California State University, Northridge

How Sustainable School Gardening Enhances STEM Education

A graduate project submitted in partial fulfillment of the requirements

For the degree of Master of Arts in Education,

Elementary Education

By

Holly Putnam

in collaboration with Tanya Koch

December 2015

The graduate project of Holly Putnam is approved:

Ms. Wendy Kaufman	Date
Raymond Brie, Ph.D.	Date
Susan Belgrad, Ed.D., Chair	Date

California State University, Northridge

ACKNOWLEDGEMENTS

I would like to thank my committee members who have graciously supported my efforts and time in creating this project.

To my chair, Dr. Susan Belgrad with full gratitude for your time, patience, wisdom and everything you have taught me about STEM education and teaching. You have touched the lives of countless children by sharing your STEM expertise with teachers. I will forever be a reflective teacher because of you.

To Dr. Raymond Brie for your guidance and teaching throughout this program. Your passion for math and technology education has been an inspiration that stays with me in the classroom.

To Ms. Wendy Kaufman, for your encouragement, smiles and good counsel at school when I needed it the most. Thank you for being a bright and steadfast star!

My fellow STEM colleagues all of you are amazing teachers, and I have loved working with you. For my partner Tanya, thank you for your support during a challenging time and endless cups of tea!

To my family and friends, especially my daughter Emily, who gave me perspective during the hard moments. Thank you for your patience Emily, mom is almost home! You are my inspiration and purpose Emily. And finally, to my Auntie Ruth for your unwavering support throughout this endeavor and your faith in me that I could do it.

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ABSTRACT

How Sustainable School Gardening Enhances STEM Education

By:

Holly Putnam

Master of Arts in Education, Elementary Education

National and local civic leaders recognize the importance of supporting conditions that create a world-class STEM workforce. Programs that encourage all students, including women and minorities in mathematics and science are showing promise. Health initiatives such as the, Let's Move, health campaign and the ASCD's Whole Child Initiative support children so that they are healthy, safe, and ready to learn have similarly made positive impacts.

Childhood obesity is a nationwide problem that requires educators to assist children in learning how and why to make healthier food choices. Studies indicate that children may eat more fruits and vegetables when they grow it themselves in the garden (Heim, Strang, and Ireland, 2009). Schools across the country need to involve students in gardening to improve student health. There is evidence to suggest that adults who spent time outside as a child in a garden or informally out in nature may be predisposed to make career choices in environmental education (Wells and Lekies, 2006). Given the environmental issues today, stewardship of the Earth must be a national priority. K-5 educators need accessible resources on implementing models to foster innovative programs that address these problems in a successful manner. This Project presents a resource guide to enable teachers to implement a sustainable school garden

program that addresses the need to promote their K-5 students' multi-sensory engagement in STEM disciplines (Williams and Brown, 2012), and the Whole Child Initiative: All children healthy, safe, engaged, supported and challenged. Implementation of the 5E model and adoption of the Next Generation Science Standards (NGSS) are included as a starting point to fostering interest in science among young children

CHAPTER ONE: INTRODUCTION

Enhancing the E in STEM Education through Sustainable School Gardening

In order to produce the educational learning opportunities for students that lead to successful employment in the 21st century global economy, teachers must use effective methods to integrate science, technology, engineering and mathematics (STEM) into the curriculum. Researchers are studying best practices in early science education in the United States (Klemmer, 2005). They have studied STEM education and have found that effective programs contain regularly implemented practices in elementary schools.

Integrated-STEM education, in particular, is now important to be implemented in classrooms across the United States as well as globally. In the elementary school classroom, STEM education refers to teaching and learning in these integrated subjects. Research has found that early and repeated exposure to STEM subjects is part of effective teaching practices that contribute to student learning and achievement in STEM disciplines (Hanover, 2012; Klemmer, 2005). STEM-integrated practices include hands-on instruction, project-based learning (PBL), lab-based learning, and use of technology-supported learning tools (Hanover, 2012).

Today's students often learn about ecological stewardship in a context of fear and despair regarding the mass extinction of animal life as the focal point (Smith, 2010). Young children can often feel hopeless in the face of such overwhelming information about environmental crises. Instead, they must become empowered in their belief that they can effect positive changes in the healing and care of the environment (McHardy, Blanchard and de Wet, 2009) and the planet.

The sustainable school garden allows our youngest students to acquire environmental awareness in a developmentally appropriate manner and provide the opportunities for them to respond with curiosity and wonder about our planet (Williams and Brown, 2012). The

inextricable connection between humans and the planet and the importance of Earth stewardship through sustainable practices becomes concrete for young students in the context of the school garden (Hirschi, 2015).

A second argument for the early introduction of sustainable school gardens arises from research about the lack of access children have to natural spaces especially among urban youth (Louv, 2008). It is typical for many children to spend an average of eight hours per day being inactive on the computer or watching television (Williams and Brown, 2012). Few parents and teachers have addressed this growing problem in a meaningful way. Thus, it becomes important that elementary schools adopt the curriculum of a sustainable school garden as such programs garner student engagement in healthy living and mindfulness regardless of socioeconomic status, ethnicity or gender. A school garden confronts unhealthy practices and transforms them into student-centered exploration, study, physical activity, and direct interaction with nature.

Healthy eating becomes a third positive outcome of ongoing school garden programs. Childhood obesity is a nationwide problem that requires educators to assist children in learning how and why to make healthier food choices. Studies indicate that children may eat more fruits and vegetables that are grown by them in the garden (Heim, Strang, and Ireland, 2009). Schools across the country need to involve students in gardening as a means to improve student health.

The implementation of a sustainable school garden, therefore, is an efficacious vehicle to integrate STEM curricula. An environment-friendly school gardening program that addresses one or more of the concerns addressed in this Project will offer students an engaging setting in which they can acquire necessary higher-level thinking skills along with other values such as environmental awareness, stewardship of the Earth and a healthful lifestyle.

The Resource Guide that has been developed in response to these issues will assist K-5 teachers in the design and implementation of a sustainable school-gardening program aligned with the Next Generation Science Standards (NGSS). Such a program will not only assist their students in learning about healthy eating and exercise but can have a strong impact on their early science achievement. The Guide has been designed to enable elementary school teachers to affect changes in student attitudes about the impact we as humans have on our planet. The early development of positive attitudes regarding stewardship of the Earth and understanding of healthy eating can result in their engagement in environmental science throughout their continued years of elementary and secondary education.

Finally, the resource guide will assist the teacher in implementing sustainable school garden programs that integrate the engineering design process through planning, creation and maintenance of a sustainable school garden. Teachers will also learn about and utilize the 5E framework (BSCS, 2006) as a helpful guide to satisfying and real-world STEM experiences. The project responds to the following premises:

1. A school gardening program aligned with the NGSS can have a strong impact on the science achievement of elementary school students;
2. Teachers who implement a school sustainable gardening program will engage diverse students (socioeconomics, gender, ethnicity and those with special needs) to develop Earth-friendly knowledge and attitudes;
3. The beneficial impact of growing a sustainable school garden on the attitudes of lower-elementary school students' health and their ability to making healthy food choices;

4. Teachers who create a successful school gardening program may have a long-term impact on elementary students' attitudes and motivation to pursue the study of environmental science in high school, college, and career.

