INCREASING K-5 STUDENTS’ NON-COGNITIVE SKILLS THROUGH STEM- INTEGRATED EDUCATION

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By
Lauren Varon

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The graduate project of Lauren Varon is approved:

John Reveles, Ph. D.  Date

Lorie Thompson, Ed.D.  Date

Susan Belgrad, Ed. D., Chair  Date

California State University, Northridge
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DEDICATION

This graduate project is dedicated to my dad, Bruce Varon. I know that he would have been proud of me for completing this graduate program and for the educator that I have become.

He would have enjoyed my newfound love of STEM education.
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ABSTRACT

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By

Lauren Varon

Master of Arts in Education, Elementary Education

Students living with economic hardship are at risk of developing low self-efficacy which in turn might lead to them dropping out of school or giving up when faced with academic and personal obstacles (Schunk and Meece, 2005). In order to promote opportunities for these diverse students to access and succeed in college, K-5 students must be provided opportunities for the acquisition of necessary non-cognitive skills such as self-efficacy, persistence, and optimism. These attributes that are most commonly associated with academic achievement, continued school retention and college or career success in science, technology, engineering, and mathematics (STEM) related fields, must be developed through meaningful student engagement by effective teachers. By implementing STEM-integrated education including the engineering design process, elementary school educators can ensure that at-risk students will be regularly engaged with real-world projects that motivate them to pursue STEM achievement and thereby persist until the curricular objectives are completed. Integrated-STEM education not only provides at-risk students with consistent opportunities to develop these non-cognitive skills but will also secure their continuing interest in STEM education.
Keywords: Science, Technology, Engineering, and Mathematics (STEM), Next Generation Science Standards (NGSS), STEM Integration, Self-Efficacy, Persistence, Non-Cognitive Skills, Soft Skills, STEM Education
CHAPTER ONE: INTRODUCTION

Becoming college and career ready is not just being able to demonstrate a sufficient amount of content knowledge; cognitive strategies must also be a part of students’ education if they are going to be successful (Kyllonen, 2012). In fact, many educators and researchers have expressed concern that students continue to be evaluated almost entirely by their intelligence quotient or IQ. Tough (2011) argues, “This push on tests is missing out on serious parts of what it means to be a successful human” (pg. 3, para 3). Self-efficacy, persistence, optimism, and motivation are non-cognitive skills that are most commonly associated with academic success, achievement, and retention in science, technology, engineering, and mathematics (STEM) related fields. These “character strengths” are the skills that founders of the successful charter schools known as KIPP Academies, David Levin and Michael Feinberg, believe will not only get students to college but will help them to succeed through graduation. These non-cognitive skills are often combined into what some researchers refer to as tenacity or “grit” (Duckworth, Peterson, Matthews, & Kelly, 2007).

Starting in infancy, Schunk and Meece (2005) argue that families provide experiences for their children that influence the development of self-efficacy. Self-efficacy, which Bandura (1997) defined as one’s belief in the ability to succeed, is enhanced when children are motivated to achieve, when they are exposed to positive academic and social models, and when they are taught strategies that they can use to overcome challenges that they will encounter in their lives (Schunk & Meece, 2005). In general, families with greater economic capital provide richer experiences that raise children’s self-efficacy compared to lower-income families. According to Schunk and Meece (2005) there is a good deal of correlational research showing that economic hardship and low levels of parent education relate to difficulties in students’ development and
learning. Families with less education and less income cannot provide the capital that could be used to stimulate cognitive development (i.e. vacations, visits to museums, books, computers and digital devices). When lower-income children experience learning problems early in school, it often results in a lower self-efficacy for learning (Schunk & Meece, 2005). Sherman (1997) has also researched the effects that poverty has on academic achievement and found socioeconomic status as one of the major predictors of becoming an early school dropout. It is not a surprise then that students who grow up in poverty also develop low self-efficacy as they have been academically at-risk for dropping out of school from their earliest grade level.

Educators and schools have the responsibility and privilege to teach non-cognitive skills so that all students, including those who may have developed low self-efficacy at an early age, can experience academic achievement and success in school. The Association for Supervision and Curriculum Development (ASCD) has developed the Whole Child Initiative in order to redefine the goals of education. The Whole Child Initiative focuses on more than just academic achievement and promotes the long-term success and development of the child (ASCD, 2015). ASCD argues that the development of a whole child involves more than acquiring knowledge and skills from school; students must also have the opportunities to develop their pro-social behavior and character through the support of parents, the school and community in order to reach their full potential.

While this is an aspiration for many schools, educators are often overwhelmed with the amount of high-stakes curricular content that they are required to teach in any given day and throughout the academic year. Goals of focusing on the whole child and developing their character often get put on hold as soon as the district leaders place pressure on schools and teachers to perform well on high-stakes assessments. Asking educators to add an additional
program that promotes at-risk students’ development of non-cognitive skills, such as social emotional learning (SEL) into their already-busy schedule might be met with resistance and/or lack of enthusiasm. However, it has become increasingly necessary to implement interdisciplinary approaches that ensure that all students are prepared to meet or exceed all the standards. Integrated-STEM education in the classroom is an effective practice that includes instruction in the core disciplines while addressing the needs of “the whole child” and their social-emotional well-being.

In the past, the “E” in STEM, engineering that did not appear until secondary school or later, was taught separately from the sciences, resulting in many students not being exposed to engineering design principles. With the implementation of the Next Generation Science Standards (NGSS) in K-12 classrooms, “students will see how science and engineering are instrumental in addressing major challenges that confront society today” (National Research Council, 2012, p. 9). Hopefully, all students, even those who have previously been marginalized in science curricula and instruction, will experience the engineering design principles that offer them real-life opportunities in defining problems that people need to address, generating and evaluating solutions, building and testing prototypes or models, and optimizing their solutions. Early exposure to engineering activities and understanding how science is relevant to both their lives and their futures may ignite students’ interest in the study of STEM majors and/or future careers in science (National Science Foundation, 2010).

In addition to acquiring knowledge and skills that students need in order to become contributing citizens in 21st century society, the engineering practices now advanced within the NGSS provide a great opportunity to reinforce important non-cognitive skills. For example, K-5 students building structures with toothpicks and gumdrops in order to withstand the weight of a
Chapter book will inevitably need to re-think their design and start the building process over again several times (engineers call these initial attempts prototypes). Each time they evaluate and improve their original designs, they are engaging in and learning the importance of persistence. By leading students through the often-redundant procedures of the engineering design process, teachers can ensure that the students are challenged by the same problem-solving stances taken by engineers who return to the problem while often modifying each new prototype or solution. In replicating this re-creative process, students acquire persistence and flexibility in thinking that leads to success. In effect, they “re-learn” a positive sense of self-efficacy, persistence, and optimism, which they may then apply to other content area studies. Tough (2011) explains that students who exhibit these non-cognitive skills along with being well behaved, hard working, and respectful become people who act that way, obtain higher grades in school and acquire better jobs after completing school.

