will connect our activity to technologies we talked about at the beginning of the lesson. We will also talk about mechanical engineers and what they do. I will have a PowerPoint with slides about electrical engineers. We will talk about how the challenge they just completed is similar to what electrical engineers do. They use circuits and electricity to improve society by creating technologies that improve our world. We will talk about different jobs electrical engineers do and how they help make our world better.

Elaborate (8-10 minutes):

The elaborate stage will occur later in the week at the end of the unit when we play Engineering Jeopardy as a review of each branch of engineering and the engineering design process we have been learning about all week.

Evaluate (5-6 minutes):

For the evaluate stage, students will complete Engineering Thought #7 about electrical engineering with the following questions on it:

- 1. What does an electrical engineer do in your own words?
- 2. What tools might an electrical engineer use?
- 3. Electrical engineers focus on the transfer of _____________.
- 4. What do electrical engineers design/maintain?

Appendix F

Source of Evidence 1: KTIP Lesson Plan: Day 5 Chemical Engineering
1. Learning Target(s)/Objectives (1C) l. Previous lesson's learning targets/objectives (Connect each target/objective to the appropriate state curriculum/content area standards.) **Standard(s):** *3-5ETS1-1*: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. *3-5-ETS1-2*: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. *3-5ETS1-3*: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. **Learning Targets:** • I am learning to analyze a design solution that meets certain criteria. • I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. • I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • I am learning to plan and carry out fair tests on a model and identify things that can be improved. m. Current lesson's learning target(s)/objective(s) (Connect each target/objective to the appropriate state curriculum/content area standards) **Standard(s):** *3-5ETS1-1*: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. *3-5-ETS1-2*: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. *3-5ETS1-3*: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. **Learning Targets:** • I am learning to analyze a design solution that meets certain criteria. • I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. • I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

- I am learning to plan and carry out fair tests on a model and identify things that can be improved.

n. Next lesson's learning targets/objectives. (Connect each target/objective to the appropriate state curriculum/content area standards)

Standard(s):

Learning Targets:

- I am learning to I am learning about the four branches of engineering.
- I am learning to sort engineering jobs into one of the four main branches of engineering.

2. **Students' Baseline Knowledge and Skills (1B, 1F)**
Describe and include the pre-assessment(s) used to establish students' baseline knowledge and skills for this lesson.

Engineering Thought #8 will be the pre-assessment for this lesson. The goal of this Engineering Thought is to activate prior knowledge for students and help them connect with content. Chemical engineering is difficult to understand so connecting it to something they use everyday (water) students can get a better understanding of what chemical engineers do and they can better learn about them. The following questions make up Engineering Thought #8:

- How much water do you think you use?
- Is water important to our world?
- What do we use water for?

3. **Formative Assessment (1F)**
Describe and include the formative assessment(s) to be used to measure student progress during this lesson.

Before: Engineering Thought #8 will be the pre-assessment to help students connect with the material and visualize on a simpler level what chemical engineers do.

During: During the lesson I will be walking around looking to see if students are working well in their groups and if they are, they will get a check. If not, they will get a minus and we will have a discussion about their behavior/lack of participation.

After: Engineering Thought #9 will be the final assessment for this lesson. Students will respond to the following questions in their notebooks:

- What is chemical engineering in your own words?
- What do chemical engineers do?
- What tools do they work with?
- Name one job a chemical engineer might do.

4. **Resources (1D)**
Identify the resources and assistance available to support your instruction and facilitate students' learning. This includes links to technology, homework, exit or bell ringer slips, readings, etc. Be specific if there is an aide in the classroom and their role.

- Two-liter
- Coffee Filters
- Cheese cloth
- Pebbles
- Sand
- Measuring cup
- Potting soil
- Measuring cup
- Water clarity testing machine
- Pipet
- Masking tape
- PowerPoint
- Engineering Notebooks

5. **Lesson Procedures (1A, 1E)**
Describe the sequence of strategies/activities and/or assessments will be used to scaffold instruction, engage your students. facilitate attainment of the lesson objective(s), and promote higher order thinking. Within this sequence, be sure to describe how the instruction will be differentiated to meet your students' needs, interests, and abilities.

Day 5: Chemical Engineer

Engage (4-5 minutes):

For the engage part, students will complete Engineering thought #8 in their notebooks. The questions are as follows:

- How much water do you think you use?
- Is water important to our world?
- What do we use water for?

These questions get students thinking about water usage. Chemical engineering is hard to explain to younger students because chemistry is not often taught at the elementary level but all students have used water in one way or another and chemical engineers filter bad things out of the water. The goal is to connect students with a simpler example to help them visualize the more complex jobs chemical engineers might do.