CHAPTER TWO: LITERATURE REVIEW

A Sustainable School Gardening Program Aligned with the NGSS

The Challenge of Educating a STEM Workforce

If the United States wishes to remain at the global helm of scientific and technological innovation, teachers must rise to the challenge of educating a workforce capable of meeting these demands or continue to lose high quality jobs to other countries (Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, 2005). STEM jobs in the U.S. are expected to grow 17 percent by 2018 (U.S. Department of Commerce, 2011). Individuals with a college degree in a STEM field can expect to earn an eleven percent higher income than those with a non-STEM degree and have greater job security (National Governors Association for Best Practices, 2011). Moreover, STEM related jobs are projected to grow 1.7 times faster than non-STEM jobs (Office of Science and Technology and Policy, 2012).

The President's Council of Advisors on Science and Technology reported in 2010 that strides were being made in preparing students for STEM occupations; however, the report stressed concerns about students' lack of interest and that students are moving away from the pursuit of the sciences. Schools must do more to inspire young children to engage in science. Teachers need access to curricula and instruction that presents science to students in meaningful contexts.

The expertise required for the STEM jobs of the future includes technological deftness, critical thinking, problem solving, ability to collaborate with others, and leadership skills (NGA Best Practices, 2011). Educators tasked with teaching these competencies, must assume different teaching methodologies and practices. Many states have adopted the Next Generation Science Standards (NGSS) in order to achieve these ends. The new standards have already generated renewed excitement about science education.

While many U.S. policymakers and educational leaders recognize the necessity of generating a capable STEM workforce, there is still much work to be done in advancing a campaign for K-5 educators to understand their role in achieving this. Women and minorities are vastly underrepresented in STEM fields of employment. Educators must acquire new perspectives, strategies, and curricula to engage all students in STEM achievement, majors, and careers.

Underrepresented minority populations (URM) and women are the missing components in the STEM workforce. Despite having a significant need in the U.S. workforce for people with STEM skills, the failure to invite, welcome and retain women and minorities to our workforce results in the fact that the U.S. does not have enough qualified STEM workers. As such, it becomes incumbent upon elementary school educators to provide the inspiration these students need to be motivated and supported in their efforts to pursue achievement, majors, and careers in STEM, as they represent the untapped source of talent for our STEM workforce (U.S. Department of Labor, The STEM Workforce Challenge, 2007). Of the population employed in STEM-related fields in 2011, women accounted for only 26 percent of the workforce, while African American represented six percent and Hispanics represented seven percent (Landivar, 2013). Thus, it falls to our educators as early as the primary grades of schooling to do a better job of promoting and attracting women and minority students to the STEM fields.

The importance of having a workforce capable of problem solving collaboratively and creatively to address global environmental issues calls for the implementation of a STEM curriculum that engages and enriches all of our students. If the U.S. wishes to remain at the forefront of technological innovation, educators must prepare students for job opportunities in engineering, technology, and science.

The U.S. is making strides towards developing a curriculum capable of producing this global workforce with the Common Core State Standards and the Next Generation Science Standards. Teachers are the catalyst for change, and garden-based learning allows educators to engage our youngest students and develops the scientific literacy required for the twenty first century.

Integration of STEM Disciplines in the Sustainable School Garden

Integrated-STEM education, in particular, is now becoming important as a key way to assure science, technology, engineering and mathematics education are implemented in K-5 classrooms across the United States as well as globally. In the elementary school classroom, especially STEM education has been absent in the early grades in each of these subjects except mathematics. Research has found that early and repeated exposure to STEM subjects is part of effective teaching practices that can contribute to student learning and achievement in STEM disciplines (Hanover, 2012). STEM-integrated practices include hands-on instruction, project-based learning (PBL), lab-based learning, and use of technology-supported learning tools (Hanover, 2012).

Innovative teaching methods such as the 5E Instructional Model (Bybee, n.d.) have been revisited given the high-level cognitive demands of the soon to be implemented NGSS. STEM integration will be among the important tools to promote positive changes in the time and quality of science instructional practices that result in student engagement and achievement. Besides promoting academics and ecology awareness foundational to the STEM related fields, school gardening also gives educators a satisfying context for teaching the importance of a healthful lifestyle (Blair, 2009). The First Lady, Michelle Obama's Let’s Move health campaign, advocates school gardening as a tool to combat the growing problem of childhood obesity

through physical exercise and healthy eating, (Obama, 2012). Her resolve is evidenced by the garden currently growing on the White House lawn and cared for by local school children. Other notable campaigns include The Whole Child Initiative, a joint venture between the CDC and the ASCD that began in 2007. This initiative posits that a child's overall physical and mental health has a direct effect on the ability to learn and experience long-term success in life. Both initiatives look to educators as the catalysts to effect changes in how and what children learn about environmental science.

Young Children Acquire Academic STEM Content Knowledge

Growing plants with children on a school campus is quite beneficial to everyone involved for several reasons. Gardens are aesthetically pleasing nature-based locations in which to spend time while learning on the school campus, as well as visiting in the community. Gardens are also an excellent way to teach hands-on lessons involving many cross-cutting science concepts included in the Next Generation Science Standards (NGSS, 2015). Engineering design and planning opportunities are abundant in many sustainable garden projects. Gardening on a school site empowers participating students to appreciate healthy food choices as well as reap the benefits of growing healthy food.

Promoting Self-Efficacy of Young Children Engaged in Gardening

Teachers seeking to introduce curricula aligned with NGSS can take advantage of the opportunity to support and inspire the thinking of students in sustainable school garden programs as lessons promote engagement. The exploration, inquiry and active engagement promoted in a gardening curriculum allow students to develop creative and critical thinking along with new ways to consider some of the environmental situations that we face as the effects of global climate change become more visible and important to address.

Sustainable gardening integrates the E in STEM as students must work together like engineers that engage in design thinking. This has the possibility to empower students to become confident, cooperative, creative, and critical thinkers (Kweck, 2011). These are the practices we must encourage and develop in our students who will become the problem solvers and creators in a global community. Students who participate in the nature-based learning of the sustainable school garden are likely to become better able to connect to nature as adults. Many researchers including, Chawla (1998) have found that children who were in direct contact with nature and developed positive experiences from that connection became adults who were more likely to be environmentally sensitive, concerned and empathetic (Blair, 2009). Also, the unstructured play and learning in nature that occurs in a garden can bring meaningful experiences students can refer back to as the most positive and pleasant experiences from childhood. A garden- based program offers children the opportunity to practice design thinking in an authentic learning context that will affect their futures.

Essentially, early elementary school children's engagement in gardening is inquiry-based learning (Bruner, 1977) in which they each can reap many benefits in all areas of STEM education—mathematics, science, engineering, and technology. With the expected implementation of the NGSS, the traditional dependence upon directed science instruction through isolated single-subject instruction will soon be replaced with students' more active engagement in scientific observation, experimentation, designing, graphing, ordering, collecting data, and demonstrating results over a period of time. Some studies indicate the value of active student engagement. Blair (2009) found that students were delighted to learn and explore in the garden where they also developed a positive and improved attitude in school and took pride in spending time in their garden. Among the findings of Blair's study, it was reported that the

gardens promoted community building and teamwork as well as a positive interaction between adults and children.

The sustainable school garden allows our youngest students to acquire environmental awareness in a developmentally appropriate manner and provide the opportunities for them to respond with curiosity and wonder about our planet (Williams and Brown, 2012). The inextricable connection between humans and the planet and the importance of Earth stewardship through sustainable practices becomes concrete for young students in the context of the school garden (Hirschi, 2015).