As students develop these cognitive skills through the use of engineering and other STEM related lessons, they not only acquire non-cognitive skills, but also develop an interest in continuing STEM education. Palmer, Maramba, and Dancy (2011) argue that America must strongly focus on increasing college access, retention, and persistence among traditionally underrepresented minorities (URM) in the sciences and science education by promoting science education to girls, students of color, students of poverty, and students with disabilities. Using STEM-integrated education, with specific focus on principles of engineering as the vehicle in which to teach students with low self-efficacy, ultimately provides them with the non-cognitive skills needed to become successful in school and to access the STEM workforce or college majors that lead them to productive work and careers.
The purpose of this Project is to introduce the ways in which teaching the principles of engineering design that are components of the NGSS will enable K-5 educators to promote students’ development of non-cognitive skills and continuing interest and pursuit of STEM education. The Project responds to the many questions that will arise as K-5 educators respond to the implementation of NGSS:

1. What are the non-cognitive skills that all students must acquire if they are to successfully achieve within the NGSS disciplines of science, technology, engineering and mathematics?

2. What are the most effective curricular and instructional methods to promote NGSS achievement along with the self-efficacy, persistence, optimism, and motivation of at-risk K-5 students?

3. How might educators assess the impact on the way in which these students engage in the engineering design practices?

4. How can educators positively affect the knowledge, skills and dispositions (KSD) of at-risk students as they provide STEM-integrated curriculum and instruction that stresses their engagement in the non-cognitive skills required for success in the NGSS?
CHAPTER TWO: LITERATURE REVIEW

The following chapter presents the scholarly literature and research on the use of STEM education in K-5 schools to prepare students for the 21st Century job market. The Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS) have included content standards (i.e. math practices and engineering standards) that promote problem solving and interest in STEM related fields. In addition to the academic content that students are required to learn, there are many non-cognitive skills associated with successful academic performance, and the outcomes of knowledge skills, and dispositions (KSD) that are integral to the NGSS. There are additional factors that predict success in school, beyond content knowledge and academic skills, which impact students’ performance in school. These factors have been called non-cognitive because they are not measured by cognitive tests such as IQ or standardized academic examinations. There have been many studies that have sought to learn and show evidence of how these non-cognitive attributes directly impact students’ current school performance and their future academic outcomes (Bandura, 1986; Bandura, 1997; Chemers, Hu, & Garcia, 2001; Collins, 1982; Pajares, 1995). At risk students who have developed low-self efficacy may benefit from learning the 4C’s (collaboration, creativity, communication, and critical thinking) associated with CCSS and NGSS, which in turn develop the non-cognitive skills that students need to be successful college students and future employees.

Why STEM Education?

America’s status as the world’s leader in innovation may be at risk as our country’s development in STEM-focused industries continues to decline (Carnevale, Smith, & Strohl, 2010). Norman Augustine, chair of the Committee on Prospering in Global Economy of the 21st Century, stood before the Committee on Science in the U.S. House of Representatives in 2005
and stated “America today faces a serious and intensifying challenge with regard to its future competitiveness and standard of living” (pg. 1, para. 4). Americans are in competition with individuals from around the world now that there are so many jobs that can be found overseas at a better salary. Even though the United States has the best universities for studying STEM-based subjects, we are still unable to produce enough STEM workers to fill the number of local, state and national jobs available in these fields (i.e. computer science and engineering). The Georgetown University Center on Education and the Workforce shows that by 2018, we will need 22 million new college degrees to fill these open positions but we will fall short of that number by at least three million post-secondary degrees. As employers demand employees with high levels of education and training to fill their positions, jobs available for workers with postsecondary education are projected to increase from 28% to 63% in all occupations (Carnevale et al. 2010). Without enough Americans to fill these jobs, American companies now outsource many of their positions to countries worldwide. Also, it is disconcerting to know that the United States has dropped behind China and India in the number of engineers supplied to the workforce (Hughes, 2009). With engineering and technological fields driving our economy it is imperative that these numbers are increased through STEM education in K-12 classrooms. Gordon (2007) argues that in order to ensure future economic success and a high standard of living, our nation’s education system must provide students with a solid mathematics and science education that prepares students to be successful in science and engineering related careers.

Unfortunately, U.S. students have a long way to go before they can be successful in college-level courses in science, mathematics, and engineering. The release of the Common Core State Standards (CCSS) in 2010 was the first time the majority of states within the U.S. agreed on what students should be learning in order to be college and career ready. These standards
address the core academic knowledge and the complex thinking skills that are required for success in the 21st century (P21 Common Core Toolkit, 2015). The CCSS integrates rigorous core academic content mastery along with critical thinking, creativity, communication and collaboration (4C’s). In addition to the CCSS, Pruitt (2015) argues that the Next Generation Science Standards (NGSS) offer a great opportunity for students to discover a love of science and help them understand the world around them. Pruitt explains that the NGSS allows for science to be learned coherently by connecting the different disciplines together. In doing so, students will become able to connect physical science with Earth science and better understand the phenomena that make science instruction interesting and fun. The NGSS has also incorporated engineering design principles into the science disciplines at all levels from kindergarten to grade twelve. By incorporating engineering into K-12 education, students will better understand how science and engineering can be used to address major challenges that confront our global society today and help inspire students to solve those challenges in the future (NRC 2012, p.9). In addition to sparking interest in the study of STEM or future careers, the NRC (2012) has found that engaging in engineering design provides an opportunity for students to engage in the 4C’s, which in turn, allows for the integration of instruction on non-cognitive skills.

**Non-Cognitive Skills**

**Self-efficacy**

The capability that humans have for self-reflection is what Bandura (1986) argued makes humans unique. Through self-reflection, people can evaluate and alter their own thinking and behavior. Self-evaluations include perceptions of self-efficacy, which Bandura (1997) described as “the belief in one’s capabilities to organize and execute courses of action required to produce
given attainment” (p. 3). Self-efficacy therefore includes the beliefs about one’s ability to successfully perform a given task or behavior. As such, self-efficacy measures focus on performance capabilities rather than on personal qualities including other psychological characteristics. An example is peoples’ ability to judge their capabilities in order to fulfill given task demands when solving a math problem. Efficacy beliefs influence the particular courses of action a person chooses to pursue, the amount of effort that will be expended, perseverance in the face of challenges and failures, and the ability to cope with the demands associated with the chosen course (Chemers, Hu, & Garcia, 2001). Unfortunately, students who have low self-efficacy in the classroom will easily give up when faced with challenges and difficult tasks instead of coping and persevering in order to succeed. Furthermore, they make premature judgments about their future ability to succeed in the challenge area, which results in lost opportunity to achieve or even excel in that area.

According to Pajares (1995) the perceptions that someone has of their self-efficacy will influence their behavior in three important ways. First, self-efficacy influences choice of behavior. A person will engage in tasks in which he feels confident and competent and avoid tasks that he does not. Second, self-efficacy will affect how long someone engages and perseveres in an activity. The higher the sense of self-efficacy the longer someone will persist in a task. Lastly, self-efficacy influences thought patterns and emotional reactions. If someone has a high sense of self-efficacy they will approach difficult tasks with confidence and serenity instead of anxiety.