Explore:

Ask:

The students will be tasked with creating their own water filtration systems. They work at the Madison County Utilities and they need their group of engineers to create a water filtration system that gets the clearest water. I will give students river rocks, coffee filters, cheesecloth, sand, cotton balls, a two-liter bottle to make a water filtration system. We will put some potting soil in 200 mL of water and put it through their water filters. Whichever teams has the clearest water will "get the job."

Imagine:

During the imagine stage, students will draw their own representations of what their model filtration system will look like. They must label what materials they plan to use and what order they plan to put them in. They will have to explain their design to their group partners so they will need to have an understanding of their design to explain to their partners when they share.

Plan:

During the plan stage, students will share their designs in their groups. The students will share their ideas and talk about what materials they think will work best and why. They will draw a water filtration design in their notebooks for their group. They can take ideas from each person or use one person's design if they all think it will work best. They will draw the final design in their notebooks for their team's model.

Create:

During the create stage, students will collect the materials they need to create their team's design. They will collect their materials from a table in the room where I will have everything set up. They will collect their materials and bring it back to their table for their groups the start building. They will have time to build their model before we test it out officially.

Test:

During the test phase, we will pour 200 mL of dirty water into the filtration system. We will let them drip while we do the explain part of the lesson and come back at the end to test them. I will put a sample into a machine and test the clarity of the water. Students will write down the clarity of their samples in their notebooks.

Improve:

During the improve stage, students will reflect on their design in their notebooks. They will answer the following questions as a reflection:

5. What could we add/take away to improve clarity?
6. Did another group's design work better? Why/why not?
7. Are there other materials not offered that I could use to improve my design?
8. How could I make the water clearer?

Explain:

During the explain stage, we will talk about chemical engineers. We will define what a chemical engineer is and what they do. I will have pictures of chemical engineers and we will talk about the different contributions they make in our society such as

- Design environmentally friendly cleaning products
- Develop chemotherapy that has fewer side effects
- Turn seawater into drinking water
- Develop ways of mass-producing vaccines to ward off epidemics
- Reduce pollution by developing cleaner sources of energy

Elaborate:

The elaborate stage will take place later in the week with engineering jeopardy to review engineering content.

Evaluate:

Students will answer the following questions in their notebooks as Engineering Thought #9:

- What is chemical engineering in your own words?
- What do chemical engineers do?
- What tools do they work with?
- Name one job a chemical engineer might do.

Appendix G

Source of Evidence 1: KTIP Lesson Plan: Day 6 Sort an Engineer

1. **Learning Target(s)/Objectives (1C)**
   o. Previous lesson's learning targets/objectives (Connect each target/objective to the appropriate state curriculum/content area standards.)

   Standard(s):

   3-5ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

   3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

   3-5ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

   Learning Targets:

   - I am learning to analyze a design solution that meets certain criteria.
   - I am learning to define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
   - I am learning to come up with multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
   - I am learning to plan and carry out fair tests on a model and identify things that can be improved.

   p. Current lesson's learning target(s)/objective(s) (Connect each target/objective to the appropriate state curriculum/content area standards)

   Standard(s):

   N/A

   Learning Targets:

- I am learning to I am learning about the four branches of engineering.
- I am learning to sort engineering jobs into one of the four main branches of engineering.

2. **Students' Baseline Knowledge and Skills (1B, 1F)**

The pre-assessment for this lesson will be Engineering Thought #10, which is designed to get students thinking and reflecting on the week. Students think about the past week and choose one of the four branches they found the most interesting and they must explain why. This will help me see if they know what each branch does through their explanations. The final engineering thought will consist of the following questions:

- Choose one of the four branches we have talked about this week (civil, mechanical, electrical, or chemical) that you thought was the most interesting. Why was this branch most interesting to you?

- Could you see yourself becoming an engineer in that branch someday?
- What did you enjoy most while learning about that branch?

3. **Formative Assessment (1F)**

Before: Engineering Thought #10 will be the pre-assessment to help students reflect and summarize what they took away from the past week of engineering challenges and learning about the branches of engineering.

During: During the lesson I will be walking around looking to see if students are working well in their groups and if they are, they will get a check. If not, they will get a minus and we will have a discussion about their behavior/lack of participation. Students will also have their informational posters about each branch to share and present to see what students took away from each branch.

After: after the lesson, I will give the draw an engineer test again for students to complete and we will play engineering jeopardy as a review. I can see how much students remember based on their answers to the questions in jeopardy.

4. **Resources (1D)**

- Chrome books/iPads
- Poster paper
- Markers/colored pencils
- Engineer sort career cards
- Draw an Engineer Test
- PowerPoint
- Engineering Journals

5. **Lesson Procedures (1A, 1E)**

Day 6: Sort an Engineer

Engage (5-6 minutes):

For the engage stage, I will have students do the final engineering thought, Engineering Thought #10, where they choose one of the branches of engineering, they found the most interesting or the challenge they loved the most and why. This will get them thinking about each of the activities and what each of the branches does.