Another argument for early student engagement in sustainable school gardens arises from research about the lack of access children have to natural spaces especially among urban youth (Louv, 2008). It is typical for many children to spend an average of eight hours per day being inactive on the computer or watching television (Williams and Brown, 2012). Few parents and teachers have addressed this growing problem in a meaningful way. Thus, it becomes important that elementary schools adopt the curriculum of a sustainable school garden as such programs garner student engagement in healthy living and mindfulness regardless of socioeconomic status, ethnicity or gender. The school garden confronts unhealthy practices and transforms them into student-centered exploration, study, physical activity, and direct interaction with nature. Healthy eating becomes a third positive outcome of ongoing school garden programs.

Effects of School Gardening Programs on Student Health and Achievement

If schools and educators are to be held accountable for the nation's' future STEM workforce of healthy-minded citizens, it follows that they must be supported to make and sustain changes in teaching practices to develop such a populace. The health of our nations' children is at risk as obesity, and physical inactivity has reached unacceptable levels. There is a plethora of

information about the growing health crisis of childhood obesity and resulting health problems such as Type Two Diabetes, especially among non-white youth (Williams and Brown, 2012) which is one of the many reasons why the U.S. Surgeon General predicts that today's population of children may have a shorter lifespan than their parents (Winne, 2008). There is also evidence that by promoting knowledge and understanding of food choices through gardening, students will adopt a healthier lifestyle. For example, a study conducted on 97 first graders to measure the effects of a gardening program created to improve the nutritional knowledge and dietary food choices found that children's' consumption of fruit and vegetables improved (Morris, Neustadter, and Zidenberg-Cherr, 2001).

Implementation of gardening programs in schools is not a new concept. As a result, there is an impressive amount of information on this topic. While school garden designs and their implementation are well documented, there are few studies that have sought to measure student academic achievement in science after participating in a school gardening program. Klemmer (2002) studied the science achievement of approximately 650 students in the 3rd, 4th, and 5th grade after participating in a school gardening program. The results showed evidence that students who participated in the hands-on school gardening program had acquired higher science achievement scores than the control group, which did not participate in the ecology unit that included the garden program. This study's conclusion also reveals an important need for teachers as early as the elementary school years to actively involve and engage female students in STEM study as analyses of the U.S. workforce indicate that there are not enough women currently working or pursuing careers in the STEM-related fields (U.S. Department of Labor, The STEM Workforce Challenge, 2007). Science exploration and study with students of mixed ages and genders through sustainable gardening is appealing to students as being outdoor allows for

natural interactions to occur among younger and older children. The curriculum more closely approximates what children do when "playing outside" as opposed to being inside the classroom under perceived scrutiny of their peers and teachers who may not realize the messages that are transmitting to young girls about science.

A STEM integrated curriculum on school gardening has been found to provide students with the needed direct experience in a natural ecosystem that is required for them to develop a lifelong interest in environmental science. Many children live in concentrated populations within our cities and lack experiences within natural open spaces in which to be creative and free to explore and observe nature. Gardens are places where children can develop such experiences as they directly acquire connections with some form of the natural world (Blair, 2009). Many researchers including Chawla (1998) cited in Blair's meta-analysis conclude that children who have been exposed to nature with positive experiences became adults who are more likely to be environmentally sensitive, concerned and active in conservation (Blair, 2009). Another researcher evaluated several effective STEM garden programs and their designs. It was found that "effective STEM instruction provides students with opportunities for hands-on experiences and real-world applications of scientific problems" (Hanover, 2012, p.14). Garden-based instruction not only has the potential to enhance a STEM program, but it may also enhance students' overall academic achievement (Klemmer et al., 2005). Therefore, school gardens especially those designed with sustainability principles can be seen to have strong potential to enhance STEM engagement for diverse elementary school learners.

Gardens Promote Children's Health Awareness

Most research involving the benefits of designing and implementing a garden-based school project involves growing fruit and vegetables that promote student appreciation of healthy

food consumption (Blair, 2009). The experience of growing edible plants is seen to enhance students' awareness as consumers, food cultivators, budgeters, conservationists, and food preparers (Ratcliffe et al., 2009). Gardening also increases fruit and vegetable consumption among young students (Ratcliffe et al., 2009). Gardening introduces students to the process of healthy and wise food choices. This is often a key motivator for teachers and parents to establish school-garden curricula that teach hands-on gardening in the early elementary years. Students who become informed and sensitive to the health concerns within our communities can help to develop solutions to such concerns and can become influential in seeking innovative, healthy ways to feed our communities.

The Effects of School Gardening on Different Socioeconomic Groups and Ethnicities

An important study on school gardening focused on a group of over 700 students at a large inner-city elementary school gardening program. Researchers found that all students showed a deeper understanding of the concept of change over time and in their ability to interact with their teachers and peers using scientific vocabulary (Rye, Selmer, Pennington, Vanhorn, Fox, and Kane, 2012). These findings are important because of the critical need for today's students to become scientifically literate adults, who are more capable of participating in the global community as stewards of the planet and the world economy that understands the concepts of sustainability. The sustainable school garden program guide offered to low SES students is a simple way for teachers to engage children in developing a scientific vocabulary along with environmentally aware perspectives that lead them to become scientifically literate adolescents and young adults who will enjoy higher achievement in school and the workplace.

A large study conducted with children from England, Kenya, and India, analyzed student perception about an international school gardening program. The study obtained evidence of the

different students' perceptions of the garden through the use of concept maps, which are similar to graphic organizers while implementing a gardening program called, Gardens for Life (Bowker, and Tearle, 2007). The researchers found significant differences between all three groups in several areas related to gardening such as knowledge and gardening tool use. What stood out, however, was the finding that English students viewed the garden in relation to garden design and leisure while the students from India and Kenya viewed the garden in terms of providing food security. The researchers concluded that while all of the students were engaged in the learning process and had positive associations with the gardening program, their perceptions were strongly influenced by their environments and culture.

Effects of Involving Families in School Gardening Programs

Another study conducted in the U.S. found beneficial effects for ethnic minority students with low SES backgrounds when participating in a school garden program focused on student knowledge of healthy eating (Ozer, 2007). The study noted that minority students from low SES backgrounds were more likely to be obese and have lower academic achievement scores and a lack of parental involvement at school. The school gardening program improved student knowledge of the importance of eating a healthy diet and fostered parental involvement in the garden which had overall beneficial effects for the students besides academics. Most educators agree that parental involvement in school positively impacts student academic performance. This study indicated that a school garden had the power to influence, educate and involve parents in their child's education.

School Gardens and Students with Special Needs

Now trending in U.S. schools is the idea of universal access to the curriculum for all of our students, and that includes students with special needs such as autism or ADHD, which is on

the rise nationwide. A study of over 700 students conducted in a large suburban elementary school focused on the positive impacts of a garden-based learning program for all students, including those with special needs, which was comprised of 23% of the participants (Rye et al. 2012). The study found that all students gained access to the science curriculum in an engaging manner including the students with significant learning disabilities. The study illustrated how teachers, when properly supported, can adapt many of the activities for students with special needs such as conducting hands-on activities like germination of seeds in the classroom, should these students be unable to access the garden physically. Additionally, this study found that the garden allowed a "sensory break" for students who are at times, overwhelmed by the school and classroom environment and may act out towards their peers and teachers in negative ways.