These behaviors can be observed in students on a daily basis both inside and outside of the classroom. For example, students who have high self-efficacy engage in all tasks presented to them with confidence and will work on the task until it is completed. Students who have low
self-efficacy will comply when working on tasks that are considered easy or more simple but when given a task that they feel is challenging or too difficult they will begin to show signs of stress, avoid the task, or give up on the task after a short amount of time. The primary goal for educators as CCSS and NGSS are implemented is to assure that all students are enabled to persist in rigorous assignments, feel confident while completing them, and work for an extended period of time without giving up. This is an important goal because according to Zimmerman (2000) academic self-efficacy is related to students’ confidence in mastering academic subjects, which in turn predicts grades in schools, and is later correlated with students’ choice of majors in college.

Bandura (1997) has argued that self-efficacy leads to higher goals being set and achieving higher goals, thus increasing the positive effects of self-efficacy by providing an evaluative context to aid self-regulation. Bandura (1997) also has argued that a high sense of coping efficacy encourages individuals to adopt courses of action designed to change hazardous environments. In other words, people with high efficacy are less likely to become stressed to the point that they become immobilized with anxiety. Students who are not able to self-regulate and feel anxious when engaging in academic related tasks, often sit at their desks and “fearing everything attempt nothing” (Quintilianus, 1878, p. 91). These students are unable to initiate the work required by a given assignment and inevitably, run out of time and are unable to complete the assignment.

Along with higher goal setting, self-efficacy beliefs are also related to an enhanced ability to use effective problem-solving and decision-making strategies, to plan and manage one’s personal resources more efficiently, and to entertain more positive expectations. Instead of seeing demanding situations as threats and becoming fearful, those with higher self-efficacy will
use coping resources to see the situations as challenges (Chemers, Hu, and Garcia, 2001) and will preserve and use problem-solving to meet those challenges. Chemers, Hu, and Garcia (2001) sought to on first-year college students, they sought to investigate areas of academic self-efficacy, optimism, and challenge-threat evaluations on first-year college students immediately after completing their first quarter of university work and also in a follow-up at the end of the first year. Based on their findings, self-efficacy and optimism were integral to first-year college students. Self-efficacy directly and indirectly showed powerful correlations to academic performance and to personal adjustment. Students who had confidence when entering college, performed significantly better during their first year than students who had less confidence.

Like first-year college students, students engaging in the engineering design process and other STEM related projects must also develop self-efficacy and optimism. Instead of giving up on projects that they are being presented with, they must learn how to see each project as a challenge and persevere while using problem solving in order to successfully meet those challenges.

The ability to make a decision about a major in college or a career decision takes a high level of self-efficacy (Lent, Brown, and Larkin, 1986). In the case of STEM-related majors and careers, many students have often turned away from these fields because of their perceived difficulty. Lent, Brown, and Larkin (1986) found that students’ beliefs about their ability to complete the educational requirements of various science and engineering fields were predictive of subsequent academic performance. One the other hand, students who had strong self-efficacy and confidence received higher grades and were more likely to persist in technical or scientific majors. Students who were more undecided about their majors, experienced less confidence in their ability to complete the tasks necessary to make career decisions (Lent & Larkin, 1984).
Working strenuously toward challenges, providing effort despite failure, and maintaining interest is what Duckworth, Peterson, Matthews, and Kelly (2007) refer to as “grit.” Children who exhibit a high level of grit work harder and longer than their peers who are less “gritty.” In a study performed by Duckworth et al. (2007) the best predictor of whether freshman cadets would return to West Point after their first, grueling summer-training course was grit. The findings of these studies indicate that self-efficacy along with other cognitive factors, is very important to the educational and vocational behavior of students considering careers in engineering and science fields.

**Non-Cognitive Factors Related to Efficacy**

When educators understand the role of the non-cognitive factors that help students become successful in their future academic careers and in their professions, they seek to develop these characteristics through integrated STEM education. Educators have long recognized that students’ beliefs about their academic capabilities play an essential role in their motivation to achieve (Zimmerman, 2000). This has become especially important as educators are challenged to present learning environments in which students achieve in the various STEM disciplines. In essence, when students are enabled to successfully complete engineering projects they are acquiring the KSD required to access and complete STEM related majors in college. Hence there is a critical need for educators to develop students’ self-efficacy and non-cognitive skills.

Many researchers have found that in addition to self-efficacy there are other non-cognitive skills that are closely related and have a significant effect on students’ learning. These non-cognitive traits include optimism, persistence, tenacity or “grit”, and motivation.
Optimism

Optimism is related to psychological well-being because it is the tendency to hold positive expectations even when someone is experiencing adversity or difficulty in their lives. Individuals with a more optimistic explanatory style are more likely to take initiative in different situations, persist even under difficult situations, take risks, be decisive, and engage in problem solving (Yates, 2002). Like many other non-cognitive traits, Seligman (1991) argues that optimistic and pessimistic tendencies are formed early and throughout childhood and have a large impact on the health, motivation, and achievement of children and adolescents.

In a study conducted over a three-year period, Yates examined the relationships between students’ optimism, pessimism, and achievement in mathematics. Pessimism was identified in students at the primary-school level and studied as to the way in which it influenced their achievement in mathematics. The study was conducted at the students’ current level and followed them as they became older and moved into middle and secondary school. When pessimistic students encountered negative events they were more likely to exhibit helpless behaviors such as passivity, sadness, and lowered self-esteem.

This finding is consistent with the work of Dweck, Walton, and Cohen (2015) who have found that students view intelligence either as a fixed quantity they possess or do not possess (a “fixed mindset”) or that intelligence is malleable which can be increased with effort and learning (a “growth mindset”). It may be that students, who develop a pessimistic attitude towards math and other content areas during their elementary years, can remain pessimistic and acquire a “fixed mindset” that persists throughout their academic careers and adulthood. If students are to form a positive relationship with the STEM disciplines along with the related academic areas,
educators must seek to create learning environments in which forming a “growth mindset” begins as early as the primary grades.

Yates (2002) has found that students in the early primary school years who viewed positive events occurring in their academics lives as long lasting, and under internal control, versus negative events as short duration, were more likely to develop task- oriented behaviors that led to higher achievement. Therefore students who have a positive experience with engineering and other STEM disciplines at a young age will likely develop higher self-efficacy and optimism. Yates (2002) recommends identifying pessimistic students as early as possible so that their negative explanatory styles towards mathematics and other content areas can be interrupted and intervention can begin to reverse their thinking. Instead of waiting for negative explanatory styles of development and then providing intervention for students, it is possible that providing STEM education at a young age, intervention will not be required.

**Persistence**

Another non-cognitive trait that is related to self-efficacy is persistence. Bouffard-Bouchard, Parent, and Larivee (1991) found that high school students with high self-efficacy for problem solving demonstrated greater levels of persistence than students with lower self-efficacy. Additionally, Collins (1982) studied students who were identified as low, middle, and high in terms of mathematics ability. After being instructed, the children were given new problems to solve and an opportunity to correct the ones that they had previously missed. Collins found that regardless of the ability of the students, children with high efficacy persisted longer and used more problem-solving strategies compared to those with low-efficacy. Both studies highlight the importance of problem solving and persistence. Students’ involvement in STEM integrated projects may increase their ability to solve challenging problems in a variety of ways
and may teach them to evaluate and improve (persist) instead of giving up when the challenge becomes difficult.

High levels of involvement in subjects and classes have been shown to be a predictor of learning gain (Tinto, 1997). Meaning, the more students are invested in learning such as STEM related activities and the higher level their effort is, the more students will learn. In addition, involvement has been found to matter the most when it comes to persistence. The more academically and socially involved a student is, the more he will interact with other students and faculty, and the more likely he is to persist. When students find these interactions positive and feel that they are integrated into the class or school and each feel like a valued member, they will persist even more (Tinto, 1998). Positive academic mindsets motivate students to persist at schoolwork and lead to improved performance.

**Motivation**

Research has found that the lack of motivation to do well in school has implications for the well being of students later in life and also for the economic growth of the country. According to Dweck, Walton, and Cohen (2014), when non-cognitive factors including self-efficacy, optimism, and persistence are in place, students will be motivated. Internal motivation that students can continue to carry with them in the form of mindsets and skills that they learn (and that educators can promote) are more effective than trying to motivate students through stickers, treats, money and other rewards. In fact, Dweck (2014) has brought together all the non-cognitive factors under an umbrella term, “academic tenacity.” She defines tenacity as the ability to work hard, set longer-term goals, and withstand challenges in order to persevere towards goals. While it is possible that many students have already acquired these characteristics when they enter school, for many these remain mindsets and skills that need to be learned by doing in
order to improve their achievement, which can be reinforced by teachers through the continuous implementation of STEM-engineering projects.

In order for students to be successful they must develop a number of non-cognitive skills. These skills can be developed starting in the primary grades by integrating STEM education; specifically, the engineering design process, which will enable teachers to focus on teaching standards while also working on students’ non-cognitive skills. The next section of the literature review discusses how STEM education helps to reinforce and develop students’ non-cognitive skills.

**Non-Cognitive Skills and Next Generation Science Standards**

In this day and age when testing requires educators to give up previous instructional time and K-5 teachers are overwhelmed by the amount of content that must be taught in order to prepare students for the latest form of standardized assessment, instruction becomes focused on academic readiness. However, Kyllonen (2012) points out that when educators focus on academic skills alone, students miss out on the instruction of non-cognitive skills, which are not measured by aptitude and achievement tests and which may not be an accurate predictor of student success in STEM related fields. The Bureau of Labor Statistics projects that by 2018 there will be more than three million job openings in STEM (Maltese and Tai, 2011). Looking ahead at the kinds of employment opportunities students will have in STEM related fields based on the needs of the growing global economy, it may become more important than ever for educators to start to consider what employers want. What are employers looking for and how can educators begin to effectively prepare their students now? In a survey conducted by Millennial Branding (2012) of 225 employers, when asked about the top four skills they were looking for in prospective employees they responded: communication skills, positive attitude, adaptability to
change, and teamwork skills. These non-cognitive factors may be indicators of positive workplace outcomes and employability, as well as predictors of academic success.

The *Next Generation Science Standards* require that K-12 science education is built around three dimensions: scientific and engineering practices, crosscutting concepts that unify science and engineering, and core ideas from the disciplinary areas of physical science, life science, earth/space science, and engineering/technology (National Research Council, 2012). Buxton (2005) points out that in addition to new standards being taught, there is another shift has been an increased attention toward promoting enhanced science education among those groups of students who have traditionally been underrepresented in the sciences and in science education, specifically girls, students of color, students of poverty, and students with disabilities. Many researchers feel that in order to accomplish these standards and reach these groups of students, curricula must integrate real-world contexts and inquiry-based methods that will help students develop the skills and knowledge they require to be successful in today’s global economy (NRC, 2012). Science and engineering standards are helping to address that challenge.

The engineering design process is one of the many project-based approaches that will promote science learning inside the classroom. Not only will teaching engineering help facilitate meeting the new science education standards but it will also encourage students to construct solutions to real problems and work cooperatively with others to find solutions (Mooney & Laubach, 2002). Students learning how to solve problems and work in a group are developing non-cognitive skills that will help them to become successful in today’s global economy. In addition, students participating in design-based learning experiences are more motivated to learn, take more ownership for their learning, and develop reasoning skills (Doppelt, 2003).
When students are engaged in design-based learning experiences such as engineering projects, they learn non-cognitive skills naturally and are more open to utilizing these skills. It is a lot more difficult to get students to learn about optimism and motivation while learning other subject areas. However, it is the goal of this Project that these non-cognitive skills and overall growth mindset that are developed through engineering will slowly over time become utilized across STEM and other content areas and throughout the students’ lives.

Human behavior and intelligence are considered malleable. While it can be difficult at time to change behavior, it is not impossible. The most difficult part is getting students on board and accepting these beliefs and because of this, new policies, program supports, and materials are constantly being revised and developed in order to help them. While we know that students’ academic behaviors can change, the question remains how educators can best facilitate these changes in ways that will promote student learning.

**The E in STEM--Engineering**

Recognizing the importance of engineering education and the need for instructional materials that K-12 teachers could utilize to accomplish this goal, educators across the nation have started to create lesson plans, resources, and curriculum that address the NGSS engineering standards. For example, at the Center for Engineering Educational Outreach (CEEO) at Tufts University, Rogers and Portsmore (2004) have been working to integrate engineering into K-12 classrooms. Their study found that engineering motivates students to learn math, science, reading, writing, communication, and design skills by giving students ownership of a project or process.

Dr. Joannis Miaoulis has been vital to the introduction and development of engineering education in K-12 schools. After working as a dean and professor at the School of Engineering at
Tufts University, Dr. Miaoulis became the president and director of the Boston Museum of Science. Miaoulis helped create the National Center for Technological Literacy (NCTL) at the museum that in turn created curriculum and professional development to help teachers integrate engineering and technology standards (Miaoulis, 2013, para 7). With the creation of Engineering is Elementary (EIE) Miaoulis (2013) believes that introducing engineering education will improve student achievement in science and mathematics, increase awareness about STEM related careers, and help increase science literacy (pg. 1, para 4). At the House Subcommittee on Early Childhood, Elementary and Secondary Education in 2013, Miaoulis pointed out that by teaching students the engineering design process, students are challenged to solve real world problems when faced with limited resources and constraints. Inevitably students need non-cognitive skills like persistence if they are going to persist in engineering a solution to these problems.

By teaching students the steps of the design progress, especially steps four and five, which are to optimize, re-design and communicate and disseminate the solution, students are given effective tools for approaching problems and creating much needed, real world solutions. Through hands-on engineering projects, students are learning how to be curious, have enthusiasm for learning, gain self-confidence, learn how to find answers, and test the validity of those answers. In other words, they are developing non-cognitive skills. Engineering may provide a foundation in effective life skills that children need to succeed in the global workforce. These life skills include but are not limited to self-control, conflict management, and decision making (Schunk and Meece, 2005).

During K-5 engineering projects, for example, students are required to set goals for their designs. They are asked to come up with a solution for the problem with which they are
presented. Asking students to set proximal goals ultimately enhances self-efficacy and skill development more effectively. In addition to improving their efficacy belief and achievement, encouraging students to set their own goals, reinforces their commitment to reaching and attaining those goals (Zimmerman, 2000).

Schunk’s (1983) research is in agreement and adds that as children observe their progress while engaged in a cognitive learning task, they experience a heightened sense of efficacy. This is similar to engineering projects in that students are evaluating their progress and development of their project in order to figure out what changes need to be made. While engineering and other STEM related projects can initially be used to help teach content area and work on non-cognitive skills, the exposure to STEM may further inspire students to continue learning more about STEM and pursue higher education and/or a profession in the field.

**Pursuing STEM Education**

Some lucky individuals can look back on their primary and secondary educational experiences and recall an experience or a teacher that inspired them or pushed them in a direction that changed their life for the better. Maltese and Tai (2011) have found that the type of experiences students have in their STEM classes during high school may play a large role in who decides to remain in the field and who leaves STEM. While high school grade point average (GPA) and high school educational aspirations were positively associated with men and women choosing to major in STEM, what is more interesting is that positive attitude toward mathematics and the number of mathematics courses completed were also positively associated with a STEM major (Maltese and Tai, 2011). This study suggests that it takes grades and mindset in order to go into STEM related fields, and that increasing students’ non-cognitive skills and creating a positive, growth mindset surrounding STEM education can and do go hand in hand.
Many researchers have found that the middle school years are integral to mathematics and science achievement. Singh (2002) feels that grades five through eight are critical for American students regarding achievement in science and math. Since math and science education is sequential by nature, performance in these subjects in middle school becomes critical if students are to take advanced courses in high school. Therefore Singh (2002) strongly believes that students must not only develop an interest in mathematics and science early but also have a positive attitude about learning if they are going to have career aspirations in mathematics, science, and engineering after they leave the school setting.

Maltese and Tai (2011) found that from an early age, interest in pursuing careers in STEM might provide the momentum in order to drive students towards the STEM pipeline. Therefore it is imperative that educators not wait until middle school to expose students to STEM experiences that assure that they acquire a growth-mindset in the K-5 years.

Since in most cases students have already made up their minds regarding science and math by the time they are in high school, school-related variables such as academic engagement, perceptions and attitudes, and knowledge of the role that mathematics and science achievement play in future career opportunities must come in elementary or middle school (Singh, 2002). According to Singh (2002) the predictors of achievement in mathematics and science are: self-concept, confidence in learning, interest and motivation, and self-efficacy. That being said, there are some ideas for intervention such as increased academic time, hands-on activities, coverage of more topics relevant to students, greater use of cooperative learning strategies, the use of varied pedagogical methods, and providing organization and support (Maltese and Tai, 2011). Additionally by the eighth-grade, attitudes toward school, patterns of school attendance, and participation in classroom activities has already been established for most students. Therefore,
research suggests that it is important to develop strategies and policies to improve attendance and participation in classroom activities in the K-5 years. Elementary school educators have the opportunity to alter students’ negative attitudes by promoting better classroom practices and by providing integrated experiences in these subject areas.

The literature provided a review of specific research on non-cognitive skills and presented the case for adapting STEM integrated lessons into the curriculum. The next section will present the methodology utilized in the creation of the website designed for this project. The methodology will present descriptions of each facet of the website created.
CHAPTER 3: METHODOLOGY

About the Project

To assist other educators in learning about the non-cognitive skills and Next Generation Science Standards associated with teaching students 21st Century Skills through STEM education, I created a website STEM and 4C’s (www.stemand4cs.weebly.com). Each page of this website has been carefully crafted for educators who are new to STEM education. When visiting STEM and 4C’s, educators will be given background information for understanding why STEM education is important and how the Next Generation Science Standards will address our country’s need for employment in STEM-related industries. One of the biggest changes for educators teaching kindergarten through fifth grade will be the addition of standards that address the engineering design process. Not only does this website provide many lessons and resources for teaching these new standards, the website will also explain the non-cognitive standards that students develop when working on projects that involve the Four C’s (collaboration, communication, critical thinking, and creativity). These 21st century skills will not only prepare students to be college and career ready but will also ensure that all students, regardless of gender, race, socio-economic background, or special need, have access to the STEM workforce.

About the Author

The “About Me” section gives viewers accessing my website some background about my professional and academic history. I want teachers to know that as a fellow educator, I too feel the pressures coming from the district, state assessments, and standards. Since, California adopted the Common Core Standards in 2010 I, like many other educators, have been learning how to incorporate these new standards into my classroom and learn the new curriculum associated with them. In the past, I spent most of the day in my classroom focused on teaching
students to read, write, and solve math problems because on paper these were the areas where my students struggled the most. One day, though, I asked students in my classroom to write their name on their spelling test and a student responded with, “What’s the point? I’m just going to fail.” I realized at that moment that while I had been doing my best to educate my students and get them to be proficient readers and writers, I was falling short when it came to addressing their social skills or soft skills that could not be addressed through assessments like the Smarter Balanced Assessment Consortium (SBAC). Until I could focus on the needs of the Whole Child I knew that my students would not be successful in college and into their careers. This happened at the same time I entered the STEM Curriculum and Instruction graduate program at CSUN. Not too long afterward, I realized that through STEM integrated instruction I could not only teach the standards but at the same time I could also address students self-efficacy and other non-cognitive skills. In my experience, teaching students how to be persistent and problem solve during engineering design challenges has translated to other subjects where students typically feel frustrated and as a result, give up.

**Home Page**

The home page contains important information that summarizes my project to the reader and at the same time, hooks them into learning more about STEM integrated education. The home page also helps the reader utilize the resources that have been provided for them throughout the website. I felt it was important to first provide research that explains why incorporating STEM education in K-12 classrooms around the country is so vital to the global
The Georgetown University Center on Education and the Workforce has shown that by 2018, we will need 22 million new college degrees to fill the open positions in STEM related degrees but we will fall short of this number by at least three million. This means that these are the jobs that are open and available to our students for which we need to prepare them. Since there are unfilled jobs in STEM related fields, companies must inevitably outsource work to other countries around the world where there are people with the training necessary to fill these jobs.

In order to ensure America’s future economic success, our education system must provide students with a strong mathematics and science education that will prepare them to be successful in science and engineering related careers (Gordon, 2007). The first step in promoting STEM education is giving educators this background information to understand why it is so important. In addition to explaining the importance of STEM education on the homepage, I also provide an explanation of the relationship between STEM and fostering the development of non-cognitive skills. A STEM integrated education that focuses specifically on engineering will provide students, especially those with low self-efficacy, the non-cognitive skills needed to become successful in school and enable them to access the STEM workforce or college majors that will better prepare them for productive careers.

**NGSS**

Many educators, including myself, are still comprehending the shift to the Common Core Standards. Learning that there will now be another shift in the standards we use to teach science, can be overwhelming. Hence, the NGSS page of my website provides information arguing that
the adoption of the NGSS is the next step needed to provide our students with the education they require in order to properly prepare them for science related fields with future job openings. I have chosen to use a short, YouTube video that provides an overview about the NGSS Standards. This video does a great job of explaining how the standards will not only help students become prepared for college and their future but also improve science achievement and understanding across grade levels K-12. I also briefly mention the “E” in STEM, engineering, because in the past engineering was taught separately from the sciences and only to secondary school students.

One of the biggest and most exciting shifts found in the NGSS is the K-5 engineering standards and practices embedded throughout the performance expectations. Understanding how to read and teach the new standards will take a good deal of professional development and collaboration with fellow educators. For that reason, I did not provide too much information. For the educators who are ready to delve deeper, I provided a link to the Next Generation Science Standards website where there are many articles, videos, and resources to help support educators as they begin to incorporate the standards into their own classrooms.

