DISSERTATION

A CASE STUDY EVALUATION OF EDIBLE PLANTS CURRICULUM IMPLEMENTED IN AN ELEMENTARY SCHOOL

Submitted by

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ABSTRACT

A CASE STUDY EVALUATION OF EDIBLE PLANTS CURRICULUM IMPLEMENTED IN AN ELEMENTARY SCHOOL

The main purpose of this study was to describe elementary teachers' attitudes and perceptions toward plant science. The secondary purpose was to create an edible plant curriculum as a vehicle for integrating STEM and 21st Century skills into Common Core Content.

Results indicate that teachers and STEM coordinators did find the curriculum to be effective in teaching the interdisciplinary standard-based and inquiry based content and skills targeted. Additionally, the curriculum development process produced a hybrid design framework that facilitated the creation of life science content as a vehicle for integrating STEM into common core content. However, several significant barriers will need to be overcome with regard to the teachers', STEM coordinators' and administrators' perception that plant science and nutrition literacy are "special" content activities versus important STEM content.

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CHAPTER I

Introduction and Theoretical Framework

STATEMENT OF THE PROBLEM

U.S. Student Performance in Science, Math, Reading and Writing

The Program for International Student Assessment (PISA) is an international academic performance study conducted every five years by the Organization for Economic Cooperation and Development (OECD) with the participation of 30 country members. The 2006 PISA assessment suggests that U.S. 15-year-olds' average scores were not measurably different from 2003 scores, keeping the United States in the bottom quarter of OECD countries. In particular U.S. 15-year-old students' average mathematics literacy score of 474 was lower than the OECD average of 498 (Aud, et al., 2011).

In other rapidly developing countries such as China, high school students demonstrated more in depth, critical thinking, reading and writing skills than their American peers. Chinese students were also mastering higher levels of scientific and mathematical knowledge and understanding. The most recent PISA assessments indicate that U.S. 15-year-olds are not as successful in applying mathematics knowledge and skills to real-world tasks as their peers in other OECD countries. Another reliable and timely source of data on mathematics and science achievement, the Trends in International Mathematics and Science Study (TIMSS) conducted a study in 2011 indicating that U.S. 4th- and 8th-grade students' performance in science has fallen behind their peers in a number of countries even though their average scores were not measurably different from their 1995 results. Though the Russian Federation students are ahead of their American peers, they continue to lag behind those in China, Taipei, the Czech Republic, England, Hungary, Japan, Korea, and Singapore (Aud, et al., 2013). These studies clearly indicate a stagnation of U.S. students' performance in mathematics and science for at least a decade and that efforts to close that gap have not been successful. U.S. students not only need better performance in science and mathematics but also to improve their ability to apply their knowledge and skills to real world problems for the purpose of innovation and advancement in the global economy.

Science Technology Engineering and Math (STEM) Workforce

Thriving mass production and distribution industries in 20th century America allowed the average citizen with low reading, writing and math skills to earn a good living as a factory or service industry worker throughout the country. By the end of the century, increasingly automated manufacturing along with outsourcing of manufacturing and services industries to lower wage foreign countries had resulted in higher unemployment, under employment and a lower standard of living for America's working class. In a briefing paper published by the Economic Policy Institute, statistics clearly indicate that U.S class of 2013 high school as well as college graduates face employment income far below their 2000 counterparts. From 2000 to 2013, inflation adjusted wages of high school graduates declined 12.6% and 8.5% for college graduates. Unemployment rates for high school graduates continue to rise from 17.5 in 2007 to 29.9% in early 2013 and for college graduates from 5.5% in 2007 to 8.8% in 2013 (Shierholz, et al., 2013). A study published by the McKinsey Global Institute (Manyika, et al., 2011) states that better matching of workers skills training to the jobs which are currently needed is required to improve employment rates and wages for young graduates Research conducted by the National Academy of Science, of Engineering and of Medicine in tandem with the National Research Council (National Research Council, 2009) points out that the U.S. now lives in a world filled with the products of scientific inquiry, and scientific literacy has become a necessity for everyone. Accessing and utilizing scientific information is now an integral part of our daily decision making process. The ability to engage intelligently in public discourse and debate about important issues which involve science and technology is no longer a luxury but a requirement for all. Scientific literacy is of increasing importance in the workplace. More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions, and solve problems. An understanding of science and the processes of science contributes in an essential way to these skills. Unfortunately, studies indicate that U.S. Students are moving away from STEM related jobs. In 1997, close to 30% of the top performing high school graduates majored in STEM fields compared to less than 10% in 2005. In 2011 only 30% of high school seniors met the college readiness benchmark for science and only 45% met the math benchmark. In conclusion there is an urgent need to reignite U.S students' interest and preparedness for STEM related careers.

In addition to the need to foster interest and preparedness for higher education in STEM fields, advancements in international communications are rapidly changing technological literacy requirements in entry-level jobs that used to require only local cultural awareness and little to no computer literacy (National Research Council, 2009). Interdisciplinary themes such as global awareness and literacy in information, media and communications technology need to be incorporated into standard curriculum materials along with a more in depth understanding of finances, business, entrepreneurial, health and environmental sciences. Schools and teachers will need to bring the classroom into the digital environment so that students can acquire and maintain proficiency in the latest skills sets needed to function and thrive in this demanding new world. Other countries are investing heavily in education for the purpose of developing scientifically and technically literate work forces. To keep pace in global markets, the United States needs to have an equally capable citizenry (National Research Council, 2009).

Agricultural Education

In contrast to the sluggish job market for young people in U.S. cities today, agricultural workers as well as professionals are in increasing demand. The Bureau of Labor predicts that in the next 10 years jobs for agricultural and food scientists will grow 9% because of the need for expertise in developing food, crops and ensuring quality and safety and also an increased national emphasis on improving health. The bureau also predicts that soil and plant scientist jobs will grow 8% in the next 10 years. Research in genomics and agricultural sustainability is expected to grow as well with a focus on crop yields which is likely to affect other fields such as biofuels. Additionally, many of the agricultural scientists currently employed are expected to retire in the next 10 years opening up those positions to a new generation of professionals (Bureau of Labor, 2014). As the global population continues to grow rapidly from 7 billion in 2011 to an expected 9.6 billion in 2050 (U.S. Census Bureau, 2013) and the challenges of climate change continue to disrupt agriculture across the globe, the need for more research and innovative problem solving is expected to increase as well (USDA, 2012).

The American Farm Bureau Foundation for Agriculture published a list of Agricultural Literacy goals entitled the Pillars of Agricultural Literacy in 2012 (American Farm Bureau Foundation for Agriculture, 2012). These goals include teaching students the relationship between agriculture, food production and healthy lifestyles. The Farm Bureaus' pillars of Agriculture Literacy also include the relationship between agriculture and the local, state, national and international economies. The Agriculture Council of America (ACA), an organization that includes leaders in agriculture, food and fiber communities, states that knowledge of agriculture and nutrition allows individuals to make informed personal choices about diet and health. A strong understanding of agriculture is necessary to ensure the development and implementation of policies that support a competitive agricultural industry in the U.S as well as abroad. Agricultural literacy includes knowledge of agriculture's history and current economic, social and environmental factors. This understanding also includes food and fiber production, processing as well as domestic and international marketing. Additionally, students need more awareness of the careers available to them in agriculture including research, engineering, business and marketing, processing and retailing, banking, urban planning, energy, and landscaping. The Agriculture Council of America (2011) advocates that agriculture is too vital to be taught only to the minute proportion of students that are considering careers in agriculture. The council recommends that all students begin learning about agriculture in kindergarten and continuing through 12th grade. The goal is to improve students' understanding of agriculture's history and its' current economic, social and environmental relevance to their personal lives.

Agricultural Literacy

In 1988, The National Academy of Science (NAS) published an article entitled "Understanding Agriculture - New Directions for Education" (NAS 1988). The NAS committee's (1988) recommended broadening the subject matter of instruction and expanding the program to include all kindergarten through twelfth grade students. The committee also recommended that colleges of agriculture in land-grant universities become more involved in curriculum reform and the development of instructional materials and media.

For the purpose of defining what subject areas and concepts agricultural literacy curriculum should include, a nationwide survey was conducted in 1991 (Frick et al., 1991). The objective was to refine a group definition of agricultural literacy, identify those subject areas falling within the framework of agricultural literacy, and to identify those agricultural concepts that every U.S. citizen should know. The result was a consensus definition: "Agricultural literacy can be defined as possessing knowledge and understanding of our food and fiber system. An individual possessing such knowledge would be able to synthesize, analyze, and communicate basic information about agriculture. Basic agricultural information includes: the production of plant and animal products, the economic impact of agriculture, its societal significance, agriculture's important relationship with natural resources and the environment, the marketing of agricultural products, the processing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products" (Frick et al., 1991). According to United States Department of Education (USDE, 2007) data, it is estimated that the total agriculture education enrollment in the U.S. was about 850,000 in 2007. This indicates that only 5 to 6 % of the total high school population is enrolled in agriculture education programs.

The Department of Agriculture (USDA) and the National Institute of Food and Agriculture are currently funding a program called Expanded Food and Nutrition Education Program (EFNEP), which is administered by the Colorado State University Extension in Colorado. EFNEP educators use age-appropriate curriculum and work with schools, after-school programs, day-camps, Head-Start and preschools. During the 2010-2011 fiscal year 134 adults and 304 youth attended EFNEP classes in Denver County, Colorado. Outcome results indicated that the adults made measurable progress in Nutrition Practices, Food Resource Management and Food Safety. However, no data was available on outcomes for the youth who participated in the program (Wardlaw & Baker, 2012). These studies have indicated an ongoing need for effective obesity prevention as well as Agricultural Literacy programs in the United States.

A 4 strand framework was developed for K-8 science learning in Taking Science to School by a group of curriculum developers (Duschl et al., 2007). Two additional strands were identified in informal learning studies. Measuring outcomes based on all six learning strands may be an excellent tool for bridging the gap between subjective informal learning and objective formal learning for the purpose of enhancing both the performance of our young people and increasing their interest in scientific careers:

Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.

Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.

Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.

Strand 4: Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.

Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.

Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.

Nutrition Literacy

The U.S. Department of Health and Human Services' Healthy People 2010 initiative defines Health/Nutrition Literacy as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (U.S. Department of Health and Human Services, Healthy People 2010*)*. The Healthy

People Initiative states that health and nutrition literacy involves numeracy skills such as measuring medications, understanding nutrition labels, and understanding the results of lab tests. It also requires knowledge of health topics such as accurate information about how the body functions and the causes of diseases. This knowledge is necessary to understand the relationship between what we eat and our health status why a healthy life style can make a huge difference in all aspects of our lives. (U.S. Department of Health and Human Services, Healthy People 2010 According to the National Assessment of Adult Literacy, almost nine out of ten adults lack proficiency in health literacy (Kirsch etal., 1993) which means that they are unable to effectively manage their health.

Obesity rates in American children is pressing and serious issue which is affecting our students' health and by extension their future productivity and success as adults. Studies have indicated that obesity in childhood and adolescence is likely to continue into adulthood. One study found that overweight children, aged 10-14 years, with at least one overweight or obese parent (body mass index [BMI] ≥27.3 kg/m^2 for women and ≥27.8 kg/m^2 for men as reported), have a 79% likelihood of overweight persisting into adulthood (Whitake et al., 1997*)*. Another study on the effect of obesity on workplace productivity suggested that obesity not only increases absenteeism but productivity when present in the work place (Gates, et al., 2008).

In Colorado, the medical costs associated with adult obesity were estimated to be $874 million in 2003 (CDC, 2005). The growing obesity rates and related chronic diseases such as diabetes and heart disease in youth across the United States are alarming. According to Shupe's (2006) Youth at Risk Behavior Survey of 9th through 12th grade students, 9.8% of this age group are obese, 10.3% are at risk of becoming obese and only 19.2% report eating 5 servings of fruits and vegetables daily. Additionally, only 29.6% engaged in the level of moderate activity deemed necessary at their age. In Colorado about 10% of youth (9th-12th grades) are overweight, and another 10% are obese, according to the 2005 Youth Risk Behavior Survey data. Approximately two-in-five youth in these grade levels are meeting current physical activity recommendation levels while twenty-seven percent watch three or more hours of television each day.

The Colorado Health Education Act of 1990 calls for K-12 grade-planned, sequential health education that is based on science and a number of programs have been implemented in Colorado schools. The Poudre School District in Northern Colorado lists Health and Wellness as its fifth strategic goal and a wellness program for staff as well as students that have been initiated. Unfortunately, no data on the effectiveness of these programs in children is currently available. A national literature review on the effectiveness of school-based obesity intervention for children between the ages of 7 and 19 between 1986 and 2006 indicates that these programs have not resulted in any persistent reduction in obesity rates of school-age children (Shaya et al., 2008).

Agricultural and Nutritional Literacy Overlap

Studies indicate that agricultural literacy curricula can be effective in improving health and nutrition literacy. Murphy et al. (2003) showed that students in a school with a Food Systems curriculum demonstrated more concern for living things as compared to the non-Food Systems control school. Students in the Food Systems School scored higher on a scale testing for improved student cooperation, behavior and better social skills. A number of other studies conducted throughout the United States have found similar benefits from school gardens: For example in 2006 a community summer garden program study measured improvement in the nutritional knowledge, attitudes, and behaviors of children (Koch, Waliczek, & Zajicek, 2006).

Another study conducted in 2005 indicated that California teachers perceive school gardens to be an effective nutritional tool to promote healthful eating habits (Graham & Zidenberg-Cher, 2005).

Education Reform

Over the last 25 years, efforts to improve education in the United States have resulted in the development of national and state standards in science as well as other disciplines.

Common Core Curriculum

In 1983, A Nation at Risk prepared by the National Commission on Excellence in Education called for higher standards for teachers and students, a core curriculum for all, higher standards for high school graduation and college entrance, a longer school day and year, and higher salaries for teachers. The federal No Child Left Behind Act (NCLB, 2001) has become a driving and demanding framework for K–12 education. This legislation imposes higher expectations for testing and accountability of teachers along with standardized assessments. Science was first added to the testing in 2007–2008 school year but continues to be limited to higher elementary and high school.

The Development of Science Standards

Since 1986, the National Assessment of Educational Progress (NAEP, 2014) has administered the achievement tests, with testing in Technology and Engineering literacy due to begin in 2014. Beginning with a historic conference of the National Governors Association and continuing into the early 1990s, President George H.W. Bush and the nation's governors developed the National Education Goals. To achieve these goals, the governors decided that national standards for science and other subjects should be developed. For science, the governors declared the following objectives for K-12:

- Use scientific principles and processes appropriately in making personal decisions.
- Experience the richness and excitement of knowing about and understanding the natural world.
- Increase their economic productivity.
- Engage intelligently in public discourse and debate about matters of scientific and technological concern.
- Be aware of careers in science, technology, and the medical sciences.

In 2002, Tanner and Allen published in the first volume of *Cell Biology Education* an important article about national science education standards for Grades K–12. In 2002, a review and evaluation of two national science standards documents for grades K-12 was published (Tanner, and Allen, 2002). The two documents: *Benchmarks for Science Literacy*, published by the American Association for the Advancement of Science (AAAS, 1993), and the *National Science Education Standards*, published by the National Research Council (NRC, 1996) outline the knowledge and skills students should know and be able to do at various grade levels in cell biology. These documents were intended to facilitate the development of state standards (Tanner, and Allen, 2002). Specific Science standards were developed by the Interstate New Teacher Assessment and Support Consortium in 2002 and implemented in most states. However, despite the implementation of the standards, U.S. Students' performance in Science did not improve compared to their peers in other countries (Aud et al., 2011).

In 2012, a framework for K-12 Science Education was developed based on the latest research published by the National Research Council (NRC, 2012). The Framework is a comprehensive set of performance expectations for students in science and engineering grades K-12. This framework is designed to guide the development of new standards for K-12 science education and also guide subsequent revisions to curriculum, instruction, assessment, and professional development for educators. The goal is to ensure that standards are designed to provide internationally benchmarked science education across disciplines and grade levels in a consistent and progressive manner (NRC, 2012).

The Framework for K-12 Science Education was then used to develop the Next Generation K-12 Science Standards (Achieve 2013). These standards were then created through a state-led cooperative effort in 2012 and include three sets of standards: Content, Science and Engineering Practice, and Crosscutting Concepts. These standards are intended to be integrated into the existing Common Core State Standards for English Language Arts as well as Mathematics to promote scientific inquiry, and innovative thinking in a consistent progressive manner across disciplines and grade levels (Achieve, 2013).

Concurrently, the Partnership for 21st Century Skills organization was created through a collaborative effort involving very successful global businesses such as Adobe Systems Incorporated, Apple, Cisco Systems, Microsoft, Oracle, Intel and national education organizations such as the American Association of School Librarians, Discovery Education, Education Networks of America, McGraw Hill Education, National Education Association, and many others. The result is a comprehensive list of skill sets for 21st century education that is designed to help students succeed as citizens and workers in this global and digital economy. Partnership for 21st Century skills provides teachers with rubrics which are designed to assess student projects for skills like creativity and innovation. The data collected from these assessments is then analyzed and graded using a four level proficiency scale: Below Basic, Basic, Proficient, and Advanced. Students are assessed not only for overall proficiency, but also for each of the NETS-S 2007 strands which include creativity and innovation, communication and collaboration, research and information fluency, critical thinking, problem solving and decision making, digital citizenship, technology operations and concepts (Achieve, 2013). The Colorado Department of Education drafted its own standards using all of the above mentioned national guidelines in addition to locally developed resources and experience. The result is a unique set of guidelines with well-defined goals (CDE, 2012).

1. Using content as the vehicle for teaching concepts and skills for the purpose of meeting the expectation of greater depth in student knowledge and skills.
2. Using a Backward/P13 Vertical Progression approach to developing curricular materials with the ‘end in mind’ being post-secondary and workforce readiness
3. Requiring that students learn to apply the knowledge learned by engaging in real life projects. This includes internet literacy, collaborative team work, critical thinking, self-direction and creative problem solving.
4. Focusing on 10 content areas: Math, Reading, Writing, Science, Communicating, Personal Financial Literacy, Social Studies, Music, Dance and Visual Arts, Comprehensive Health and P.E., and Drama and Theater Arts
5. Developing proficiency in Academic Language (Social Instructional, Language Arts, Mathematics, Science and Social Studies)
6. Promoting Emotional and Social Wellness of Students and Staff across all activities

Elementary Teachers and STEM

Next Generation Science and 21st Century skills development suggest approaches to science education that are very different from the prevailing teaching methods. In particular, the new standards call for pedagogical approaches that foster students' understanding of the connections between science and other types of knowledge and how science is relevant to their lives and their communities. There is also an emphasis on science education and scientific literacy for all students instead of more narrowly targeting those who intend to pursue higher education in science. Moreover, science is to be introduced to students much earlier in their academic preparation than it was in the past. These major changes in pedagogical approaches and scientific literacy requirements have clear implications for the education and ongoing professional development of teachers, curriculum development and implementation, and classroom design.

The National Research Council's Framework for Science Education was used to develop grade specific science standards which were published in 1996. These standards were revised in 2013 (New Generation Science Standards) and include three dimensions:

Practices. The rigorous practices scientists use when they are investigating and building theories and models of the natural world and also the practices used by engineers when they are designing and building models and systems.

Crosscutting Concepts. Crosscutting concepts is a method of organizing data in a scientific manner for the purpose of making connections between different fields in science and identifying patterns, similarities, and diversity, cause and effect; scale, proportion and quantity; systems and system models; energy and matter; structure and function; stability and change.

Disciplinary Core Ideas. The purpose of this dimension is to focus instruction and assessment on the fields of science that are considered to be the most important by making sure instruction is focused on ideas which meet at least two of the following guidelines: “Have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline; Provide a key tool for understanding or investigating more complex ideas and solving problems; Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; Be teachable and learnable over multiple grades at increasing levels of depth and sophistication” (Archive, 2013).

STEM Professional Development for Elementary Teachers

The challenges of teaching science may be greater in elementary schools than those faced by secondary and college science teachers who specialize in one discipline versus having to teach multiple disciplines at multiple grade levels (Davis et al., 2006). Job dissatisfaction appears to be the main reason that math and science teachers leave their jobs (Ingersoll, 2001). Part of the reason for this dissatisfaction may be due to the complexity and quantity of standards science teachers are expected to understand and integrate. Most States including Colorado consider teachers with degrees or certification in general elementary education to be “qualified” to teach mathematics and science as well as all the other content required. However, teachers do not necessarily feel that they have the knowledge or experience needed (Greenberg and Walsh 2008). There is no guidance on how teachers can go about achieving these lofty goals within their very limited time, science training and resource constraints (Davis, et al., 2006). The lack of easily accessible, affordable, grade and standard based curricula resources was another source of job dissatisfaction according to a study published in 2001 (Ingersoll, 2001).

A comprehensive review of 17 studies on the performance outcomes of different approaches in teaching Science in elementary schools suggested that the use of science kits did not result in positive outcomes on science performance measures. However, inquiry-oriented instructional approaches such as cooperative learning, integrating science and reading appear to result in improved interest and performance in science. The successful courses tend to emphasize the use of specific, well-articulated strategies designed to develop students' understanding, curiosity, and ability to apply scientific methods. These interventions consistently emphasize the importance of professional development and coaching to promote the use of the more promising approaches by teachers (Slavin et al., 2012).

A recent study conducted by the University of California, Berkeley concluded that despite their desire to teach science, elementary school teachers are under pressure to concentrate on English Language Arts and Mathematics, which limits the amount of time available for Science and other subjects. However, a few schools have begun integrating science with other content areas such as English Language Arts. The study found that teachers who regularly integrated science with other subjects offered science an average of 130 minutes a week, compared with an average of 94 minutes per week for teachers who rarely or never integrated science (Dorph et al., 2011).

STEM Curriculum to Promote Agricultural Literacy

A study conducted to evaluate elementary teachers' attitudes about agricultural literacy indicated that elementary teachers generally believe that agriculture is a viable integrating tool to teach across disciplines (Bellah & Dyer, 2009). Agriculture Literacy inherently includes the exploration of all of the STEM fields and for this reason may constitute an effective vehicle for integrating STEM into Common Core content.

Improving Math and Science Performance

A study on the impact of experimental instruction strategies found that participation in agriculturally-oriented experiential activities positively impacts the development of science process skills (Mabie & Baker., 1996). Participants in the school garden program in California experienced significant gains in overall GPA in math and science, and improvement on a standardized psychosocial questionnaire (Murphy et al., 2003). A number of studies have shown that involvement with school nature areas has a direct relationship with improved academic performance. In 2005 (Klemmer et al., 2005) reported that third, fourth, and fifth grade students who participated in school gardening activities scored significantly higher on science achievement tests compared to students who did not experience any garden-based learning activities. Dirks and Orvis (2005) demonstrated that involvement with Junior Master Gardeners resulted in gains in academic knowledge in science, horticulture, and environment. A broad study of 40 schools from across the U.S. showed that environment-based education curriculum resulted in better performance on standardized achievement tests (Lieberman & Hoody, 1998).

Promoting Emotional and Social Wellness of Students and Staff

One of the Colorado Department of Education's academic goals is to improve emotional and social wellness across disciplines. Murphy's (2003) study of middle school students showed that students in a school with a Food Systems curriculum demonstrated more concern for living things as compared to the non-Food Systems control school. Students in the Food Systems School scored higher on a scale testing for improved student cooperation, behavior and better social skills. Participants in the school garden program experienced significant gains in overall GPA in math and science, and improvement on a standardized psychosocial questionnaire (Murphy et al., 2003). Teachers stated that their school (Food Systems School) was more conducive to learning (more order, better morale). Compared to the control school, teachers rated their school higher in the following dimensions:

Overall educational climate

- More cooperation among staff
- General satisfaction with being a teacher at this school
- Order and discipline are maintained satisfactorily
- General teacher morale is high
- Students in this school pay attention during class

Knobloch (2008) reviewed teacher's beliefs related to integrating agriculture into elementary school classrooms. The results indicated that teachers are more likely to use agriculture literature curriculum material that fits into the grade specific academic content they are currently teaching and into the educational goals already established instead of materials that focus on agriculture industry and careers in agriculture (Knobloch, 2008).

Purpose of this Study

National and Colorado State education goals are currently focused on improving STEM education and common core proficiency as well as addressing childhood obesity. Assessment data related to these topics is of great value in developing effective methods of meeting these goals. Improving agricultural literacy is an importance aspect of STEM education not only because of the career opportunities likely to develop within the next decade but because it embodies all of the STEM fields.

The purpose of this study was to develop and conduct a case study at a Northern Colorado STEM elementary school: The case study was designed to collect and analyze input from teachers and other staff members on several topics:

A. the incentives and barriers to using a grade specific, standard based edible plants curriculum to integrate inquiry based agricultural STEM learning across common core content.

B. the effectiveness of this project-based curriculum in fostering student learning related to standards as well as 21^{st} century skills and nutritional literacy.

Research Questions

Existing Curricular Resources. What types of resources are currently available for teachers looking to integrated project-based agricultural literacy? Do these agricultural literacy materials include the following characteristics?

- 1intentionally integrate S.T.E.M. content with other accountability requirements (Reading, Writing, Communicating and Mathematics).
- grade specific, standard based
- incorporate 21^{st} century global awareness skills such as improving students understanding of the relationship between agriculture, food, nutrition and their personal health and future success.
- promote health and nutrition literacy
- promote the development of professional language
- include complete Lesson Plans
- include student learning outcome measurements
- include a continuous improvement process as an essential component to the development and evolution of effective curricula materials and this process needs to be scientifically designed to collect, compile and analyze and incorporate both objective and subjective input from the students and teachers involved.

- readily accessible to teachers (internet accessible and downloadable)
- affordable curricular resources with very few additional materials needed to be purchased or procured to complete the activities

Curriculum Development. What existing curricular materials, curriculum design models and schools of thoughts can be used to develop an innovative edible plant based curriculum as a vehicle for integrating STEM into Common Core content while fostering 21st Century skills development and nutritional literacy?

Curriculum Evaluation. How do in-service elementary teachers at a Northern Colorado elementary STEM school respond to the edible plant curriculum?

- How do teachers choose to implement the lessons, including modifications made to the lessons?
- Do teachers find that the lessons plans meet the standards and 21st Century skills targeted?
- Do student learning outcomes indicate measurable progress in acquiring the knowledge and skills targeted?
- What aspects of the curriculum make it attractive to elementary school teachers?
- What do elementary teachers need to be able to integrate project-based agricultural STEM curricular materials into their existing activities?

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CHAPTER 2

Curriculum Development

INTRODUCTION

The Importance of Higher Performance in Science, Mathematics, Reading and Writing

Recent statistical studies clearly indicate that U.S students' performance in mathematics and science has been out paced by several foreign counties for at least a decade and that efforts to close that gap have not been successful. U.S. students not only need better performance in science and mathematics but also to improve their ability to apply their knowledge and skills to real world problems for the purpose of innovation and advancement in the global economy (NCSS, 2013).

The Importance of Developing Integrated STEM Curricula

The National Science Foundation associated science, information technology, engineering, and math with the acronym "STEM" in the 1990s. STEM is the integration of the subject areas necessary to achieve success in today's global economy. The knowledge and skills involved in STEM do not exist separate from each other in the workforce and therefore should not be taught separately in the classroom. The Common Core State Standards for Math and Language Studies initiated in the 1990s by the National Governors Association (GA) (Corestandards.org, 2012) and the Next Generation Science Standards (NGSS, 2013) emphasize the importance of integrating STEM disciplines, evidence based reasoning and academically productive dialogue into existing curriculum. Educators must now transition from single subject inquiry-based activities to integrated, real-world, real-time driven practices (Woodruff, 2013).

The Value of Using Agriculturally-Oriented Experimental Activities as a Vehicle to integrate STEM Across Disciplines and Grade Levels.

One of the ways inquiry based teaching could be effectively integrated into common core content is through hands-on agricultural science activities which could also be a conduit for nutritional literacy. A study conducted to evaluate elementary teachers' attitudes about agricultural literacy indicated that elementary teachers generally believe that agriculture is a viable integrating tool to teach across disciplines (Bellah, &Dyer, 2009). Another study on the impact of experimental instruction strategies found that participation in agriculturally-oriented experiential activities positively impacts the development of science process skills (Mabie, & Baker, 1996). Advances in agricultural science and skilled worker preparedness are of increased importance given the rapid global population growth: from 7 billion in 2011 to an expected 9.6 billion in 2050 (U.S. Census Bureau, 2013) and the challenges of climate change (USDA report, 2013). According to United Stated Department of Education (NSDE 2013) data, only 5 to 6 % of the total U.S. high school students are enrolled in agriculture education programs. The Agriculture Council of America (ACA, 2011) states that a strong understanding of Agriculture is necessary in creating and implementing policies that support a competitive agricultural industry in the U.S as well as abroad. Additionally, the National Institute of Food and Agriculture states that increased knowledge of agriculture and nutrition is needed to promote informed personal food choices about diet and health (NIFA, 2012). Obesity rates in children continue to increase rapidly with studies clearly indicating that obesity in childhood is likely to continue in adulthood (Whitake, 1997*),* and that obesity in adulthood increases absenteeism and health issues while decreasing productivity (Gates et al., 2008).

The Difficulties Facing Elementary Teachers in Integrating New Standards

Integrating the new standards into current common core curriculum content is quite a challenge, in part because it represents a shift in mindset and in the learning environment for curriculum developers, teachers and students. The days of teachers focusing solely on delivering static content and practices related to required subjects, and students simply absorbing and repeating this information back are gone. The curriculum developer must now design materials that promote scientific curiosity regardless of the subject matter. The elementary teacher must learn to be a facilitator of scientific inquiry by asking open ended questions regardless of the subject matter, encouraging collaborative discussions and personal creative decision making. The student must become an apprentice scientist as a way of life in all of his/her daily activities. A recent study conducted by the University of California, Berkeley concluded that despite their desire to teach science, elementary school teachers are under pressure to concentrate on English Language Arts and Mathematics, which limits the amount of time available for Science and other subjects. However, a few schools have begun integrating Science with other content areas such as English Language Arts. The study found that teachers who regularly integrated science with other subjects offered Science an average of 130 minutes a week, compared with an average of 94 minutes per week for teachers who rarely or never integrated science (Dorph et al., 2011). Another major difficulty facing Colorado elementary teachers in integrating STEM and other content into their curricular activities is the very demanding "teach to the test" focus imposed by the Colorado Education Accountability Act of 2009 (S.B. 09-163) which holds the state, districts, individual public schools and teachers accountable for student performance on standardized testing for reading, writing and mathematics. The focus of these tests is to measure the student's static knowledge and skills instead of the student's ability to grasp, apply and transfer concepts and skills in a scientific manner. The demands of "teaching to the test" (reading, writing and mathematics) also limit the teacher's ability to integrate inquiry based pedagogical approaches because facilitating open-ended discussions and collaborative activities requires significant amounts of class time.

Purpose of this curriculum design study

National and Colorado state education goals are currently focused on improving STEM education and common core proficiency as well as addressing childhood obesity and nutrition. Assessment data related to these topics is of great value in developing effective methods of meeting these goals. For this reason, a case study of a Northern Colorado Elementary STEM School was developed. The focus of the study was to identify the incentives and barriers experienced by teachers when they implemented a standard based agricultural and nutrition literacy curriculum on edible plants as a vehicle for integrating STEM learning and 21^{st} Century skills development across common core content.

Internet Search for Existing Curricular Materials

In 2012, a comprehensive internet search was conducted by the researcher to identify available standard based agricultural and nutrition literacy curriculum resources for elementary teachers. A general internet search using the terms agricultural literacy curricular materials was conducted using a rubric previously developed by a committee of Colorado State University professors and graduate students in 2012. Of the 43 state departments of education that have websites, only 2 had links to agricultural literacy curricular resources. For this reason, the search was expanded to a general internet search using the terms agricultural literacy curricular materials and the rubric was modified to include all of the academic and content standards required for the case study. This rubric included the following categories: STEM and Common

Core content integration; grade specific, standard based, 21st century global skills integration, promotion of health and nutrition literacy, development of professional language, complete lesson plans, student learning outcome measurements, teacher assessment and continuous improvement process, readily accessible to teachers, affordable curricular resources.

The search was limited to 100 standard based agricultural and nutrition literacy curricula resources. An in-depth review of these resources was conducted and validated through inter coder reliability analysis by members of a Colorado State University Education Department committee which include a Department of Education professors and three graduate students Findings indicated a lack of free downloadable, interdisciplinary agricultural and nutrition education resources available to teachers. Additionally, findings indicated the need for the development of curricula which includes complete lesson plans; promotes scientific inquiry across disciplines and grade levels, and measures student performance and progress. For these reasons, an edible plant curriculum was developed as a vehicle for integrating STEM, 21st Century skills across existing common core elementary school content.

Curriculum Design Questions

How can standard-based Plant Science content be structured as an effective vehicle for teaching integrated STEM and common core skills while promoting nutrition literacy? What design components are required to:

1. ensure real-life relevance for a diverse population of teachers and students
2. meet the teacher's need for ease of access to materials, affordability of materials, relevance to existing curriculum, integration into existing curriculum
3. foster greater depth of understanding of abstract concepts progressively over time
4. promote common core skills development

5. integrate STEM knowledge and skills
6. encourage 21st Century Skills development
7. measure student learning outcomes efficiently
8. Facilitate continued improvement of materials based on teacher assessment

THEORETICAL FRAMEWORK

Colorado Academic Standards

With the goal of improving student performance, the Colorado Department of Education developed standards which integrate Common Core Skills, 21st Century Skills and Next Generation Science Standards as well as locally developed resources and experience. The result is a unique set of guidelines with well-defined goals (CDE, 2012). These standards were used in the development of the curriculum because they embody both national and state priorities with regard to improving student performance and their ability to succeed in our increasingly global and competitive world. These standards consist of:

1. Using content as the vehicle for teaching concepts and skills for the purpose of meeting the expectation of greater depth in student knowledge and skills
2. Using a Backward/P13 Vertical Progression approach to developing curricular materials with the "end in mind' being post-secondary and workforce readiness
3. Requiring that students learn to apply the knowledge learned by engaging in real life projects. This includes internet literacy, collaborative team work, critical thinking, self-direction and creative problem solving

4. Focusing on 10 content areas: Math, Reading, Writing, Science, Communicating, Personal Financial Literacy, Social Studies, Music, Dance and Visual Arts, Comprehensive Health and P.E., and Drama and Theater Arts

5. Developing proficiency in Academic Language, Social Instructional, Language Arts, Mathematics, Science and Social Studies

6. Promoting emotional and social wellness of students and staff across all activities

Curriculum Development Models

The academic standards and guidelines recommended for curriculum development by the Colorado Department of Education (CDE) were therefore chosen as the main instruments in the development of the Edible Plan Curriculum because the case study was conducted in a Northern Colorado elementary STEM school. Three national renowned curriculum developers were recommended by the CDE: why are the following numbered? They are separate pubs that informed your methods—present them in a more seamless way.

Concept-Based Curriculum for the Thinking Classroom by Dr. Lynn Erickson emphasizes the importance of a three dimensional teaching model adding a Concepts and Principles component to the existing Factual Content and Processes and Skills focused model. She suggests using a current event or topic of local, state, national and global importance as the conceptual lens (main idea) through which students filter information. Activities from various other disciplines can then be built into the curriculum. For example, if the topic is the human body, activities involving comprehensive health, science, literature and the use of language processes could be integrated into the curriculum. Over-arching essential questions are then defined as the framework in which the students' understanding evolves from concrete facts to abstract concepts to generalization of abstract concepts (Erickson, 2007).

***Rigorous Curriculum Design*, Larry Ainsworth** focuses on the identification of the main (priority) standards to be taught as the first step in designing curriculum. Other standards that can connect and support the priority standards are then identified and taught. The CDE recommends incorporating all of the Colorado Academic standards into curriculum materials. In Ainsworth's design study units can be topical, skill-based or mathematical. He strongly recommends the use of a calendar to plan the sequence and timing for units such that all standards are taught and assessed over the course of the year. Similar to Dr. Erikson and McTighe and Wiggins, he recommends the formulation of essential questions which are open-ended, rigorous and designed to spark the student's interest in the topic and focus on the instruction materials that will be assessed. He also stresses the importance of "unwrapping" the concepts by identifying specific nouns and/or nouns phrases that the student is expected to fully understand. Ainsworth also talks about the "big ideas" as the outcome of the course and defines them as the foundational understandings: the main ideas, conclusions and generalizations taught and learned by the students over the course of the year (Ainsworth, 2010).

***Understanding by Design Framework* by McTighe and Wiggins** is a well reputed and CDE recommended design tool for the edible plant curriculum because it emphasizes the importance of maintaining a logical flow of learning over time. This model uses a backward approach to curriculum design which is one of the main recommendations of the CDE and involves starting with the end goals ("Big Ideas") of the curriculum. These big ideas are the transferable concepts, principles and theories which create the focal point through which students gain real life meaning. The big ideas are then used to prioritize content. Over-arching topical questions relevant to the "big ideas" are then used to generate thought provoking dialogue and conceptual understanding which is transferable to new situations. This model is also designed to provide high quality assessments of the students' understanding of the material and their ability to transfer the knowledge and skills acquired to solving real world problems (McTighe & Wiggins, 2005).

Project Based Learning (PBL)

In addition to the guidelines recommended by the CDE, a project-based approach was integrated into the curriculum design because an edible plant science project was the vehicle chosen to integrate STEM and common core skills learning across disciplines and grade levels. Project-based learning was introduced as an educational approach to K-12 education in 1918 by William Kilpatrick who suggested that combining math, science and social studies into class projects could help students develop an understanding of their lives while preparing to work within a democracy. Kilpatrick's design called for learner question driven projects (Kilpatrick, 1918) John Dewey also believed that children learn best through experiences that are relevant to their own interests, and through activities that allow for individual differences (Dewey, 1899). Recent studies suggest that project-based learning can provide the vehicle students need to tackle real-life problems in a meaningful manner. Project based learning also promotes student directed and collaborative learning (Thomas, 2000). Researchers indicate that students who struggle in traditional instructional settings have often been found to excel when they work in a project based learning environment (Barron, and Darling-Hammond, 2008). The awarding winning *Knowledge in Action* (NCSS, 2013) project-based study sponsored by the George Lucas Educational Foundation recommends using learning cycles in which students can apply their knowledge again and again. It also suggests structuring the course such that it fosters a personal "desire to know" among students and thereby a self-directed motivation to learn (Barron, B and Darling-Hammond, L, 2008).

METHODOLOGY

Curriculum Development Process

Project Based Framework for Integrated STEM and Common Core Content

All three design models promoted by the Colorado Department of Education (2013) recommended using a big idea or 'conceptual lens' as the central focus through which students can filter information (McTighe & Wiggins, 2005, Ainsworth, 2010, Erickson, 2013). The design models also use over-arching, essential questions related to the "big idea." These questions define the framework in which the student's understanding evolves from concrete facts to abstract concepts to generalization of abstract concepts (McTighe &d Wiggins, 2005, Ainsworth, 2010, Erickson, 2013).

The big idea in STEM is that all human beings require certain essential things to survive and thrive: a clean environment with clean water, safe and nutritious food, and effective shelter from the elements. The essential question contained in this big idea is: How does a student develop the knowledge and skills needed to obtain and maintain these essentials things; and by extension, how does a community, a city, a state, a country, and the world obtain, maintain and improve these essential things? Based on the above premises a curriculum design framework was developed by the researcher which could be applied to any project-based content a developer/teacher might choose to use as a vehicle for integrating STEM and 21st Century skills and common core skills into existing elementary school curriculum. The Framework was then applied to edible plant content with the intent of igniting the student's curiosity about:

- where the plants they eat come from; how they are processed for consumption (Social Studies standards); what is their nutritional value (Comprehensive Health and

Nutrition standards); and what is their economic value locally, statewide, nationally and globally

- how edible plants are grown/ produced including addressing water and environmental management issues (Life Science Standards)
- using the scientific method to grow edible plants, to collect data and address problems (Science, Technology, Engineering, Mathematics), and understand the components of healthy recipes (Math, Comprehensive Health and Nutrition Standards)
- sharing, discussing, collaborating in addressing the problems they encounter, and writing about their own theories, findings and conclusions about global issues that affect them personally (Reading, Writing and Communicating standards) See Table 1:

Table 1 - Project-Based Framework for Integrated STEM and Common Core Content

Essential Components	Description of Component	Component Applied to Edible Plant Curriculum
Conceptual Lens/Big Idea	All human beings have certain essential needs which must be met for survival and growth. These essential needs include clean air, water, environment, nutritious food and adequate shelter from the elements	The study of Common/Popular Edible Plants inherently explores the problems related to clean water, food and environment as well as engineering shelter from the elements for these plants
Essentials Questions Related to the Big Idea	What knowledge and skills does a student need to acquire to fulfill their own essential needs as an individual and by extension as an inter-dependent community, city, state, nation, and planet?	The study of Common/Popular Edible Plants encompasses Life Science standards, information technology to research origins and issues related to growing and preparing plants for consumption, engineering projects to address environmental or space issues in growing plants, and mathematics to collect and analyze data collected, related to local, state, national and global food and nutrition issue
Project/Content Vehicle for Integration of STEM and Common Core Skills	Select a real-life, real-time standard-based project that inherently addresses the above STEM questions in manner that is personally and concretely relevant to teachers and students but has the potential to evolve into more abstract and generalized concepts of these same issues at the community, city, state, national and global level.	Studying and growing commonly eaten plants such as potatoes and tomatoes is personally relevant to a diverse population of teachers and students. Personal experience in growing/studying edible plants can evolve naturally over time from addressing concrete problems in a personal/local environment to tackling these issues more abstractly at the city, state, national and global levels
Incorporating Grade Specific Standard Base Content Across Disciplines	Review Department of Education grade specific standards and design activities such that they are relevant to the project while meeting these standards	See Unit and Lesson Plan Templates for details on how grade specific Social Studies, Math, Reading, Writing, Communicating, Comprehensive Health and Nutrition, and Life Science standards were integrated into the edible plan activities

Table 1 cont. - Project-Based Framework for Integrated STEM and Common Core Content

Essential Components	Description of Component	Component Applied to Edible Plant Curriculum
Structuring activities to encourage the development of 21st Century skills development by exploring, discussing, engaging in problem solving of real life issues	**Critical Thinking**: Does this make sense? Is there any other way to look at this situation? **Collaboration:** Can we solve this problem together? What suggestions do you have? Should we divide up the tasks or do as a group? **Invention:** How can we use what we already know along with our imagination to create a new/better solution to this problem? **Self-Directed:** What is your personal opinion on this matter? If you were in charge, how would you solve this problem? **Information Literacy:** What internet based resources can we use to research the facts?	See Progressive Learning Framework (Table 3) for details on how activities are structured to encourage inquiry based learning, critical thinking, collaboration, invention, self-direction and information literacy by integrating Understanding by Design components: Engage, Explain, Expand, Explain, Evaluate
Fostering retention and transfer of knowledge and skills	Use simple lesson plans that are identical in each unit which makes it easy for the teacher to prepare and creates student learning cycles which foster the retention and transfer of knowledge and skills	See Unit and Lesson Plan Sample (Table 2 and 3) for details on how simple unit and lesson design allows for the same knowledge/patterns/skills to be practiced for each plant/grade levels
Increasing complexity of concept understanding over time	Use same subject matter from lower to higher grade level but with content evolving from concrete, personally relevant study of the edible plant for younger students to more abstract State/National and Global understanding of issues at more mature age levels	See Progressive Learning Framework Model and Example (Table 3) for details on how subject is the same from grade to grade but the complexity of the concepts explored about the subject become more complex over time.
Developing proficiency in academic language	"Unwrapping" concepts by naming processing and principles studied in the lesson using academic terminology	See how academic language is integrated into the various components (Table3) of the curriculum

Table 1 cont. - Project-Based Framework for Integrated STEM and Common Core Content

Essential Components	Description of Component	Component Applied to Edible Plant Curriculum
Length of lesson and length of activities based on teacher's input on time constraints	45 minutes is the average time allocated to a lesson at the Northern Colorado STEM school	See Lesson Plan Sample (Figure 3) for estimated time slots allocated to the lesson plans
Measuring Student Learning Outcomes	Each lesson plan will include the student worksheets needed to record individual student's work pre and post intervention. Grade specific Standard Based Assessment tools for analyzing the data collected are included in the curricular materials	See sample Lesson Plan student worksheet (Figure 4) and sample corresponding student assessment tool (Figure 5) for details on how this was applied to the edible plant curriculum
Teacher Assessment/Continuous Improvement Process	Teachers Assessment Tools to collect their input on the curriculum's effectiveness in meeting academic and grade specific content standards are included in the curricular materials	See sample Teacher's Assessment Tool for details on how this was applied to the edible plant project (Figure 6)

Unit and Lesson Plan Design

Case Study Constraints versus Full Potential of the Framework

The edible plant curriculum was designed to be used in a case study and therefore the number of grades, units and lesson plans created was dictated by the expected time constraints of participating teachers. However, this project could be easily expanded into a yearlong STEM integration vehicle with units/lessons occurring throughout a student's elementary school education.

Unit Design

Flexible and Expandable Design

For the purpose of the Case Study, the number of lesson plans per unit was limited to three with content limited to grade appropriate Reading, Writing, and Communicating, Mathematics, Life Science, Comprehensive Health and Nutrition standard-based activities. However, the number of lessons plans could easily be expanded to include all 10 Colorado disciplines using grade specific lesson templates.

Inquiry and Standard-Based Design

As outlined in the lesson plan framework (Table 3), each lesson includes inquiry/standard based activities facilitated by the teacher using open ended questions which promote integrated and progressive STEM awareness as well as the development of common core and 21st Century skills over time. The age/cognitive development/attention span of each grade level was used to determine the length of each activity and the total lesson plan was designed to be completed within 30 to 45 minutes.

Retention and Transfer of Knowledge through Learning Cycle Design

Repetition of the same lesson plans/activities from unit to unit creates learning cycles in which students can practice applying their knowledge again and again as recommended by recent project-based learning research (Barron, and Darling-Hammond, 2008). The Understanding by Design Framework (McTighe and Wiggins, 2005) was the main instrument used in designing the Units and Lesson Plans (see Table 2 and 3).

Table 2 - Unit Design-Project-Based integrated STEM and Common Core Skills Development

Essential Components	Overall Unit Design	Lesson Plan One Social Studies Edible Plant Research Project	Lesson Plan Two Experimental Edible Plant Science Propagation Project	Lesson Plan Three Writing Project with Edible Plant/Health and Nutrition as the Subject
Simple Repetitive Unit and Lesson Plan format for teacher's ease of use and to foster student retention of skills and transfer of knowledge	Each Unit is focused on one commonly eaten plant (Unit 1 = Potato; Unit 2 = Tomato; Unit 3 = Sweet Potato). The same Units/Plants are studied at each grade level with increasing complexity of concepts. Each Unit contains 3 lesson plans: an information research project, an experimental science project. A creative writing project	Grade specific standard based Social Studies focus in which the student discovers the origins and migration of the plant historically and geographically using a timeline	Grade specific standard based Life Science inquiry based propagation project involving hands-on scientific method germination, water management, environmental management, data collection and analysis	Grade specific standard based Reading, Writing and Communicating focus using the RAFT method to write about an edible plant and its health and nutritional value. Students will explore practices that help them develop into independent writers using a writer's notebook to record their thoughts
Integration of additional interdisciplinary standard based content	Interdisciplinary Unit design with plant science topic used as a vehicle to integrate standard-based common core content with other disciplines	Grade specific Math, Reading, Writing and Communicating standards are integrated into the activities in the form of word problems and writing/expressing findings	Grade specific Math as well as reading, writing and communicating Standards are integrated into the activities as a means of calculating and communicating results	Grade specific Comprehensive Health and Nutrition standards are integrated into the RAFT project along with Comprehensive Health and Nutrition standards
Project/Content as a Vehicle for Integration of STEM and common core skills	Units are designed to include activities designed to develop integrated STEM and common core skills	Information technology is used to explore the origins of the edible plant and other facts about the plant and its uses while practicing their	Integrates all STEM disciplines into an experimental Inquiry based project in which students also practice their reading, writing and communicating	Students develop creative writing skills while exploring and expressing their own opinions and approach to addressing a global issue: food and

		Math skills	skills	nutrition

Integrating Progressing Learning and Professional Language into Grade Specific Design:

Progressive Learning

As outlined in the Progressive Learning Framework (Table 3), the content of the lessons was designed to foster progressively deeper understanding and mastery of STEM related knowledge as well as common core and 21st Century skills over time. In particular, the design systematically encourages the student to evolve from a younger, more concrete, personal and local perspective, to a more mature, abstract and generalized understanding of integrated STEM issues at the State, National and Global level (see Table 3).

Professional Language Development

One of the Next Generation Science skills that students are expected to develop is the use of professional/academic language (Achieve, 2013). The content of the lesson plans was designed to introduce the use of scientific terms and language by first having the teachers use the language when introducing the concepts and then having the students use these scientific terms when presenting their work (see Table 3).

Table 3- Framework for Integrating Progressive Learning and Professional Language into Lesson Plan

Component	Applied to Lesson 1– 3rd Grade	Applied to Lesson 1 – 4th Grade
Progressive Grade Based Complexity of Concepts	Grade specific Standard based Social Studies assignment: Origins of the edible plant and historical timeline of the edible plant trade and how it became available in the students' own community/state. Internet research of origin and history of the edible plant. Grade specific word problem and other math operations (Standard 3.4.3). Grade specific Reading, Writing and Communicating assignments	Grade specific Standard based social studies assignment :(SS-Geography 2.1 -Use various geographic tools) Review of origins of the edible plant/history of the trade but add study economic importance at local, state, national and global level. Internet search used to study the above question followed by Grade Specific Standard Based writing and math assignments. Formal introduction to the Scientific Method applied to the project
Progressive Grade Based Learning Objectives	Sequence historical dates important to events related to the edible plant (timeline)	Read maps and analyze data to determine global economic importance of the edible plant. Identify top edible plant producing countries on a world map
	Identify origins of the edible plant on a world map and diagram how it was introduced to other countries through trade (timeline)	Calculate the differences between edible plant consumption per person over a period of time using mathematical operations and graph reading
	Calculate the shortest and longest times between important edible plant events using mathematical operations	Record hypothesis, findings and conclusions using scientific method.
Assessment of Student's progress by analyzing pre and post artifacts which are collected at the end of the class	Informal Formative: Pre Intervention Map Knowledge - Pre-intervention scientific knowledge of the edible plant	Informal Formative: Pre - intervention Map reading skills and knowledge
	Formal Summative: Post-Intervention/ Map knowledge and Post Intervention scientific knowledge of edible plant. Evaluation of student's mathematics performance on timeline and word problems	Formal Summative: Post-intervention economic knowledge and evaluation of student's mathematics word problems and graph reading abilities

Table 3 cont. - Framework for Integrating Progressive Learning and Professional Language into Lesson Plan

Component	Applied to Lesson 1- 3rd Grade	Applied to Lesson 1 - 4th Grade
Engage the students using edible plants that are familiar and popular. Introduce relevant **Academic Language** and ask students to use this language in their writing and communicating assignments for the purpose of developing **21st Century Skill**s	Tell the students that they will be learning facts about the edible plant and engage in activities related to this plant. Pass around two popular products that contain the edible plant. Ask the students to find the name of the edible plant in the ingredients listed on the packaging. Ask students to share the names of other products that contain the edible plant.	Tell the students that they will be: 1. discussing/expressing their opinions (**hypothesis)** on the economic importance of the edible plant; 2. They will use information technology to find (**research)** the facts about the economic importance of the edible plan; 3. They will compare their original opinions (**hypothesis)** to the facts (f**indings)** and discuss what they have learned about the edible plant (**conclusion)** through this process (**scientific method).** Ask the student to use this academic terminology throughout the project
	Pass around the worksheets and ask the students to write down all of the facts they already know about the edible plant Ask the students to think about where the edible plant may have come from originally, write down their opinion (**Hypothesis - Critical Thinking and Self Directed)** and color in the location on their world map worksheet	Divide the class up into small groups to discuss their opinions (**Hypothesis)** on the economic importance of the edible plan at the State, National and global Ask the students use their notebooks to write down (**record)** their own (**hypothesis - Critical Thinking and Self-directed)** on the economic important of the edible plant in their community, state, nation and globally.

Table 3 cont. - Framework for Integrating Progressive Learning and Professional Language into Lesson Plan

Component	Applied to Lesson 1 – 3rd Grade	Applied to Lesson 1 - 4th Grade
Explore the topic using **information technology**. Integrate **Academic Terminology** and **21st Century Skill**s related to processes.	1. Ask the student to form small groups and instruct them to work together (**collaboratively**) to find the origin of the edible plant by going to website listed on their worksheet. Instruct students to write down (**record)** their (**findings)** in their notebooks	1. Ask the student to divide up into small groups and instruct them to work together (**collaboratively**).Using the websites addresses listed on their worksheet, find the original homeland of the edible plant, the important historical trade related events/dates and **record** their **findings** in their lab note books
	2. **Collaborating** in the same small groups, instruct the students to research the history of the edible plant by going to the website listed on their worksheet. Assist the Students in creating a timeline of the important events/dates by assigning individual students to represent each event/date. Instruct the students to put the events in chronological order.	2. Working **collaboratively** in groups, ask students to share their opinion (**hypothesis**) on how important the edible plant is economically in their state, nationally and worldwide. Have students **record** their **hypothesis** in their lab notebooks. Then use the website listed on their worksheet to **research** the economic importance of the edible plant and **records** their **findings** on the worksheet map. .
Expand the Student's understanding of the importance of the edible plant; ask students to use **Academic Language** in their writing assignments	Ask the students to write down the facts they learned about the edible plant trade in chronological order. Ask Students to **calculate** the difference between the longest and the shortest times between important edible plant events.	Ask the students to calculate the differences between edible plant consumption per person over a period of time using math and graph reading (worksheet)

Table 3 cont. - Framework for Integrating Progressive Learning and Professional Language into Lesson Plan

Component	Applied to Lesson 1- 3rd Grade	Applied to Lesson One - 4th Grade
Student's ability to **Explain** concepts and processes using academic language and **Evaluate** the results of the process	1. Instruct Students to compare the results from their internet search (**findings)** to the **hypothesis** they had written down in the previous activity and write down what they have learned (**concluded)** from this process	1. Instruct Students to compare the results from their internet search (**findings)** to their **hypothesis** and write down what they have learned (**concluded)** from this process (**scientific method).** Facilitate a discussion about the value of the Scientific Method as a **rigorous** tool for **researching** information and how it can be used to answer the important questions in our lives
	2. Ask students to share with the class their original opinions (**hypothesis)** on the origins of the edible plan, what they learned through the internet search (**findings)** and how that changed their opinion (**conclusion)** about the origin of the edible plant.	2. Ask students to use academic language to describe to the class the **scientific method** they used to study the economic important of the edible plant, from **hypothesis** to **researching** the facts, to **recording findings** and making **conclusions** about the **findings.**

Teacher Assessment Tool

A teacher assessment tool was designed for each grade level for the purpose of collecting input from teachers to evaluate the barriers and incentives they experienced in implementing the edible plant curriculum for the purpose of continued improvement of the materials. The assessment included evaluation of the effectiveness of the curriculum in meeting academic as well as specific content standards. The assessment also included general questions about the overall value of the curriculum and room to add other suggestions for improvement (see Table 4).

Table 4 -Teacher Assessment Tool - Standards - Edible Plan Curriculum 3rd Grade

Standard	Activity	Responses	
		Yes	No
Math 3.4.3.a.iii Solve word problems involving addition and subtraction of time intervals in minutes using a number line diagram	Students collaboratively created a timeline representing the important dates related to the origins and history of the plant.		
Math Standard 3.3. Time and attributes of objects can be measured with appropriate tools	Using their data collection notebooks, student collect data related to observations of the plant growth		
Reading, Writing and Communicating 1. Oral Expression and Listening	Students listened to a story about the plant during which the teacher paused to ask the students for their predictions on what would happen next and their opinion on credibility		
Reading, Writing and Communicating 4. Research and Reasoning: Researching a topic and sharing findings are often done with others. Inference and points of view exist	Students wrote down their knowledge of the plant pre-intervention. The teacher facilitated collaborative discussion about each plant issue in which all students participated. Post intervention the students wrote down what they had learned and what questions they still had.		
Life Science 2.1 The duration and timing of life cycle events such as reproduction and longevity vary across organisms and species	Plant Germination and Scientific Inquiry through Observation		
Comprehensive Health - Physical and Personal Wellness Standard 2.1 Demonstrate the ability to make and communicate appropriate food choices	Students listened and discussed a story about a child's resistance to eating the plant they are studying and how that resistance was overcome using imagination to view the plant differently.		
Comprehensive Health - Physical and Personal Wellness Standard 2.1 Demonstrate the ability to make and communicate appropriate food choices	Talked about products that have tomatoes in them, learned to read food labels and talked about health value of products		

Social Studies Geography Standard 2.1 Use various types of geography tools to develop spacial thinking Social Studies Geography Standard 2.2 The concept of regions is developed through an understanding of similarities and differences in places	Use of a world map to find continent, oceans and describe natural and human feature of the place of origin of the Tomato Talk about where the tomato comes from, similarities between Fort Collins versus the country of origin of the tomato		

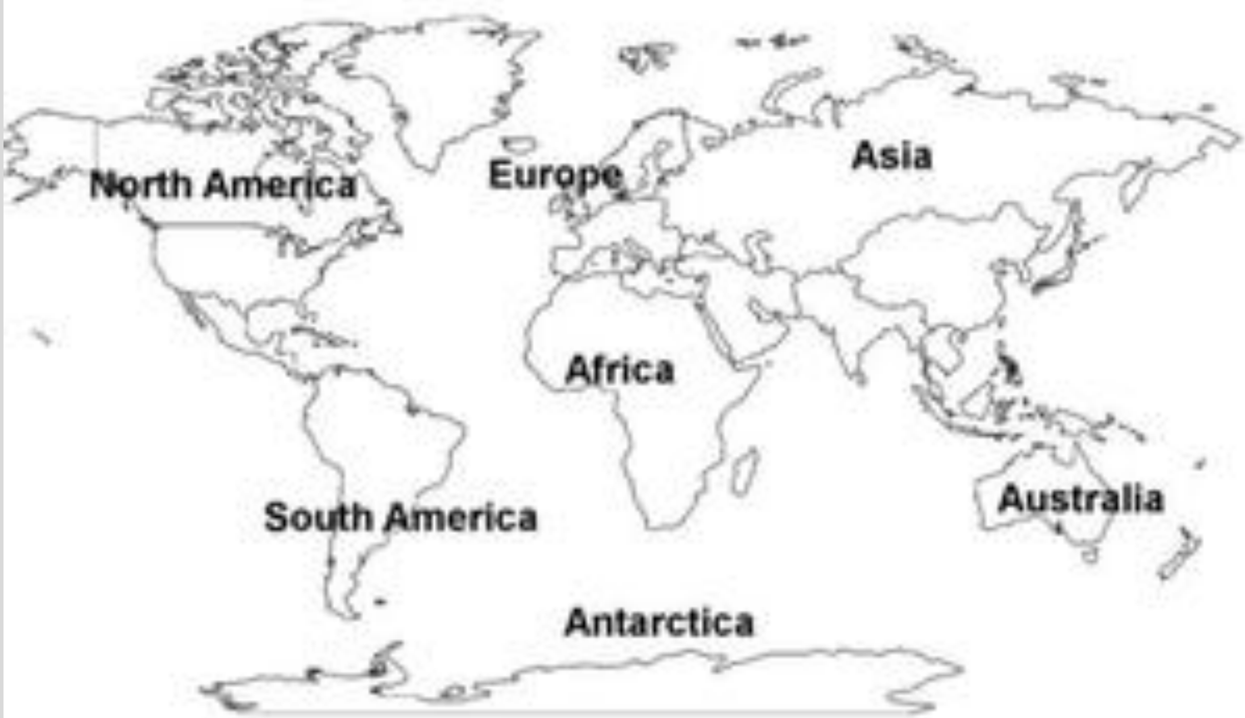
Table 4 cont. -Teacher Assessment Tool - Standards - Edible Plan Curriculum 3rd Grade

Skill	**Activity**	**Responses**	
		Yes	**No**
Critical Thinking/ Problem Solving	Students were asked to predict how many tomatoes/potatoes would be produced from one seed. Students were asked to come up with solutions to prevent over or under watering of plants. Math Problems/Timeline		
Communication/ Self Direction	Students expressed their personal opinions and predictions. They proposed water management solutions, environmental conditions, scientific facts about plants		
Collaboration	Students were asked to work collaboratively in groups in internet research project		
Creativity/Innovation	Students came up with creative ways of solving under-over-watering issue		
General Assessment Questions		**Yes**	**No**
Was the curriculum Teacher Friendly?			
Did you Modify the Lesson? Why?			
Did you choose to not implement some lessons? Why?			
Did you choose to have another educator teach portions of the lessons? Why?			
Would you recommend this curriculum to your colleagues? Why			
Do you like the unit/lesson design? Why?			
Other suggestions for improvement? Use note section to explain			

Student Learning Outcome Data Collection and Analysis Tools

Student worksheets for all lessons plans were designed to record individual student performance data which was collected at the end of each lesson by the teacher. A corresponding learner-outcome analysis spreadsheet tool for each lesson was also developed for easy record keeping and analysis of student learner outcomes. An example of these tools is illustrated in Figures 1 and Table 5.

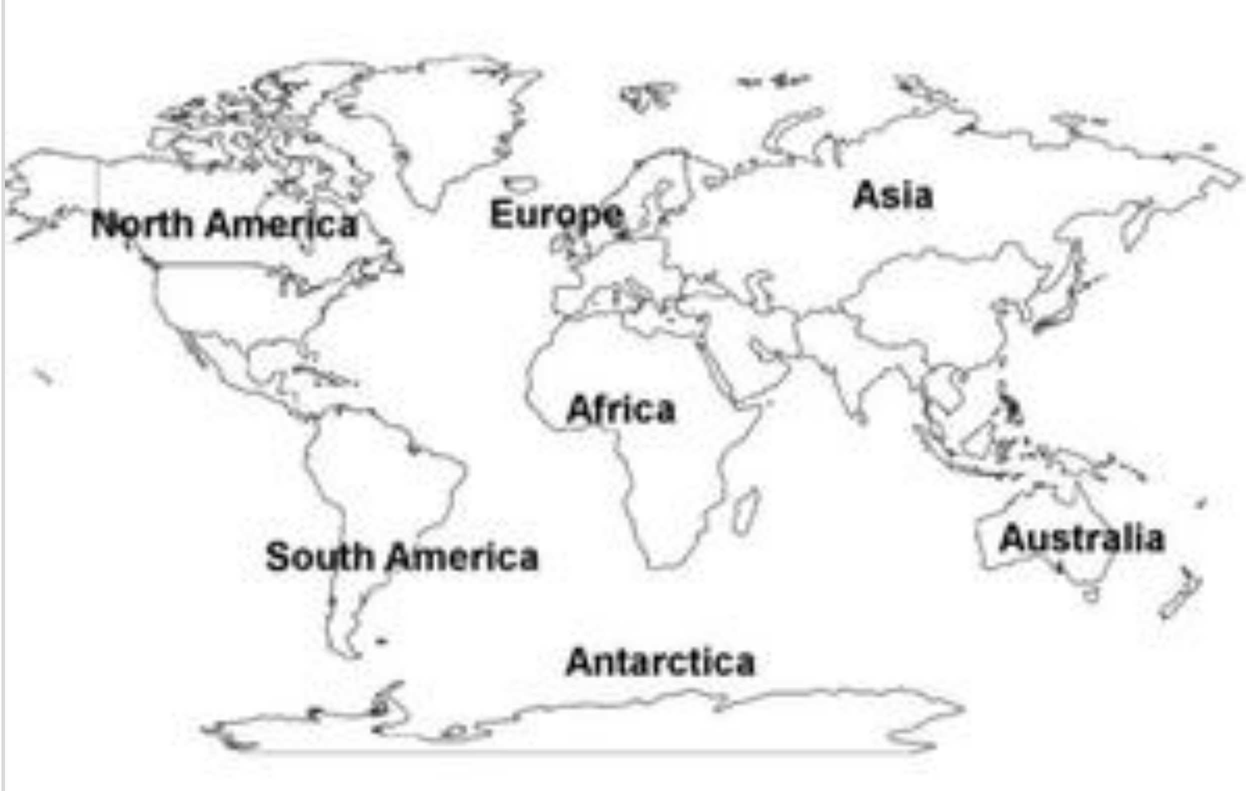
1. **What do you know?** Write down all of the facts you already know about potatoes**.**
2. **Think about it**: - Where do you think the first potatoes came from?
3. **Record** (Write down) your opinion (hypothesis): Color in the location on the map purple to identify the potatoes' original homeland. Write down the name of the country.



Find out if your opinion matches the facts – work with other students and your teacher to verify the facts using the internet. Go to the follow website address and look up the origins of the potato

http://www.potato2008.org/en/kids/index.html

4. **Record (write down)** the original homeland of the potato by coloring the location on the map and writing down the name of the country**.**



5. **How did it happen?** Find out how potatoes came from their original homeland to your homeland by working with other students and your teacher using the internet. Go to the following website and look up the history of the potato trade: http://www.nhm.ac.uk/nature-online/life/plants-fungi/seeds-of-trade/page.dsml?section=cropsandpage=spreadandref=potato

6. **Reproduce (copy)** the important events and dates in the order in which they happened by recreating the timeline you helped create with other students and your teacher.

7. **Calculate** the shortest and longest times between important edible plant events using mathematical operations.

8. **Compare** what you first thought was the location of the potato's homeland (**Hypothesis**) and what you found out through your internet research (**Findings**)?

10 What have you learned (conclusion) from this activity?

Figure 1 - 3rd Grade Student Worksheet Sample - Purple Potatoes Unite - Lesson One - Social Studies

Table 5 - Student Learning Outcome Data Analysis Worksheet Template - 3rd Grade Unit

	Standard	How Standard was Applied	How Standard was Applied	How Standard was Applied
Student Unique Identifier	Life Science 2.2 Students gain an understanding of the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment	Students collect data related to time dated observations of the edible plant's growth in their lab notebooks (1 is Yes, 0 is No)	Students writes down scientific facts they knew about the edible plant pre-intervention (1 is Yes, 0 is No)	Students writes down scientific facts they learned about the edible plant post-intervention (1 is Yes, 0 is No)
Student 1				
Student 2				
# of Correct Answers				
% of Correct Answers				
Student Unique Identifier	Math Standard 1.1 The whole number system describes place value relationships and forms the foundation for efficient algorithms	Students use dates to calculate the shortest amount of time between historical events related to the edible plant (1 is Yes, 0 is No)	Students use dates to calculate the longest amount of time between historical events related to the edible plant (1 is Yes, 0 is No)	
Student 1				
Student 2				
# of Correct Answers				
% of Correct Answers				

Table 5 cont. - Student Learning Outcome Data Analysis Worksheet Template - 3rd Grade Unit

	Standard	How Standard was Applied	How Standard was Applied
Student Unique Identifier	Writing and Composition Standard 3.1 A Writing process is used to plan, draft, and write a variety of literary genres	Student builds a RAFT after teacher reads I will never not ever eat a tomato by dissecting the story and creating their own using the same format (1 is Yes, 0 is No)	Students writes down their hypotheses, research findings and conclusions regarding the edible plants original homeland (1 is Yes, 0 is No)
Student 1			
Student 2			
# of Correct Answers			
% of Correct Answers			
Student Unique Identifier	Social Studies Geography Standard 2.1 Use various types of geography tools to develop spacial thinking	Students use a world map to identify the original homeland of the edible plant (1 = Yes, 0 = No)	
Student 1			
Student 2			
# of Correct Answers			
% of Correct Answers			
Student Unique Identifier	Social Studies Geography Standard 2.2 The concept of regions is developed through an understanding of similarities and differences in places	Students reproduces to a timeline of important events/dates related to the edible plant trade across geography and time	
Student 1			
Student 2			
# of Correct Answers			
% of Correct Answers			

Establishing Trustworthiness

Once the curriculum was complete it was reviewed by a Colorado State University professor of horticulture as well as a Colorado State University professor of education. Thereafter it was submitted to the School District's Director of Research and Evaluation as well as the Director of Curriculum and Assessment and the District STEM coordinator for approval. Once these initial approvals were obtained, it was submitted to the Colorado State University Instructional Review Board (IRB) for approval. Once IRB approval was obtained a website was created to provide ease of access for teachers including links to affordable and effective resources, student pre and post-performance measurement tools, teacher assessment process and continued improvement process. The website was reviewed by a Colorado State University Professor of Education, two STEM coordinators and two elementary teachers.

RESULTS

Framework for Using Life Science as a Vehicle for Integrating STEM Common Core and 21s Century Skills Development

The process of creating an edible plant curriculum that uses plant science as a vehicle for integrating STEM and 21s Century Skills development into Common Core Content resulted in the development of a user friendly project-based framework. This framework facilitates the development of standard specific, project-based STEM activities that incorporate specific 21st century skills development into common core content. The framework also integrates the design principles of the three reputed curriculum designer recommended by the CDE. It is easily adaptable to other Life Science content as vehicles for STEM integration and also allows for easy expansion into a yearlong, school wide project (see Table 2, 3, and 4)

Website Development

The literature clearly indicates that teachers need easily accessible curricular materials and have complete lesson plans (Ingersoll, 2001). For this reason, A Google site (https://sites.google.com/site/edibleplantscurriculum/) was developed by the researcher and all of the curricular materials needed to implement the edible plan curriculum were uploaded into the website. The website was then used by the teachers and the staff members who participated in the case study.

Components of the Curriculum

Introduction to the Curriculum – Plant Science Is STEM:

The purpose of this introduction is to help teachers understand that the study of edible plants is inherently STEM content and that it can be used as a vehicle to integrate STEM content with common core skills development.

A Concept Map of the Units and Lesson Plans

A colorful and easy to read concept map was develop to help teachers get an overall view the units and lesson plans.

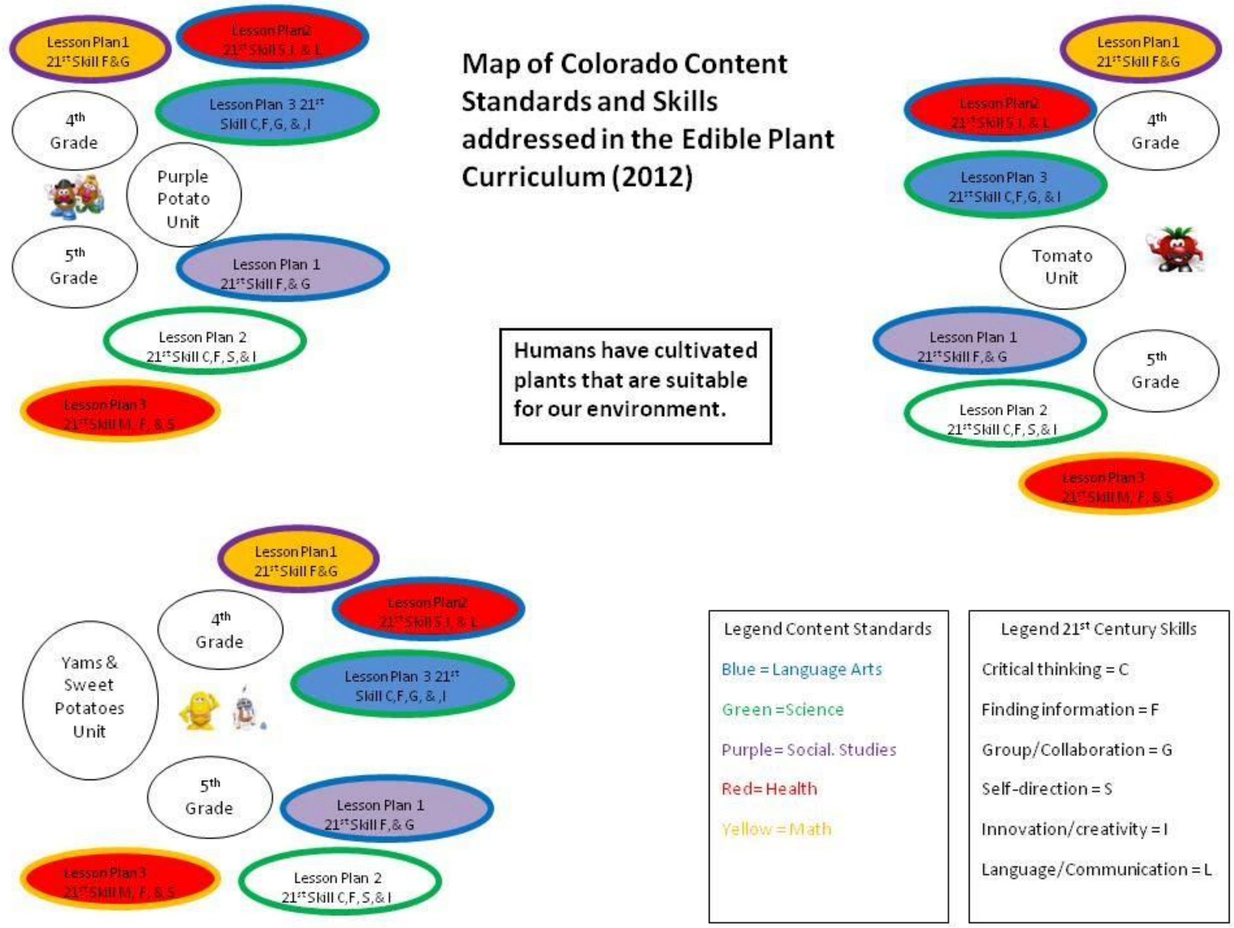


Figure 2 - Concept Map of standards and skills addressed in the Edible Plants Curriculum

Standards and Skills

A complete listing of the National and Colorado State standards and skills addressed in the curriculum was developed and uploaded to the website and was designed as a reference tool for teachers.

Unit Outline

Each Unit of the curriculum includes a detailed outline that is presented in the format recommended by Wiggins, Grant and J. McTighe (2005). This format was selected because it has been previously used in Colorado schools and is likely to be familiar to most teachers.

Table 6 - Sample Unit Outline – Purple Potatoes – 4th and 5th Grade

Title of Unit	Purple Potatoes	**Grade Level**	4th and 5th
Curriculum Area	Plant Science	**Time Frame**	4 weeks
Developed By	Leila Graves		
Identify Desired Results (Stage 1)			
Content Standards			
1. National Science Standards Content Standard 1 (Science Inquiry) Content Standard 3 (Life Science) Content Standard 5 (Science in Personal and Social Perspectives) 2. National Health Standards 2 (Analyze the influences of family, peers, culture, media, technology, and other factors on health behaviors-Grades 3-5) Standard 3 (Demonstrate ability to access valid information, products, and services to enhance health-Grades 3-5) Standard 5 (Demonstrate ability to use decision making skills to enhance health-Grades 3-5th 3. CO Mathematics Standard 3 (Students use data collection and analysis, statistics and probability in problem-solving situations and communicate the reasoning used in solving these problems). Standard 5 (Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems) 4. CO Social Science Standards 1.1 (Use and construct maps, globes,...) Standard 3.2 (Students know the characteristics and distribution of physical systems of land, air, water, plants, and animals) Standard 5.1 (students know how human actions modify the physical environment) Standard 5.2 (Students know how physical systems affect human systems) Standard 5.3 (students know the change that occur in meaning, use, location, distribution, and importance of resources) Standard 6.1 Students know how to apply geography to understand the past)			

Understandings	**Essential Questions**	
Overarching Understanding	**Overarching**	**Topical**
1. Cultivated vs. Wild Plants. 2. Plants have human health benefits. • Pigments • Nutrients 3. Plants evolved secondary compounds to help them survive.	How can change in one part of an ecosystem affect change in other parts of the ecosystem? How do humans have an impact on the diversity and stability of ecosystems?	How do plants regenerate? Why are sunlight and water essential to

• Beneficial • Toxic 3. Human digestion of plants. Boiling, frying and baking of potatoes.	How many humans can the Earth feed?	plant life? Cultivated plants vs. Native plants? Where are the origins of potato cultivation? How has the location of potato production changed over time? What is the nutrition value of the potato?
Related Misconceptions		
Organisms in a population are important only to those other organisms on which it serves as a food source. How to calculate data graphed data and how to read those graphs There is no link between fluctuations in population size and environmental issues like food supply and the spread of disease. Populations can increase indefinitely because resources are unlimited. Environmental problems are not real or are blown out of proportion.		

Knowledge Students will know…	**Skills** Students will be able to…
The origin of the potato and its global importance. How has potato production migrated across the world? How to create a healthful meal using potatoes. How to sprout potatoes. How to sprout sweet potatoes. The relationships between plants, people in an environment and the need for balance in nature.	1. Interpret data on global the economic worldwide importance of the potato. 2. Identify the origins of the potato on a world map and how it was introduced to other countries through trade. 4. Demonstrate knowledge of the nutritional value of potato by designing a meal that incorporates a healthy potato dish. 5. Diagram and explain potato plant biology and reproduction. 6. Construct a testable hypothesis. 7. Conduct a propagation study and collect data. 8. Graphically represent data from

	propagation study 9. Determine whether hypothesis was supported with evidence.

Assessment Evidence (Stage 2)	
Performance Task Description	
Goal	Conduct a scientific experiment and collect data
Role	Scientist
Audience	General Public
Situation	Construct a testable hypothesis
Product/Performance	Graphically represent data from propagation study
Standards	National Science Standards Content A (Science Inquiry) Content F (Science in Personal and Social Perspectives) CO Mathematics Standard 3 (Students use data collection and analysis, statistics and probability in problem-solving situations and communicate the reasoning used in solving these problems). Standard 5 (Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems)
Other Evidence	
Descriptive food essay Graph and data analysis	

Learning Plan (Stage 3)	
Where are your students headed? Where have they been? How will you make sure the students know where they are going?	Discuss what students know (or think they know) about the origin, global economic importance, nutritional value of the potato.
How will you hook students at the beginning of the unit?	Show students potatoes with different color fleshes and a bag of different color fleshed potato chips (Whole Foods Market

	for supplies).
What events will help students experience and explore the big idea and questions in the unit? How will you equip them with needed skills and knowledge?	Students will research on the internet with the provided web links the origins and global economic importance of potato, demonstrate knowledge of nutritional value of potato by designing a meal that incorporates a healthy potato dish, diagram and explain potato plant biology and reproduction.
How will you cause students to reflect and rethink? How will you guide them in rehearsing, revising, and refining their work?	Students will create a testable hypothesis. Students will conduct a propagation study and collect data. Then student will share graphically represent data from propagation study then class will then determine whether hypothesis was supported with evidence.
How will you help students to exhibit and self-evaluate their growing skills, knowledge, and understanding throughout the unit?	Through participation in small group and class discussions, as well as through writing assignments that allow reflection.
How will you tailor and otherwise personalize the learning plan to optimize the engagement and effectiveness of ALL students, without compromising the goals of the unit?	During cooperative group work, the teacher will carefully select which students will work together. In addition, writing assignments will be individual, allowing students to express their own ideas, which may not echo the group position.
How will you organize and sequence the learning activities to optimize the engagement and achievement of ALL students?	First show students different color fleshes potatoes and the bag of chips. Let the students discuss what they know (or think they know) about the origin, global economic importance, nutritional value of the potato. This will allow students to explore their personal interest. Then next activity the students will research on the internet with the provided web links the origins and global economic importance of potatoes. Then they will demonstrate knowledge of nutritional value of potato by designing a meal which incorporates a healthy potato dish. Next they will diagram and explain potato plant biology and reproduction. Then students will construct a testable hypothesis comparing

	potato seeds sprouting to sweet potato sprouting. Then students will conduct the germination experiment and collect data, which will require a collaborate effort. Students will then share their graphically represented data. Then class will then determine whether hypothesis was supported with evidence. The final assignment (reflective essay on potato sprouting) will require that students work independently, although they will be required to draw on readings and prior unit activities. Students will have a safe way to explore ideas first in a group before formalizing their own ideas in individual work.

Lesson Plans

Complete Lessons Plans for all units and grade levels were developed using the project-based framework (see figure 3).

Lesson Tomato Timeline
Grade 4th
Standards

1. **SS-Geography** 2.4th grade.1 (Geographic tools)
2. **M-Mathematics** 1.4th grade.3 (Use of algorithms: use operations to solve problems)

Length: From start to finish this activity may take 30-50 minutes.

Concepts: Students will be introduced to the origin of tomato and will explore the historic timeline of tomato trade around the world.

Level/prerequisites:

Students should have learned the 7 continents and should be able to label these on a map with minor assistance. Students should have learned about the migration of people and animals so refer back to these when introducing the idea of the migration of plants. You might need to review these prior to this lesson.

Skills:

1. Sequencing of events
2. Map reading
3. Mathematical problem-solving

Learning objectives: Students should be able to:

1. Sequence historical dates important to tomato events
2. Identify the origin of tomato on a world map and diagram where and when it was introduced to other countries through trade.
3. Calculate shortest and longest times between important tomato events using mathematical operations

Assessment:

Informal Formative

- Pre Map
- Map reading skills (identification of continents)

Formal Summative

- Post Map
- Evaluate students' illustrations and worksheets (timeline, mathematical word problems)
- Check students' journals as they record their thoughts and ideas

Instructional plans: Materials: Tomatoes and different tomato products (ketchup, tomato sauce, etc.) Maps (2 per student) and worksheets (see appendix A and B).

Student Action	Teacher Action
Engage: Show students the different tomato products (ketchup, tomato sauce, etc.) Students will write in their notebooks their thoughts (hypothesis) about the origins of tomatoes and on how the tomato migrated to Colorado. Students will color in red on the world map provided in their lab manual where they believe tomatoes originated.	Pass around the different products and let the students discuss the different ingredients of the products. Lead discussion on the different products that contain tomatoes. Require each student has a thought (hypothesis) about tomato origins Lead discussion on tomato origins.
Explore: In pairs students will identify the important tomato facts (Appendix A and B) or on the internet by going to: http://www.thetomatozone.co.uk/ Students will compare their originals thoughts about the origins of tomato with the results of internet search or handout.	Help students identify the origin of tomatoes. Refer to world map in classroom. If there is no access to a computer; print up Appendix A and B for the 4th grade students and hand it out. Remind students to stay focused on the task. Help students navigate the website. If using the handout then make sure the student finds the main points and are able to compare their original thoughts to the findings.

Expand: Students will create a timeline that tracks the migration of the tomato marking important events as found in Appendix C	This assignment can be started in class and then finished as a homework assignment or given as homework if class time is limited.
Explain: Students should share their original thoughts about the origins of tomato with the results of the internet search and timeline.	Ask students to provide explanations of why they chose the specific origin of the tomato they did if it is different than the actual origin.
Evaluate: Students will share timeline worksheet and maps with one another to compare their results.	Lead class discussion on final worksheet and map activity.

Figure 3 – Sample Lesson Plan

Teacher Assessment Tool (see Table 4)

Teacher Worksheets and Student Worksheets (see Table 5)

Student Learning Outcome Analysis Tool (see Table 6)

DISCUSSION AND CONCLUSION

An edible plant curriculum was needed for a case study at a STEM elementary school in Northern Colorado. For this purpose a review of existing agriculture literacy curricula was conducted to identify resources that could be used as a vehicle to integrate STEM with common core content and 21st Century skills building. No resources were identified that met all of the criteria needed and for this reason, a curriculum was created. Drawing from a combination of three reputed curriculum designs (McTighe, J. & Wiggins, G. 2005, Erickson 2007, Ainsworth 2010) and recent project-based research (Barron, & Darling-Hammond, 2008), the process of building the curriculum resulted in the development of a project-based framework for integrating STEM and 21st Century skills into Common Core Content. Plant Science was used as the integration vehicle in the edible plant curriculum. However other subject matter that inherently involves STEM skills such as environmental science could be selected as the integration vehicle using the same project-based framework. Additionally, the unit and lesson plans were designed to facilitate expansion of the curriculum into a yearlong/school wide project.

Additional case studies to further evaluate the value of the edible plant curriculum as a vehicle for integrating STEM and 21st century skills is recommended. The development of other curriculum using the same framework but different subject matter (as the STEM integration vehicle) is also recommended.

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CHAPTER 3

A Case Study of the Implementation of Edible Plants Curriculum at a STEM Elementary School

INTRODUCTION

STEM Competency of American Students

American students' performances in mathematics and science has been out paced by several foreign counties for at least a decade and efforts to close that gap have not been successful(National Center for Education Statistics [NCES], 2013). Students in the U.S. not only score lower in science and mathematics compared to their non-American counterparts, but need to improve their abilities to apply knowledge and skills to real world problems. Without such skills, the next generation will be unprepared for being innovative for our uncertain and changing future, and the U.S. will lose its global competitive edge (NCES, 2013).

In response to these concerns about K-12 students' science, technology, engineering, and mathematics (STEM) knowledge and skills, the National Research Council (2012) convened an interdisciplinary group of scientists, engineers, and STEM education researchers to develop a document, *A Framework for K-12 Science Education,* to outline what specific, comprehensive set of performance expectations should be followed by educators of science and engineering for students in grades K-12. This framework was designed to guide the development of new national academic science standards for K-12 science education and also guide subsequent revisions to curriculum, instruction, assessment, and professional development for educators. The goal is to ensure that standards are designed to provide internationally benchmarked science education across disciplines and grade levels in a consistent and progressive manner (National Research Council [NRC], 2012).

The Framework for K-12 Science Education informed the *Next Generation Science Standards* (Achieve, 2013), which were released in April 2013. These standards were created through a state-led cooperative effort and included three types of standards: Content, Science and Engineering Practice, and Crosscutting Concepts. These standards were intended to be integrated into the existing Common Core State Standards for English Language Arts as well as Mathematics to promote scientific inquiry and innovative thinking in a consistent progressive manner across disciplines and grade levels (NGSS, 2013). Hence, unlike the previous national standards, The National Science Education Standards (NRC, 1996), the "Next Gen" standards stress crosscutting themes and identify the interdisciplinary nature of science concepts. Concurrently, the *Partnership for 21st Century Skills* organization was created through a collaborative effort involving very successful global businesses such as Adobe Systems Incorporated, Apple, Cisco Systems, Microsoft, Oracle, Intel and national education organizations, such as the American Association of School Librarians, Discovery Education, Education Networks of America, McGraw Hill Education, National Education Association, and many others. The result is a comprehensive list of skill-sets for 21st century education that is designed to help students succeed as citizens and workers in this global and digital economy. *Twenty – first Century Skills* provides teachers with rubrics, which are designed to assess student projects for skills like creativity and innovation. The data collected from these assessments are then analyzed and scored using a four level proficiency scale: Below Basic, Basic, Proficient, and Advanced. Students are assessed not only for overall proficiency, but also for each of the National Educational Technology Standards which include creativity and innovation, communication and collaboration, research and information fluency, critical thinking, problem solving and decision making, digital citizenship, technology operations and concepts (Achieve, 2013).

The Colorado Department of Education (CDE) drafted its own standards over time, using all of the afore-mentioned national guidelines along with locally developed resources and input. The result is a unique set of guidelines with well-defined goals (CDE, 2012).

- Using content as the vehicle for teaching concepts and skills for the purpose of meeting the expectation of greater depth in student knowledge and skills.
- Using a Backward/P13 Vertical Progression approach to developing curricular materials with the "end in mind' being post-secondary and workforce readiness
- Requiring that students learn to apply the knowledge learned by engaging in real life projects. This includes internet literacy, collaborative team work, critical thinking, self-direction and creative problem solving.
- Focusing on 10 content areas: Math, Reading, Writing, Science, Communicating, Personal Financial Literacy, Social Studies, Music, Dance and Visual Arts, Comprehensive Health and P.E., and Drama and Theater Arts
- Developing proficiency in Academic Language (Social Instructional, Language Arts, Mathematics, Science and Social Studies)
- Promoting Emotional and Social Wellness of Students and Staff across all activities

Supporting Elementary Teachers in Increasing STEM Competency

Integrating these new standards into current common core curriculum content can be a challenge for teachers, in part because it represents a shift in mindset and in the learning environment for curriculum developers, teachers and students (Tilgner, 1990). The days of teachers focusing solely on delivering static content and practices on required subjects and students simply absorbing and repeating this information back are gone. The curriculum developer must now design materials which promote scientific curiosity regardless of the subject matter. The elementary teacher must learn to be a facilitator of scientific inquiry by asking open-ended questions regardless of the subject matter, encouraging collaborative discussions and personal decision-making. The student must become an apprentice scientist as a way of life in all of his/her daily activities. A recent study conducted by researchers from the University of California, Berkeley, concluded that despite teachers' desire to teach science in elementary school are under pressure to concentrate on English language arts and mathematics, which limits the amount of time available for Science and other subjects (Dorph et al., 2011). However, a few schools have begun integrating Science with other content areas such as English Language Arts. The study found that teachers who regularly integrated science with other subjects offered science an average of 130 minutes a week, compared with an average of 94 minutes per week for teachers who rarely or never integrated science (Dorph et al., 2011). Likewise, Romance and Vitale (200) conducted a 5-year study with 51 teachers and 1200 students and found that when language arts curriculum was integrated with science, it resulted in increased attitudes and confidence towards both, as well as increased competencies. These results suggest that integrating STEM content with other core competencies in reading, writing, and mathematics is a promising strategy.

Another major difficulty facing elementary teachers in integrating inquiry-based learning is the very demanding "teach to the test" focus imposed by the Colorado Education Accountability Act of 2009 (S.B. 09-163), which holds the state, districts, individual public schools, and teachers accountable for student performance on standardized testing for reading, writing and mathematics. The focus of these tests is to measure the students' knowledge and skills instead of each student's ability to grasp, apply, and transfer concepts and skills in a scientific manner. The demands of "teaching to the test" (reading, writing and mathematics), leaves little time for other subject matter or more time consuming inquiry based pedagogical approaches (Kohn, 2001; Smith, 1991).

Teaching STEM through Agricultural Topics

STEM concepts can be more engaging for students when presented through curricula that require students to explore socio-scientific issues (SSIs). SSIs are immediately relevant to society and to citizens, who must consider scientific concepts in order to make decisions about socially important issues. SSIs do not have "right" or "wrong" answers; however, in order for a citizen to be informed in trying to resolve the issue, he or she must have a firm grasp of related scientific concepts. One of the ways inquiry-based teaching might be effectively integrated with common core content is through hands-on agricultural socio-science activities that can also be a conduit for nutritional literacy.

There is promise in exploring agriculturally centered curriculum activities as a means to help elementary students explore the four core subject areas: science, mathematics, language arts, and social studies, while learning about the origin and current production of food crops. A study conducted to evaluate elementary teachers' attitudes about agricultural literacy indicated that elementary teachers generally believe that agriculture is a viable integrating tool to teach across disciplines (Bellah & Dyer, 2009). Another study on the impact of experimental instruction strategies found that participation in agriculturally oriented experiential activities positively impacts the development of science process skills (Mabie & Baker, 1996).

Moreover, advances in agricultural science and skilled worker preparedness are of increased importance given the rapid global population growth: 7 billion in 2011 to an expected 9.6 billion in 2050 (U.S. Census Bureau, 2013) and the challenges of climate change (USDA, 2012). Only 5 to 6 % of the total U.S. high school students are enrolled in agriculture education programs (U.S. Census Bureau, 2013). The Agriculture Council of America (2011) stated that a strong understanding of agriculture is necessary in creating and implementing policies which support a competitive agricultural industry in the U.S as well as abroad. Concurrently, it is becoming more imperative that children know not only where their food comes from, but how consumption of quantity and quality of food can impact their health. Obesity rates in children continue to rapidly increase, and studies clearly indicate that obesity in childhood is likely to continue in adulthood (Whitaker et al., 1997). Obesity is an economic concern, as well, because adult obesity is associated with increases in absenteeism and health issues and decreased productivity (Gates et al., 2008). The National Institute of Food and Agriculture proposes that increased knowledge of agriculture and nutrition is needed to promote informed personal food choices about diet and health (USDA NIFA, 2012).

In light of the need for standard-based interdisciplinary curricular materials designed to promote scientific inquiry as well as agricultural and nutrition literacy in elementary school, an edible plants curriculum was developed, implemented, and evaluated over the 2012-2013 academic year. The curriculum was designed around common edible plants as themes for each of three units. Through lessons which address multiple core content standards (language arts, social studies, mathematics, and science), the overall objective of the curriculum is to promote agricultural and nutrition literacy. Prior to implementation, the local school district's science and health curriculum coordinator approved the curriculum materials. Colorado State University human subjects approval was also granted in order to collect data from teachers in their respective classrooms. A website with all resources was shared with teachers so they would have easy access to all lessons plans with links to free and effective resources, and student pre and post-performance assessment tools.

Purpose of the Study

National and Colorado state education goals are currently focused on improving STEM education and common core proficiency as well as addressing childhood obesity and nutrition. Evaluating curricular materials which address STEM competencies as well as literacy skills (reading, writing, and numeracy) is essential. Furthermore, it is particularly important to determine how teachers respond to and implement agricultural socio-scientific curriculum developed with recent STEM and literacy reform efforts in mind. Understanding how and why teachers implement specific curriculum can inform curricula developers so they know what characteristics teachers consider when choosing lesson plans.

The purpose of the current study was to study teachers at a single elementary school that chose to implement and evaluate curriculum designed around edible horticultural crops. A case study approach was employed to collect and analyze elementary teachers' perspectives on the incentives and barriers to using the curricular materials.

Theoretical Framework for the Case Study

The data collected and analyzed was grounded in the Teacher-Centered Systemic Reform Model (TCSR; Woodbury & Gess-Newsome, 2002). This model describes different reform efforts within schools but posits that reform is sustainable only when teacher beliefs are central to any effort. The TCSR "integrates the previous perspectives and highlights teacher thinking as a central factor shaped by the interdependent influences of the general context of reform, a teacher's personal profile, and the structural and cultural contexts of teachers' work within embedded systems" (Woodbury Gess-Newsome, 2002). Woodbury and Gess-Newsome argue that teacher beliefs, in the context of school, local, regional, and national concerns, can help researchers and administrators better understand why some reform efforts are successful and others are not. The TCSR is primarily grounded in social cognitive theory (SCT), which explains that people's behavioral decisions (Bandura, 1977). SCT predicts that knowledge, skills, and attitudes are driving forces that influence behaviors. Woodbury and Gess-Newsome (2002), similarly found that teacher thinking (knowledge and attitudes) explained teacher practice (behaviors). What their model adds to SCT, though, is that contextual factors are important variables when examining the behaviors teachers' exhibit. These behaviors include what lessons, how, and when teachers decide to teach certain lessons. Both TCSR model and SCT theory are relevant in this study because they provide a framework for analysis of perceptions and evaluation by in-service teachers of the Edible Plant curriculum. All of the teachers are part of the faculty at one elementary school which is undergoing a reform effort to become more STEM-centric.

METHODS

Two questions guided this case study: 1) What are the incentives and barriers for elementary teachers at one STEM school for using the Edible Plant curriculum? And 2) Do the participating teachers perceive the Edible Plant Curriculum to be effective in integrating 21st Century Skills and *Next Generation Science Standards* into their existing curriculum materials while promoting agricultural and nutrition literacy?

Context

The study was conducted at a northern Colorado elementary school, located five miles from a mid-sized land grant university, which chose to become STEM-centric in 2008. The decision to become a STEM-centric school was initiated by the previous principal of the school (a former president of the National Elementary School Principal Association), who is the spouse of a college of Agricultural administrator. The school was recently renamed a STEM public elementary school in Fall 2013 by the local school board. Although the numbers vary, the school typically has around 330 K-5th grade students enrolled each academic year. The school is set in the center of town and serves a mixed income population; however, only sixteen percent of the students are classified as English Language Learners. 16% of the student body qualifies for Free and Reduced Lunch, a typical indicator of the socio-economic status of the student population. This school also provides special services for students on the autism spectrum.

The school is part of a “choice” district, which means that parents may choose to send their children to any school in the district even though they are ensured a spot at their “neighborhood” school. As a result of this policy, administrators often feel compelled to market their schools to ensure a high enough enrollment to justify keeping their faculty and staff, or in some cases, keeping their school open. Four elementary schools out of 30 in this district chose to become STEM-centric to attract new students and to maintain existing students at their schools. One of those schools chose to downplay the “STEM” label in order to focus on fundamental literacy skills (reading, writing, and numeracy) of its students. Of the remaining three schools, each has chosen different strategies of working towards their new curricular focus. One school has decided to develop more STEM curricular materials to integrate the arts with science, technology, engineering, and mathematics. Another school determined that its teachers were too overwhelmed to integrate STEM into all subjects each day and only teaches STEM one day a week. Hence, the final school, a STEM Elementary in Northern Colorado, was selected as the implementation site for the Edible Plants curriculum. This edible plants curriculum was disseminated to teachers via the following website: https://sites.google.com/site/edibleplantscurriculum/.

Participants

Because the Edible Plants curriculum was developed for upper elementary (grades 3-5), those teachers were invited to implement and evaluate the curriculum materials. Teachers were recruited both in person and through email by both the researcher and the district science and health curriculum coordinator. Although all of the teachers indicated willingness to implement some of the curricular materials, not all of them were able to fit more into their instructional schedule for the year. Teachers were then given the option of only reviewing the materials online even if they did not implement the lessons. If they did choose to implement the lessons, they were asked to consent to being observed and video-recorded. Student artifacts from the implemented lessons were collected, as well. Ten teachers chose to evaluate the curriculum but not implement it and two teachers implemented and evaluated the curriculum a total of 2 times.

Data Collection

Eight sources of data were collected; 1) school website; 2) observational field notes; 3) video transcripts of lesson implementation; 4) curriculum evaluation tool for teachers; 5) formal interviews with teachers; 6) formal interview with STEM coordinator; 7) informal interviews with school community members; and 8) student artifacts from the lessons. The collection of various types of data allowed the researcher to triangulate the findings to inform on what were barriers and incentives teachers perceived or that were inferred from observations to using interdisciplinary STEM curricular resources.

School website. The school website was reviewed to get a clear understanding of the school's described mission, philosophy, and approach to teaching STEM. The elementary STEM school model is not well defined in the literature so individual schools' interpret what being "STEM-centric" means to them (Balgopal and Sample McMeeking, 2014). While STEM policy and interest is increasing and educators and schools are "going STEM," there are few models in how the integration and implementation of STEM education is achieved in elementary schools (http://www.stemschool.com/). For this reason, this school's mission is to develop a model for school level integration of STEM. This model seeks to provide a framework for instruction, programming, and school culture. The intent is to provide a tangible and visible model of school-level structure to integrate STEM in a way that preserves the larger STEM initiative and works in the elementary environment. For this purpose the school used the *Next Generation Science Standards* (Achieve, 2013) and the *Framework for K-12 Science Education* (National Research Council, 2012) to guide their STEM school model (Figure 1). A STEM coordinator was hired to facilitate the integration of the program. It was the first coordinator with two degrees in environmental science and a Ph.D. in Educational Leadership, who developed the STEM school model. In addition, she launched a newsletter to keep parents and students up to date on events and programs. The goal of the STEM coordinator and the principal was to promote student and parent involvement in STEM activities, thus fostering students' STEM identities ("increased competencies and confidence," as the STEM coordinator explained). The school also has a blog that faculty and staff members use to keep the school community up to date on their school garden efforts, which they call, "Stems of learning" (http://stemsoflearning.wordpress.com/).

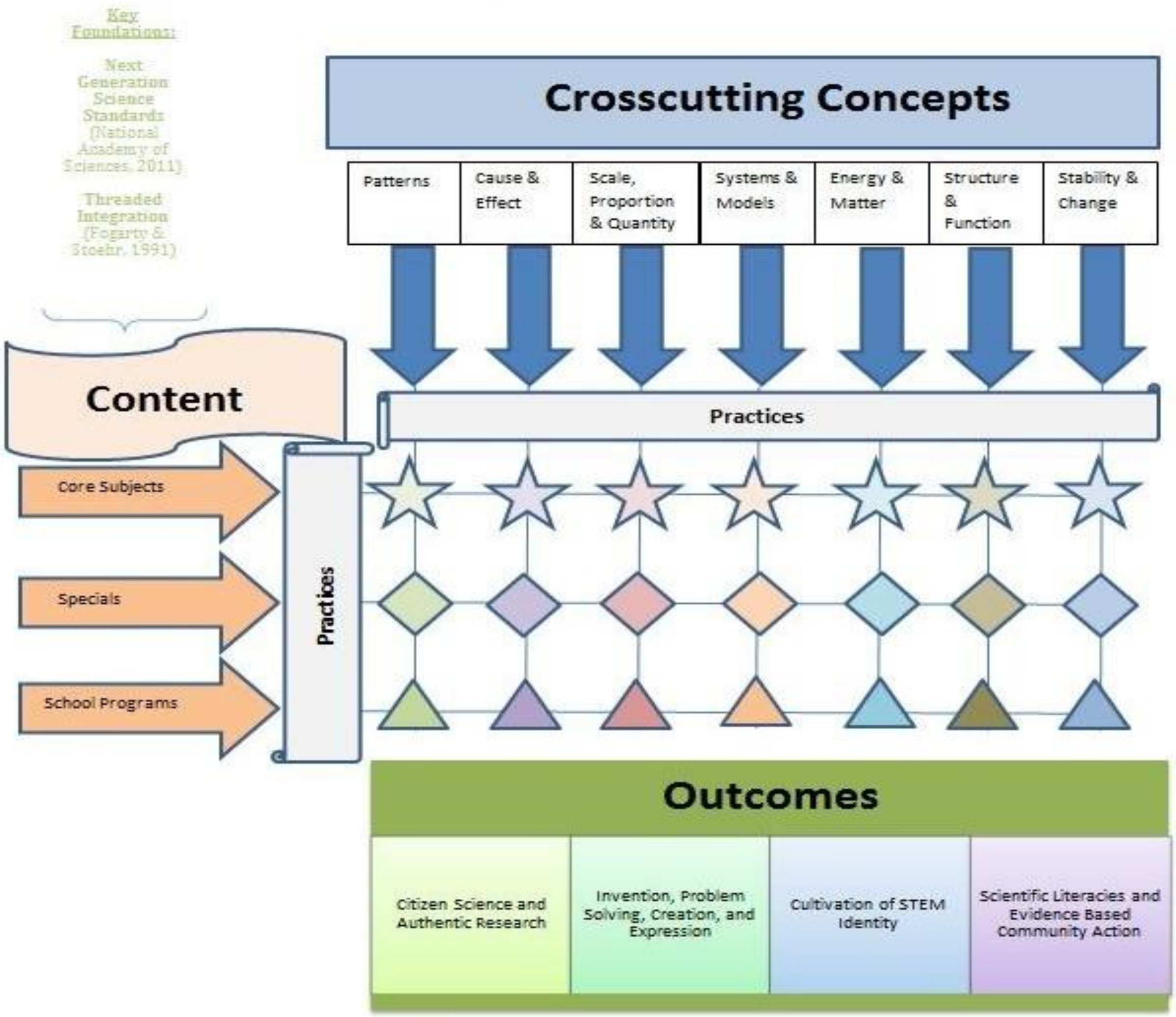

Figure 4. The Elementary STEM School Model based on recent science education reform documents (Achieve, 2013; NRC, 2012). This model was designed by Alexis Soffler and Jennifer Chadwick-Conway.

An annual event called STEM Night was initiated in 2010. STEM Night is an opportunity for the school to open its doors for the community during which community members, students, and teachers can highlight STEM activities that are engaging and hands-on. The event has typically drawn 500-700 people each year during the two hour event. The events are always held in the evening during which students could showcase their work on bulletin boards and in library exhibits. The purpose of this event is to promote the STEM identity that the school staff and administrators are trying to develop.

Observational Field Notes. Field notes were collected during classroom interventions, STEM Nights over three years (2011, 2012, and 2013), and informal interviews with parents and the principal during school visits. When lessons were implemented in classrooms by teachers, I was able to record notes on how the teacher interacted with students, the interest level (based on questions and comments) that students exhibited, and the flow of the lesson. These notes were corroborated by a coding of the video transcripts. Because I participated as a presenter/ volunteer I had the opportunity to interact with parents and others during this event. Finally, informal interviews with the principal, parents, and teachers were conducted each time I spent at the school getting to know the teachers and build rapport with staff. After each visit I recorded my impressions of the school's interest in moving towards STEM curricula and how it defined STEM. I always introduced myself as a Horticulture student.

Video analysis of lesson implementation. Three interventions were conducted, each involving students from two third grade classes and their teachers at the STEM elementary school. The teachers reviewed the edible curriculum website and selected parts of lessons from the tomato and potato units. The materials from the potato unit were taught twice to two different classes, once to 33 students and a second time to 25 students. The materials from the tomato unit were taught to a class of 33 students. Two third grade teachers taught the lessons. The school's STEM coordinator, two gifted and talented paraprofessional educators, one parent volunteer and I observed the interventions. Videos of the classroom interventions (# minutes in total) were transcribed for analysis.

Formal Interviews. Teachers were interviewed after each intervention using semi-structured prompts. Each teacher was asked the same questions (Appendix A), but was asked to expand based on their individual responses. The purpose of the interviews was to determine the teachers' perceptions of the curricular materials, as well as their perceptions of how they could best meet their STEM learning objectives and whether Edible Plant lessons would help them do so.

Teacher curriculum evaluation tool. Teachers were invited to use an evaluation tool that accompanied the curricular materials found online to provide feedback on the curriculum. The responses were used to collect and analyze teachers' perceptions of the effectiveness of the curricular materials in meeting grade specific common core standards (reading, writing and mathematics), life science (agricultural content), comprehensive health standards (nutrition content) as well as 21st century inquiry-based skills. The evaluation clearly listed each content standard and how that standard was applied to a specific learning activity in the lesson plan. During the post-intervention interviews teachers and STEM coordinators were asked to evaluate whether they felt each standard was met when they conducted the activity during the intervention. The interviews were audio recorded and later transcribed for analysis.

An interview of the STEM coordinator. The STEM coordinator, who observed one of the interventions, was interviewed using a semi-structured format. The interview protocol followed the same prompts used for the teacher interviews (Appendix A); however, because the STEM coordinator's role at the school differed slightly from that of the teachers, these data were used to help corroborate other findings. The STEM coordinator's role was to help teachers integrate STEM in as many ways as possible in their daily instruction. This particular coordinator had a BS and MS in environmental science and chemistry. Her PhD was in Educational Leadership with a focus on small group interactions during science inquiry lessons. She was a strong advocate of the teachers in the school and was willing to help them implement lessons that were interdisciplinary and unconventional if teachers asked for assistance. The interview was audio recorded and was later transcribed for analysis.

Informal interviews with school community members. Two enrichment teachers and a volunteer parent who attended the lessons and assisted throughout the curriculum activities were interviewed informally during and after lesson implementations. Informal interviews were also conducted with parents, students and other teachers as well as the principal of the school during STEM Nights. These notes were recorded after leaving the school.

Student lesson artifacts. Teachers collected student artifacts (materials produced during the lesson) after each of the interventions. Student work included completing the activities that were developed as part of the Edible Plant curriculum. Student personal identifiers were removed and replaced by numeric identifiers, as per the CSU Institutional Review Board approved protocol.

Data Analysis

A qualitative case study was the main method chosen for this study because the purpose of this research is to obtain an in depth understanding of how teachers and students in an elementary STEM school would respond to the Edible Plants Curriculum though some of the data collected was student learning results which were analyzed using basic descriptive statistics.

Robert Stake’s recommended approach to data collections was chosen with data being collected through a variety of different means such as interviews, observations, audio and video, and documents. This method was appropriate for this study because similar findings found through different means can enhance the theory generating capability of the case and also support the validity of the assertions made by the participants in the case as well as the researcher’s perceptions. Additionally, documenting that similar findings related to a question originate from different collection methods is also effective in managing the subjectivity of the researcher's observations and allows the case to speak for itself (Stake, 2005).

There are a number of different kinds of case studies including:

1. Single (singular) cases focused on one entity versus multiple or collective cases that focus on several entities often over different periods of time
2. Intrinsic cases that focus on one specific phenomenon and how that phenomenon may be different, rare or unique from others versus instrumental cases that describe a specific case of a more generalized phenomenon
3. Naturalist cases that describe an entity in all its aspects in a specific context versus pragmatic cases that focus one or several specific aspects or approaches which is refined through experiences encountered over the course of the study (Willig, and Stainton-Rodgers, 2008).

The Edible Plant case study focused on a single entity (a STEM elementary School) as an instrumental example of STEM elementary schools and with a pragmatic focus on several specific questions that were defined in advance of the study.

Constant comparative coding was used to analyze the raw data collected from observational notes, informal and formal interviews, and videos (Strauss and Corbin, 1990). This method was appropriate for this study because most of the data collected were qualitative. Comparison and contrasting the responses and comments of the different participants enabled the formation of categories, boundaries of categories, assigning segments to categories, summarizing the content of each category, finding negative evidence and discovering the patterns used to articulate the findings (Tesch, 1990). Cross verification from two or more independent sources was used to confirm the validity of each finding in the study. This method is used for qualitative research and consists of analyzing a research question from multiple perspectives for the purpose of validating the data collected (Patton, 2002).

The open coding process involved identifying teachers' responses to the curriculum and supporting evidence from multiple sources of data. The second round of coding involved collapsing these initial codes into selective codes, which fell into two categories: incentives and barriers. Incentives to implement this curriculum included: 1) feasibility and accessibility of the curriculum resources; 2) engaging for students; 3) interdisciplinary; and 4) increased student learning outcomes. The barriers included teachers' concerns about: 1) time and 2) their own confidence and knowledge about plants. Time seemed to be a concern because none of the teachers considered agricultural-based curriculum materials to be addressing STEM content; therefore, it was seen as a supplementary curriculum that took time away from other STEM-curriculum. Finally, the selective codes were once again collapsed into axial codes that were informed by social cognitive theory and the teacher-centered system reform model. These codes included knowledge/ skills; attitudes/ perception; and behavior.

Descriptive statistics were used to analyze the evaluation of the curriculum materials during formal interviews with two third-grade teachers and two STEM Coordinators (a current district coordinator and a former district coordinator). Descriptive statistics were also used to analyze student learner outcomes pre and post interventions. This method was used in order to provide simple summaries about the sample and the measures as well as simple graphics analysis (Tesch, 1990).

Trustworthiness of data collection

The curricular materials used in the case study, as well as assessment tools used by participating teachers and students, were reviewed by an expert panel (two professors—one in Horticulture and one in Education) at Colorado State University prior to implementation. The curriculum was then approved by the CSU Instructional Review Board (I.R.B.) and also endorsed by the school district's STEM coordinator. A Department of Education professor, involved in curriculum development studies, reviewed and coded 20% of the data. The inter-rater coding reliability was 90%, after which any discrepant codes were discussed until agreement was reached. This method was selected because it is a measurement of agreement among multiple coders that can be used to verify constructs emerge during data analysis (Kurasaki, 2000).

FINDINGS

Three main findings were identified and have been classified as: knowledge and skills; attitudes and perceptions; and behavior (instructional decisions). These final codes were used to develop the final propositions: 1) teachers do not consider Agricultural topics to be STEM and 2) teachers make curricular decisions based on cost: benefit analyses that includes their confidence of the curricular content, accessibility of curricular materials, and time constraints. Teachers' level of perceived content knowledge and skills, as well as their confidence in teaching some lessons were based on their interpretation that Edible Plant lessons are enrichment activities. Unless lessons were identified as meeting other core content standards, teachers made decisions based on whether they thought it was worth the time or not to teach the lesson.

Do Agricultural Topics Meet STEM Standards?

Plant Science was considered "special" content rather than STEM learning. Video transcripts of the interventions document active student engagement and interest in the inquiry based plant science content. Students were asked to document their findings in an informal and optional manner while other activities were in progress. The video transcript and the interviews confirm that the teachers consider this curriculum a "special" activity connected to the school garden rather than a means of measuring student learner outcomes in math, reading, writing, communication, social science, life science, comprehensive health and nutrition. Both STEM coordinators stated that they could see the value of integrating this type of curriculum but not above grade three because 4^{th} and 5^{th} grade science curriculum focuses on other subject matter. They did not view Plant Science as an important component of STEM learning across grade levels. Teachers generally do not engage in gardening themselves so teaching to these standards caused some discomfort and anxiety. This was also true of teaching nutrition. This finding was confirmed in member-checking interactions with teachers.

Knowledge/ Skills. Teachers expressed a concern about their content knowledge. Many of these comments also supported the code of "attitudes and perceptions," but are presented in knowledge/skills category because of the focus of their concerns. Five educators described or implied their lack of training in teaching plant science and agricultural literacy presented a barrier for teaching the Edible Plant curriculum. For example, one teacher explained, "Now that I have seen you demo the planting portion of the lesson twice I would feel comfortable teaching that lesson." Before having the lesson being modeled, she shared that she was unconfident. Some teachers even told their students that they did not have the skills, "I have something known as a black thumb, the opposite of a green thumb. This is why we are so lucky to have [researcher/curriculum developer] with us here today." Another teacher said in a follow up interview, "I can barely keep a plant alive. I did ok with basil this summer. But now it's dead. Better luck next year."

Teachers, as well as one of the STEM coordinators were unable to see how the Edible Plant curriculum could be used to teach other standards other than science. Because plant science is explicitly mentioned in 4^{th} and 5^{th} grade content standards, teachers argued that the content was not necessary for them to master, as one teacher said in a follow up interview, "We are not focusing on plants this year. We are focused on the human body. So the only time we talk about food is when we discuss the human digestive system."

In other instances, teachers' knowledge and skills about edible plants was demonstrated through their implementation of the lessons. Teachers demonstrated their knowledge of plants content during mathematics, language literacy, or social studies activities.

> "…they worked in teams to try to solve words problems that included the longest period between the important dates on the timeline" (regarding math instruction).

All of the educators interviewed and/or observed were confident about language literacy instruction, as the following two narratives illustrate.

> "I started the lesson by asking the students to write down everything they know about tomatoes. While the students took turns planting their tomato seeds I asked the remaining students to write down everything that they had learned about tomatoes along with any additional questions they still had about tomatoes."
>
> "The STEM notebooks were used over the course of the study so that students can write down their observations about their own plant's growth.

> "First I asked the student to locate where they believed tomatoes originated. Then we read the Tomato facts for the timeline, which included Thomas Jefferson serving tomatoes at his dinner, which coincides with the current social studies we are studying" (regarding a social studies lesson).

When asked about the Comprehensive Health and Physical Education standards, one teacher explained,

"I read the book *I Will Never Not Ever Eat a Tomato* and led a discussion with good student participation about the health value of tomatoes and other vegetables."

Third Grade teachers chose to implement the first lesson in both the Potato and Tomato units. The teachers appeared knowledgeable about the math, reading, writing and social studies content that was part of the lesson.

None of the teachers chose to implement the Sweet Potato versus Yam unit because, as they explained, they would not be planting these plants in their school garden (intended to be a Pizza Garden). The teachers also stated that they felt that sweet potatoes and yam were less familiar to students and therefore they would be less receptive to this subject matter. In this case, teachers made a curricular decision based on their ideas of their students' content knowledge. They justified not using a lesson because it would expose students to a plant with which students were likely not familiar. It may be presumed that the teachers were also unfamiliar with these two food crops based on their rationale.

Attitudes and perceptions. Teachers did not demonstrate content knowledge of agricultural literacy. Third grade teachers chose not to implement the third lesson of both the tomato and potato unit because they were uncomfortable with the agricultural activities (planting tomato seeds and sprouting potatoes). This finding was confirmed by both of the third grade teacher formal post-intervention interviews and informal interview of 5th grade teacher who evaluated the curriculum. This was also confirmed 4 times in the video transcript of the interventions and informal interview of parent volunteer who assisted during interventions and later facilitated the planting of their Pizza garden.

Behaviors: Choosing and implementing curriculum. *Four* educators (two teachers and two STEM coordinators) lamented not having access to free, accessible (downloadable), and appropriate (standards-based) curricular resources. This observation was reconfirmed in my own study looking for curricular resources that support agricultural literacy (see chapter 2). For example the school's STEM coordinator said in a follow up interview,

> I don't have a curriculum to work with. I have to find resources on my own to work with and have to find a way to use the same material for each grade (K-5th) which is not always easy to find on the internet. I have limited resources to work with and have to find a way to use the same material and modify it for each grade (K-5th) with little time to reset between classes.

> One of the classroom teachers explained that cost was equally important,
> I will tend not to use a resource if I have to pay for. If I can find a similar resource that is not as good but is free, I will choose the free resource and make it work. This sentiment was shared by another teacher, who stated during a post-intervention interview, "Due to budget constraints we really can't afford to pay for resources so we are always looking for free grade appropriate resources which are hard to find."Teachers selected lessons

> that they believe would engage their students to learn. Attributes of engagement that teachers described included: group work, self-directed learning, and hands-on inquiry activities. “The students worked as a team to determine whether the timeline was set up correctly.” Students writing down Pre-Post Intervention Science facts promote self-directed learning, as was observed during the video analyses. Students worked individually using clipboards, paper, and pencils to record what they knew before and after the lesson. Hands-on activities prompted student questions and engaging in problem solving, as noted through observations during the lessons as well as by teachers and the STEM coordinators. In particular, the students were very inquisitive during the seed planting activity. The student artifacts also illustrated that the activity sparked student interest in more scientific learning (Figure 1).

Elementary teachers feel strapped for time knowing that they must address several content standards (Science, Mathematics, English Language Arts, Social Studies, Comprehensive Health) during each week. They consistently described time as a factor when choosing lessons. As one upper elementary teacher noted, “Time is limited.” Third Grade teachers chose to implement part of lesson 2 of the Tomato Unit but none of lesson 2 of the potato unit due to time constraints. This finding was confirmed during formal post-intervention teacher interviews “When we went though [the curriculum], we gleaned it for time. There wasn’t a scientific reason for why we picked what we did. We simply said what do we have time to get through? Which is pretty much what teaching is.” One of the teachers who implemented the lesson spent much of the instructional time trying to keep students focused on the content and learning objectives. She continually stated, "one two three, eyes on me." If classroom management activities become too time-consuming it is clear that instructional time is compromised.

Time refers to not only instructional time, but includes planning time. If a teacher is less familiar with a lesson’s content, he or she must consider if there is enough time to become familiar. Interestingly, teachers made decisions that weighed more in favor of reading, writing, and mathematics standards (those assessed on standardized tests). The STEM coordinator shared, “I have to work all day Thursday at the other STEM school because they only do STEM once a week. So I have to see all grades kindergarten to 5th grade back to back in one day. I emphasize the process skills as opposed to the content that they are hopefully getting in the classes or alternately teach engineering and engineering design because they are not getting that content in class. The rest of the time is spent on reading, writing, and mathematics.” In this case, one of the STEM coordinators, along with the classroom teachers, discussed STEM topics as those that are separate from the other content areas.

A revealing perception of teachers is that teaching plant science and agricultural literacy is not an important component of STEM (one teacher) or that it is not STEM but rather a ‘special content’ similar to music, theater, and art. Hence, teachers do not choose lessons that they interpret as being STEM or agricultural because, in their limited time to meet all of the other core content standards, they do not want to select “filler” lessons. When asked explicitly about agricultural literacy, one teacher said in a follow up interview, “I’m not sure how to define this… …stories with farming in it or just the ability and knowledge about plants/gardens?” This is curious because the school prides itself on its school garden, which is presented with great pride on the school's website, "stems of learning."

Choosing curricular resources

All teacher interviews and both STEM coordinator interviews described educators' need for curricular materials to be free because there is no budget for purchasing lessons. Two teachers mentioned the website, "Teacher Pay Teacher," as a good resource for finding lesson plans but indicated that not all of the lessons are free. In addition, teachers preferred lessons that are easily downloadable. The teachers spoke positively about the Edible Plants curriculum being available on a website along with all of the necessary student artifacts. In fact, both 3rd grade teachers suggested that the Edible Plants Unit Plans should be promoted on the "Teacher Pay Teacher" website.

Teachers chose lessons based on whether they address their target standards. The curriculum was designed so that the same standards were addressed in both plant units using similar activities for the purpose of encouraging transfer of knowledge and skills through practice. Therefore results from both units (potato and tomato) were combined for each standard addressed in the curriculum. The teachers and the STEM coordinators all found that the curriculum materials were very effective in teaching to the mathematics, reading, writing and communicating standards as well as the life science, comprehensive health and nutrition, and social studies standards targeted (Table7).

Table 7 - Teacher Assessment Data (68 responses)

For each standard/activity, four educators evaluated whether the curricular materials effectively addressed the targeted standards. The only standard for which some educators disagreed was "oral expression and listening."			
Standard	**Activity**	**Responses**	
		Yes	**No**
Math 3.4.3.a.iii Solve word problems involving addition and subtraction of time intervals in minutes using a number line diagram	Students collaboratively created a timeline representing the important dates related to the origins and history of the plant.	8	0
Math Standard 3.3. Time and attributes of objects can be measured with appropriate tools	Using their data collection notebooks, student collect data related to observations of the plant growth	8	0
Reading, Writing and Communicating 1.1 Oral Expression and Listening Formal and Informal	Students listened to a story about the plant during which the teacher paused to ask the students for their predictions on what would happen next and their opinion on credibility	4	4
Reading, Writing and Communicating 4.1. Research and Reasoning and 4.2 Researching a topic and sharing findings are often done with others. Inference and points of view exist	Students wrote down their knowledge of the plant pre-intervention. The teacher facilitated collaborative discussion about each plant issue in which all students participated. Post intervention the students wrote down what they had learned and what questions they still had.	8	0
Life Science 2.1 The duration and timing of life cycle events such as reproduction and longevity vary across organisms and species	Plant Germination and Scientific Inquiry through Observation	8	0
Comprehensive Health - Physical and Personal Wellness Standard 2.1 Demonstrate the ability to make and communicate appropriate food choices	Students listened and discussed a story about a child's resistance to eating the plant they are studying and how that resistance was overcome using imagination to view the plant differently.	8	0
Comprehensive Health - Physical and Personal Wellness Standard 2.1 Demonstrate the ability to make and communicate	Talked about products that have tomatoes in them, learned to read food labels and talked about health value of products	8	0

appropriate food choices			
Social Studies Geography Standard 2.1 Use various types of geography tools to develop spacial thinking	Use of a world map to find continent, oceans and describe natural and human feature of the place of origin of the Tomato	8	0
Social Studies Geography Standard 2.2 The concept of regions is developed through an understanding of similarities and differences in places	Talk about where the tomato comes from, similarities between Fort Collins versus the country of origin of the tomato	8	0

Student Learning Outcomes

As a result of participating in the Tomato Unit 97% (32/33 students) demonstrated increased knowledge of plant science outcomes. In addition, 45% (15/33 students) expressed interest curiosity in learning about tomatoes (Figure 5).

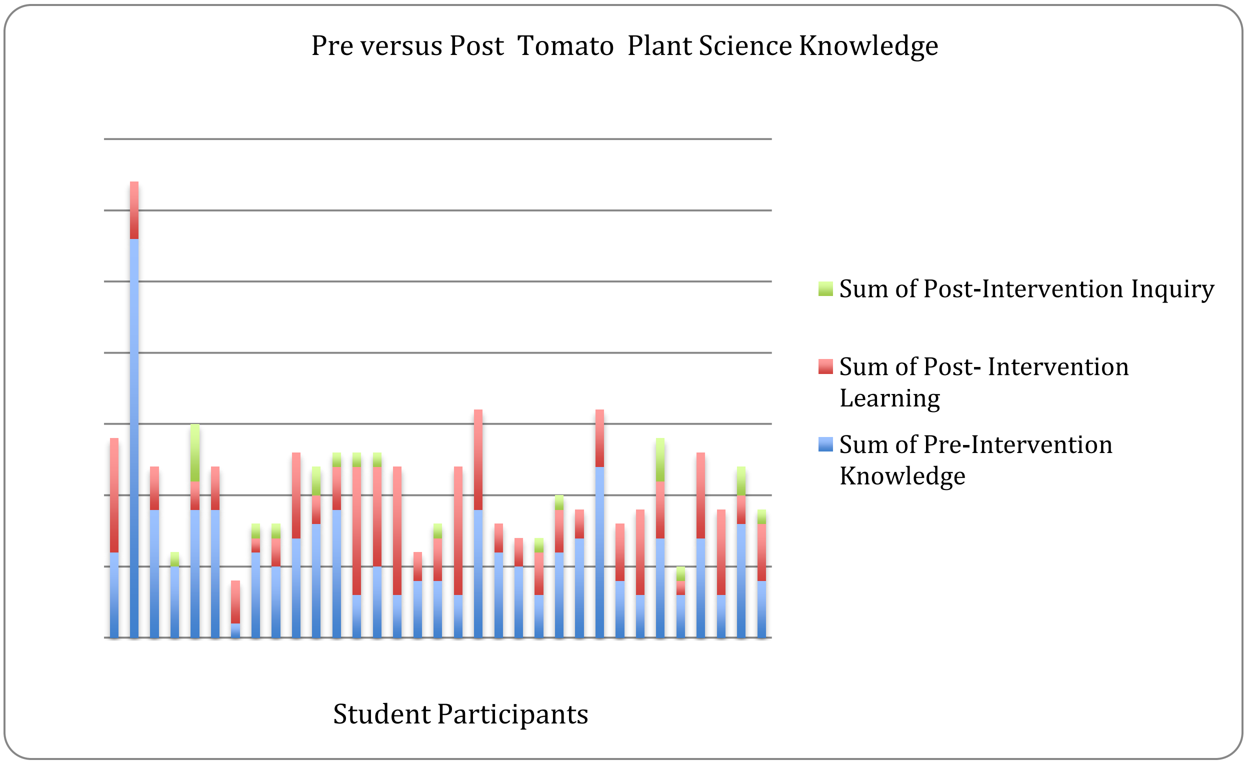

Figure 5 – Student outcomes pre and post tomato unit in a 3rd grade class (n=33).

As a result of the Potato Unit, 97% (32/33 students) demonstrated increased knowledge of plant science after the lessons. In addition 60% (20/33 students) expressed increased curiosity in learning about potatoes after the lessons (Figure 6).

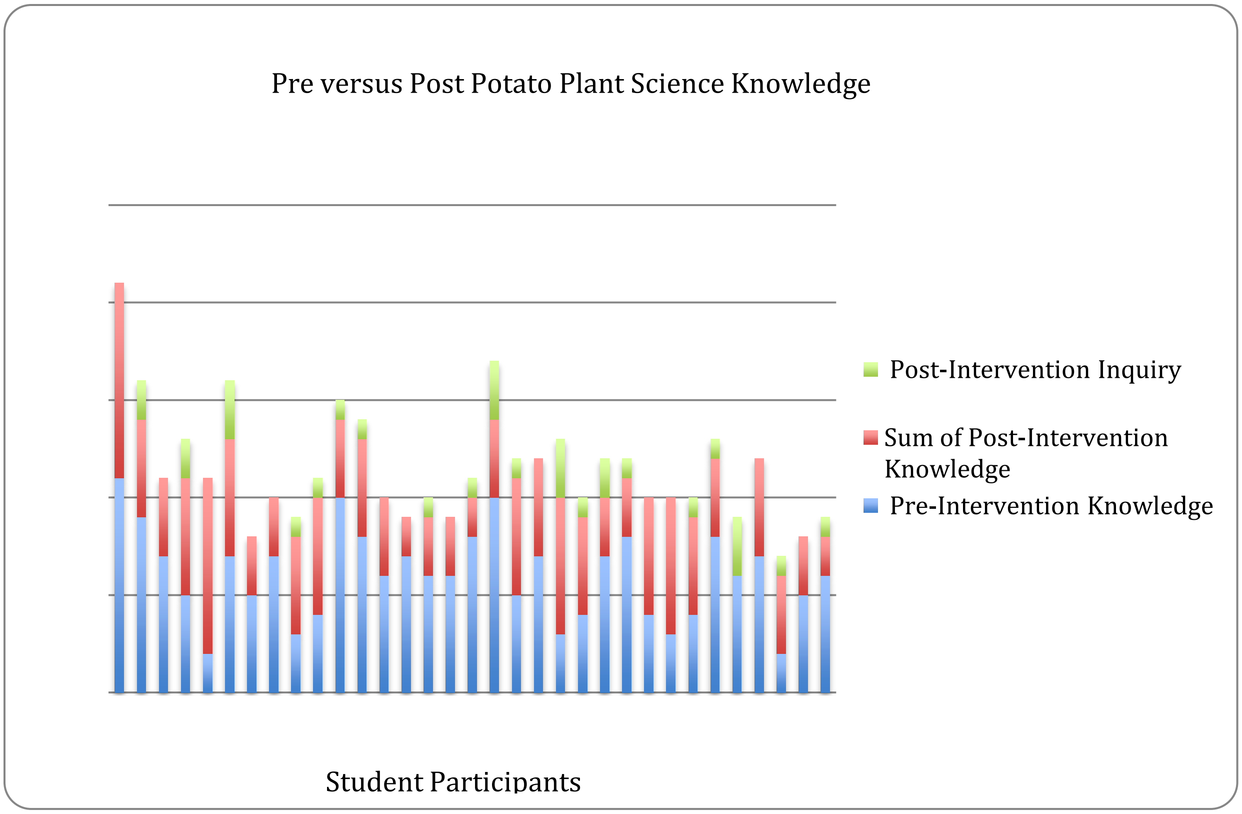

Figure 6 - Student learning outcomes of 3rd grade students (n = 33) after potato unit.

The Edible Plant lessons yielded more variable results for mathematics outcomes than plant content knowledge (Figure 7). After participating in Tomato Unit lessons, 66% (22/33 students) placed at least six of the dates correctly on the timeline; 33% (11 students) placed five or fewer of the dates correctly on the timeline. Seventy-five percent of the students (25/33 students) completed three or more of the word problems correctly; 25% (8 students) completed two or fewer word problems correctly. Sixty percent of the students (20 students) showed their work on when solving math problems.

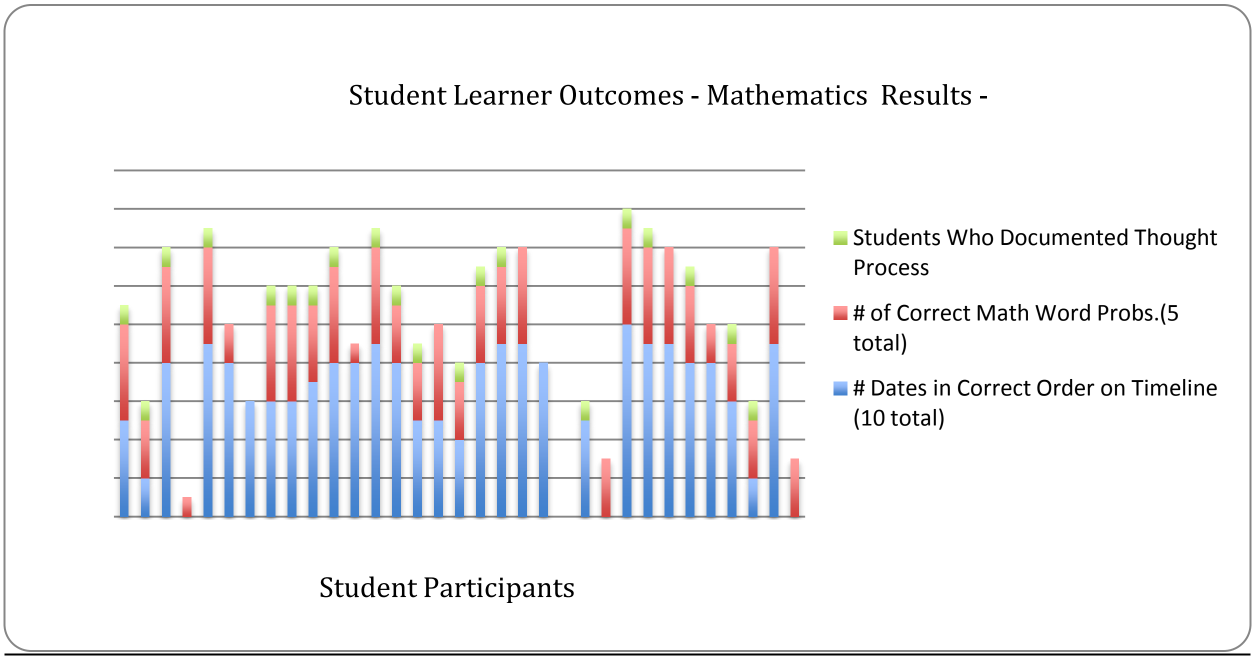

Figure 7 - Math lesson outcomes for 3rd grade students (n = 33).