The findings of this study illustrate the need for implementation of a garden-based learning curriculum that allows all children regardless of learning abilities to access the school curriculum and improve their educational outcomes. The study also shows the potential of the school garden to relieve some of the pressure and strain that teachers and students experience in the classroom as they may need the "sensory break," to which the article refers. The anxiety, frustration and pent-up energy of these students can be released by interaction with nature outside in the garden, allowing them to focus when they return to the classroom. These students benefit from having universal access to the curriculum as the garden program makes use of many different learning modalities often absent in the traditional classroom In many inner city schools in underserved neighborhoods; students are exposed to many stressors at home caused by poverty. These students have difficulty adjusting to school on a daily basis and would greatly benefit from the sensory break the garden provides from the classroom.

School Gardens and Student Attitudes toward Environmental Science

Children living in the inner city from low SES families typically spend less time outdoors interacting with nature (Strife, and Downey, 2011). A study conducted by Wells and Lekies (2006) found that adults who had experience with nature, either in the wild, or of a domesticated manner such as a garden before the age of eleven were more likely as adults to have positive associations with nature and in some cases, these experiences led to adult environmentalism. The researchers conducted a survey of just over 2,000 adults between the ages of 18 to 90 living in the central United States. Although the study used adult participants, it is relevant to this work, as the analysis of data collected during the study showed significant findings regarding the individual's association with the natural world and knowledge of biodiversity and plants and trees (Wells and Lekies, 2006).

Together, these studies indicate the potential and importance of engaging children in nature beginning at an early age. Inner-city school children with limited access to interactions with nature must have these experiences in the school environment if the possible long-term effects are to include becoming adults with a propensity towards acquiring knowledge about ecology and having concern for the natural world. Implementation of a school garden is often the first positive interaction with nature that may ignite student interest in environmental science. Indeed, it could be argued that a school garden-based science curriculum may help level the playing field so minority students of low SES, would be more likely to pursue a career in STEM.

Impact of School Gardening on Best Teaching Practices in STEM Instruction

The Hill Elementary School used an inquiry-based method for implementation of their school gardening program with positive results in student academic and social-emotional outcomes (Rye et al. 2012). The positive outcomes that Hill Elementary School experienced

using an inquiry-based method have been applied to the garden-based learning program offered here to improve the educational and social-emotional outcomes for the students. Educators seeking to advance equitable access to scientific literacy and integrated-STEM activities can embrace inquiry-based teaching methodologies that engage all students. This may improve the chances that students from underrepresented and underserved populations such as minorities and women in high poverty schools have in the pursuit of college and careers in STEM.

Overall, the research literature indicates many positive impacts on elementary students' attitudes towards science, scientific understanding and academic achievement when they participate in a school gardening program. The literature demonstrates how educators can provide opportunities for all students to become scientifically literate thus developing deeper scientific understanding and critical thinking skills in the engaged learning environment that is found in the school garden. It is important to note that many of the researchers' findings on the gains made by their student populations revealed that the student inquiry promoted by experiential learning, constructivist teaching methodologies such as project based learning (PBL) assured the successful implementation of the school garden base. A resource that provides a simple, easy-to-follow-guide may inspire many elementary school teachers to pursue the implementation of a sustainable school garden program that addresses the NGSS Standards while also providing satisfying and important engagement of students in scientific inquiry.

Student Self-Efficacy in STEM

Building children's sense of self-efficacy is as crucial as developing an awareness of healthy living and meaningful learning in the areas of STEM education. According to Albert Bandura (1994), self-efficacy is the belief someone has in themselves to do things that are meaningful. People with a strong sense of self- efficacy are successful problem solvers. They

also develop a keen interest in activities they are engaged in, and they form a strong sense of commitment to what they are involved in accomplishing. These individuals may also develop resilience. Enhancing students' self-efficacy through the integrated-STEM curricula of sustainable gardening has the potential to help them become more resilient when faced with difficult problems in life as well as to confidently make positive choices when growing up. This type of self-efficacy is ultimately what we want students to develop and learn throughout their lives.

Students who become engaged as active learners in a gardening curriculum readily see the real-life necessities of being thoughtful everyday problem solvers who create meaningful solutions. Therefore, it has become essential to promote this level of inquiry that leads to self-efficacy during the elementary school years. Teachers of young elementary school students must become able to engage students in using knowledge in positive and powerful ways (Kwek, 2011) to understand problems and respond with innovative solutions. Incorporating a sustainable school garden program within a STEM curriculum can provide this opportunity for teachers to assist diverse students who might otherwise not be engaged, to acquire strong STEM self-efficacy in the classroom. This is because students are directly involved in the design and planning of the garden. As the activities are designed with student's interests in mind, gardens can evolve into interesting projects that further capture their interest to solve real-world problems and environmental challenges. Table 2.1 indicates the areas in which a school gardening program can affect student's attitudes towards Science, Technology, Engineering, and Mathematics (STEM).

Table 2.1

Science and Engineering Practices

Asking questions and defining problems	Gardening immerses students
Developing and using models.	
Planning and carrying out investigations	
Analyzing and interpreting data	
Using mathematics and computational thinking	
Constructing explanations and designing solutions	
Engaging in argument from evidence	
Obtaining, evaluating, and communicating information	
Source: NGSS	

The time is now for educators to utilize teaching methods that engage their students as we see the dropout rate in many high schools continue to grow. Therefore, aspects of inquiry-based, experiential learning have been integrated into the Resource Guide described in the next two chapters.

CHAPTER THREE: METHODOLOGY

The Sustainable School Garden: Theory, Design, and Development

About Our Project

To assist elementary educators in implementing STEM activities into their curriculum, we created a resource website, "Classroom Gardens" found at www.classroomgardens.net. Our purpose in creating the website is to provide educators with tools and resources to create a classroom garden and also investigate other science activities that align with the NGSS to prepare students with the 21st century skills necessary to be successful at school and beyond.

About the Authors

A brief biography of Tanya and Holly is included as a greeting to visitors of the website, informing them about our project and to make a more personal connection with teachers. The authors realize how precious time is for educators tasked with many projects and district mandates. The authors seek to communicate that we share the same experiences as many public school teachers. We recognize the value of educators supporting each other to implement more effective teaching strategies for acquiring 21st century skills. Tanya and Holly are in the process of earning their Master's Degree in Curriculum and Instruction of STEM education and NASA Endeavor Leadership Certification.

About the Value of Experiential Learning that Occurs in the Garden Program

The Resource Guide assists elementary educators who wish to address Common Core State Standard (CCSS) and NGSS for underrepresented minority (URM) students by creating a Sustainable School Garden Program in their school. The sustainable school garden is a rich experiential learning setting where students have hands-on opportunities that allow them to construct their meaning through interaction with their peers and teachers (Bowker and Tearle, 2007). The experiential learning experience that occurs for children engaged in the school

garden resource guide is central to its success. Students become deeply engaged acting as scientists while they explore, investigate and observe what happens during the plant life cycle process and provide the ongoing care needed for a sustainable garden. Teachers are encouraged to get out of their comfort zone and employ new teaching methodologies. Enthusiasm and curiosity along with highly positive student attitudes towards learning are begun when young children are offered the opportunity to be the creators and caregivers for the sustainable school garden.

Inquiry-Based Learning Structures in the Sustainable Garden Program

The nature of science (NOS) is the important thread that runs through and integrates all the various fields of science. Lederman, Lederman, and Antink, (2013) discuss the importance for educators to teach the NOS. Just as scientists make use of scientific inquiry to identify and solve real-world problems, so should educators present the science inquiry model to introduced and teach science concepts. This resource guide on creating a sustainable school garden-based curriculum addresses the NGSS DCI and Cross-Cutting Concepts where students are immersed in the NOS that is systemic to implementation. This resource can become a helpful vehicle for K-5 educators who seek to motivate their students with inquiry-based STEM teaching and learning strategies that emphasize scientific inquiry and problem-solving in a real-world context.

Engineering and Design

The website includes information about engineering and includes links to NASA's Engineering Design Process as well as the introductory videos that NASA provides specifically for elementary educators on their NASA's Beginning Engineering Science and Technology (BEST) website. This page opens with an example of a library box for the garden and allows educators to submit pictures of their library boxes. The page contains a PDF of NASA's BEST

guide that educators can download for use in their classroom instruction. The NGSS for engineering appendices and standards are included to illustrate how garden-based learning meets these standards.

The Pollinators

This page highlights the importance of bees, butterflies and birds for the garden and provides multiple links to other sites that have collections of lessons from kindergarten through 12th grade. The links also include Life Lab and kidsgardening.org that are rich in resources and content for project based and inquiry learning in science.

BSCS 5E Instructional Model

Inquiry-based instruction using the 5E lesson model includes engagement, exploration, explanation, elaboration, and evaluation. This page provides educators with a link to the BSCS site should they wish to learn more about the 5E model and the value of using this method to deliver instruction. There is also a lesson plan template that can be downloaded as a guide for the teacher just beginning to become familiar with this framework.

Resources

The resource page contains a variety of suggested professional books for teachers as well as materials for students and links to other sites that have information about gardening programs including the *4-H Curriculum*. The authors found, Daniel Goldman's resources valuable for a pedagogy that illustrates the value of involving young children in environmental science as well Michael K. Stone and the Center for Eco-literacy's *Smart by Nature*, for the importance of fostering environmental stewardship. The link to BetterLessons.com is an excellent website that has many lessons developed by master teachers that are aligned with the CCSS and the NGSS. There is another tab for various children's literature to integrate into any of the lessons.

Gallery

The gallery displays pictures from the Vaughn Next Century Learning Center in Pacoima, California. Parents and students were involved in creating a sustainable garden together with the teaching staff. This experience has connected the school and local community in many ways and continues to be an engaging factor in STEM education for the students.

Funding

Information about funding resources, as well as a helpful video for starting a school garden, is found on the website. There are many grant opportunities available for teachers with many noted on the *Kids Gardening* site.

Innovation in Teaching Practices through Teacher Collaboration and Blog

Improving K-6 curriculum and instruction aligned with the NGSS with tools such as the 5E Instruction Model to promote STEM integration, is a daunting task. Because too often, K-6 teachers work in isolation from their peers that has become one of the key roadblocks to their professional growth and attainment of pedagogical content knowledge (PCK) in science and mathematics. If teachers are to effectively infuse STEM-integration into the school curriculum, time for collaboration with peers is essential to foster the needed improvement in their teaching practices. While the sustainable school garden addresses many facets of STEM achievement and the development of a healthy student populace, educators need real and ongoing support in their efforts to implement school gardens. Implementing professional learning communities is a promising way to champion teachers' access to the necessary knowledge, resources and support needed to affect successful STEM achievement for their students. The website includes a blog to provide ongoing dialogue as teachers make curricular changes to make these skills accessible for all children, regardless of socioeconomic status. It is expected that the site will address many

educators' questions and concerns as they design and implement a program to improve student health and foster environmental stewardship.

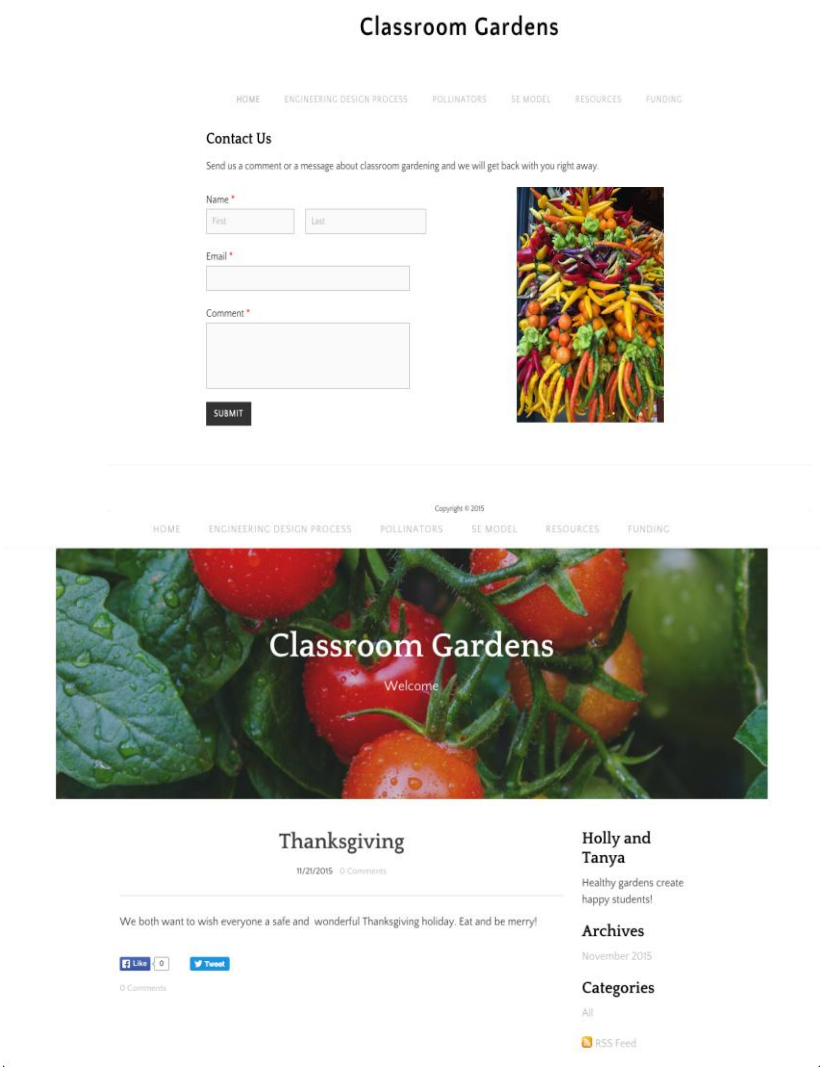
CHAPTER FOUR: RESOURCE GUIDE

The website, www.classroomgardens.net, is a resource guide for teachers using the website host Weebly (www.Weebly.com). Weebly provides a platform to showcase the objectives of enhancing engineering in STEM education through a sustainable garden. Weebly allows us to share a compilation of resources we found useful directly to educators or other interested parties who want to improve student engagement through STEM curriculum. The project website responds to the following premises:

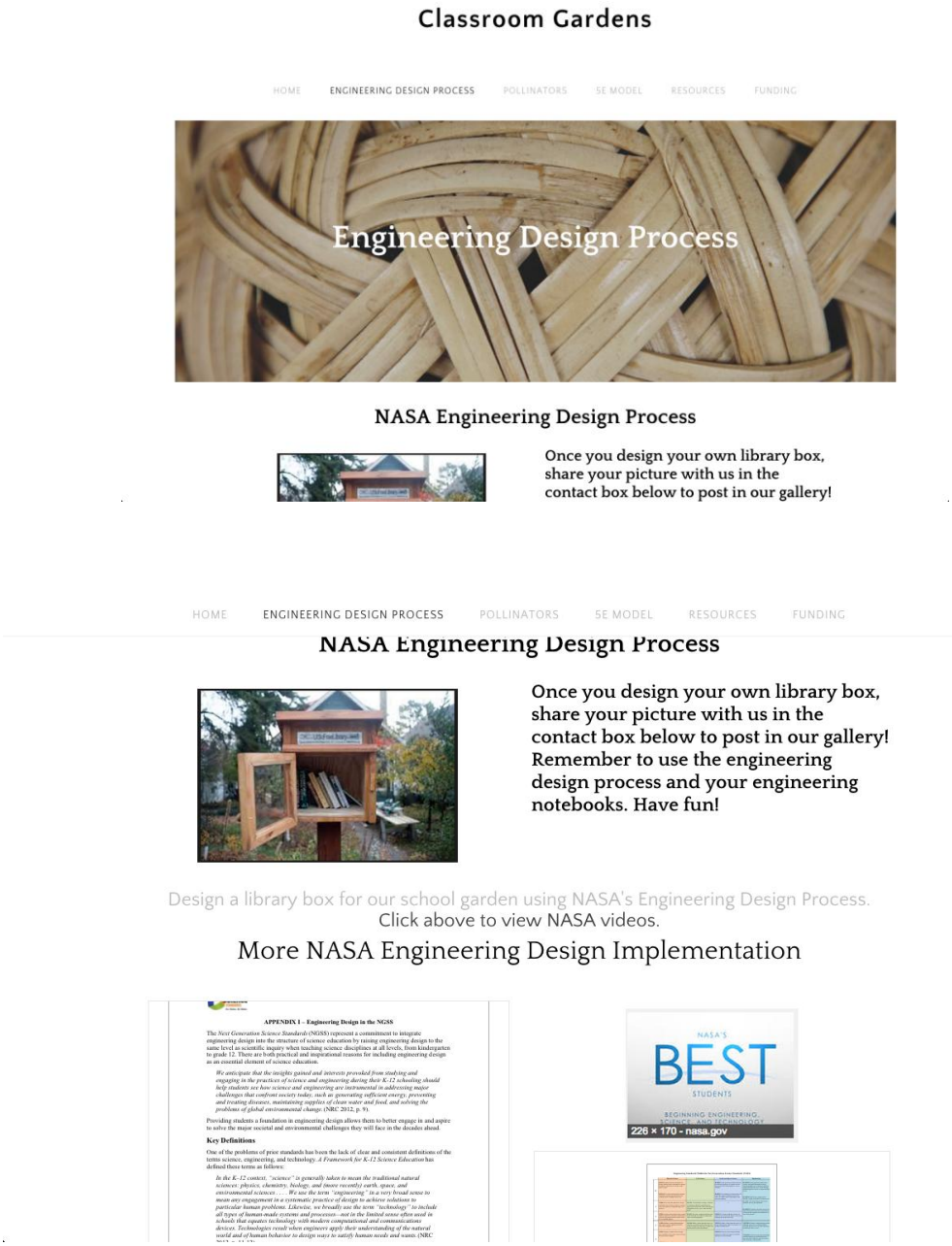
1. A school gardening program aligned with the NGSS can have a strong impact on the science achievement of elementary school students;
2. Teachers who implement a school sustainable gardening program will engage diverse students (socioeconomics, gender, ethnicity and those with special needs) to develop Earth-friendly knowledge and attitudes;
3. The beneficial impact of growing a sustainable school garden on the attitudes of lower-elementary school student's health and ability to make healthy food choices;
4. Teachers who create a successful school gardening program may have a long-term impact on elementary students' attitudes and motivation to pursue the study of environmental science in high school, college, and career.

We chose to use Weebly as our website host because it provides a technologically effective tool in a real-world arena. Using a Weebly website makes searching for STEM curriculum to implement sustainable classroom gardening effective and convenient. Creating a website with these tools provide teachers with what they can use to prepare students to become 21st century global participants.

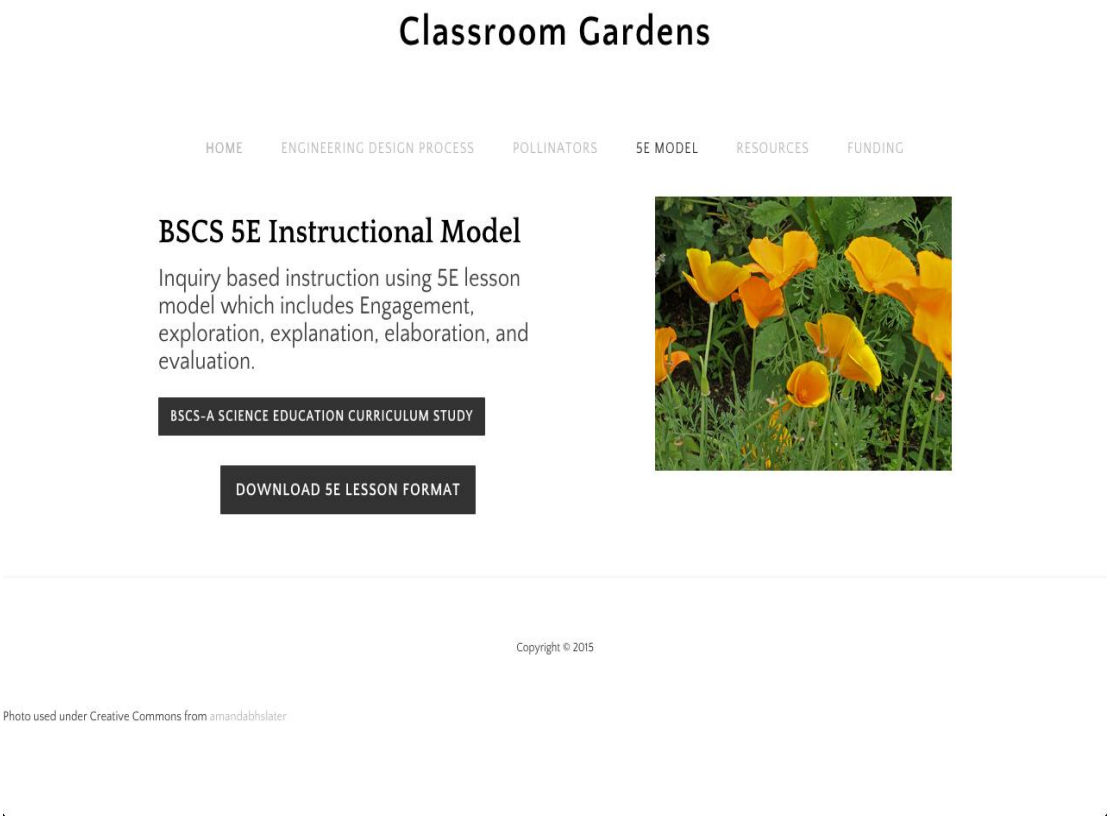
Realizing the importance of an on-going dialogue, the website includes a blog and a contact page should educators have questions and concerns.



Additionally, the website will assist the teacher in implementing sustainable school garden programs that integrate the engineering design process through planning, creation and maintenance of a sustainable school garden.



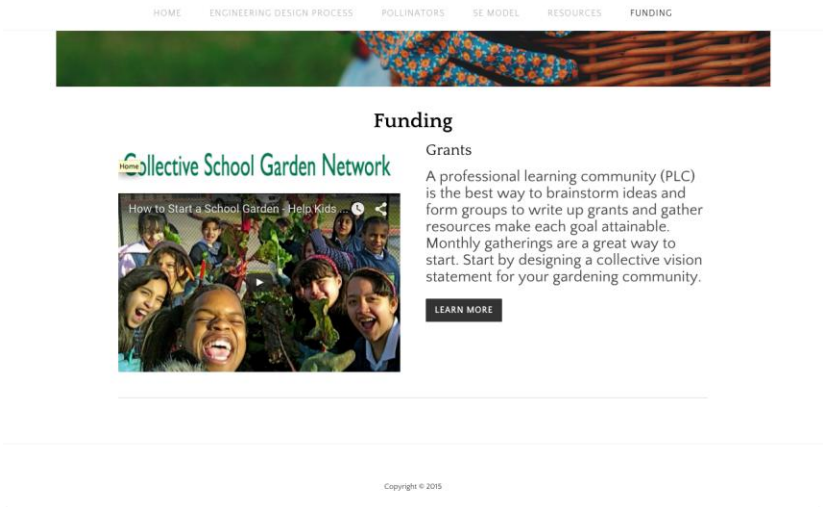
Other resources from Western Growers Foundation have also been included to promote inquiry-based instruction using the 5E Framework format that consists of engagement, exploration, explanation, elaboration, and extension. Teachers will also learn about and utilize the 5E framework model (BSCS, 2006) as a helpful guide to satisfying and real-world STEM experiences.



Funding for material sources for educators to implement a sustainable school garden is included with links to various grants and methods to be cost efficient.

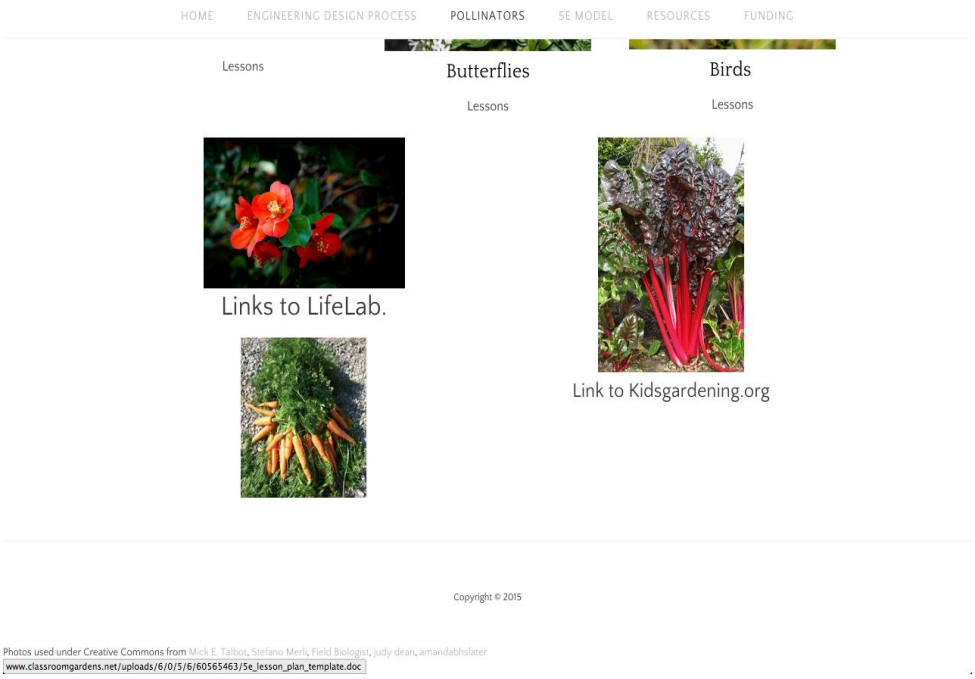
The website can be used to guide educators in their implementation of a sustainable school garden. The website includes various resources for teachers to engage students in planning the garden that starts in the classroom. For example, the literature can be used to open PBL units related to the garden.

Some materials used to develop the sustainable garden website have been adopted from modified resources for an elementary classroom from the California School Gardens Network at the CSGN.org website.

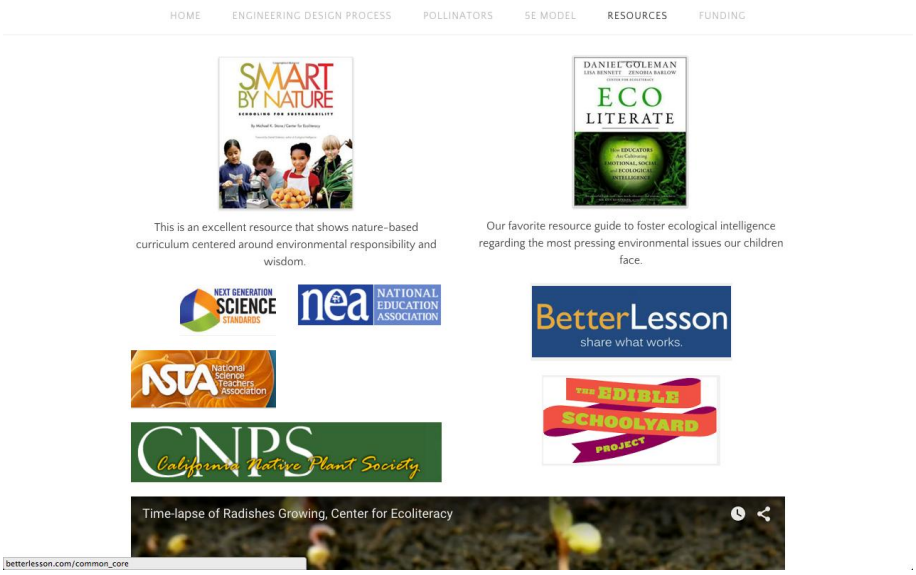


Suggested instruction could begin in the classroom two to three days per week for 50 minutes and continue in the garden two days per week for 50 minutes after that. Teachers will find helpful ways to bring the curricula into the classroom regularly as there could be an ongoing

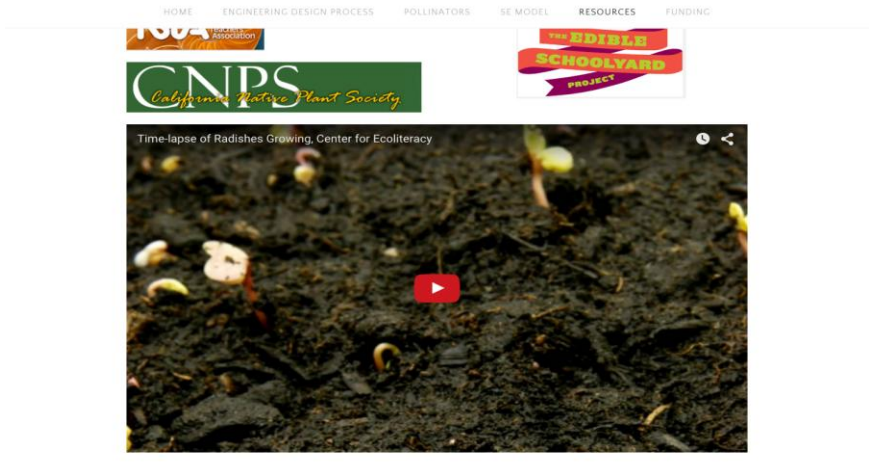
student reflection component with student interactive science journals. Weekly procedures and teacher tips to implement the garden PBL aspect of the program are provided. This website provides resources for teachers to plan the scope and sequence as well as pacing of the introductory aspect of the program through the integration of the engineering design process. This makes it possible for teachers to incorporate the school garden curriculum instruction into their NGSS-aligned STEM objectives with resources adopted and modified from non-profit organizations such as Life Lab Science Program and the Center for Eco-literacy.