Explore (15-20 minutes):

During the Explore stage, students will be tasked with becoming an expert on one of the four branches of engineering we talked about in class. I will have students draw them from an envelope, so the selection is random. Students will then use the iPads and chrome books to research the branch they got with jobs, tools, and other important things about the branch they get.

Next, students will be doing their research about their branch. They will write down in their notebooks some facts about the branch they get. This will be a layout for the informational poster they will create about their branch.

After researching their branch, students will draw a sketch of their informational poster in their notebooks to lay out the poster before they create it. They will decide as a group what information should be on the poster and what information they should leave off.

Finally, the groups will create their poster. Based on previous experience with this group, I will assign jobs within the groups to keep arguments from breaking out. Each group will have an artist, 2 writers, and 2 readers. The writers and readers will work together to get the information from their books onto the poster. The artist is in charge of drawing any pictures they choose to put on the poster.

Explain (5-7 minutes):

During the explain part of the lesson, each group will present their posters to the class. They will teach their classmates about their branch of engineering. This will work as a refresher since we had been learning about the branches in the previous lesson. They will need this information to complete the extend activity. We will also have students in the audience ask questions about the posters and they have to be able to answer questions about their branch of engineering. I will have students jot down some notes about each branch in their notebooks as each group presents so they can use that information during the extend activity.

Elaborate (10-15 minutes):

During the elaborate stage, we will play a game called Engineer Sort. I will start by sorting students into four groups. We will jigsaw the groups from the explore stage. Each group will have at least one person who was an expert in each branch. So, each group will have someone from the mechanical, chemical, civil, and electrical engineer group. This will be a game in which students have a poster with each of the 4 branches written on it. The students will have an envelope full of different engineering jobs. They will pull them out and sort them based on the branch that job fits under.

Evaluate:

The evaluate stage will consist of students taking the Draw an Engineer Test again to evaluate their change in perceptions towards engineers based on their experiences during the week. We will also play engineering jeopardy as a review for the week and as a fun conclusion to the unit.

Appendix H

Draw an Engineer!

1. In the box below, draw what you think an engineer looks like.

2. Describe what the engineer in your picture is doing.

3. What tools do you think an engineer uses?

4. What skills might an engineer have?

5. What does an engineer do?

6. Could you see yourself being an engineer when you grow up? Why or why not?

Appendix I

DRAW AN ENGINEER CHECKLIST

Appearance of Engineer

- ☐ Species:
  - ☐ Human
  - ☐ Non-human
  - ☐ No person
- ☐ Skin Color:
  - ☐ Brown
  - ☐ Peach
  - ☐ Yellow
  - ☐ Green
  - ☐ None
  - ☐ Other:
- ☐ Gender:
  - ☐ Male
  - ☐ Female
  - ☐ Unknown
- ☐ Other Attributes:
  - ☐ Crazy Hair
  - ☐ Glasses/Goggles
  - ☐ Lab Coat
  - ☐ Laborer's Clothing
  - ☐ Other:

Location:

- ☐ Indoors
- ☐ Outdoors
- ☐ Underground
- ☐ Underwater
- ☐ Space
- ☐ Can't Tell

Inferences of Actions:

- ☐ Making/Fixing/working with hands

- ☐ Operating/driving machines & vehicles
- ☐ Designing/inventing/creating products
- ☐ Experimenting/testing/creating knowledge
- ☐ Explaining/Teaching
- ☐ Observing
- ☐ No Action inferred
- ☐ Other:

Objects:

- ☐ Other People (total #:)
- ☐ Non-humans/monsters, etc.
- ☐ Body parts – parts in jars, brains, etc.
- ☐ Robots
- ☐ Computers
- ☐ Building tools (wrench, hammers, etc.)
- ☐ Measuring tools (rulers, tape measures, etc.)
- ☐ Plants
- ☐ Animals
- ☐ Rocks
- ☐ Construction Vehicles
- ☐ Other Vehicles
- ☐ Writing objects (pens, papers, etc.)
- ☐ Rockets/space vehicles
- ☐ trains/train tracks
- ☐ Fictional machines
- ☐ Other machines
- ☐ Books
- ☐ Furniture
- ☐ Math symbols
- ☐ Blueprints/drawings/graphs
- ☐ Diplomas/awards
- ☐ Weapons – guns, bombs, etc.
- ☐ Civil structures – bridges, buildings, etc.
- ☐ Chemistry – flasks, test tubes, etc.
- ☐ Technology – TV, radio, computers, etc.
- ☐ Medicine – germs, syringes, etc.
- ☐ Meteorology
- ☐ Sports
- ☐ Signs of thinking
- ☐ Other: