ELEMENTARY STEM: INTEGRATED LESSONS

By

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A Project Submitted in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF EDUCATION

in

ELEMENTARY EDUCATION

University of Alaska Fairbanks

December 2016

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Acknowledgements

I would like to thank Dr. Cindy Fabbri, the chair of my committee, for her guidance, support, and wisdom throughout this process. I feel fortunate to have had her as a professor, mentor, and advisor. She has had a large part in this project and its outcome, and I am proud to have worked with her for the past two years. I would also like to thank Dr. Denise Thorsen and Mrs. Kathleen Wright for serving on my committee, and for their assistance and flexibility in helping me bring this project to fruition. The lessons and kits created would not be nearly as comprehensive nor clever if other professional teachers were not willing to contribute to them, so thank you to my fellow esteemed educators. The principal at Pearl Creek Elementary School, Katherine LaPlaunt, has encouraged my endeavors and provided me with valuable feedback in a positive and constructive way. I would also like to express my gratitude to the University of Alaska Fairbanks' College of Mining and Engineering, and the Alaska Space Grant Program, for providing me with funds to produce and supply the Science, Technology, Engineering, and Mathematics kits. Additionally, several organizations including the Pearl Creek Elementary School Parent-Teacher Association, Delta Kappa Gamma Honor Society, and the Alaska Science Teachers Association provided me with mini-grants for which I am truly grateful; these funds helped to replenish the STEM kits during piloting and dissemination. Lastly, I would like to thank my wife Meagen, for being supportive of my continuing education, and for her willingness to take on extra responsibilities in our personal lives during this project. I would not have been able to complete this project without her patience and perseverance.

Explanation of Terms/Acronyms

Common Core State Standards – The CCSS are a set of standards, describing the recommended content to be covered by teachers of students spanning from kindergarten through twelfth grade. These standards include specific instructions for English/Language Arts, Mathematics, History/Social Studies, Science, and Technical subjects. The National Governors Association (NGA) and the Council of Chief State School Officers created these sets of standards in 2010, and to date, forty-two states and the District of Columbia have adopted them. The State of Alaska did not choose to adopt the CCSS in its original format, however the state has implemented a modified version of the protocol (Common Core State Standards Initiative, 2015). In 2012, the Alaska State Standards were initiated, offering similar guidance with nuanced changes for "Clarity, Alaskan Context, and standards that Alaskan teachers value" (Alaska Department of Education & Early Development, 2012).

Next Generation Science Standards – The final versions of the NGSS were published in 2013. They are intended for kindergarten through twelfth grade students, and were created by a collaboration of the National Research Council (NRC), National Science Teachers Association (NSTA), American Association for the Advancement of Science, and Achieve. To date, fifteen states have officially adopted them. Over forty states have individual districts that have adopted the NGSS as part of their curriculums, and twenty-six states are considered "Lead Partners" (Next Generation Science Standards, 2016). In 2016, The Fairbanks North Star Borough School District revised its science standards, and aligned them closely with the NGSS.

STEM – This is an acronym for the subjects of Science, Technology, Engineering, and Mathematics. If you asked ten different science, technology, engineering, or math teachers how they would define 'STEM' they will most likely offer a variety of responses. According to the National Science Teachers Association (2012), STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.

FNSBSD – An acronym for the Fairbanks North Star Borough School District.

Intermediate Grade Level – Grades four, five, and six.

Abstract

The primary purpose of this project was to increase elementary students' STEM literacy and interest in STEM-related fields. The secondary purpose of this project was to improve educator self-efficacy to teach STEM in their own classroom. To do this, I created, tested, and revised a series of STEM lessons and kits appropriate for Intermediate elementary students. Participants in this project included: eight through twelve year-old elementary students, three "Highly Qualified" certified elementary teachers from the FNSBSD, and other teacher collaborators from California and New Jersey. This project also enlisted the help of several expert students and faculty from the University of Alaska Fairbanks. The method used was a collaborative, cyclical, anecdotal, and highly reflective Action Research approach. The final product is a series of five STEM lessons and kits that can be used in an Intermediate elementary classroom. The lessons and kits have been tested and revised many times, and are ready for dissemination for other educators to use. I recommend that teachers become familiar with the content included in the lessons and kits, particularly because national standards have recently changed, and these lessons offer methods for teaching this new material. The accompanying kits are also intended to be user-friendly. It is my hope that these kits find their way into many classrooms, and bring students and teachers knowledge and joy. I will continue working on integrated STEM lessons and kits in the future.

Introduction

For this project, I investigated STEM resources available to elementary teachers in the Fairbanks North Star Borough School District. Listening to discourse in multiple Intermediate classrooms, I found evidence that students lacked foundational knowledge and/or interest in STEM because of under-exposure to STEM-related fields. I garnered opinions from colleagues about their proficiencies and attitudes towards teaching STEM subjects. I specifically looked for areas of apprehension and asked how I could help. I also probed for successes and advice from other professionals about what worked for them, and how to build on those principles. I concluded that I wanted to provide Intermediate elementary students with rich, well-rounded, STEM experiences in the classroom, while giving teachers valuable instructional lessons that they could use for years to follow.

The purpose of this project was to increase students' STEM interest and literacy, while improving teacher self-efficacy to teach STEM in an elementary classroom. After creating engaging, comprehensive, standards-based lessons and associated kits, I shared these with four colleagues and we tested them in our PLCs and classrooms. I used my experiences and feedback from this process of analyzing, reflecting, and refining, to create highly effective lessons. The outcome is an understanding of what standards-based, user-friendly, STEM lessons and kits look like.

What does a standards-based, user-friendly, STEM lesson/kit look like? I sought to answer this question and share my project with colleagues. Three other Intermediate grade level teachers cooperated on this project. It was highly reflective and collaborative by nature. Qualitative, anecdotal feedback was the foundation for many of the modifications.

What does increased STEM interest and literacy look like in an Intermediate elementary classroom? I sought to address this question in the same way I approached my appraisal to the need for this project. I asked the students. I conducted classroom conversations following the lessons to improve the modules, their design, and teacher delivery. Lastly, I gave qualitative, summative assessments, and utilized comments from students to measure interest and guide learning.

Rationale

Personal Significance – There is growing concern nationwide that we are not adequately preparing students, teachers, and practitioners in the areas of STEM (Sorenson, 2010). This quote was personally significant to me. As a recent graduate of a teacher licensure education program, I was required to take both science and mathematics methods courses at the graduate level and I found them to be of great value and interest. Technology today is ever-evolving and intertwined in our society and classrooms in many different forms, and I am confident teaching it, and utilizing it. However, when I started my teaching career, I had little-to-no experience with engineering as a teacher or student. If I had had an option for a STEM course or elective during my teacher preparation program, I would have opted for that as well.

I feel my studies through the University of Alaska Fairbanks' School of Education were excellent and left me well prepared to lead students through their elementary years, but I am always striving to be a better educator for my students. One field in particular that interests me is STEM, and this was a large motive for this endeavor. I chose to produce a project, because I wanted to have a useful end-product that would benefit my class, and could be shared with colleagues to generate positive outcomes for more students. Equally, this was an opportunity to develop professionally and study challenging content.

As a teacher in the Fairbanks North Star Borough School District, I am fortunate to have a multitude of STEM resources and materials available to me from the Library Media Services Department at our downtown administrative building. However, I have often been apprehensive to explore the options obtainable, as they are cumbersome and overwhelming in size, content, and scope. In addition, my content knowledge was limited when I started this project, and I did not have the confidence or knowhow to teach STEM in my classroom. I imagined other educators were experiencing similar reservations, so this endeavor sought to address these issues, by creating simple, integrated STEM lessons and kits for the benefit of Intermediate students and teachers alike. This idea is loosely based on the FNSBSD's Art Kit Program, where small, focused kits are circulated across schools from the administration building.

Need for this project – After facilitating discourse and conducting informal formative assessments with students across three years of instruction – including student teaching – I concluded that the majority of children at the fourth grade level were perplexed and underexposed to STEM-related fields. Furthermore, students seemed to question the interconnected nature of these fields. I hypothesized that those students who lacked interest and foundational knowledge during our conversations were not exposed to STEM subjects in previous years. In some instances, I had students who had come from other school districts, where science and technology were "optional" components of the curriculum at the elementary level, and engineering was omitted entirely. Math appeared to be the only STEM subject with which students consistently demonstrated competence, albeit at varying proficiencies.

Over the past decade, there has been a trend in elementary schools toward spending less time on science and more time on reading and mathematics (Blank, 2012). This may be because of the growing pressure put on teachers to have their students perform "well" on standardized tests, and many requirements that are tied to reading and math performance. In conversation with another professional educator from the Lower 48, this question was posed to me: "If my kids are being tested in English/Language Arts and Math, and I have limited amounts of time for instruction or prep, why should I even teach science or STEM, they're not tested and I am not evaluated on STEM scores?"

This was a sad moment of realization for me. My response was: "Is this the way we need to teach? To the test?" "I prefer to teach the entire child, and from my passions and heart, across all subjects. The kids will be able to tell what is genuine and worthy, and therefore inherently have maximum buy-in." "In addition, STEM subjects are very much interrelated, and the implementation of it in the classroom may invigorate students about learning." "Lastly, when kids are involved in STEM activities, they practice collaboration, communication, critical thinking, and creativity, which is pertinent in all aspects of school and life." Needless to say, I did not see eye-to-eye with this other teacher.

Beyond philosophical differences, it is also an equity issue. A lack of science education during elementary years puts students at a disadvantage down the road. They are missing foundational concepts about how the world works and is understood (Personal Communication, Cindy Fabbri, 2016).

Educational Significance – This project was aimed at creating integrated, user-friendly, STEM lessons/kits for elementary students and schoolteachers alike. The primary purpose of generating this collection of lessons was to enhance child engagement and enthusiasm, while building foundational exposure to the aforementioned fields.

The secondary purpose of this project was to provide educators with new and relevant resources in a simplified way, so that they might successfully obtain enhanced background knowledge and confidence on each topic. The introduction to STEM-related fields is accomplished through a hands-on, exploratory format that is integral to the program's success. The value for educators are: concise lessons that are fresh, relevant, and aligned to current learning objectives. The future of STEM education in Fairbanks, Alaska, is intertwined with the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS). In 2014, The Fairbanks North Star Borough School District (FNSBSD) adopted a new math curriculum aligned closely with the CCSS, and in 2016 the District revised its science standards to closely match the NGSS. The project also ventured to provide resources necessary to transition from a traditional science curriculum to stand-alone lessons to teach a more comprehensive, integrated, STEM experience that meet the intent of the new standards.

The final product is a set of five STEM lessons, with the accompanying kits, that can be used by any teacher in an Intermediate elementary classroom.

Literature Review

STEM and Elementary Students – It is important to create a foundation of STEM-related language and context, and generate excitement in STEM fields at an early age. A study by Yoon et al. (2014) suggests that elementary school is the point where students start losing interest in science. This project intended to engage students at the elementary level in a STEM approach to address this problem, and also to help students to recognize that STEM subjects are very much interrelated. This project aimed for students to see themselves as Scientists, Technicians, Engineers, and Mathematicians at a young age, and to gain confidence by using real-world problems/concepts to facilitate learning.

Integrating STEM education into elementary classrooms has the power to impact learning and attitudes toward these subjects at a pivotal age, through a hands-on, inquiry based approaches to learning, while simultaneously increasing academic achievement (Hernandez, 2014). There has been a buzz about the term STEM for longer than a decade, and the implementations of it in elementary classrooms are constantly evolving and exciting. STEM lessons have been some of my most enjoyable teaching moments, and I feel that my students pick up on this. I believe that my positive energy has transferred to my kids and created significant learning for all types of learners. The lessons and kits for this project have been designed to include auditory, visual, and kinesthetic methods of delivery. This has resulted in effective teaching and learning experiences for teachers and students.

The Trends in International Mathematics and Science Study (TIMSS) puts U.S. fourth graders and eighth graders about average among industrialized and rapidly industrializing countries (Gonzales et al., 2009). We simply need to do better than this and it starts with early education and exposure. We have the ability to get kids interested in STEM fields, asking questions, and prolong interest for their later years in education. A study from Sullivan (2006) goes further by suggesting that, "Specifically, elementary STEM education is critical to instill, because cognitive development theories, and that early exposure can result in prolonged interest in STEM fields. Ultimately producing more professionals in the respected fields." Sullivan continues,

> "Exposure to engineering may be most profound in grades 3 through 8. In these formative years, hands-on engineering experiences, conveyed through inquiry-based,

design-oriented instructional methodologies, can support the learning of standards-based science and mathematics while stimulating student learning and making engineering come alive." (p. 7-8, 2006).

Although Sullivan's study was conducted ten years prior to this project, the evidence is both compelling and relevant, and it supports the theory, that early STEM in the classroom is a benefit for students' development and interest in STEM fields.

Essential skills such as critical thinking, creativity, communication, and collaboration are the foundations on which STEM is built, and this needs to be emphasized early in a child's educational career (Hernandez, 2010). This project aimed to have students involved in communicating, collaborating, and thinking critically and creatively. Furthermore, it has been shown that these are areas of overlap in math, English/language arts, and science standards, and therefore learning in one area also facilitates learning in the others.

Public education in Fairbanks is at a critical point; decisions regarding which standards should and should not be taught to students by educators are in flux, and there is a strong push for individualized learning, while maintaining a cooperative element. This project and its tools offer opportunities and time to highlight individual originality, inspiration, and innovation while sharing and interacting with others.

STEM and Elementary Teachers – Some integrated STEM education programs target in-service teachers rather than or in addition to students, often through professional development activities tied to a specific curriculum. Goals for these programs frequently aim to build teachers' knowledge of subject-matter and pedagogical content knowledge relevant both to individual STEM subjects and to making connections between and among them. A related goal is to boost educators' pedagogical skills in subjects to which they may have had little exposure. This is especially true for professional development programs targeted to afterschool educators, who typically have little coursework in mathematics, science, or engineering (Honey et al, 2014). What happens when there is not a plan in place for teachers to participate in professional development tied to STEM? It would be ideal for districts to have trainings, but in the event they do not, it is up to the classroom teacher to educate and train themselves.

Elementary teachers are the gatekeepers to fostering the gifts and talents of future STEM innovators (Cotabish et al., 2013). In order for teachers to cultivate interests in STEM fields in their students, they must know how to teach in an integrated way, and they must know how students learn STEM concepts. Teachers also need to be familiar with the language of STEM, and have an understanding of STEM-related fields.

According to the President's Council of Advisors on Science and Technology, the most important factor in ensuring excellence is great STEM teachers, with both deep content knowledge in STEM subjects and mastery of the pedagogical skills required to teach these subjects well (President's Council of Advisors on Science and Technology, 2010). Implications of Fairbanks teachers being under-prepared to deliver STEM education to their classrooms and bring our kids to the forefront of the global workforce could result in Fairbanks students not being leaders in the global workforce. International comparisons of U. S. students' performance in science and mathematics place the United States in the middle of the pack or lower (President's Council of Advisors on Science and Technology, 2010).

A study by Honey et al., STEM integration in the K-12 classroom stated that the role of a teacher in a STEM classroom is (2014, P. 93):

> "Teachers can provide effective instruction by engaging students in learning with the support and guidance they need (without doing the thinking for them). They should be attentive to learners' needs as they work with them, individually and in groups, and be able to ensure the positive and productive involvement of all as well as facilitate engagement when group work breaks down. They should also have techniques to guide (or redirect, as necessary) learners toward achieving the learning goal. It is important to recognize that requests for help are evidence of active engagement in learning and not an indication of a deficit. Teachers also need to be prepared to offer hints that steer individual and group learners toward insight into problems without being overly directive."

This was a major objective in this project. That eventually the classroom teacher will be familiar with the content, anticipate problems/issues, guide when and where necessary without being overbearing, and allow for the kids to grow and explore on their own.

It was important that this study was approached in a strategic manner for the betterment of the students and development of educators, while diminishing apprehension to integrating STEM lessons. Fairbanks elementary public school teachers are already required to teach across all subjects: including, but not limited to English/Language Arts, Math, Science, Technology, Health, Social Studies, and Art. Learning new content, creating new cross-curricular lessons, combined with time restraints can be a daunting task. It can create a sense of anxiety and lead to avoidance altogether; especially in an environment of high-stakes standardized testing. A study done by the Minnesota P-20 Education Partnership (2011, p. 36) states:

> "The values and belief systems of pre-service and in-service teachers might be obstacles to the teaching and learning process of STEM. Many elementary teachers are "generalists" and are primarily concerned with nurturing a child's development of language and mathematical skills along with a general development of students' academic competency. Most elementary teachers do not have a STEM mindset (for a number of reasons) and are therefore unprepared to create the inquisitive atmosphere necessary for the development of STEM learning. Students may also catch these attitudes."

For this project to be successful, I had to create meaningful and interesting lessons. I had to make sure that the lessons were authentic and based on real-world concepts. Students are intuitive and capable of deciphering teacher signals both verbal and non-verbal. The impacts of a highly involved, knowledgeable, and passionate educator can elevate a classroom to higher levels of engagement and learning.

There have been studies that highlight the value of STEM integration in the classroom as well as the effects on teacher self-efficacy. (Yoon et al., 2008) states that a teacher's content knowledge (pertaining to STEM) directly correlates to self-efficacy, and a more self-confident a teacher makes a stronger impact in the classroom. However, it is simply not possible for every elementary teacher to become a STEM expert, however all elementary schools can and should have at least one expert teacher in STEM education (Levy et al., 2008). If a STEM expert in a particular school can serve as a leader in their realm, they can be a source of expertise and guidance to their colleagues. Elementary schools could also benefit from high-quality, research-based materials, like the user-friendly lessons and kits that were created. It is necessary for such resources to be readily available with a clearly defined lesson plan and the appropriate materials included, delivering stimulating opportunities for STEM learning (Levy et al., 2008).

Participation in a group activity to design specific lessons can be an effective professional development opportunity (Penuel et al., 2007). Teacher collaboration was essential for this project; therefore, professional development was inherently present. Contributors to this project participated in Professional Learning Committee meetings that were focused on the STEM lessons and kits. Teachers provided valuable feedback and suggestions for modifications, conversations, observations, and note taking about lessons and kits. Teachers learned alongside of their students. By the end of the project, one objective was to have improved, comprehensive, and refined standards-based, integrated STEM lessons that are available for elementary school students and teachers in the Fairbanks North Star Borough School District. This goal was met, with slight variances. Instead of a “STEM Unit,” there were separate lessons, that targeted specific learning objectives, set forth by the new science standards.

STEM and Jobs – Fostering the development of students’ interest and identity in STEM is an important potential outcome of integrated STEM experiences. Interest and identity are thought to lead to continued engagement in STEM-related activities as reflected in course selection and choice of out-of-school activities, college major, and career path (Honey et al., 2014). This may be an immeasurable long-term goal of this project and even the possibility of this being a reality, is enough to produce STEM lessons and kits suitable for teaching.

An increasing number of jobs at all levels—not just for professional scientists—require knowledge of STEM (Lacey & Wright, 2009). According to the U.S. Bureau of Statistics, STEM jobs are projected to grow rapidly and substantially. While all jobs are expected to grow by 10.4%, STEM jobs are expected to increase by 21.4%. Similarly, 80% of jobs in the next decade will require technical skills (BLS, 2008). Additionally, the U.S. will have over one million job openings in STEM-related fields by 2018; yet, according to the U.S. Bureau of Statistics, only 16% of U.S. bachelor’s degrees will specialize in STEM. What does this mean? As a nation, we are not graduating nearly enough STEM majors to supply the demand (BLS, 2008). The National Academy of Sciences, National Academy of Engineering, and Institute of Medicine have linked K-12 STEM education to continued scientific leadership and economic growth in the United States (2011). “Between 2010 and 2020, the United States will experience a major talent meltdown.” (Gordon, 2009). This is a major concern, considering the impacts of STEM education are far reaching, and touches the lives of many people in our nation. The majority of jobs in the world today are connected to STEM-related fields on one way or another. “The primary driver of the future economy and concomitant creation of jobs will be innovation, largely derived from advances in science and engineering . . . four percent of the nation’s workforce is composed of scientists and engineers; this group disproportionately creates jobs for the other 96 percent” (National Academy of Sciences, National Academy of Engineering, and

Institute of Medicine, 2011). This project did not aim to deliver scientists and engineers to the doors of universities, but rather expose kids to the foundations of the respected fields in many ways, so that they may hold interest beyond that of elementary years. This may translate to continued interest and further pursuit of higher education in STEM-related fields.

STEM and Curriculum – The state of Alaska has rejected the adoption of the Common Core Education Standards and has created the Alaska State Standards, which are very similar to those of the Common Core. In the FNSBSD, the math, science, and technology curricula are not integrated. Furthermore, the District recently adopted new subsets of math, science, and technology standards, and only now does the science curriculum have components of engineering, which is a key element of STEM. Each field is separate in and of itself, and at Pearl Creek, it is up to the classroom teacher to design appropriate, efficient, and user-friendly instruction. Engineering materials are available through the District's Library Media Services Department; however, they are arduous, and a formalized curriculum is still being developed for this essential component of STEM.

Levy, Pasquale, & Marco (2008) concluded that elementary teachers face constraints in teaching STEM that include insufficient content knowledge and lack of confidence, lack of materials and facilities, and lack of support from their schools. While there is not currently a lack of materials and resources, I found that many of them were often overwhelming and time-consuming in both preparation and delivery. In addition, the newly adopted standards do not align comprehensively with what is available for use; the resources are becoming dated or labeled for different grade levels. This was a unique time to introduce new lessons and kits that coincide with the newly adopted standards.

Improvements were warranted in STEM curriculum development and integration within the Fairbanks North Star Borough School District. For this project, I sifted through resources at the District's offices, attended professional development conferences for STEM-related fields, met with educator mentors, university faculty and students, and scoured the web for usable information. After sorting through what I had found, I chose and adopted what I thought were engaging activities that aligned with the standards that were going to be implemented in the coming school years.

STEM and Integration – One hallmark of integrated approaches, though not unique to them, is the use of real-world situations or problems. They can bring STEM fields alive for students and deepen their learning, but they may also pose particular challenges for them (Honey et al., 2014). The lessons and kits for this project were designed to integrate STEM into an Intermediate elementary classroom using real-life issues and situations, so that the kids would be able to relate and identify with the scenarios presented to them. This was an extremely important aspect of the lesson designs and activities, and subsequently resulted in higher engagement and greater understanding.

STEM and Learning Styles – Class sizes at Pearl Creek Elementary School are increasing rapidly and each year I have had more kids. When I first started my teaching career, I had twenty-five students, and most recently I have thirty-one. Managing classes with large numbers presents its own challenges, one of which is appealing to all learning styles, so that all students may be successful. Each lesson and kit have aspects that touch on visual and auditory learning, but it was my intention to have the kids engaged in hands-on activities as much as possible. For kinesthetic learners in the room, which I believe that most elementary kids are, this was optimal. Integrated STEM experiences typically call on students to engage in activities that involve the use of tools or manipulation of objects, and claims have been made that this use enhances learning (Honey et al., 2014). All of the kits have kids creating, manipulating, and/or engaged with activities associated with tools or objects in order to build understandings and explanations based on evidence.

Statement of Bias

I approached this project with two years of experience teaching in the school district. I was also a youth development volunteer in the United States Peace Corps for two years in Albania previous to my certification. Prior to my classroom career, I was an expert data analyst for a large real estate developer in New Jersey. My own personal experiences in the business world and overseas have shaped the educator I am, and my approach to preparation and execution. I am in the early stages of my teaching career and I am the first in my family enter the education profession. While my business background required me to integrate math and technology often, I mostly deferred to scientists and engineers for expert advice, but never really understood the basics behind their respected fields. This was a new and refreshing area for me to explore and I was eager to rekindle science training I had been exposed to, and to learn basic engineering concepts. I had never been exposed to engineering or STEM as a child learner.

It should also be noted that part of my philosophy of education is, that a strong emphasis of communication, collaboration, creativity, and critical thinking foster a foundation for learning and growth in an elementary classroom. This project was a direct reflection of my beliefs about how children learn and retain knowledge, while being fully engaged in their environment and activities.

Lastly, this project took a large amount of time and investment. Funding from grants provided the means to start and maintain the kits. Without the grants and my commitment, producing this many lessons and kits would not have been possible. I am proud of the final products and happy to share them.

Participants and Limitations

Participants – This study was not part of any initiatives at any of the schools in the FNSBSD. I used guidelines set forth by The University of Alaska Fairbanks' Research Policies. There were three sets of participants: Intermediate grade level students, Intermediate grade level Teacher-researchers, and students from the University of Alaska Fairbanks' School of Mining and Engineering. Professional Learning Committee sessions were confidential, conducted with teacher-researchers only, and were not measured as high risk. Minors are considered a vulnerable population. Data on student achievement was used only to evaluate effectiveness of the lessons under development and were not disseminated to a wider audience.

There were a total of three "Highly Qualified," Certified, elementary teachers that participated in this project. For logistical reasons, this study was purposefully limited to three teachers that teach Intermediate grade level students in the FNSBSD, and their students. In addition, faculty and students from the University of Alaska Fairbanks' College of Mining and Engineering provided valued feedback on lesson content and design to the researcher. Lastly, two elementary teachers from California and New Jersey provided constructive criticism for additional modifications.

Classroom demographics varied greatly in this study. At Pearl Creek Elementary School, several kits were used in straight fourth grade classes (just fourth grade students), multi-age (fourth, fifth, and sixth graders in the same class), and mixed-age (combination of two grades in one room). In California, it was a straight fourth grade class, and in New Jersey, it was a mixed-age class (fourth and fifth graders).

Teacher classroom experience for this study varied from twenty-two years to less than a year of service; so pedagogic skills and content knowledge were wide-ranging for this project. This was by design, as wisdom and proficiency from a diverse group of professionals were key components to the processes and outcomes. New teachers and student teachers offered important feedback, while seasoned educators provided detailed insights from their years of instruction. Improvements were made to the lessons and kits after comments and anecdotes were received from all the educators involved.

I was the primary researcher in this project, and I asked for the assistance of four additional, Intermediate grade teachers for the purpose of diversity and differentiation. Often, variation is a skill that a teacher must master, and widening this project to other schools outside of Alaska helped this project to be more adaptive. Collaborative group sessions were held during allocated times, and participation was voluntary.

Limitations – The STEM lessons and kits pertained specifically to the fourth grade science curriculum adopted in 2016, and fourth grade math curriculum adopted in 2014, by the FNSBSD. They were also designed for differentiation, so that teachers in grades three, five, and six, could easily adapt them into their classes. The curriculum and standards that the FNSBSD have adopted are similar to those in the other states where the kits were used.

Student Populations – The Fairbanks North Star Borough School District (FNSBSD) currently has 13,716 students enrolled in 40 schools, including three charter schools, in Alaska's interior (Hughes, 2014). Pearl Creek Elementary is a public school that serves approximately 485 students, ranging from kindergarten to sixth grade, and 70 are in fourth grade. (Hughes, 2014). The student population at Pearl Creek in 2014 consisted of 72.4% Caucasian, .2% African-American, 4.3% Hispanic, 1.2% Asian, 9.1% Alaskan Native, .2% Hawaiian Pacific Island, 1% American Indian, and 11.5% two races or more (Hughes, 2014). This project was first piloted with Intermediate teachers at Pearl Creek Elementary School in Alaska. Subsequently, the lessons and kits were shared with teachers and students in other Intermediate classes in California and New Jersey. Demographic information has not been determined of the additional schools and Intermediate grade teachers included in this project. In the 2014-15 school year, the average fourth grade class size in the Fairbanks North Star Borough School District was 27.9 students. At Pearl Creek, it was 28.4 students (Hughes, 2014). This is a small sample size when compared to the district-wide grade-four student population, but was sufficient to build well-rounded final products.

Methods and Findings

Philosophical Perspective – Constructivist and Social Constructivist frameworks were the theoretical basis' for this project. Teacher collaboration was, in many ways, the foundational tool for which this project relied on. Schwandt (2007, p. 38-39) states,

> "Constructivism means that human beings do not find or discover knowledge so much as construct or make it. We invent concepts, models or schemes to make sense of experience, and we continually test and modify these constructions in the light of new experiences. Furthermore, there is an inevitable and sociocultural dimension to the construction. We do not construct our interpretations in isolation but, rather, against a backdrop of shared understandings, practices, language, and so forth."

To delve deeper into constructivism, Schwandt (2007, p. 39) continues to elaborate on strands of constructivism and writes, "A second strand of constructivism focuses more on social process and interaction and is generally known as social constructivism." Finally, he states that social constructivism, "Emphasizes the actor's definition of the situation; that it seeks to understand how social actors recognize, produce, and reproduce social actions and how they come to share an inter-subjective understanding of the specific life circumstances." This project builds on the philosophy of social constructivism because of its anecdotal, collaborative, and communicative characteristics.