Engineering

When I first learned about STEM, I felt I had the least amount of background knowledge in, and experience with engineering. Now I can say that engineering has become one of my favorite subjects to teach as well as my students’ favorite activity in which to participate. Not
only does engineering provide students an opportunity to problem solve, but it also gives them a chance to go through the engineering design process in order to design and build products that can be used in the real world. As we think about the global issues that are affecting our world now such as climate change, pollution, and sea level rise we must begin preparing our students now how to collaborate, communicate, and think creatively and critically in order to find solutions.

Engineering design challenges where students are learning how to work as a group and redesigning prototypes provides a huge opportunity for students to develop non-cognitive skills they may lack, while concurrently learning how science and engineering can be used to address major challenges that people face. When students are engaged in design-based learning experiences such as engineering projects, they learn non-cognitive skills naturally and are more open to utilizing these skills. It is a lot more difficult to get students to learn about optimism and motivation while learning other subject areas. However, as these non-cognitive skills and overall growth mindset develop slowly over time through engineering, the skills will become utilized across other content areas and throughout the students’ lives.

This page was also a great opportunity to explain the differences between engineering standards taught in grades K-2 compared to grades 3-5. Through the diagrams provided by the NGSS website, educators can see the progression of the engineering design process and how that is slowly rolled out and built upon throughout grades K-5. By the time students reach high school they will not only be prepared for upper level science courses but more importantly, interested and excited to enroll in these courses.
Non-Cognitive Skills

District leaders are constantly placing more and more pressure on educators to prepare their students to perform well on high-stakes assessments. It has gotten to the point where focusing on the whole child and the development of soft skills often gets pushed aside or placed on hold so that there can be more teaching time for the academic subjects. However, it is now evident through the number of students who are unable to graduate from college that academics and SAT scores alone cannot predict a student’s success. If students have low self-efficacy in the classroom they are at increased risk for giving up when faced with challenges and the same may be true once they reach college. Students with low self-efficacy must be taught to cope and persevere if they are going to succeed as a student and employee.

This page discusses the acquisition of non-cognitive skills and points out that self-efficacy, persistence, optimism, and motivation are non-cognitive skills that are most commonly associated with academic success, achievement, and retention in STEM related fields. Self-efficacy includes the belief in oneself to successfully complete a task or assignment. These beliefs will also influence a student's decision or course of action. Meaning a student with low self-efficacy will not only find upper division science and math courses difficult but perhaps refrain from taking them in the first place. Optimism is an important non-cognitive skill and closely linked to self-efficacy because if a student stays optimistic or holds onto positive expectations about the outcome of an event or task then they are more likely to persist while problem solving during difficult situations. Someone who has developed a pessimistic attitude may exhibit a passive
attitude towards learning and school. Closely linked to feelings of optimism and pessimism is motivation. A student who is optimistic is more likely to feel motivated to complete a task, even if that task is difficult, compared to a student who is pessimistic and is convinced that they are not going to be successful. Students, who are optimistic, have high-self efficacy, and persistent will be more likely to not only persist but also say motivated to do so.

The primary goal for educators as they implement CCSS and NGSS is to assure that all students are able to persist in rigorous assignments, feel confident while completing them, and work for an extended period of time without giving up. By implementing STEM integrated lessons and engineering design challenges in their classrooms teachers are also developing students’ non-cognitive skills at the same time. Learning how to cope with an engineering challenge and persevere throughout the redesign process, will not only increase a student's self-efficacy and optimism but will likely help them stay motivated while learning the challenging standards that the NGSS has developed. As a fellow educator, it makes my job a bit easier if I know that my students are learning a number of standards all at the same time. This is a great opportunity for educators to involve students in STEM integrated projects, which will teach them to evaluate, improve, and persist instead of giving up when the challenge becomes difficult. At the bottom of the page I decided to provide educators links to the 16 habits of mind and The ASCD Whole Child Initiative in case they are interested in learning more about how STEM integrated education can address a child’s needs and the skills that are required to become successful in the 21st Century.

Lessons

This section of the website contains lessons that are based on the NGSS standards and are grade-level friendly. All of these activities incorporate the Four C’s (communication,
collaboration, creativity, and critical thinking), which are present in the CCSS as well. By choosing one of the lesson plans provided on this page teachers will using STEM integrated instruction as a way of promoting non-cognitive skills. The nine lessons that I chose to include on the website are just a small sample of the engineering challenges and STEM integrated lessons that are available to educators. I chose to share lessons that I have used personally in my classroom and that my students have enjoyed completing. I created some of the lessons through the STEM graduate program and the others were created by NASA and Code.org.

Above each of the lessons is the title, the non-cognitive skills that can be reinforced throughout the lesson, and the link to where the original lesson plan can be located. While there are suggested grade levels for each of the lessons, I chose not to highlight the grade level because I feel strongly that many of these lessons can be adapted for younger or older grade levels. Many teachers fear that they will choose a lesson that some of their students have completed in a previous grade but I believe that students may have a completely different learning experience even if they have been exposed to the same material before. Students will have different background knowledge going into the lesson, they might be working with a different group of students who have different ideas, and the challenges can always be tweaked to change the difficulty of the activity.

The first lesson is One Man’s Trash is Another Man’s Treasure, which I created for an engineering course. This lesson is an engineering design challenge where students must think about a piece of trash that can be re-purposed into a useful item. I like this lesson because it requires very little preparation on the teacher’s part but it also requires students to think critically and creatively about an everyday item that would normally end up in the trashcan. Pollution and
overfilled landfills are very real problems that our students and future engineers must start to think about.

*Launch It* is an engineering design challenge found in NASA and Design Squad’s *On the Moon* curriculum. Using two straws, a balloon, and tape, students have to design and create a rocket that could be launched in order to hit a target. This was a difficult challenge for my students because the prototype had to be airtight in order for it to be successful. For this reason, this is a perfect activity for addressing persistence. When students are not successful the first time in creating their rocket and launcher they must continue to redesign until they are successful.

I adapted the third lesson *Touchdown*, created by NASA, to meet the needs of my second graders and teachers who participated in a professional development about engineering that I led. This is a great example of how design challenges can be adapted in order to change the difficulty. The lesson plan suggests showing students how to create a spring by folding an index card. When I used this lesson with my staff, I did not show them how to create a spring because I felt that some of the teachers could come up with the idea on their own. However, when I replicated the lesson with my second graders not only did they not think of the spring idea on their own but they also decided not to use the idea after I showed them how to do it. Students were busy listening and collaborating with their partners about how they were going to design and create their own shock absorbers and did not need my ideas.

The next lesson, *Building with Pasta*, is an ideal challenge for fostering communication skills among students in grades K-5 with limited resources. With just uncooked spaghetti, marshmallows, and tape students must construct the tallest tower possible. This was one of the first challenges that I gave my students this year and it was fascinating to observe which students
worked together, which ones chose to work independently, what communication skills were already present, and which skills needed to be developed. The lesson plan is suggested for grade levels 5-8 because of the math skills that can be incorporated into the lesson.

*Pasta Rovers* was a lesson that was a great learning experience for my students and for me as an educator as well. In this challenge, students must create a rover using only pasta, glue, and disk-shaped candy mints for wheels. Once the rovers are designed and built they must roll down a ramp and travel at least one meter. For primary students, I recommend using white glue and older students can use a glue gun. I was very worried when we began this challenge because I did not think that second grade students would be able to design the axle of the car in a way that would allow the car to roll. However, I was quickly proven wrong when a group of girls working on their design were able to figure out how to put spaghetti through the mints allowing the mints to roll. This is a great example of how new standards and curriculum are more difficult for teachers then for students. Students showed a lot of persistence and collaboration throughout this challenge even when pieces of pasta fell off their rover or when their rover slid instead of rolled down the ramp.

In addition to the coding activities that are available online to students at Code.org, there are also “unplugged” activities included throughout their courses that do not require technology. The next lesson, *Building a Foundation*, is one of the unplugged activities where students learn persistence through building a foundation that can hold up a book. The only problem is that the materials that students can build their foundation out of are gumdrops and toothpicks (marshmallows and toothpicks could be used also). Students spend thirty minutes working with a partner to build a foundation that will hold the book that the class selected. This is a great
example of a powerful lesson that incorporates engineering and non-cognitive skills and only takes about 30 minutes to complete.

Similar to Building with Pasta, Stacking It Up is another great lesson for educators who are just getting started with engineering, or for classrooms that need more work with communication and collaboration. Using only a rubber band and string students must figure out how to first, unstack the cups and then place them on top of one another to make a structure that looks like a pyramid. The major constraint for this challenge is that students are not allowed to touch the cups with their hands. Groups must work together and communicate in order to utilize the materials they were given and complete the task.

Each time I use the Soda Straw Rocket, created by NASA, I am reminded of how deceptively simple this challenge is. Students are required to create their rocket using the template for the body and the fins that are provided on the directions page. For younger students, creating the rocket and measuring the distance that it can fly might be enough of a challenge. But for older students, this project can become very challenging once one considers all the variables that can affect the distance the rocket flies. What is the length of the rocket? What is the length of the nose cone? What is the angle at which you should launch your rocket? As students start to test these variables and come up with their own they begin thinking like engineers and scientist. This is a great activity that requires creativity and perseverance in order to complete.

Rover Races is a lesson that originally was created by NASA for fifth through ninth-grade students that I adapted for second graders. This activity focuses on flexibility in thinking and communication as students work together to establish communication procedures with a “rover” on Mars. Students take turns acting as the rover driver to try to get their rover (made of students) through an obstacle course using a series of commands. In addition to learning an
important lesson about specific and precise directions, which is a lesson in computer science, students will also be using non-cognitive skills such as encouragement, active listening, and perseverance while working with their team.

Assessments

It is important to align assessments with the engineering practices. The assessments provided on the website include examples of rubrics, checklists, and a learning log that can be used by educators to assess the non-cognitive skills of students during STEM integrated lessons. Depending on the grade level, students can also use the assessments in order to rate their partner, group members, or even use it as a self-reflection. It is important to let students know ahead of time before the project begins what the social skills and habits of mind expectations are. Making the expectations and rules clear for the students will both avoid confusion during the activity and give the students social skills to focus on throughout the task.

The rubrics provided on the assessment page provide great ways for students to be assessed using a scale from 1 to 4. “Rate Your Mates” is a rubric that uses child friendly feedback in a way that allows students to reflect on the members in their group and the work and contribution that each member played. This is a great example of how to keep each member in a group accountable for working throughout the project. The other rubrics are examples for how a teacher may rate students’ habits of mind at three different grade levels (Pre-K, K, and 3rd).
A checklist is another example of an assessment tool that educators and students can use to assess non-cognitive skills. The first checklist that I provided could be used by a teacher or student and adapted to any social skills that the class is working on. This can also be a great way to have students self-reflect after a lesson. The group-processing checklist uses a race analogy in order to make the assessment more kid friendly. Students can rate their group according to three levels (slow start, gaining momentum, or won the race). This is a perfect example of how a group can work together to self-assess after completing an activity. The last checklist provided is an example of a cooperative group checklist that students can use to assess the members of their group and how they cooperated throughout the challenge. Cooperation can easily be switched to a different non-cognitive skill that the group was working on throughout a given challenge.

The last assessment tool I provided on this page is an example of a learning list. Learning lists and logs are excellent ways to find out more about a students’ experience during an activity or after a lesson. Students are asked to answer questions to help them reflect on their experience. I provided a learning list that consists of typical questions such as what did you like best and what did you like the least about this activity? More questions that are specific to the challenge and/or lesson may be added. Evaluating non-cognitive skills through assessments is a highly effective way to track students’ growth as they continue to engage in STEM integrated lessons.

**Supporting Literature**

The supporting literature page is a testament to my personal learning and growth in the STEM related fields. These books and many more not yet highlighted on this page have contributed to my expanding knowledge of what STEM means, why it is important, and how to implement it into my classroom. Some of the texts listed are for the educator and many are suggested read alouds for a class. I found that even though students are now being prepared to
communicate, collaborate, and develop their non-cognitive skills throughout an engineering design challenge, it has still become necessary to discuss these skills individually as conflict arises. For students who are unfamiliar with communicating with their peers or who have difficulty with problem solving, engineering can be very challenging. I have found that addressing these skills through literature has been very helpful. Books like *The Most Magnificent Thing* and *Mistakes That Worked* provide great opportunities to discuss the importance of staying positive and not giving up in the face of a challenge, even if things are not going exactly as planned.

**Resources**

In addition to the sample lessons provided, I wanted to provide educators a wide assortment of resources, workshops, and websites that they could explore when developing their own project. All of the websites and links listed, I have used personally and highly recommend. Jet Propulsion Laboratory (JPL), NASA/Design Squad, and NASA provide free lesson plans and workshops to educators, parents, and students. The workshops at JPL, for example, are for those educators ready to enhance their STEM knowledge and leave with lessons plans to implement right away. Even though Engineering is Elementary (EiE) and PEAK Student Energy Actions do not provide free resources, I felt that they were important resources to link to my website because both these
organizations are leaders in creating curriculum for educators that address the NGSS, especially engineering, and focus on real-world problem solving. I also provided a link to an article that discussed the difference between a fixed mindset versus a growth mindset. It is imperative that we as educators maintain a growth mindset when implementing these new resources in our classroom and seek to instill a growth mindset in our students.

**Blog**

Not only is it important for students to communicate and collaborate, it is also imperative that educators communicate and collaborate with colleagues at their school site and across school sites. Our experiences in implementing STEM integrated lessons and curriculum are valuable to others and must be shared in order to learn from one another. Using the blog, teachers can leave feedback about the resources and lessons that were provided in this webpage or can share other resources that they have found that are successful in their classroom. Each day I learn about new resources from my fellow educators that I hope to try in my own classroom. It is my hope that this blog will become a place where these ideas and experiences can be shared. Implementing STEM and engineering is new to so many of us and sharing our knowledge is a great way to make sure that all of our students benefit.
CHAPTER FOUR: PROJECT WEBSITE

There is a sense of urgency within the field of education to better prepare students to enter a 21st century global workplace. With STEM instruction on the rise and the adoption of the Next Generation Science Standards (NGSS) fast approaching, many teachers are searching for information and resources that they can use in their classroom. By surveying the teachers at my school, I learned that even though the majority of the staff felt strongly that it was important for all elementary students to learn about STEM and for them to be exposed to the design process, many of them were unfamiliar with the NGSS, engineering design process, and 21st Century Mind Skills. Also, many teachers said that they did not know where to look for STEM integrated resources and were in need of lesson plans and/or curriculum to teach the new standards. Based on this information I knew that I wanted to create a website that teachers could access in order to find information about STEM, NGSS, engineering, and find lesson plans and resources that could help them start implementing the new standards in their classrooms.