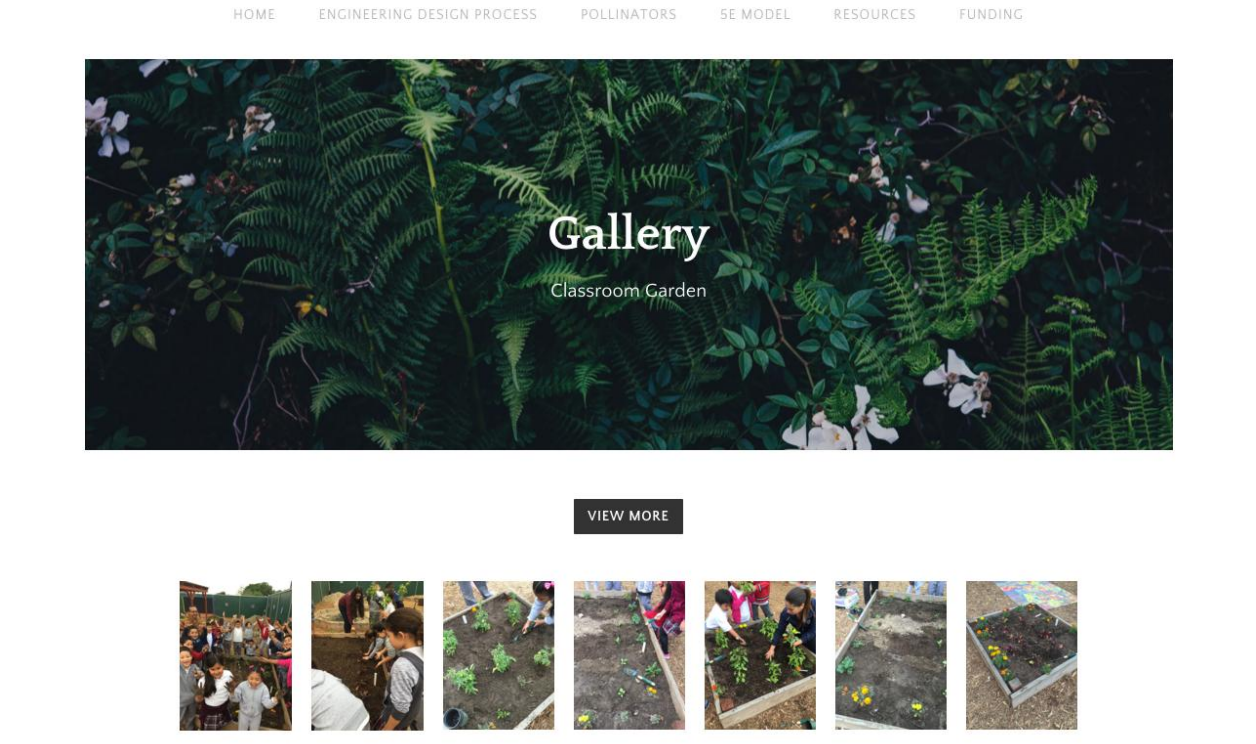
Resources are included to assist teachers in planning the garden with students, teachers, administrators, parents, and community members. It also includes how the sustainable garden site will be mapped out and designed with designated locations of varied garden bed areas, storage, compost, sitting, and watering system areas.



The website also includes information about maintenance of the garden, planting seeds, watering, testing soil, transplanting, pruning, weeding, harvesting, protecting plants, maintaining compost, mulching, Again, each aspect of the process will be helpfully aligned with NGSS standards as gardening addresses STEM disciplines through introduction to natural plant and animal life cycles.



A section of the website is devoted to garden management as it is helpful to integrate PBL student teams who have regularly scheduled jobs. A community workday is suggested to promote a comprehensive plan to begin garden projects with parent, family and community support. Suggestions such as engaging the students in creating a sign-up wall for family and community volunteers to help with earlier "heavy work" are included. A holiday and vacation program is also suggested in this section with recommendations for special activities and community events. Having a team of students create a supply list for replenishing the garden program as it grows provides another learning opportunity.



The Gallery page of the website highlights the ever-evolving school garden at Vaughn Learning Center. This sustainable garden continues to flourish with the commitment of the teachers, students, and community. The photographs show pictures of second graders working alongside teachers and the parent community.

CHAPTER FIVE: CONCLUSION AND DISCUSSION

Sustainable school gardens should be developed and maintained by teachers, parents, community volunteers, and students as part of STEM curriculum involving best practices. In this way, every elementary school might ensure that students will gain an essential, nature- based experience in which they will become sensitive to the future of the environment and the planet. By implementing a sustainable school garden on the elementary school campus, students will also have an opportunity to engage in design thinking, and inquiry-based instruction aligned with the NGSS standards. Teachers will acquire a satisfying way of shifting to more dimensional instructional models as they integrate the STEM disciplines through the 5E model.

Teachers and administrators seeking to implement a sustainable school garden program will need to receive encouragement and support as they implement STEM activities in the school garden. Ongoing professional development that promotes inquiry into their students' learning and ways in which they can further develop as effective 21st-century educators are also important.

This concept of teacher professional growth and support will require further research since the literature reviews show that there are many constraints to implementing garden design curriculum that include lack of time, lack of support, and lack of continued professional development for teachers (Ratcliffe, 2011). School and community leaders along with elementary school teachers will play a pivotal role in school-based sustainable garden programs.

Further research as to the best effective professional development to develop the STEM content knowledge and effective inquiry-based teaching methods that would enhance the garden program will also be a necessary undertaking

Further research will reveal if school-based sustainable garden learning will equally benefit boys and girls (Klemmer, et al. 2005). Further research could also determine if sustainable garden-based learning will similarly help special needs students.

Students will feel success only if teachers feel support and are motivated to continue the garden project (Ratcliffe, 2011). When this happens, students will have the opportunity to become aware of their natural surroundings through garden-based instruction. The benefits of implementing a school garden to enhance a STEM program in an elementary school setting will spread throughout the community and into future grades. Student engagement will become a reality and will remain positive as a result of hands-on inquiry-based learning in the school garden. This positive engagement will enhance the STEM program within the school. Students who learn in the garden will have a better opportunity to make healthy eating choices (Ratcliffe, 2011).

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APPENDIX

JOINT PROJECTS ADDENDUM

Submitted by:
Tanya Koch Holly Putnam

ID# ID# _____

Project Title: Enhancing the E in STEM Education through Sustainable School Gardening

The Division of Responsibilities is as Follows:

Holly shall complete these specific and unique tasks:

1. Introduction/Research question (Individual)
2. Literature Review (Individual)
3. Joint project methods
4. Joint project Resource Guide
5. Conclusion (Individual)

Tanya shall complete these specific and unique tasks:

1. Introduction/Research question (Individual)
2. Literature Review (Individual)
3. Joint project methods
4. Joint project Resource Guide
5. Conclusion (Individual)

Reviewed and Accepted by:

Dr. Susan Belgrad, Project Chair

Associate Vice President of Research and Graduate Studies.