Action Research – An Action Research Design (Creswell, 2015; Mertler, 2014; Sagor, 2000) was implemented in this study to facilitate a cooperative, cyclical, learning experience that is relevant to the participants because the focus was determined by the researchers and modified for improvements. This approach employed a team-based inquiry process to study newly developed local resources and focused on lesson revision and enhancement.

Creswell (2015) states that Action Research is ongoing process that is highly reflective and cyclical in nature. For two years, this study flowed from teacher-researcher, project design, implementation, reflection, and revision, and this matches the description of an Action Research (Mertler, 2012) approach to collecting and analyzing information using primarily qualitative methods (Figure 1).

What Action Research Is and Is Not

What it is…	What it is not…
• A process that improves education through change	• Problem-solving
• Collaborative	• Doing research on or about people
• Cyclical	• Linear
• Practical and relevant	• Conclusive
• Within context of teacher's environment	• Generalizing to larger populations
• How we can do things better	• Why we do certain things
• Explores, discovers and seeks to find creative solutions	• The implementation of predetermined answers
• A way to improve instructional practice by observing, revising, and reflecting	• A fad

Figure 1. What Action Research is and is not (Mertler, 2009).

In everyday practice, I am a reflective teacher, and I believe that most educators are. In addition, I feel that teachers naturally want to share their ideas, anecdotes, and improve their overall efficacy. Again, Action Research is highly reflective, recurrent, and collaborative. Riel's Action Research Model (Mertler, 2009) illustrates the process and describes the actions that were taken in this project (Figure 2). The plan of action and cyclical reflection used in this project was ongoing (e.g., intermittent meetings for two years), and it was a useful approach as it enabled the involved teacher-researchers to be more successful at what they care most about – improving their teaching and enhancing learning opportunities for their students.

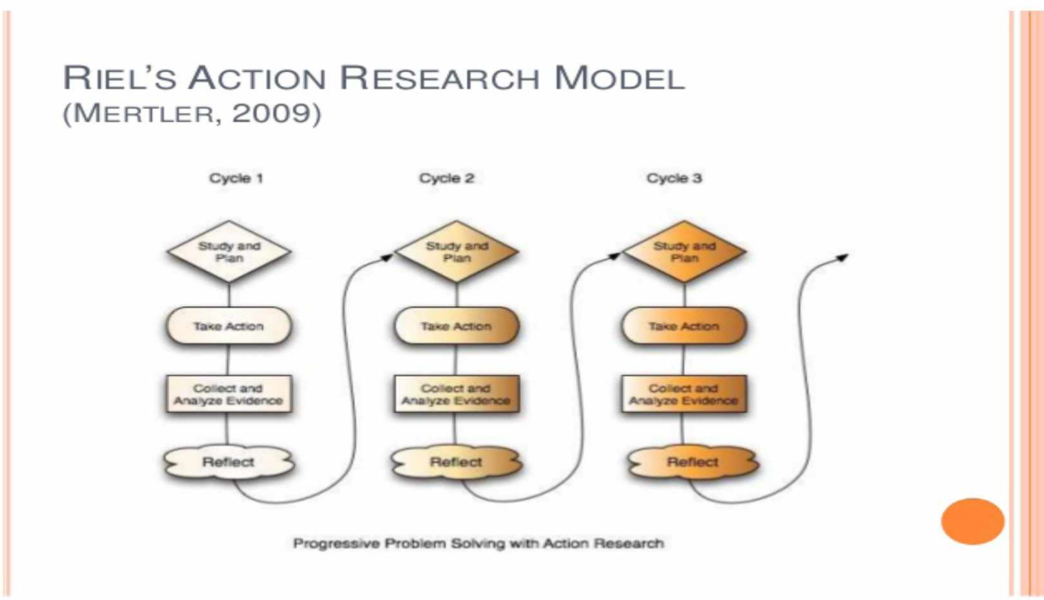

Figure 2. Riel's Action Research model (Mertler, 2009).

Timeline of Activities – Table 1 is a visual aid that shows the sequence of events followed for this project. This was helpful for the outcome of the project, reflection, and to stay on track.

	Year 1 (2015)				Year 2 (2016)			
Activity	Jan - Mar	Apr - June	July - Sept	Oct - Dec	Jan - Mar	Apr - June	July - Sept	Oct - Dec
Investigated STEM resources and materials available appropriate for project	X	X	X	X	X	X	X	X
Individually developed and refined lessons and kits	X	X	X	X	X	X	X	X
Met with M.Ed. committee member(s)	X	X	X	X	X	X	X	X
Met with colleagues at Pearl Creek Elementary PLCs	X	X	X	X	X	X	X	X
Participated in ED 601 – Intro to Applied Social Science Research at UAF		X						
Participated in ED 603 – Field Study Research Methods at UAF			X					
Participated in Mickelson Exxon Mobile Teachers Academy			X					
Presented and revised project proposal to M.Ed. committee			X	X				
Facilitated STEM Workshops				X	X			
Individually used kits in New Jersey				X				X
Colleague used kits in California				X				
Met with university faculty and students from the School of Mining and Engineering at UAF					X			
Participated in Alaska Space Grant Symposium in Anchorage, Alaska						X		
Participated in ED 593/697 – STEM in the K-8 Classroom					X	X		
Project write-up, revisions, and defense with M.Ed. committee							X	X

Table 1. Timeline of Activities

Content Workshops – I applied to the Mickelson Exxon Mobile Science Teachers Academy in Houston, Texas and was accepted to participate in a week-long training and exploration of science and STEM-related activities and lessons. I chose some of the major concepts and activities that I participated in there, and applied them to my class, and found that some of them were appropriate and engaging, while equally, some of the activities were difficult to translate and reduce into a kit. There were also several times when I found a lesson or concept that was great, but I was not able to make it user-friendly or reduced in size to accommodate my goals, so I returned to the drawing board. Lastly, I was selected to facilitate a STEM Workshop back in Fairbanks, Alaska, for other teachers in the district. This was a weekend event in the fall of 2015, where I shared lessons, content knowledge, and information that I attained during the

Mickelson Exxon Mobile Science Teachers Academy. I also piloted two kits with the participants at the event.

University Classes – Another method of collaboration that I used was a course called: K-8 STEM in the Classroom, through the University of Alaska Fairbanks' School of Education. This proved to be a valuable resource and learning experience. I was able to communicate online with other educators around the country and share ideas and lessons via Black Board. I was able to get feedback on potential plans for implementation, and in the end, the instructor created a spreadsheet of resources and lessons compiled from the class of 32 students.

Professional Learning Committees – The National Commission on Teaching and America's Future (2013) found that effective STEM learning teams have shared goals, scheduled times for meetings, collective responsibility, and a goal of increasing student achievement. During the 2015-2016 school year, certified elementary school teachers at Pearl Creek and throughout the District are required to meet for Grade Level Professional Learning Committees. In simpler terms, this is an allotted time and opportunity for teachers that work in the same grade levels to discuss collaborations, issues, logistics, field trips, and any other pertinent information that may contribute to the betterment of the overall education of their students or themselves. I chose to utilize this as a chance to solicit "testers" of the kits and ask for feedback. This proved to be a valuable opportunity for me to get input from other teachers on lessons.

Extending the Lessons – Originally, I thought that logistically, the lessons and kits could only effectively be tested using teachers working at one particular grade level, at one particular school, and then disseminated for additional vetting thereafter, where students would not have a "Repeated" experience. For example, I piloted a kit in my own class – the "Towers" lesson – during the 2014-2015 school year, and subsequently made my first kit from that content and material. A fifth grade teacher at the same school used the kit in her class, with some of my former students and most of the students that were in my fourth grade class the year before, recalled the lesson immediately, and were able to work through the activity quickly with optimum proficiency while being natural leaders in their respected groups. This was part of the feedback I received. At first, I thought this to be a problem, but during the defense of my project, a committee member had a wonderful suggestion. She stated that as students progress beyond my class, future teachers may be able to use previous knowledge and experiences to expand and prompt additional skills, and provoke critical thinking skills. This could be advantageous, particularly because the students already have foundational knowledge and familiarity with the concepts and materials in the kits, and learning extensions may be added; new lessons and content-specific lesson enhancements may be proposed. For instance, a lesson on force and motion on a horizontal plane can be extended by creating a new challenge on a vertical plane.

Share with a Pal – A colleague of mine at Pearl Creek went to California on a personal trip and while she was there, she met up with her pen pal class and was asked to bring a lesson or activity with her to do with the class. She chose to bring the "Towers" lesson (see appendix Lesson One) and did it with the classes that she visited. She was amazed with the different designs that kids came up with, especially based on their location and experiences, particularly referring to water-type towers, which are a lot less prevalent here in Alaska. In California, water towers are common, and the students were able to connect the real-world application almost immediately. As for the Alaskan students, there were several kids that connected the tower with "Watchtowers," that are used for hunting in the fall.

I was also fortunate to visit our pen pal class in New Jersey to facilitate two lessons over a two-year period. I was the primary facilitator for the lessons, accompanied by their classroom teacher. When I visited, I was comfortable delivering the lessons and kits without the assistance of the written guides and materials. It was a great feeling to be able to do so confidently and efficiently, and at that point, I realized that other professional educators could have the same successes and acquisition of knowledge. It was apparent that once I learned the way I wanted to teach the lesson, the content and foundations stayed the same. It was also at that point that I realized that I could deliver this lesson many times, and each time, I would/could refine something to make it place-based or locally relevant.

University Experts – In addition to the guidance of certified elementary educators, professional and content advice was given to the researcher from students and faculty at the university level as well. The "Towers" lesson was piloted with a team of scientists and engineers for the purpose of accuracy and engagement across multiple levels of skill. I was invited to try my kit with high-level engineers and physicists from the University of Alaska Fairbanks and this proved to be a paradigm shift in many ways. Until that meeting, one of the main purposes of my lesson was to help students understand the major differences between science and engineering, but I was enlightened, when a participant pointed out that they are actually a lot more the same and inter-connected, and that should be the driving point.

Conclusion

Success or Failure – The main goal of this project was to create an interest, excitement, and foundational knowledge in STEM-related fields among Intermediate grade level students. The secondary goal was to offer teachers a user-friendly resource that could help them teach STEM-related lessons in their class and get more comfortable with the content. I believe that the outcome of this project was a success for my students and colleagues, but if I were to offer a truly objective reflection, there are several things I would do differently in the future should the project be replicated and expanded. A reoccurring obstacle emerged throughout the series of lessons, and this was timeliness. I tried to fit as many standards into my lessons, to make them all-around, fully integrated, rich lessons. As I move forward and continue to develop STEM lessons for my students, I will scale them down and isolate one particular field, and let the other subsequent fields fall into place naturally. I would also use the multitude of lessons already out there, and not try to combine them for more substance. I often had to remind myself: the kids being taught range from ages eight to twelve, so keep it simple.

Self-reflection – As a teacher, I am always applying self-reflection practices and continuously tweaking lesson plans, schedules, materials, and other such classroom procedures to make them better. Because of this, informal research will be ongoing throughout my career. My aim for this project was to provide a fully-integrated STEM Unit that is engaging to elementary students, user-friendly, and standards-based, for teachers across the Fairbanks North Star Borough School District. I discovered by the end of my project, that sometimes I pushed too hard for full-integration of all the respected STEM fields, and this may not have been necessary. For example, if I needed to target a particular math standard, I would simply add a budget to the lesson, but in some instances, a budget was not called for or appropriate. I realized that if I let the STEM fields fall naturally in their places for the lesson and not cramming in as many standards as I could, I would have more impactful lessons and improved learning experiences.

Prior to the start of this project, I was ashamed to admit that I did not really understand all the aspects of STEM-engineering in particular. One of the main reasons I chose this path, was to educate myself, surround myself with professionals in the field, and better my knowledge for the benefit of those I educate and for myself. I am proud to say that I now have a strong foundation in *all* of the STEM-related fields as a result of this project, and I will continue to expand on this knowledge. I enjoyed the entire process, even the struggles and long hours. With the first quarter of the 2016/2017 school year just coming to a close, I am only beginning to see the remarkable payoff of the project on my new group of students, and on Pearl Creek Elementary as a whole.

The Research Process – During this project, I learned a tremendous amount about the process of research. Specifically, the courses ED 601 Introduction to Social Science Research, and ED 603 Field Study Research Methods at University of Alaska Fairbanks were particularly challenging, but were instrumental parts in the outcome of this project.

As for my experiences researching, I began this endeavor, trying to find literature that would match my goals and objectives, but I now realize that I should have done the opposite. I should have reviewed the literature surrounding my subject, and approached my project differently. In the end, I am pleased with the information that I found to back up my project, but this could have been a lot simpler of a process. I feel strongly that I have contributed to the betterment of my students, my colleagues, and my own professional development, and I am always striving to be more efficient and effectual in my activities.

Contributions to the Field of Education – A colleague of mine revealed to me that she is relieved to have kits like these available to her. She also noted that she feels that she is able to confidently and skillfully integrate newly adopted standards into her class better. She now calls her "Science Block," a "STEM Block." It is my hope that other educators feel this way using these STEM kits. For the future of my own classroom, I will use these tools for many years, and even if standards change again, the aspects of collaboration, creativity, communication, and critical-thinking are ongoing and present in the lessons.

I also hope that these kits find their way to the teacher-preparation program at the University of Alaska Fairbanks. I would be proud and honored if student-teachers vetted and/or used them with their classes, and furthermore, would be inspired to make their own. I would greatly appreciate any constructive criticism, suggestions for enhancements, or propositions for enrichment that they would offer.

What does a standards-based, user friendly, STEM lesson/kit look like? – In the beginning of this project, I asked the question, "What does a standards-based, user friendly, STEM lesson/kit look like?" I believe that I have answered this question with this project and after many rounds of revisions, I believe my final products provide the proper evidence. Each kit was designed to be engaging, simple, and compact. I spent a lot of time scrutinizing and selecting appealing activities that matched the content I was supposed to be teaching. I believe this was an extremely important part of the project, because if the activities were interesting, engagement would be optimal, and the lessons would have more impact on student achievement.

Logistically, I had custom canvas bags made that were two-feet by two-feet in size. All the contents of the lesson needed to fit, or the lesson was not viable for the project. At times, this was also a constraint. Each kit comes complete with a four-part binder, and most, if not all, of the required materials. Part one of each binder consists of: Lesson Information – the focus, summary, objectives, and acknowledgements. Part two contains: Materials and Procedures – an articulated copy of items in the kit or that the teacher will need, recommended time allotment, and recommended actions to follow. Part three has: Background Information – content and communication pertinent to the particular lesson, so the user is able to learn and be more confident about the concepts included in the kit. Part four of each kit includes: Standards/Assessments/Differentiation. Teachers often have to reference what standards that they are teaching to administration and for their own records. Part four also provides all the formally articulated standards and where they came from. Teachers are frequently held accountable for measuring student learning. Each kit provides multiple levels and methods for assessment, therefore providing differentiation and proper documentation. Lastly, each kit gives suggestions for enrichment and scaffolding support for different types and levels of learners.

What does increased STEM interest and literacy look like in an Intermediate Elementary classroom? – I also asked the question, "What does increased STEM interest and literacy look like in an Intermediate elementary classroom?" I am proud to report that I have seen and heard first-hand, answers to this inquiry. On several occasions, I witnessed children utilizing key concepts and practices taught in lessons that were given. For example, after one of our bridge building sessions, several students in class had asked if they could stay after class, and build other structures that could hold weight and serve a real-world purpose using the K'NEX pieces from the bridge building kit. I was immediately curious about what they had in mind and excitedly said yes. The students subsequently built towers. They used information and knowledge they had gained from the "Towers," lesson and replicated the lesson, using different materials, on their own time (recess), while showing genuine interest and literacy in key STEM concepts. The conversations that I overheard – as they were working - were amazing, and included relevant STEM language. They even made a new budget and came up with a new challenge for their classmates.

I was also surprised when I observed two students using problem-solving skills that they acquired during one of our lessons, out on the playground. I was on recess duty, and I saw that two of my students could not agree on which would have first turn on a particular swing. Earlier that morning, the same two students could not agree which would be the "Banker" first, and which would be the, "Builder" first. We talked, and I suggested that they simply, flip a coin, accept the outcome, and move on, taking turns. They came up to me on the playground and asked me for the coin we used earlier, because they wanted it to be "Fair," and that they were "Working together, to work it out." In this particular instance, they were able to take a strategy that we used in one of our STEM lessons, and apply it to the real-world, to solve a problem that they were having, collaborating to get it done, and communicating their feelings and needs creatively. While this conflict had nothing to do with any of Newton's Laws of Motion, it was a proud moment of validation for me as their teacher, because there was evidence of an impact from our lesson. It showed that STEM-related skills had transferred to a real-life situation, literally in our own backyard.

Inspiration – This project gave me some of the defining and uplifting moments, and I was immediately hooked. I heard a group of young girls (fourth graders) chatting during an activity and one girl said, "This STEM stuff is so cool, I want to be an engineer when I grow up." These are the words a teacher loves to overhear. On another occasion, I had a student tell me, "I never knew that STEM is everywhere, that's so cool, Mr. Sassman." For that particular student, on that particular day, he realized how important and connected STEM fields are, and how much our world is reliant on experts in those areas. I am sure that there were comments I did not hear from students, but I know I have reached a few students and that validates my efforts and goals.

Another substantial moment I had was when a colleague of mine decided to bring one of my kits with her on a trip. She had been collaborating with another class through pen pal letters and was visiting their area in California. She was asked to teach a lesson and she decided to bring the Towers kit. She had given the lesson before and was familiar with it, and she chose to share that lesson – from a multitude which she could have – and the kids loved it. Her feedback was invaluable and I was honored that she shared her knowledge and experiences when she returned. Furthermore, she said the kit traveled well through several airports.

External Considerations – Classroom time with students is limited, often interrupted with several outside influences – all good reasons – such as band, orchestra, tutoring, Response to Intervention, Special Education, specials, counselors, and other school wide events. Classroom instruction time is precious, and to choose succinct, impactful lessons are imperative. I often found that time constraints were often my most significant limiting factor, and given the opportunity, I would have preferred to modify all my lessons to span a longer time frame. I would have also spent less time on each individual lesson for development. I realize that I often over-prepare and indulge in additional details when it comes to lesson planning, and this project was no exception. I found that I spent too much time on the first two lessons, trying to perfect them, so they would universally fit into any class and include all aspects of STEM. As the project progressed, I also knew that I had to create more, pilot more, refine and edit less, and pick lessons that were engaging and effective. Every group of students and every teacher are different, so I must allow the natural flow and management to be more fluid, less scripted. This is why the last two lessons in the project are simplified in the procedural areas. Furthermore, I realized that not every lesson needs to have a tremendous amount of standards attached to them. Simple lessons were often the most impactful.

Project Extensions – After the defense of this project and discussion with my M.Ed. Committee members, it is apparent that this project can take on new and different dimensions beyond that of what I had anticipated or saw at the end of this process. It was suggested to me that teachers at different grade levels can use the kits and expand on prior lessons and content knowledge, and expand students' higher level thinking and be creative with the materials they are given. For example, one suggestion was to take a kit that was meant for teaching force and motion, and have the kids use what they learned and know form the previous lessons to create demonstrations or solutions to new problems that they may encounter associated with force and motion. Perhaps on day I will be teaching in a multi-age class, and this would be a particularly important observation and modification to my lessons/kits.

What's Next

Potential Dissemination – It seems as though National, State, and local teaching standards are ever-evolving and there is not one correct way to teach STEM in the classroom, however, it is my hope that other teachers find value in my project and elect to utilize the lessons and kits to expose their elementary students to STEM fields. I hope to generate excitement and foundational knowledge for students, but also for the betterment of teacher instruction. I understand that the kits I have made will always be tweaked formally and informally, and teachers will find successes in their own ways.

The District's Library Media Services Department, which is the center for teachers to check out resources for their rooms, may be the best avenue to reach more educators. At a minimum, I will use these kits at my school for my own classroom instruction and for other teachers to use with their students. I am fortunate to have a storage room in my class, so I am able to keep learning materials and supplies there. It is handy and convenient, especially for ongoing projects. The trick is, not to fill it with clutter, but worthwhile content.

A few obstacles I see with maintaining the kits myself are the replenishment and management of the kits. Currently, the district has an entire department dedicated to this function for the Art Center and its curriculum materials. I would be willing and able to do this for my school, and logistically it would be possible to do for others through the District's Inner mailing system, but I am not sure as to how time consuming this would or could be. Potentially, it could also get to be very expensive to keep replenishing materials and time consuming reorganizing the kits after they are returned. I will however, keep refining my kits and perhaps chose others to be selected for implementation with the FNSBSD.

If I could suggest a method to offering these kits to the greater public with restocking and replenishment, I would ask either the Art Department or the Library Media Services to take these on and put them into their operations and system.

More Kits – I would like to keep going! Ideally, it would be great to keep creating five to six kits per year hereafter. Realistically, my aim is to create one or two high-quality kits per year and spend time in my class testing them. I would follow a similar path to vetting the lessons and ask colleagues in my building to test them for me as well. Additionally, I would design the lessons before ordering the bags that they go in. This was an issue at times, because I limited my lesson developments to what materials could fit in the carrying cases that were custom made.

I have passions for STEM, elementary education, and my kids. I believe that these types of activities and projects add to my class and the overall elementary experience. Most importantly, my lessons and kits engage students in important fields that will affect our future, promote critical thinking, collaboration, communication, and creativity. Lastly, my efforts create foundational STEM knowledge, excitement for learning, and help my fellow educators be the best they can be.

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Appendices/Products

Lesson One:
Towers

TOWER CHALLENGE
Lesson Information – Part One

<u>Lesson Focus</u>

"Towers" is an introduction to engineering and explores how engineers work to solve challenges in the real world. The lesson will focus on the Engineering Design Process using towers while integrating science, technology, and mathematics to create an all-inclusive STEM (Science, Technology, Engineering, and Mathematics) lesson.

<u>Lesson Summary</u>

There are many different designs and uses of towers. Students work in teams to design and build a tower out of everyday materials that can sustain weight at a minimum height for a specific amount of time while keeping a budget. Students will design, build, test, evaluate, revise, and share their results with the class.

<u>Grade Level</u>

This lesson is designed for Intermediate (grades 4-6) level instruction.

<u>Objectives</u>

- Students will understand the relationships of science, technology, engineering and mathematics.
- Students will understand how to work as a team to solve real-world problems.
- Students will understand the how STEM influences their community and the world.

<u>Optional Writing Activity</u>

Have the students write an informative writing piece about environmental challenges and/impacts that may occur with towers. Consider the many types of towers that were discussed, their functions, the weather, topography, population, biodiversity, and other factors that may impact the design of the tower they have chosen to design/write about.

<u>Optional Extension Activity</u>

Have students test their designs to see if they are scalable by doubling or tripling in size, capacity, and strength. Consider using additional time and money constraints as well. Extra materials are stocked in the kit for this optional extension activity.

<u>Acknowledgements</u>

This kit has been funded in part by:

The Alaska Space Grant Program and the University of Alaska Fairbanks' College of Mining and Engineering. The Delta Kappa Gamma Teachers Association, The Pearl Creek Parent Teacher Association, and The Alaska Science Teachers Association.

TOWER CHALLENGE
Materials and Procedures – Part Two

Materials for Students (per group of 4-5)

Materials Included in Kit (enough for a class of 30 Students)

- Ten paper cups (3 oz.)
- Ten plastic cups (3 oz.)
- Two strips of masking tape (1 ft. each)
- Two pieces of construction paper (9” x 12”)
- Scissors (1 pair)
- One Ruler (12”)
- 5x7 Note Card (1 per student)
- Beanie Babies (6)
- Engineering Design Process/Scientific Method Poster (1)

Time Frame – Lesson
120 minutes

Time Frame – Preparation
30 Minutes to review lesson background and procedures. All items needed for the lesson are provided in the kit. It is recommended that the teacher try the lesson one time in its entirety to become familiar with the information, processes, procedures, and kit.

Suggested Procedures
(PHASE ONE)
1. Teacher will distribute large 5 x 7 note cards to each student and answer the following prompt on the lined side of their note card and write: “Write as down as many animals you can think of in 1 minute.”
2. Next, the teacher will have the students share animals in their groups and compile a master list to share (this will demonstrate that working as a team is more effective with coming up with ideas and answers). Most groups *should* have a larger, more complete list after collaborating, setting the tone for good teamwork and discourse about it.
3. Teacher will facilitate discourse with the class. Questions should start with: What is science? What is engineering? What are the differences between science and engineering? What is math? What is technology? The teacher will have in-depth conversations with the students about all four aspects of STEM fields and give examples of how they are interconnected and related

across many aspects of life and society (refer to Kit Part Three for answers and suggested conversation notes).

4. Teacher will hang poster board of The Engineering Design Process/ Scientific Method and talk with the students about the two processes.
5. Teacher will talk about towers to the students by asking them: What is a tower? What are the used for? What are some other towers you may know of? What are some that we have in Alaska, specifically Fairbanks? How are some of these towers similar and different? How are they unique in their designs? (Refer to Kit Part Three for answers and suggested conversation notes).
6. Students will use their STEM notebooks or a sheet of paper and start a new page titled "Towers." Below the title of the lesson, the students will copy from the board their "I can" statements. These are provided in the kit:
    A. "I can tell you one way that Science, Technology, Engineering, and Mathematics are related."
    B. "I can work with a team to solve real-world problems."
    C. "I can tell you how STEM is connected to my local community and/or the world."
7. Teacher will play the short video clip from the following link to introduce what engineering is: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10515
8. Teacher will have the students create a vocabulary box in their STEM Journals (if applicable).
9. The teacher will assign each student in each group with a specific job: Challenge Captain, Materials Master, Testing Coordinator, Chief Architect, Rapid Reporter. All students will be responsible for keeping a record for their group's budget. After assigning the roles, define them.
10. Students will start the Engineering Design Process by exploring ASK: What is the problem? What are the constraints and/or conditions? The teacher will have the students the students talk in their groups about the task set forth. How can you build a tower 12" tall (minimum) that can hold a Beanie Baby for 20 seconds using the materials given? The students should discuss this in detail and really emphasize the actual Engineering Design Process. Teacher will also give the students a list of materials and constraints on the board. The teacher will define the work CONSTRAINTS as a lesson term. The teacher will have the students record in their STEM Notebooks (if applicable).
11. Students will IMAGINE and brainstorm ideas with their desk mates. As a group, they will come up with the solution that they feel is best and that they would like to design. Challenge Captain will make the final decision about which design that the group will proceed with.

12. Students will PLAN and draw a picture of their diagram of their proposed model in their STEM Notebooks (or Rapid Reporter) and present it to the teacher so they may acquire their materials. Their picture should also include a list of materials that they will need. Previously given to the class.

(PHASE TWO)

1. The Materials Master will collect all the materials needed at this point.
2. Students will CREATE their design and follow their plan. The Chief Architect will be the head of this task. After the students have finished with their tower, they will ask the teacher to run a test or trial. The teacher will come over and have the Testing Coordinator place the Beanie Baby on the top of the tower for twenty seconds. PLEASE NOTE AND ADVISE THE STUDENTS IN THE BEGINING AND REMIND THEM: THE STUDENTS WILL BE ALLOWED ONLY 25 MINUTES TO BUILD. THIS IS A TIME CONSTRAINT. SET THE TIMER AND WHEN THE 25 MINUTES ARE OVER, HAVE ALL STUDENTS STOP WHERE THEY ARE IN THE CREATION PROCESS.
3. Students will IMPROVE and make revisions to their towers if or where necessary. If there are no revisions necessary, teacher will either chose to add more constraints or add the optional activities.
4. At this point, there may also be a budget introduced. PLEASE NOTE: THE BUDGET MAY BE INTRODUCED AT THE BEGINNING OF THE LESSON. Students may elect to improve their design by making it less expensive and still sturdy enough to do the job. There is a proposed budget of items at the bottom of this sheet. THIS IS A DIFFERENTIATION TECHNIQUE. YOU MAY ELECT TO INTRODUCE THE BUDGET AT THE BEGINNNING OF THE LESSON.
5. At the end of the session and after all groups have had their towers tested, have a class wrap-up discussion about the Engineering Design Process and the types of towers we have in our society. In addition, how they affect our society, life, and environment. Give one of the suggested assessments attached with this kit if so desired.

TOWERS ITEMIZED BUDGET

ITEM	COST	QUANTITY	TOTAL EXPENSE (Cost x Quantity)
PLASTIC CUPS	$2 EACH		$
PAPER CUPS	$1.75 EACH		$
TAPE	$1.00 PER INCH		$
CONSTRUCTION PAPER	$5.00 PER SHEET (cannot be pro-rated)		$
SCISSOR RENTAL	$1.50		$
RULER RENTAL	$1.50		$
TOTAL PROJECT EXPENSES			$

TOWER CHALLENGE
Background Information – Part Three

What is science?
Noun - the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment.

A systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe.

What is a scientist?
Noun - A person who is studying or has expert knowledge of one or more of the natural or physical sciences.

What is engineering?
Noun - the branch of science and technology concerned with the design, building, and use of engines, machines, and structures.

What is an engineer?

- Engineers apply scientific and mathematic knowledge to create solutions for various technical problems.
- Engineers and scientists are slightly different, with engineers focusing more on the application of science. They are often seen as the link from scientific discoveries to their application in the real world.
- Different disciplines of engineering include chemical engineering, civil engineering, electrical engineering and mechanical engineering. These disciplines can be further broken down into even more specialist roles such as molecular engineering and structural engineering.
- As an engineer you may work on the production of products, the building of structures, the design of computer systems, the manufacturing of vehicles and other roles.
- When building structures, materials, systems and machines, it is important for engineers to be practical with regards to safety and cost.
- Engineers can be in charge of large projects that rely on safety and reliability. Engineering societies often have codes of practice and ethics put in place that helps maintain good practices and work of a high quality among engineers.
- The word engineer comes from Latin words meaning ‘devise’ and ‘cleverness’.

What are the similarities between science and engineering?
Scientists tend to explore the natural world and discover new knowledge about the universe and how it works. Engineers typically apply that knowledge to solve practical problems, often with an eye toward optimizing cost, efficiency, or some other parameters.

Simply put:
Engineers want to know how something works and scientists want to know why.

What is math?
Noun - the abstract science of number, quantity, and space. Mathematics may be studied in its own right (*pure mathematics*), or as it is applied to other disciplines such as physics and engineering (*applied mathematics*).

What is technology?
Noun - the application of scientific knowledge for practical purposes, especially in industry.
"Advances in computer technology"

- Machinery and equipment developed from the application of scientific knowledge.
- The branch of knowledge dealing with engineering or applied sciences.

What is a tower?
NOUN

1. A building or structure higher than it is wide, either isolated or forming part of a building.
2. Such a structure used as or intended for a stronghold, fortress, prison, etc.
3. A tall, slender structure used for observation, signaling, watering, or pumping.

VERB

1. To rise or extend far upward, as a tower; reach or stand high.
2. To rise above or surpass others.

What are they used for?
Towers have been a part of developed societies for hundreds of years. There are many different kinds of towers and they serve a variety of purposes.

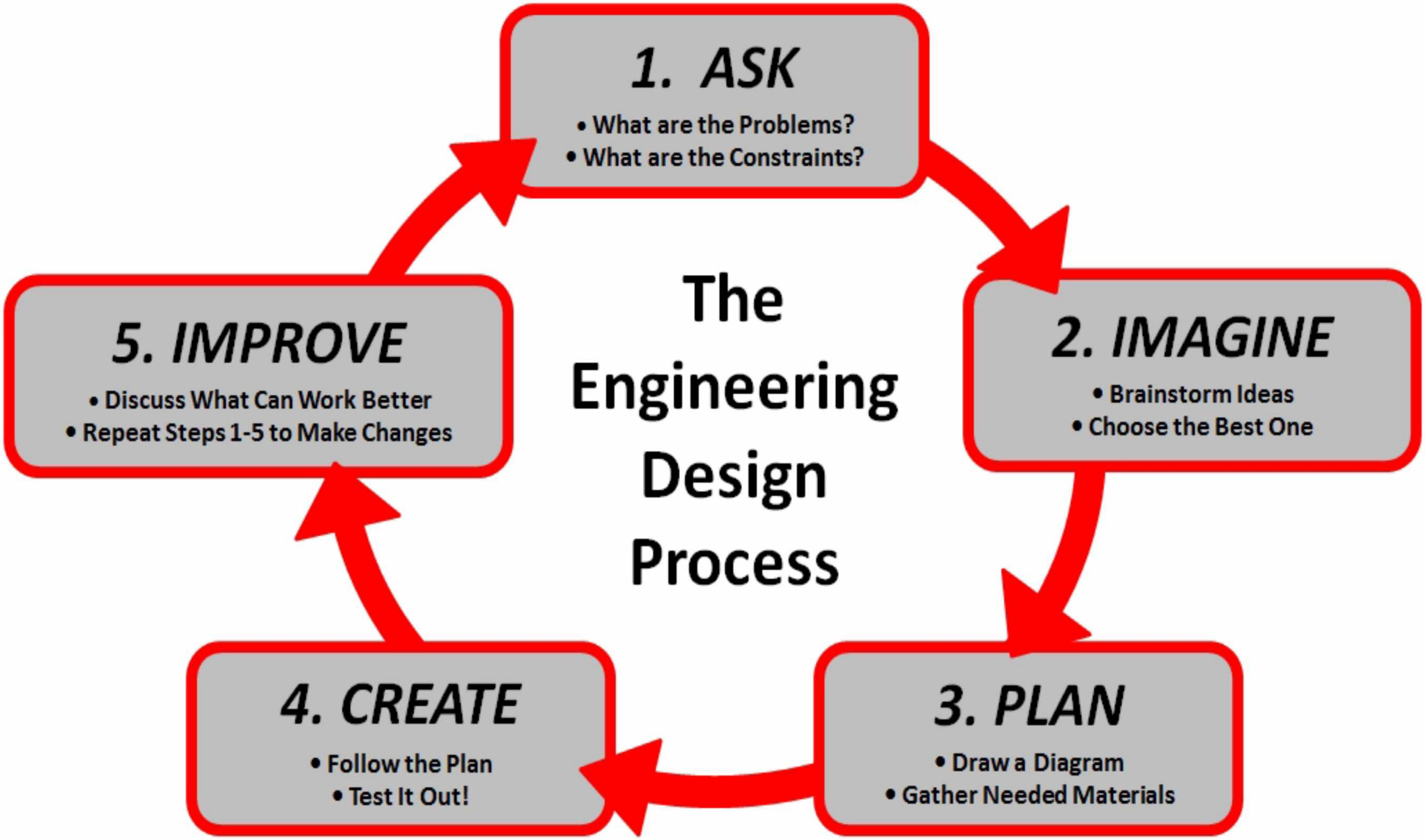
What are some towers you may know of?

Fire look-out tower	*Observation tower*	*Watch tower*
Prison tower	*Silo*	*Lighthouse*
Bell tower	*Clock tower*	*Church spire*
Water tower	*Oil drilling tower*	*Chimney*
Skyscraper	*Bridge tower*	*Airport control tower*
Wind turbine tower	*Radio tower*	*Radar tower*
Antenna tower	*Cellular tower*	*Electrical tower*
Satellite tower		

What are some that we have in Alaska, specifically Fairbanks?
Open ended dialogue.

How are some of these towers similar and different?
Open ended dialogue.

ENGINEERING DESIGN PROCESS DIAGRAM



TOWER CHALLENGE
Standards/Assessment/Differentiation – Part Four

<u>Standards</u>
Fairbanks North Star Borough School District Science Curriculum 2016
ETS1.A: Defining engineering problems – Possible solutions a problem is limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
ETS1.B: Designing solutions to engineering problems – Testing a solution involves investigating how well it performs under a range of likely conditions.
ETS1.C: Optimizing the design solution – Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and constraints.

4-PS4-3: Generate and compare that use patterns to transfer information.

ESS3.A: Natural resources – Energy and fuels that humans use is derived from natural resources and their use affects the environment in multiple ways. Some resources are renewable over time and others are not.
ESSA3.B: Natural hazards – A variety of hazards happen from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but take steps to reduce their impacts.
4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes.

Fairbanks North Star Borough School District Mathematics Curriculum – January 2014
4.MD.1: Know relative sizes of measurement.
4.MD.6: Explain the classification of data from real-world problems shown in graphical representations the use of terms range and mode with a given set of data.

Fairbanks North Star Borough School District Technology Curriculum – January 2014
Alaska Technology Content Standard C: A student should be able to use technology to explore ideas, solve problems, and derive meaning. For this lesson, a student who meets part of this content standard should:

1) Use technology to observe, analyze, interpret, and draw conclusions.
2) Solve problems both individually and with others.
3) Create new knowledge by evaluating, combining, or extending information using multiple technologies.

Alaska Technology Content Standard E: A student should be able to use technology responsibly and understand its impact on individuals and society. For this lesson, a student who meets part of this content standard should:

1) Evaluate the potentials and limitations of existing technologies.
6) Evaluate ways that technology impacts culture and the environment.

Next Generation Science Standards Crosscutting Concepts

- Interdependence of science, engineering, technology and mathematics.
- Influence of engineering, technology, science, and mathematics on society and the natural world.

<u>Additional Optional Standards</u>

Alaska Department of Education and Early Development English/Language Arts Standards – January 2014

Anchor Standard – Write informative /explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content (W.4.2.a-e).

<u>Assessment</u>

There are three options of assessments included with this lesson:

The first is a rubric for formative assessment. This can be facilitated during the lesson and activities and filled out by the teacher during or immediately after the lesson.

The second is an exit slip with short answer responses.

The third is a student self-evaluation rubric similar to the teacher version, modified for student language.

The fourth is a 3-2-1 exercise. Sheets attached and they are differentiated.

*Additional assessments can be made using the Engineering Design Process Sheet given to each group as well as using student STEM Notebooks if those are used in the class.

Assessments will be based on the objective set forth in the beginning of the lesson:

- ❖ Students will understand the relationships of science, technology, engineering and mathematics.
- ❖ Students will understand how to work as a team to solve real-world problems.
- ❖ Students will understand the how STEM influences their community and the world.

STUDENT NAME____________________________ Date ____________

TOWER CHALLENGE EXIT SLIP

1. Explain one way that science, technology, engineering and mathematics can be related to each other.

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2. Write down one specific thing that you did well, when you worked as a team member.

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3. Tell me one way that STEM can affect your local community and/or world?

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STUDENT NAME______________________________ Date ____________

TOWER CHALLENGE SELF-ASSESSMENT – Give and *honest* self-reflection

Category	4	3	2	1
Problem-solving	I looked for and suggested solutions for problems.	I helped with other people's solutions and didn't make suggestions.	I didn't look for or suggest any solutions, but helped.	I didn't try or help with any solutions.
Contributions	I contributed to the group and class. A lot of effort.	I helped either the class OR group. Tried hard.	I sometimes helped, sometimes off task. Did the minimum of what was required.	I barely helped or participated.
Attitude	I always had a positive attitude with this project.	I often had a positive attitude, but I got frustrated sometimes.	I was positive and polite, but I was very frustrated.	I often had a negative attitude toward the project
Focus of the task	I stayed on task and did whatever was needed. I was a self-manager.	I was focused most of the time with a few distractions. Maybe not a self-manager yet.	Other group members had to often remind me to keep be on task. Still working on being a self-manager.	I let others do most or all the work. I don't think I am a self-manager yet.
Working with others	I listened and shared well. I tried to help work well together and it was great.	I tried not to make "waves" in the group. It wasn't too hard to work together.	It was difficult to work together, but we did it. Sometimes I could have been a better team member.	I was often not a good team player and made issues for the group.

STUDENT NAME____________________________ Date ____________

TOWER CHALLENGE 3-2-1 CHALLENGE

(3) Things you learned were:

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(2) Interesting things were:

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(1) Question I still have:

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STUDENT NAME___________________________ Date ___________

TOWER CHALLENGE 3-2-1 CHALLENGE

(3) Name three ways science, technology, engineering and mathematics can be related to each other:

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(2) Name two ways STEM can affect your local community and/or world:

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(1) Interesting idea to think about:

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Lesson Two:
Brooklyn Bridge K'NEX

BROOKLYN BRIDGE **K'NEX**

Lesson Information – Part One

Lesson Focus

"Brooklyn Bridge K'NEX" is a multidisciplinary exploration about bridges and real-world challenges. The lesson will fully integrate science, technology, and mathematics to create an all-inclusive STEM (Science, Technology, Engineering, and Mathematics) lesson.

Lesson Summary

Bridge builders have to consider many things when designing and building bridges. Location, function, timetable, cost, safety. The longer it takes to build a bridge, the more money it costs. Certain materials may or may not be available. In teams, students will build a bridge using K'NEX with a variety of constraints.

Grade Level

This lesson is designed for Intermediate (grades 4-6) level instruction.

Objectives

- Students will understand that there are different types of bridges.
- Students will build a bridge that holds weight.
- Students will keep a budget.
- Students will work as a team to solve real-world problems.

Optional Extension Activity

Have the students write an informative writing piece about environmental challenges and/impacts that may occur with bridges. Consider the many types of people/jobs involved in the process of bridge building. What were the types of bridges that were discussed and write about their functions, the weather, topography, population, biodiversity, and other factors that may impact the design of the bridge they have chosen?

Acknowledgements

This kit has been funded in part by:

The Alaska Space Grant Program and the University of Alaska Fairbanks' College of Mining and Engineering. The Delta Kappa Gamma Teachers Association, The Pearl Creek Parent Teacher Association, and The Alaska Science Teachers Association.

UNIVERSITY OF ALASKA FAIRBANKS

Alaska Space Grant Program

NASA

BROOKLYN BRIDGE K'NEX
Materials and Suggested Procedures – Part Two

Materials for Students (per group of 4-5)
K'NEX Bridge Building Kits (6) – Each come with a book of bridge designs
Graphing Paper
Books from your classroom (keep track of number and order)
The Brooklyn Bridge by Elizabeth Mann or *Brooklyn Bridge* by Lynn Curlee (depending on the grade level or time constraints).

Time Frame – Lesson (2 sessions)
120 Minutes

Time Frame – Preparation
30 Minutes to review lesson background and procedures. All items needed for the lesson are provided in the kit. It is recommended that the teacher try the lesson one time in its entirety to become familiar with the information, processes, procedures, and kit.

Suggested Procedures
(PHASE ONE)

1. Teacher will read aloud either *The Brooklyn Bridge* by Elizabeth Mann or *Brooklyn Bridge* by Lynn Curlee (depending on the grade level or time constraints).
2. Students will use their STEM notebooks or a sheet of paper and start a new page titled "Brooklyn Bridge K'NEX." Below the title of the lesson, the students will copy from the board their "I can" statements.
    A. "I can name four different types of bridges."
    B. "I can build a bridge that holds weight."
    C. "I can keep a budget."
    D. "I can work as a team to solve real-world problems."
3. The teacher will facilitate discourse with the class about four different types of bridges we have in the world today. The teacher will ask: **What is a bridge? Who builds them? How do the builders know what to build? Do they cost money?**
4. After a class discussion about bridges, the teacher will assign students to groups and each student will have a specific job: Materials Master, Testing/Building Coordinator, Chief Architect, Accurate Accountant.

(PHASE TWO)

1. Teacher will have the students create a vocabulary box in their STEM Journals or on a separate piece of paper and draw a picture of each corresponding bridge (if applicable). It will include:
    A. **Beam bridges** are made of horizontal beams supported by piers at each end, such as the Brooklyn Bridge.
    B. **Truss bridges** are a combination of triangles made of steel.
    C. **Arch bridges** are made up of arches supporting the bridge and are naturally strong.
    D. **Suspension bridges** are long bridges, such as the Golden Gate Bridge.
2. Students will start the Engineering Design Process by exploring **ASK**: What is the problem? What are the constraints and/or conditions? The teacher will have the students the students talk in their groups about the task set forth. How can you build the strongest bridge with the lowest cost in 45 minutes? Teacher will also give the students a list of materials, costs, and constraints on the board.
3. Students will **IMAGINE** and pick an idea from the list of bridges in their K'NEX books with their desk mates. As a group, they will come up with the solution that they feel is best. **Challenge Captain** will report to the teacher about which design they choose.
4. Students will **PLAN** and the **Chief Architect** will draw a sketch of their group's proposed model. **Rapid Reporter** will present it to the teacher so they may acquire their materials. The **Materials Master** will collect all the materials needed at this point. Their 45-minute clock starts when the group receives all their materials.
5. Students will **CREATE** their design and follow their plan. The **Chief Architect** will be the head of this task. After the students have finished with their bridge, they will ask the teacher to run a test or trial. The teacher will come over and have the **Testing Coordinator** begin to stack books on the bridge adding a book accordingly. See how many books the bridge can hold before it falls or breaks. Keep track of the number of books and the order in which they are put on for consistency among groups.
6. Students will **IMPROVE** and make revisions to their bridge if or where necessary to make the stronger, better, more cost effective, etc.
7. At the end of the session and after all groups have had their bridges tested, have a class wrap-up discussion about the Engineering Design Process and the types of bridges we have in our society. In addition, how they affect our society, life, and environment.
8. Teacher will play the short video clip from the following link: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10515

BROOKLYN BRIDGE K'NEX
Background Information – Part Three

When engineers design a bridge, they must consider how the bridge will be used, how long and wide it should be, and how much weight it has to hold. There are four main types of bridges:

Vocabulary
Type of bridges: *beam, truss, arch, suspension*
Additional vocabulary: *arch, beam, deck, column, fixed arch, footing, portal, strut*

Explain to students that they are going to be engineers today as they design their own bridges.

Show students various types of bridges. What do they all have in common? What are some differences? Which bridge is the strongest? Look at the shapes that are used to construct each bridge. Which shape is the strongest? Which is the weakest? Why might you use each type of shape to build a bridge?

Proposed questions for discussion:
What is a bridge?
What are they used for?
What are some types of bridges?
What and where are some that we have in Alaska? Fairbanks?
How are bridges similar and different?

BROOKLYN BRIDGE K'NEX
Standards/Assessment/Differentiation – Part Four

<u>Standards</u>
Fairbanks North Star Borough School District Science Curriculum 2016
ETS1.A: Defining engineering problems – Possible solutions a problem is limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
ETS1.B: Designing solutions to engineering problems – Testing a solution involves investigating how well it performs under a range of likely conditions.
ETS1.C: Optimizing the design solution – Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and constraints.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Fairbanks North Star Borough School District ***Mathematics*** *Curriculum – January 2014*
4.MD.2: Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses objects, and money.

Fairbanks North Star Borough School District ***Technology*** *Curriculum – January 2014*
Alaska Technology Content Standard C: A student should be able to use technology to explore ideas, solve problems, and derive meaning. For this lesson, a student who meets part of this content standard should:

2) Solve problems both individually and with others.
3) Create new knowledge by evaluating, combining, or extending information using multiple technologies.

Next Generation Science Standards Crosscutting Concepts

- Interdependence of science, engineering, technology and mathematics.
- Influence of engineering, technology, science, and mathematics on society and the natural world.

<u>Assessment</u>

There are three options of assessments included with this lesson:

The first is a rubric for formative assessment. This can be facilitated during the lesson and activities and filled out **by the teacher** during or immediately after the lesson.

The second is an exit slip with short answer responses.

The third is a student self-evaluation rubric similar to the teacher version, modified for student language.

The fourth is a 3-2-1 exercise. Sheets attached and they are differentiated.

*Additional assessments can be made using the Design Cycle Sheet given to each group as well as using student STEM Notebooks if those are used in the class.

Assessments are based on the following criteria and are differentiated:

A. "I can identify four different types of bridges."
B. "I can build a bridge that holds weight."
C. "I can keep a budget."
D. "I can work as a team to solve real-world problems."

STUDENT NAME______________________________ Date __________

Brooklyn Bridge K'NEX Exit Slip (If you need more room, use the back of this sheet)

1. What are the four types of bridges you learned about today and which one did your team build?

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2. What process did your team use to build? How did *you* help to follow your team's plan?

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3. What was the total cost of your team's bridge and what could your team do to improve the bridge or cost?

STUDENT NAME______________________________ Date ____________

Brooklyn Bridge K'NEX Self-Assessment

Category	4	3	2	1
Problem-solving	I looked for and suggested solutions for problems.	I helped with other people's solutions and didn't make suggestions.	I didn't look for or suggest any solutions, but helped.	I didn't try or help with any solutions.
Contributions	I contributed to the group and class. A lot of effort.	I helped either the class OR group. Tried hard.	I sometimes helped, sometimes off task. Did the minimum of what was required.	I barely helped or participated.
Attitude	I was always had a positive attitude with this project.	I often had a positive attitude, but I got frustrated sometimes.	I was positive and polite, but I was very frustrated.	I often had a negative attitude toward the project
Focus of the task	I stayed on task and did whatever was needed. I was a self-manager.	I was focused most of the time with a few distractions. Maybe not a self-manager yet.	Other group members had to often remind me to keep be on task. Still working on being a self-manager.	I let others do most or all the work. I don't think I am a self-manager yet.
Working with others	I listened and shared well. I tried to help work well together and it was great.	I tried not to make "waves" in the group. I wasn't too hard to work together.	It was difficult to work together, but we did it. Sometimes I could have been a better team member.	I was often not a good team player and made issues for the group.

STUDENT NAME____________________________ Date ____________

Brooklyn Bridge K'NEX 3-2-1 CHALLENGE

(3) Things you learned were:

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(2) Interesting things were:

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(1) Question I still have:

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STUDENT NAME______________________________ Date ____________

Brooklyn Bridge K'NEX 3-2-1 CHALLENGE

(3) List three types of bridges you learned about today.

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(2) Name two ways you helped your team today:

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(1) List one way your group could improve on your team's bridge:

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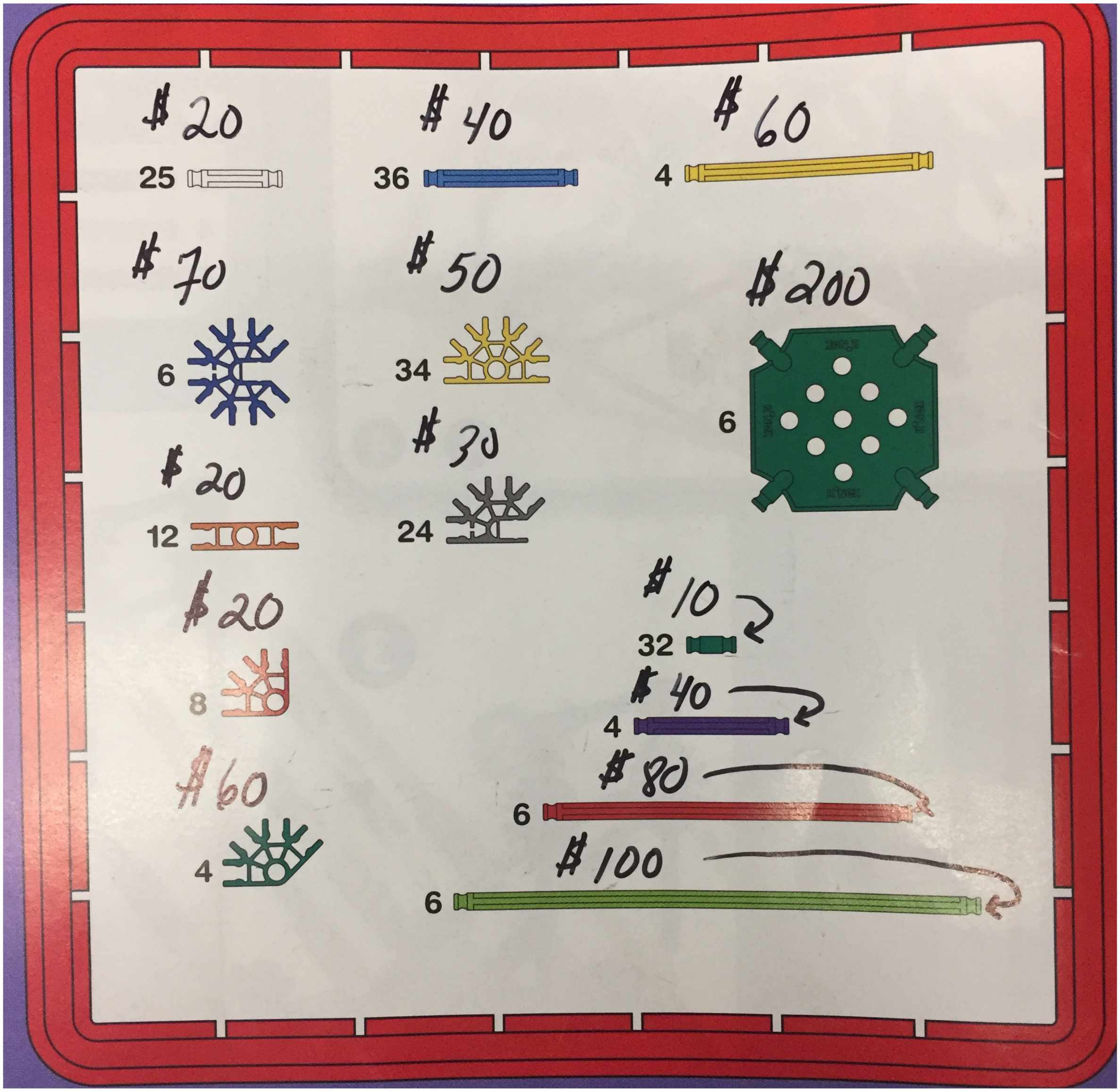

Make sure you check costs and add them into you final budget.

Lesson Three:
Exploding Canisters

EXPLODING CANISTERS
Lesson Information – Part One

Lesson Focus
"Exploding Canisters" explores Newton's Laws of force and motion. This lesson will integrate science, technology, engineering, and mathematics to create an all-inclusive STEM (Science, Technology, Engineering, and Mathematics) lesson.
Lesson Summary
It is recommended to deliver this lesson over multiple sessions for time and effectiveness. The first part is teacher-led discourse and demonstrations of how forces act on each other. The second phase features the engineering design process, where students will create their own demonstrations of Newton's Third Law of Motion. The third phase of this lesson includes graphing, and digitally converting information to show the relationship of force, motion, mass, and matter.
Grade Level
This lesson is designed for Intermediate (grades 4-6) level instruction.
Objectives
- Students will observe demonstrations of Newton's Second and Third Laws of Motion.
- Students will design a demonstration Newton's Third Law of Motion using a list of materials given.
- Students will understand Newton's Second and Third Laws of Motion.
- Students will understand what Mass and Matter are.

Acknowledgements
This kit has been funded in part by:
The Alaska Space Grant Program and the University of Alaska Fairbanks' College of Mining and Engineering. The Delta Kappa Gamma Teachers Association, The Pearl Creek Parent Teacher Association, and The Alaska Science Teachers Association.

EXPLODING CANISTERS
Materials and Procedures - Kit Part Two

(IT IS HIGHLY RECOMMENDED THAT THE TEACHER KEEP ALL THE MATERIALS OUT OF SIGHT FROM THE STUDENTS UNTIL THEY ARE READY TO HAVE THEM)

*Hot Wheels Race Track (2 large, 4 small pieces)
*Blue Connectors (5)
*Nickels (9)
*Safety Goggles (5)
*35 mm film canisters (2)
*Alka-Seltzer tablets (5 total)
*Measuring Tape (1)
*Graphing Paper
*Denotes Materials Included in Kit * (enough for a class of 30 Students/6 Groups)

Materials for Teacher – not included in the kit
Rolling Chairs (2)

Time Frame
180 Minutes

Time Frame – Preparation
60 Minutes for lesson review, background, and procedures. Most items needed for the lesson are provided in the kit. Two rolling chairs will be needed from the teacher. **It is highly recommended that the teacher go to the web sites provided in this kit to verify access and proper functioning, as well as, how to navigate the sites for students.** The kit has pictures for reference and examples, but it is recommended that the teacher try all of the activities prior to teaching the lesson.

Note: you must be signed into your teacher account at https://www.k12northstar.org to access the BrainPop videos.

https://www.brainpop.com/math/geometryandmeasurement/isaacnewton/

https://www.brainpop.com/science/motionsforcesandtime/newtonslawsofmotion/

https://nces.ed.gov/nceskids/createagraph/ - Graphing (play around with this)
Suggested Procedures

(PHASE ONE)

1. Teacher will show the following two (2) videos from *BrainPOP*: https://www.brainpop.com/science/motionsforcesandtime/newtonslawsofmotion/ https://www.brainpop.com/math/geometryandmeasurement/isaacnewton/ to introduce the lesson (please note: you must be signed into your teacher account at https://www.k12northstar.org before you can access *BrainPOP*).
2. Teacher will facilitate discourse with the class. Questions should start with: What is matter? What is mass? The teacher will have in-depth conversations with the students about mass and matter.
3. Students will use their STEM notebooks (or paper) and start a new page titled "Exploding Canisters." Below the title of the lesson, the students will copy from the board their "I can" statements. These are provided in the kit:
   D. "I can tell you what Newton's Second and Third Laws of Motion are."
   E. "I can work with a team to collect data and explain my understanding of Newton's Second and Third Laws of Motion."

(PHASE TWO)

1. This part is called "Pushing Back." In this part of the lesson, the teacher will have two rolling chairs, preferably the same size and weight. This should also be conducted on a flat, level surface suitable for rolling chairs.
2. The teacher will select two students to sit in each one and push off from each other using both hands and keeping feet in the air. Before the test, the students will hypothesize what will happen. This is a demonstration of how mass and matter act on each other.
3. The lighter student should travel farther than the other student. (Please Note: Teacher will need to keep in mind student sensitivity to weights and genders). It is also effective to have the teacher as one subject and pick a student for the other subject to eliminate any issues.
4. Teacher will discuss with the class how mass and matter act on one another. (More mass needs more force; less mass=less resistance or momentum)

(PHASE THREE)

1. Teacher will explain to the students that they will need to create a demonstration of how mass and matter act on each other using the materials that they will be given. Teacher will also demonstrate how the canisters and Alka Seltzer work prior to the activity.
2. Teacher will write on the board a list of the materials, constraints, the Engineering Design Process for the kids to copy into their notebooks (or on a piece of paper). The teacher will work with the students to define the word CONSTRAINTS.
3. Teacher will separate students into equal groups up to 5 kids.

4. Teacher will go over roles and define them. Teacher will assign each student in each group with a specific job: Challenge Captain, Materials Master, Testing Coordinator, Chief Architect, Rapid Reporter.
5. The class will start the Engineering Design Process by exploring **ASK**: What is the problem? (How can I demonstrate how force and motion are related using only the materials I am given in a certain amount of time?). What are the constraints and/or conditions? The teacher will have the students the students talk in their groups about the task set forth.
6. Students will **IMAGINE** and brainstorm ideas with their group members. They will work together to come up with the solution that they feel is will best demonstrate Newton's Third Law of Motion.
7. Students will **PLAN** together and the **Chief Architect** will draw a picture of their proposed model on the graphing paper provided in the kit. Their picture should also include a list of materials that they will need. Previously given to the class.
8. The **Challenge Captain** will present their plan to the class at the end of this phase). The **Materials Master** will collect all the materials needed at this point. Their 45-minute clock starts when the group receives all their materials.
9. Students will **CREATE** their design and follow their plan. The **Chief Architect** will be the head of this task. After the students have finished building their designs, they will ask the teacher to run a test or trial. The teacher will come over and have the **Testing Coordinator** facilitate the tests.
10. Students will **IMPROVE** and make revisions if or where necessary to make their demonstration more effective and prove their hypothesis. If there are no revisions necessary, teacher will either chose to add more constraints or add the optional activities.

(PHASE FOUR)

1. After all the groups have demonstrated their ideas to the teacher. The teacher will choose one idea from the groups for the class to replicate in front of the class. The class will collect data during this demonstration.
2. The class will make written graphs to represent the data they collected. This should be a line graph. The kit has an example of a line graph that will represent the procedures followed in this kit.
3. After the students have completed their written graphs, they may go to the web site: https://nces.ed.gov/nceskids/createagraph/ to create a digital copy of their line graph.

PLEASE NOTE: The additional background information is for teacher reference and enrichment for appropriate situations and may be directed by the teacher. Information has been provided, but it is not necessary to convey all the lesson materials.

EXPLODING CANISTERS
Background Information – Part Three

What is Matter?
Definition: Matter has many definitions, but the most common is that it is any substance that has mass and occupies space. All physical objects are composed of matter, in the form of atoms, which are in turn composed of protons, neutrons, and electrons.
States of Matter: Matter can exist in various phases: solid, liquid, gas, or plasma. Most substances can transition between these phases based on the amount of heat the material absorbs (or loses).
What is Mass?
Definition: A measure of how much matter is in an object.
For Example: A gold bar is small but has a mass of 1 kg (2.2 lbs.), so it contains a lot of matter. Mass is commonly measured by how much something weighs. However, weight can change depending on where you are (like the moon), while the mass stays the same. Mass is measured in grams, kilograms, and tonnes per the Metric System. Mass is measured in ounces or pounds in the US System.
Newton's Laws of Motion
First Law – The first law says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed (THINK OF OUR EGG DROP DEMONSTRATION). Motion (or lack of motion) cannot change without an unbalanced force acting.
Second Law – The second law shows that if you exert the same force on two objects of different mass, you will get different accelerations (changes in motion). The effect (acceleration) on the smaller mass will be greater (more noticeable). The difference in effect (acceleration) is entirely due to the difference in their masses. (THINK OF HOW FAR AND FAST THE CANISTER WENT WITH AND WITHOUT NICKELS IN IT OR PUSHING BACK IN CHAIRS)
Third Law – The third law says that for every action (force) there is an equal and opposite reaction (force). Forces are found in pairs. It's an issue of symmetry. Acting forces encounter other forces in the opposite direction. There's also the example of shooting a cannonball. When the cannonball is fired through the air (by the explosion), the cannon is pushed backward. The force pushing the ball out was equal to the force pushing the cannon back, but the effect on the cannon is less noticeable because it has a much larger mass. That example is similar to the kick when a gun fires a bullet forward. (THINK OF WHEN YOU ADDED MORE NICKELS TO THE CANISTER OR WHEN THE TEACHER HAD MORE MASS WHEN PUSHING BACK)

EXPLODING CANISTERS
Standards/Assessment/Differentiation – Part Four

Standards
Fairbanks North Star Borough School District Science Curriculum 2016
ETS1.A: Defining engineering problems – Possible solutions a problem is limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
ETS1.B: Designing solutions to engineering problems – Testing a solution involves investigating how well it performs under a range of likely conditions.
ETS1.C: Optimizing the design solution – Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and constraints.

4-PS4-3: Generate and compare that use patterns to transfer information.

Fairbanks North Star Borough School District ***Mathematics*** *Curriculum – January 2014*
4.MD.1: Know relative sizes of measurement.

Fairbanks North Star Borough School District ***Technology*** *Curriculum – January 2014*
Alaska Technology Content Standard C: A student should be able to use technology to explore ideas, solve problems, and derive meaning. For this lesson, a student who meets part of this content standard should:

1) Use technology to observe, analyze, interpret, and draw conclusions.
2) Solve problems both individually and with others.
3) Create new knowledge by evaluating, combining, or extending information using multiple technologies.

Alaska Technology Content Standard E: A student should be able to use technology responsibly and understand its impact on individuals and society. For this lesson, a student who meets part of this content standard should:

1) Evaluate the potentials and limitations of existing technologies.
6) Evaluate ways that technology impacts culture and the environment.

Next Generation Science Standards Crosscutting Concepts

- ❖ Interdependence of science, engineering, technology and mathematics.
- ❖ Influence of engineering, technology, science, and mathematics on society and the natural world.

<u>Assessment</u>

There are three options of assessments included with this lesson:

The first is a rubric for formative assessment. This can be facilitated during the lesson and activities and filled out **by the teacher** during or immediately after the lesson.

The second is an exit slip with short answer responses.

The third is a student self-evaluation rubric similar to the teacher version, modified for student language.

The fourth is a 3-2-1 exercise. Sheets attached and they are differentiated.

*Additional assessments can be made using the Design Cycle Sheet given to each group as well as using student STEM Notebooks if those are used in the class.

Assessments will be based on the objective set forth in the beginning of the lesson:

- ❖ Students will observe demonstrations of Newton's Second and Third Laws of Motion.
- ❖ Students will design a demonstration Newton's Third Law of Motion using a list of materials given.
- ❖ Students will understand Newton's Second and Third Laws of Motion.
- ❖ Students will understand what Mass and Matter are.

STUDENT NAME_________________________ Date ____________

EXPLODING CANISTERS Self-Assessment

Category	4	3	2	1
Problem-solving	I looked for and suggested solutions for problems.	I helped with other people's solutions and didn't make suggestions.	I didn't look for or suggest any solutions, but helped.	I didn't try or help with any solutions.
Contributions	I contributed to the group and class. A lot of effort.	I helped either the class OR group. Tried hard.	I sometimes helped, sometimes off task. Did the minimum of what was required.	I barely helped or participated.
Attitude	I was always had a positive attitude with this project.	I often had a positive attitude, but I got frustrated sometimes.	I was positive and polite, but I was very frustrated.	I often had a negative attitude toward the project
Focus of the task	I stayed on task and did whatever was needed. I was a self-manager.	I was focused most of the time with a few distractions. Maybe not a self-manager yet.	Other group members had to often remind me to keep be on task. Still working on being a self-manager.	I let others do most or all the work. I don't think I am a self-manager yet.
Working with others	I listened and shared well. I tried to help work well together and it was great.	I tried not to make "waves" in the group. I wasn't too hard to work together.	It was difficult to work together, but we did it. Sometimes I could have been a better team member.	I was often not a good team player and made issues for the group.

STUDENT NAME_____________________________DATE_____________

EXPLODING CANISTERS Exit Slip (If you need more room, use the back of this sheet)

1. What is mass? What is matter?

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2. Explain ONE (1) of Newton's three Laws of Motion.

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3. How are Science, Technology, Engineering, and Mathematics related?

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STUDENT NAME_____________________________DATE_____________

EXPLODING CANISTERS 3-2-1 CHALLENGE

(3) Things you learned were:

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(2) Interesting things were:

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(1) Question I still have:

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STUDENT NAME_____________________________ DATE ____________

EXPLODING CANISTERS 3-2-1 CHALLENGE

(3) Newton's Three Laws of Motion are:

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(2) Ways Science, Technology, Engineering, and Mathematics are related:

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(1) Interesting idea to think about:

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Lesson Four:
Egg Drop

EGG DROP – Lesson adopted and modified from Exxon Mobile Science Teachers Academy
Lesson Information – Part One

Lesson Focus

"Egg Drop" is a lesson designed to introduce Newton's First Law of force and motion. The lesson will use the Engineering Design Process using a list of materials as constraints to the experiments performed.

Lesson Summary

Students will complete the penny/card activity and the coin challenge. Students will be asked the question: How can the egg land (unbroken) in the glass using only a broom as an outside force? Students will then relate their solutions to the initial activity of the coin challenge and to Newton's First Law of Motion.

Skills

Observing
Communicating
Inferring/hypothesizing
Interpreting
Problem Solving
Probability

Grade Level

This lesson is designed for Intermediate (grades 4-6) level instruction.

Objectives

- Students will design a demonstration of Newton's First Law of Motion using a list of materials given.
- Students will explain Newton's First Law of Motion.

Acknowledgements

This kit has been funded in part by:
The Alaska Space Grant Program and the University of Alaska Fairbanks' College of Mining and Engineering. The Delta Kappa Gamma Teachers Association, The Pearl Creek Parent Teacher Association, and The Alaska Science Teachers Association.

UAF™ UNIVERSITY OF ALASKA FAIRBANKS

Alaska Space Grant Program

NASA

EGG DROP
Materials and Procedures – Part Two

Materials for Students (per group of 4-5)
- 3 raw eggs (NOT PROVIDED IN THE KIT)
- 3 empty cardboard toilet paper rolls
- 1 shallow aluminum pizza pan (30-50 cm diameter)
- 3 clear glasses of water (approximately 1000 ml)
- 1 straw broom (NOT PROVIDED IN THE KIT)
- 1 paper or plastic cup per participant
- 1 index card per participant
- 1 penny per participant
- 5 nickels per participant
- 1 plastic knife per participant
- Why Doesn’t The Earth Fall Up? By Vicky Cobb

Time Frame
120 minutes

Time Frame – Preparation
30 Minutes to review lesson background and procedures. MOST items needed for the lesson are provided in the kit. It is recommended that the teacher try the lesson one time in its entirety to become familiar with the information, processes, procedures, and kit.

Suggested Procedures
1. Begin a short book talk on Why Doesn't the Earth Fall Up? It is a good way to introduce the physical properties of motion to participants and to get students thinking of why everyday objects behave the way they do. The book also does a great job introducing the historical contributions from the likes of Isaac Newton, Ptolemy, Copernicus, and Galileo. Read two to three sections of the book out loud to participants. Some good ones include, "Why Can't You Stand an Egg on Its End?", "Which Falls Faster, a Bowling Ball or a Marble?", and "Why Does a Rolling Ball Stop Rolling?". Allow time for discussion.

2. Penny/Card Activity: Distribute one small cup, one index card, and one penny to each participant. Place the index card on top of the cup with the penny placed on top of the index card. The cup, card, and penny are all at rest. Participants will flick at the card from the side, making sure not to hit the cup or penny in the process. Use Newton’s first law to explain what happened. Have a class discussion.

3. Coin Challenge: Distribute five nickels and one plastic knife to each participant. Stack five nickels in a pile on top of each other. The goal is to knock the bottom coin out from underneath the other coins by hitting it with the thin edge of the knife. This needs to be done quickly. The bottom coin will move because the force of the knife acts on it. Inertia will keep the other coins in the stack above it from moving with the bottom coin. The other coins will drop straight down to form a stack of four. Compare the two activities with the students. How are they similar? How are they different? In what ways do the activities illustrate Newton's First Law of Motion? Review Newton's First Law of Motion (Every object persists in its state of rest or of uniform motion in a straight line unless it is compelled to change that state by forces impressed on it. In other terms, things tend to keep on doing whatever they're doing until something else affects them. This is also called inertia.)

4. Teacher will have some materials set up near the edge of a table in the front of room. A glass of water will be on the bottom. The pizza pan will be centered directly on top of the glass. The toilet paper roll will be up on end, centered on the pie pan. The egg is placed and balanced on the toilet paper roll. The pizza pan must extend slightly passed the edge of the table.

3. Teacher will then give the students the list of materials on the board and the students will have to use what they have learned from the first two activities to design a way to get the egg from its current position, into the glass of water, unbroken, using only the straw broom acting as an outside force? Allow plenty of time for hypotheses, creative responses, and different designs.

4. After the students have proposed their ideas, the teacher will stand on the straw portion of the broom, pulling the top of the handle towards self and aimed at the setup. After a countdown (led by the students) the handle is let go. The handle hits only the pan (and the edge of the table) sending the pan and the toilet roll across the table. The egg, affected only by gravity falls into the beaker directly below.

5. Lots of discussion will follow regarding the motion of the items in the activity.

6. Guide participants to relate the demonstration to Newton's First Law of Motion and have them try it in their groups.

7. The demonstration will again be performed again using up to three raw eggs at a time in front of the class.

EGG DROP
Background Information – Part Three

Newton's Laws of Motion
First Law – The first law says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed (THINK OF OUR EGG DROP DEMONSTRATION). Motion (or lack of motion) cannot change without an unbalanced force acting.