In addition to creating a resource that would be helpful to teachers, I also wanted to create a project that could not be thrown away or that would be forgotten. When I think about the resources that I use most often, they are documents, websites, or blogs that I can easily access on my computer instead of looking through files or piles of papers. Creating a website would make the information easily accessible to teachers everywhere and could be formatted in a way that would not be overwhelming to someone newly interested in STEM. Even though I had
no previous experience making websites, I felt that this would be a great opportunity to prove to myself that I could use technology in a way that was new to me and create a living resource that can always be changed and modified with new information and resources.

Creating a website through the free website host Weebly (www.Weebly.com) was made incredibly easy through their customizable menus and features. My vision for the website was that it would contain helpful information and resources in way that would be easy for everyone to navigate and find. The menu bar containing the titles for each page, is clearly visible at the top of the website making it easy for readers to access any information that they are looking for and travel from page to page.

STEM and 4C Education

There are also buttons found throughout the website that will link a viewer to other related pages. I have tried to include many of the free options that Weebly has to offer in an effort to make the website accessible to different kinds of learners. The YouTube video, for example, will speak to auditory learners while the photographs and diagrams will help visual learners. Kinesthetic learners will find the lesson plans provided helpful so that they can experiment on their own or get started with their class. In addition to the text and diagrams that I have included on the website, I thought it was important to include photographs of students engaging in these engineering design challenges. Implementing STEM integrated curriculum and design challenges can often seem impossible or overwhelming to many educators. It is my hope that seeing photographs where students are engaged, collaborating, communicating, and having fun will encourage educators to dive in and give an engineering challenge a try.
Using a website as the platform for this project will allow growth and change in the future. Every day I encounter more and more resources and this will continue as the NGSS becomes adopted by more states. *Weebly* has made updating and changing portions of the website very easy and simple which will enable me to keep my website up to date with current information. In addition to sharing this website with my school staff, I hope that educators from other schools will also find it helpful. By adding a blog to the website, I can promote a dialogue between educators who can share resources and best practices with each other.
CHAPTER 5: DISCUSSION AND IMPLICATIONS

Discussion

The website STEM and 4C’s (www.stemand4cs.weebly.com) was created as a resource for educators new to STEM education who are ready to begin implementing STEM integrated lessons into their classrooms. This website specifically focuses on helping educators implement engineering design challenges into their classrooms because it is a great way to begin teaching the NGSS standards while at the same time incorporating the Four C’s which in turn will instill the 21st century mind skills that students need to be successful in college and in any type of career they choose. Educators are provided with lesson plans that are easy to follow, very engaging, and require very little materials. The resource page provides links to other useful websites that contain more lesson plans and information for those ready to learn more. My advice to educators is to read the information provided on the website and try one of the activities I have provided on the lesson page.

Based on the post survey results I collected from a recent professional development on engineering design challenges, implementation of STEM and STEM related lessons will take time. Teachers are at varying levels in terms of how comfortable they are with technology and the new standards, which makes it difficult to know what kind of resources will be the most helpful. There are some educators who are ready to dive in and begin implementing engineering challenges right away while there are others who are requesting more professional development, time, and resources. This was one of the reasons why I decided to create a website as way to support educators. Those who are new to STEM can experiment with one of the lesson plans presented on the website while those educators who are ready to dive in and learn more about
NGSS can access other websites through the links embedded throughout each page. Creating a website gives me the ability to adapt my information, lessons, and resources over time.

**Implications**

In addition to providing meaningful information about the importance of STEM integrated lessons and engineering design challenges, my project explored the use of these activities as a way to develop and enhance students’ non-cognitive skills. Maltese and Tai (2011) found that the type of experiences students have in their STEM classes during high school might play a large role in who decides to remain in the field and who leaves STEM.

Teachers at the elementary and middle school level have a huge role in helping young students become interested in those fields and be prepared for these high school level science courses. The NGSS promotes the sequential learning of science and has been built on a framework based on the science that all students K-12 students should know (NRC, 2012). As educators at elementary schools we can start preparing our students now for high school and college by teaching them the foundational NGSS standards related to physical science, life science, earth science, and engineering design. By incorporating STEM education into our classrooms, we will also be providing students with the non-cognitive skills that they need in order to study STEM related fields in college and enter the STEM workforce.

Many parents often tell me that their children are not interested in STEM or pursuing a STEM related job so they do not see a purpose in including STEM education in the classroom. While I admit that a career in STEM might not be the right fit for every student, I do believe that some students may not be interested in STEM because of lack of exposure. I didn’t become interested in STEM education until graduate school. I often wonder what my major in college might have been or what career I might have chosen to pursue if I had been exposed to STEM at
an earlier age. Bridging the achievement gap in the United States involves making sure that all students, regardless of where they go to school, experience a quality education that will prepare them to be global citizens. Exposure to STEM education is necessary during the early years in their development because it will give more students the opportunity to take STEM related courses and enter the STEM workforce.

Regardless of what jobs students will hold in the future, there are many benefits for all children to receive early exposure to engineering design challenges and other STEM content. In a survey conducted by Millennial Branding (2012) of 225 employers, the top skills they were looking for in employees were: communication skills, positive attitude, adaptability to change, and teamwork skills. Being passive learners in a classroom will not develop these skills; instead, these skills will only develop by actively participating in the group and partner work involved with engineering challenges. Collaborating, communicating, utilizing critical thinking, and being creative in order to solve real world problems help to prepare students for the 21st Century Workforce.

A common concern that I hear from most educators is that there is not enough time in the day to teach everything that students are required to learn. I believe that the next step in STEM education is creating more resources that will allow educators to teach interdisciplinary units where science, technology, engineering, math, and language arts can be integrated together through Project Based Learning (PBL). One educator working in isolation cannot do this type of work. PBL units of this magnitude require educators working collaboratively in order to develop units that will meet multiple standards, cross different subject areas, and engage their students. As teachers begin to implement STEM integrated lessons in their classrooms and learn more about NGSS, I hope to begin to include examples of PBL on my website as well.
In the future, teachers will use the lessons from my website and incorporate other STEM integrated courses based on the NGSS into their classrooms. But more studies need to be conducted researching how the habits of mind and self-efficacy are related to STEM education. Throughout this project, my students that have experienced engineering design challenges have displayed more persistence, optimism, and motivation. Next steps would study how STEM education, specifically engineering design challenges, make a difference to the teachers’ practice and how it makes a difference to the students.
REFERENCES


Association for Supervision and Curriculum Development. (2014). Whole school whole community whole child.