Second Law – The second law shows that if you exert the same force on two objects of different mass, you will get different accelerations (changes in motion). The effect (acceleration) on the smaller mass will be greater (more noticeable). The difference in effect (acceleration) is entirely due to the difference in their masses. (THINK OF HOW FAR AND FAST THE CANISTER WENT WITH AND WITHOUT NICKELS IN IT OR PUSHING BACK IN CHAIRS)

Third Law – The third law says that for every action (force) there is an equal and opposite reaction (force). Forces are found in pairs. It's an issue of symmetry. Acting forces encounter other forces in the opposite direction. There's also the example of shooting a cannonball. When the cannonball is fired through the air (by the explosion), the cannon is pushed backward. The force pushing the ball out was equal to the force pushing the cannon back, but the effect on the cannon is less noticeable because it has a much larger mass. That example is similar to the kick when a gun fires a bullet forward. (THINK OF WHEN YOU ADDED MORE NICKELS TO THE CANISTER OR WHEN THE TEACHER HAD MORE MASS WHEN PUSHING BACK)

EGG DROP
Standards/Assessment/Differentiation – Kit Part Four

Science as Inquiry
Physical Science
Motion and Forces
Transfer of Energy

Standards

Fairbanks North Star Borough School District Science Curriculum 2016
ETS1.A: Defining engineering problems – Possible solutions a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
ETS1.C: Optimizing the design solution – Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and constraints.

Fairbanks North Star Borough School District ***Technology*** *Curriculum – January 2014*
Alaska Technology Content Standard C: A student should be able to use technology to explore ideas, solve problems, and derive meaning. For this lesson, a student who meets part of this content standard should:

1) Use technology to observe, analyze, interpret, and draw conclusions.
2) Solve problems both individually and with others.
3) Create new knowledge by evaluating, combining, or extending information using multiple technologies.

Assessment

There are three options of assessments included with this lesson:

The first is a rubric for formative assessment. This can be facilitated during the lesson and activities and filled out **by the teacher** during or immediately after the lesson.

The second is an exit slip with short answer responses.

The third is a student self-evaluation rubric similar to the teacher version, modified for student language.

The fourth is a 3-2-1 exercise. Sheets attached and they are differentiated.

*Additional assessments can be made using the Design Cycle Sheet given to each group as well as using student STEM Notebooks if those are used in the class.

Assessments will be based on the objective set forth in the beginning of the lesson:

- Students will design a demonstration of Newton's First Law of Motion using a list of materials given.
- Students will explain Newton's First Law of Motion.

STUDENT NAME_________________________ Date ___________

EGG DROP EXIT SLIP

1. Explain Newton's First Law of Motion.

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2. Explain a new way to demonstrate Newton's First Law of Motion?

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3. How did you demonstrate Newton's First Law of Motion?

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STUDENT NAME______________________________ Date ____________

EGG DROP SELF-ASSESSMENT – Give and *honest* self-reflection

Category	4	3	2	1
Problem-solving	I looked for and suggested solutions for problems.	I helped with other people's solutions and didn't make suggestions.	I didn't look for or suggest any solutions, but helped.	I didn't try or help with any solutions.
Contributions	I contributed to the group and class. A lot of effort.	I helped either the class OR group. Tried hard.	I sometimes helped, sometimes off task. Did the minimum of what was required.	I barely helped or participated.
Attitude	I always had a positive attitude with this project.	I often had a positive attitude, but I got frustrated sometimes.	I was positive and polite, but I was very frustrated.	I often had a negative attitude toward the project
Focus of the task	I stayed on task and did whatever was needed. I was a self-manager.	I was focused most of the time with a few distractions. Maybe not a self-manager yet.	Other group members had to often remind me to keep be on task. Still working on being a self-manager.	I let others do most or all the work. I don't think I am a self-manager yet.
Working with others	I listened and shared well. I tried to help work well together and it was great.	I tried not to make "waves" in the group. It wasn't too hard to work together.	It was difficult to work together, but we did it. Sometimes I could have been a better team member.	I was often not a good team player and made issues for the group.

STUDENT NAME___________________________ Date ____________

EGG DROP 3-2-1 CHALLENGE

(3) Things you learned were:

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(2) Interesting things were:

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(1) Question I still have:

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Lesson Five:
Egg Crate

EGG CRATE
Lesson Information – Part One

Lesson Focus
"Egg Crate" is a lesson designed to reinforce the Engineering Design Process using a list of materials as constraints to the experiments performed.
Lesson Summary
Students will work in teams of two to design and construct a cargo crate to protect an egg from breaking. The crate will be dropped free fall at a height of 20 feet optimally.
Grade Level
This lesson is designed for Intermediate (grades 4-6) level instruction.
Objectives
- ❖ Students will use the Engineering Design Process to create a crate that will drop an egg safely using a list of materials and keep a budget.
- ❖ Students will work as a team to solve real-world problems.

Acknowledgements
This kit has been funded in part by:
The Alaska Space Grant Program and the University of Alaska Fairbanks' College of Mining and Engineering. The Delta Kappa Gamma Teachers Association, The Pearl Creek Parent Teacher Association, and The Alaska Science Teachers Association.

EGG CRATE
Materials and Procedures – Part Two

Materials for Students (per group of 2)
- One 8.5" x 11" sheet of standard copy paper
- 15 drinking straws
- 15 tongue depressors
- 100 CM of string
- 100 CM of masking tape
- 5 rubber bands
- 1 raw egg (NOT INCLUDED IN KIT)

Time Frame
120 minutes

Time Frame – Preparation
30 Minutes to review lesson background and procedures. MOST items needed for the lesson are provided in the kit. It is recommended that the teacher try the lesson one time in its entirety to become familiar with the information, processes, procedures, and kit.

Suggested Procedures
1. Teacher will facilitate discussion on the Engineering Design Process.
2. Teacher will pair students and give them a list of materials.
3. Students will write in their STEM Notebooks or on a sheet of paper ASK: How can I drop a raw egg from a height of 20 feet and protect it from breaking or cracking using the materials I have in an allotted amount of time and with a budget.
4. Students will IMAGINE: What their design will look like and brainstorm different ideas for how they would like to construct their crate.
5. Students will PLAN: By drawing a diagram of what their crate will look like and list the materials they will use including their budget.
6. Students will CREATE: Their build their crate according to their plans and make modifications where necessary.
7. After 45 minutes (testing place should already be set up), the teacher will have all the groups gather to watch their classmates test their creations.
8. If time allows, the teacher will allow the students another opportunity to improve on their crates. If time is restricted, the teacher will ask the class or groups how they could improve on their original designs.

Egg Crate
Background Information – Part Three

What is engineering?
Noun - the branch of science and technology concerned with the design, building, and use of engines, machines, and structures.

What is an engineer?

- Engineers apply scientific and mathematic knowledge to create solutions for various technical problems.
- Engineers and scientists are slightly different, with engineers focusing more on the application of science. They are often seen as the link from scientific discoveries to their application in the real world.
- Different disciplines of engineering include chemical engineering, civil engineering, electrical engineering and mechanical engineering. These disciplines can be further broken down into even more specialist roles such as molecular engineering and structural engineering.
- As an engineer you may work on the production of products, the building of structures, the design of computer systems, the manufacturing of vehicles and other roles.
- When building structures, materials, systems and machines, it is important for engineers to be practical with regards to safety and cost.
- Engineers can be in charge of large projects that rely on safety and reliability. Engineering societies often have codes of practice and ethics put in place that helps maintain good practices and work of a high quality among engineers.
- The word engineer comes from Latin words meaning 'devise' and 'cleverness'.

Simply put:
Engineers want to know the optimal solution to a problem.

Why is this relevant? In the real-world, there are certain situations where goods or products need to be dropped into a place, and the cargo needs to land safely. For example: Food and medical supplies may need to be air-dropped into locations in need and a plane cannot land safely. Or in Alaska, sometimes goods or materials need to be delivered, and dropping from the air is a calculated risk that costs money.

EGG CRATE
Standards/Assessment/Differentiation – Kit Part Four

Standards

Fairbanks North Star Borough School District Science Curriculum 2016
ETS1.A: Defining engineering problems – Possible solutions a problem is limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
ETS1.B: Designing solutions to engineering problems – Testing a solution involves investigating how well it performs under a range of likely conditions.
ETS1.C: Optimizing the design solution – Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and constraints.

ESS3.A: Natural resources – Energy and fuels that humans use is derived from natural resources and their use affects the environment in multiple ways. Some resources are renewable over time and others are not.

Fairbanks North Star Borough School District Mathematics Curriculum – January 2014

Fairbanks North Star Borough School District Technology Curriculum – January 2014
Alaska Technology Content Standard C: A student should be able to use technology to explore ideas, solve problems, and derive meaning. For this lesson, a student who meets part of this content standard should:

1) Use technology to observe, analyze, interpret, and draw conclusions.
2) Solve problems both individually and with others.
3) Create new knowledge by evaluating, combining, or extending information using multiple technologies.

Next Generation Science Standards Crosscutting Concepts

- Interdependence of science, engineering, technology and mathematics.
- Influence of engineering, technology, science, and mathematics on society and the natural world.

<u>Assessment</u>

There are three options of assessments included with this lesson:

The first is a rubric for formative assessment. This can be facilitated during the lesson and activities and filled out **by the teacher** during or immediately after the lesson.

The second is an exit slip with short answer responses.

The third is a student self-evaluation rubric similar to the teacher version, modified for student language.

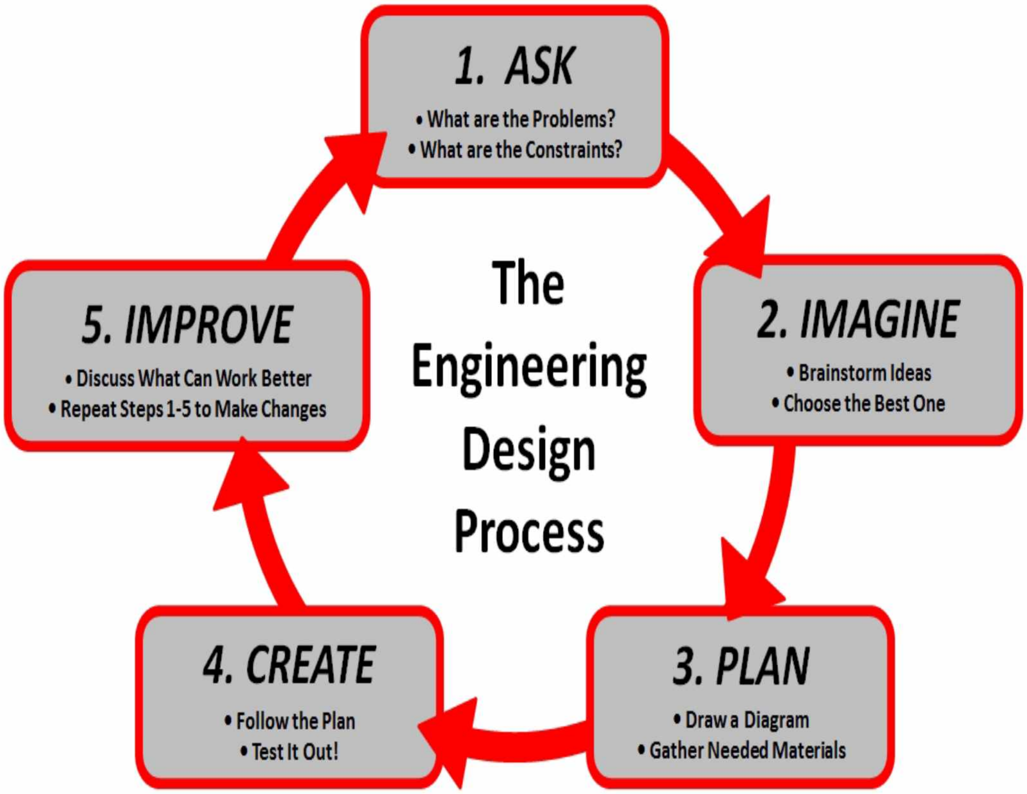
The fourth is a 3-2-1 exercise. Sheets attached and they are differentiated.

*Additional assessments can be made using the Design Cycle Sheet given to each group as well as using student STEM Notebooks if those are used in the class.

Assessments will be based on the objective set forth in the beginning of the lesson:

- Students will understand the Engineering Design Process to create a crate that will drop an egg using a list of materials and keep a budget.
- Students will work as a team to solve real-world problems.

ENGINEERING DESIGN PROCESS DIAGRAM



EGG CRATE ITEMIZED BUDGET

ITEM	COST	QUANTITY	TOTAL EXPENSE (Cost x Quantity)
SHEET OF PAPER	$5.00 MAX 1		$
DRINKING STRAWS	$.50 EACH		$
TONGUE DEPRESSORS	$.50 EACH		$
STRING	$1.00 PER 25 CM		$
MASKING TAPE	$1.00 PER 50 CM		$
RUBBER BANDS	$1.50 EACH		$
RAW EGG	$5.00		$
TOTAL PROJECT EXPENSES			$

STUDENT NAME___________________________ Date ____________

EGG CRATE EXIT SLIP

1. Explain the Engineering Design Process.

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2. How did you work with your partner to make your egg crate?

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3. What would you do to improve your design?

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STUDENT NAME_____________________________ Date ____________

TOWER CHALLENGE SELF-ASSESSMENT – Give and *honest* self-reflection

Category	4	3	2	1
Problem-solving	I looked for and suggested solutions for problems.	I helped with other people's solutions and didn't make suggestions.	I didn't look for or suggest any solutions, but helped.	I didn't try or help with any solutions.
Contributions	I contributed to the group and class. A lot of effort.	I helped either the class OR group. Tried hard.	I sometimes helped, sometimes off task. Did the minimum of what was required.	I barely helped or participated.
Attitude	I always had a positive attitude with this project.	I often had a positive attitude, but I got frustrated sometimes.	I was positive and polite, but I was very frustrated.	I often had a negative attitude toward the project
Focus of the task	I stayed on task and did whatever was needed. I was a self-manager.	I was focused most of the time with a few distractions. Maybe not a self-manager yet.	Other group members had to often remind me to keep be on task. Still working on being a self-manager.	I let others do most or all the work. I don't think I am a self-manager yet.
Working with others	I listened and shared well. I tried to help work well together and it was great.	I tried not to make "waves" in the group. It wasn't too hard to work together.	It was difficult to work together, but we did it. Sometimes I could have been a better team member.	I was often not a good team player and made issues for the group.

STUDENT NAME_____________________________ Date _____________

EGG CRATE 3-2-1 CHALLENGE

(3) Things you learned were:

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(2) Interesting things were:

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(1) Question I still have:

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