During the potato lesson, 70 % (23 students) placed at least six of the dates correctly on the timeline; 30% (10 students) placed 5 or less of the dates correctly on the timeline; 67% (23 students) completed three or more of the word problems correctly; 33% (11 students) completed two or fewer word problems correctly (Figure 8). Sixty percent of students (20 students) showed their thought process in completing the Math problems by writing out their problem-solving process.

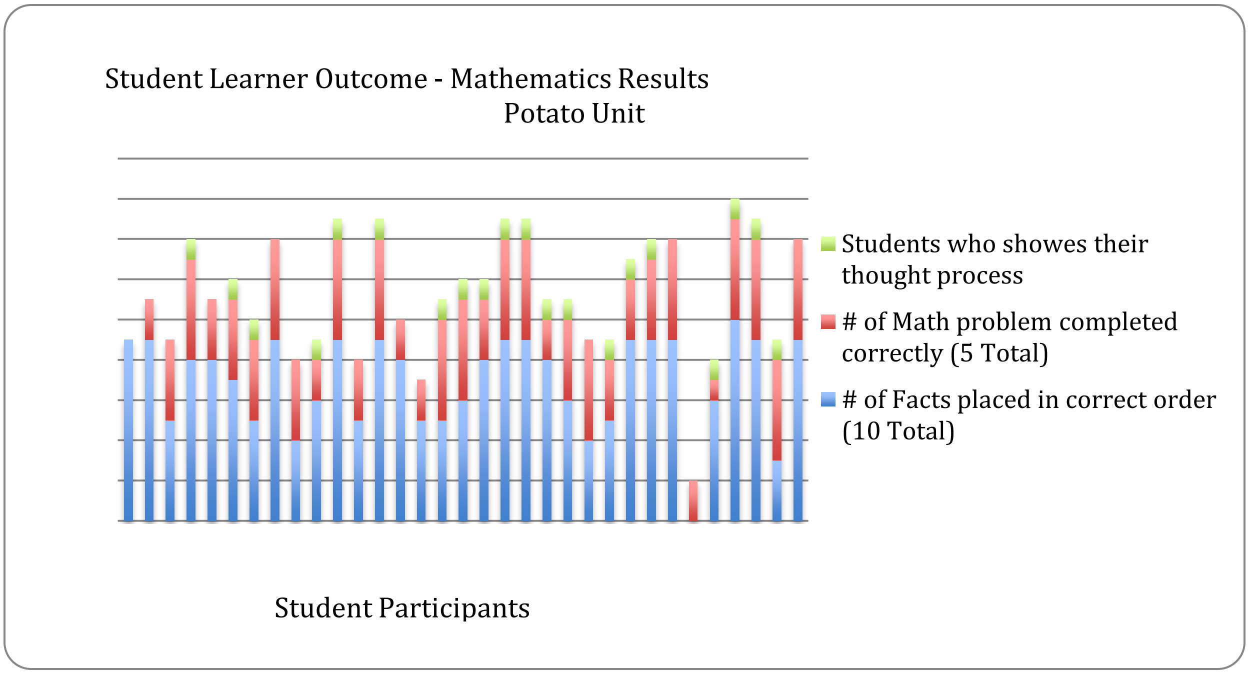

Figure 8 - Student learning outcomes during the potato unit in a 3rd grade class (n = 33).

Social studies outcome indicated that students struggled with geographic knowledge before the lesson (10% for tomatoes and 16% for potatoes), but that all students (100%) were able to identify the origin of either tomatoes or potatoes after the lesson.

Health and Nutrition Literacy Outcome

The students read the labels of products that contained the edible plant and the teacher lead a discussion about the nutritional value of the plant. As documented in the video transcript of the Tomato Unit, this discussion resulted in several students changing their mind about disliking tomatoes because they realized that they were regularly eating tomatoes in familiar products like spaghetti sauce and ketchup. In the video transcript of the potato unit, the discussion about products resulted in students realizing that how you prepare the plant and what other ingredients are involved can make it healthy or unhealthy to eat. Lauren Child' story entitled 'I will Never Not Ever Eat a Tomato'(Lauren Child, 2000) was used by the third grade teacher to lead a discussion about changing our perceptions about foods by using our imagination, how looking at foods differently can change our minds about our likes and dislikes.

Summary of curriculum evaluation

The results of the case study indicated that that the Edible Plant Curriculum was well received by the intervention teachers, who stated that they would use the materials again because it very relevant to their third class garden project, is free, and is easily downloaded from the internet. They would also recommend it to others but would integrate more movement into the activities to address limited attention span of third grade students. Video transcripts also documented that classroom management was a time constraint issue with regard to maintaining students' attention and focus on the tasks at hand even though there were a total six adults present to assist in managing the flow of the activities for 33 students (1 adult to 5.5 students). The teachers as well as the STEM Coordinators emphasized the time constraints imposed by requirements of "teaching to the test" as stimulated by the Accountability Act of 2008.

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DISCUSSION

The case study results indicated that curriculum materials similar to the Edible Plant curriculum could be effective in integrating inquiry-based, standards-based, grade-specific agricultural and nutrition literacy into existing common core elementary school curricula. Previous studies have come to this same conclusion; in particular, a comprehensive review of 17 studies on the performance outcomes of different approaches in teaching science in elementary schools suggested that the use of science kits did not result in positive outcomes on science performance measures (Slavin, Lake, Hanley, & Thurston, 2012). However, inquiry-oriented instructional approaches such as cooperative learning, integrating science and reading appeared to result in improved interest and performance in science. The successful courses tend to emphasis the use of specific, well-articulated strategies designed to develop students' understanding, curiosity, and ability to apply scientific methods. These interventions consistently emphasized the importance of professional development and coaching to promote the use of the more promising approaches by teachers (Slavin et al., 2012).

Several significant barriers will need to be overcome with regard to the teachers, STEM coordinators and administrators belief that plant science and nutrition literacy are "special" content activities versus important STEM content as well as vehicles for promoting inquiry based learning across common core disciplines. Though previous studies have also concluded that *Next Generation Science Standards* will require large-scale professional development (PD) for all science teachers (Wilson, 2013), no comprehensive professional development programs designed to promote the value of using edible plant science as a topic for inquiry-based learning across disciplines at the elementary school level were identified. Even at the high school level, agricultural education focuses on the industry and on careers in agriculture as separate content. This makes sense because agricultural education is a part of the Career and Technical Education (CTE) programs in the K-12 system. It is not typically integrated with core content areas, such as science and mathematics. A study conducted in 2008 reviewed teachers' beliefs related to integrating agriculture into elementary school classrooms. The results indicated that teachers are more likely to use agriculture literacy curriculum material that fits into the grade specific academic content that they are currently teaching and if they meet the educational goals already established, instead of materials that focus on agriculture industry and careers in agriculture (Knobloch, 2008). These findings are informative to those educators who recognize that agricultural studies require the application of science, mathematics, social studies, and language arts. However, this message is not conveyed to elementary teachers, who then miss opportunities to help their students learn about the origins of food.

In the absence of professional development programs that could improve elementary teachers' understanding and comfort level with the plant science and nutritional literacy content of the curriculum, short 3 to 5 minute Professional Development Learning (PDL) videos demonstrating these activities in detail could be added to the curriculum materials and used not only as a teacher resources but as student learning tools. A short introductory PDL could also be added to the material to make sure that teachers understand that the lessons plans are specifically designed to promote inquiry based learning across disciplines and grade levels. A PDL specifically designed for 4th and 5th grade teachers could be added to emphasize the value of grade specific progressive studies in plant science as a vehicle for inquiry based learning.

It is recommended that once the above referenced improvements to the Edible Plants Curriculum are completed, a second case study be conducted at a different elementary STEM school for the purpose of evaluating whether the changes in the presentation materials are effective in addressing the professional development needs identified in the first case study. It is also recommended that this case study be conducted at a lower income elementary STEM school for the purpose of evaluating whether the materials are effective when they are used in a more diverse environment.

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CHAPTER 4

Discussion and Implications

Summary of the Case Study Findings

The case study findings indicated that the edible plant curriculum was an effective vehicle for integrating STEM and 21st Century skills development into common core content. Additionally, at the time the case study was implemented a last minute request for expansion of the curriculum to 3rd grade standards was easily accommodated because the framework was designed to facilitate easy expansion to other grades and subject matter. However, effective curriculum frameworks and content delivery systems are not enough. One of the key findings of the case study was that the teachers and staff members involved did not feel that they had the training needed to teach plant science. This confirms previous findings from other studies (Greenberg & Walsh 2008). Additionally, they did not consider plant science to be STEM content. They did not see the value of repeating activities/exercises across content/grade levels. Time constraints kept teachers from implementing all of the three lessons in each unit and class management was a constant challenge throughout the interventions.

RECOMMENDED IMPROVEMENTS TO THE EDIBLE PLANT CURRICULUM

Yearlong School Wide Curriculum Expansion

A review of elementary school science learning outcomes (17 studies) conducted in 2012, found that expanding science instruction throughout the year including cooperative learning and science-reading/research was more likely to result in student science learning than short intensive interventions (Slavin, et al., 2012). Additionally, several studies have demonstrated that Food Systems Schools scored higher on a scale testing for improved student cooperation, behavior and better social skills (Murphy, et al., 2003). Students experienced significant gains in overall GPA in math and science, students also scored higher on a standardized psychosocial questionnaire. Teachers stated that their school (Food Systems School) was more conducive to learning (more order, better morale) compared to the control school; teachers rated their school higher in the following dimensions:

- Overall educational climate
- More cooperation among staff
- General satisfaction with being a teacher at this school
- Order and discipline are maintained satisfactorily
- General teacher morale is high
- Students in this school pay attention during class

For the purpose of further testing the value of the Edible Plant Curriculum as a vehicle for integrating STEM with common core content while promoting 21^{st} Century and professional language skills as well as emotional and social wellness, it is recommended that the curriculum be expanded to a yearlong pilot program at a STEM elementary school. As demonstrated during the case study, the curriculum can easily be expanded to other grade levels. Additional units can be added using other popular edible/non-edible plants or other grade specific Life Science content. Additional Lesson plans can be added to integrate more STEM and common core content as well as special content.

Professional Development Learning Components as an Integral Part of Curricular Materials

Whether the project is expanded to a school wide pilot program or not, it's important to keep in mind that one of the key findings of the case study was that that teachers/staff do not have the time needed to study and assimilate new content and approaches to teaching science. Other studies have also found that time constraints related to the demands of accountability requirements can significantly impede teachers' ability to teach other subject matter or engage in more time consuming inquiry based pedagogical approaches (Kohn, 2001; Smith, 1991).

For the purpose of addressing this professional development need while taking into consideration the teacher's time constraints, it is recommended that a series of short professional development audio/visual recordings (PDLs) be developed. These 3 to 5 minute audio/visual recordings would then become an integral part of the curriculum materials.

Plant Science is STEM

One of the important findings of the case study was that teachers/staff did not consider agricultural life science and nutrition content to be STEM. For purpose of educating teachers/schools about the importance of agricultural literacy and how it inherently contains STEM content, it is recommended that a short PDL be developed and included in the curricular materials: This PDL would serve as an introduction to the curriculum and focus on demonstrating how Edible Plant Science is inherently STEM content and how the study of edible plants can be used as a vehicle to integrate STEM and 21st Century Skills development into common core content. The PDL would illustrate that the activities/exercises were designed to be relevant to the teachers and students' personal everyday life while sparking curiosity and interest in:

- math and science applied to real life problems,
- history and geography of the plants they eat every day,
- using information technology to find the answers to important questions
- using reading, writing and communications skills to explore, understand and explain how the scientific method is used to study edible plants.

Project-Based Units/Lesson Plans Design

The case study findings indicate that the teachers who participated in the case study did not see the value of repeating similar activities and exercises across content and grade levels. For this reason, it is recommended that a short PDL be created to assist teachers in understanding the pedagogical philosophy that was used in designing the Unit/Lesson Plans: Knowledge in Action (NCSS, 2013) and how this design has been shown to foster retention and transfer of knowledge and skills, including generalization of concepts. The Units/Lesson Plans Framework used to design the edible plant curriculum encourages retention of concrete standard based life science, math, reading, writing, communications, social studies and nutrition content through repetition of similar activities/exercise. It also fosters the development of conceptual thinking and generalization by pointing out that the ideas/principals/issues that apply to one edible plant often apply to other edible plants that come from different parts of the world.

Consciously Integrating 21st Century and Professional Language Skills Development

Teacher assessments of the curriculum conducted after the interventions indicated that when prompted, the teachers/staff who participated in the case study found that the lessons they taught during the intervention did foster critical thinking, problem solving, creative thinking, collaboration and self-directed decision making. It also encouraged the use of professional language. However, the teachers were not intentionally fostering this skill development – the way the activities were designed naturally brought up opportunities for critical thinking, self-directed problem solving, collaborative work, and the use of professional language to describe the process. Though this finding suggests that the curricular material itself is effective in fostering 21st Century skill development in a natural integrated manner, I hypothesize that these skills could be reinforced and assimilated more fully if teachers named and reinforced the skills at the time they are used by students. For this reason, it is recommended that a short PDL on these topics be developed and included in the curricular materials. This PDL would briefly go over the framework used to integrate 21st Century and professional language into the activities/exercises and how this same framework could be used to integrate this kind of skills development into any content. Lesson plans also include specific notations about opportunities to talk about a specific skill and how it applies to the activity at hand.

Integrating Special Content

One of the academic goals of the Colorado Department of Education is to focus on all 10 content areas. This includes Math, Reading, Writing, Science, Communicating, Personal Financial Literacy, Social Studies, Music, Dance and Visual Arts, Comprehensive Health and P.E., and Drama and Theater Arts. The edible plant curriculum explicitly includes 7 of the 10 content areas (CDE, 2012). However, Music, Dance and Visual Arts, Drama and Theater, and Financial Literacy content could easily be incorporated into the activities and exercises already included in the curriculum. For example, the timeline exercise could become the subject of a social studies based theatrical skit which the students could write and act out, adding music and dance as well as props. Financial literacy is addressed briefly in the calculation exercises related to production yields but could be expanded to include calculating the cost of the edible plants we eat and how to budget for those costs. For this reason, it is recommended that a short PDL be included to prompt teachers to consider adding these components to the curriculum activities. Additionally, it is recommended that specific ideas for integrating these three content areas be added to each lesson plan.

The Value of Co-teaching

Co-teaching was not one of original guidelines for implementing the Edible Plant Curriculum during the case study. However, the third grade teachers chose to co-teach the lessons together. It was observed that the teachers supported and assisted each other throughout the intervention in the following manner:

While one teacher focused on class instruction, the other focused on class management, supervising individual students during their experiments.

Dividing the class into activity groups with one teacher facilitated self-directed written assignments while the other lead a much small group of student in the seed planting activity.

The teachers appeared to have different and complementing pedagogical strengths with one teacher being effective at engaging individual students in answering specific content related questions while the other encouraged critical thinking about the plausibility of the story she read and creative thinking related to alternate story lines.

In the case study it was found that co-teaching was very effective in giving students one on one instruction/support while also keeping all of the students engaged and on task.

For this reason, it is recommended that a short PDL explaining the value of co-teaching this kind of content be included in the curricular materials.

Combining Professional Development Learning For Teachers with Student Learning

Introducing and Reinforcing Learning Goals for Each Lesson.

Written instructions for teachers to assist them in preparing for each lesson plan are already included in the curricular materials However, short lesson specific PDLs could be designed to help teachers communicate to students these learning goals and talk about the purpose of the activities at the beginning of each lesson. These PDLs would be designed to assist in fostering and reinforcing retention of specific content while building 21st century skills and promoting the development of conceptual thinking and generalization.

Edible Plant Science Content

Ideally, teachers interested in teaching the edible plant propagation lessons would take a plant propagation course at a local college. However, elementary school teachers are expect to teach a variety of subjects for which specialized in depth training would also be advised but hardly feasible because of time and funding constraints. As an alternative to in depth training, the development of short, step by step PDLs could be used to provide teachers with the specific knowledge and specific procedure needed to complete propagation/plant study activities using a rigorous scientific approach. These PDLs could be designed to be first watch by the teacher in preparation for the activity and then used in the classroom as an introduction to the activity. This would help the teacher assimilate the knowledge and methodology while promoting student listening skills. The following PDL topics are recommended:

What is needed to grow the edible plant (soil and food, water management, protection from the elements, etc.)?

- How to plant the seeds
- Keeping a Scientific Notebook (chronological notes and observation, measurements, how issues are addressed, outcomes, recommendations for future projects)

Using Information Technology

Though the students at the case study STEM school had access to I-Pads and teachers valued them as a learning tool, they chose not to implement the internet research component of the curriculum due to time constraints.

For the purpose of assisting teachers in efficiently teaching the students how to access the websites/information sources and do the assigned research, the researcher recommends that PDLs be created to use in the classroom with simple step by step instructions.

Inquiry-based Teaching as a Class Management Strategy

It was observed that during both interventions the third grade teachers consistently applied positive reinforcement strategies such as ignoring individual inappropriate behavior while redirecting attention to a student that was concurrently exhibiting appropriate behavior and praising that student (Madsen C.H. et al, 1968). The teachers also continuously used other positive redirect strategies such as instructing the students to count to three and focus on the lead teacher (Madsen C.H. et al, 1968). Despite the application of these strategies, a general restlessness, lack of student focus and attention was a continuous challenge for the teachers during the social studies, math and writing assignments. I observed that during this part of the intervention the teachers used a ‘teach to the content’ pedagogical approach: reading historical facts, asking the students put these dates in chronological order and to perform other math problems that were not directly relevant to the students everyday life. I also observed that the teachers did not use open ended questions to engage the students' curiosity, critical thinking or creativity in discussing the topic or solving the math problems. In contrast, during the Edible Plant storytelling activity which immediately followed the social studies and math exercises, the teachers paused frequently and used open ended questions that pointed out the relevance of the story to the students' personal life. The teachers used questions to facilitate an exploration of the nutritional value of the edible plant, creative thinking about alternate endings to the story, and critical thinking about relationships between siblings. During the storytelling portion of the intervention, less class management was needed. The students were able to sit quietly. They were more attentive and actively participated in the discussion. During the plant propagation activities, a clear, consistent inquiry-based approach was used to engage the students in the scientific method. The students actively volunteered self-directed creative problem solving with enthusiasm and prolonged attention. No class management strategies were needed during this part of the intervention.

In conclusion, observations appear to indicate that inquiry based teaching may improve class management because it engages the student in a personally relevant manner. Additional research is recommended with a focus on exploring this question in a scientific manner. Secondly, the Edible Plant Curriculum was designed to encourage inquiry-based teaching across all content including social studies and math. However, the teachers who participated in the case study chose to apply these strategies to the storytelling activity but not to social studies or math exercises. This finding appears to indicate that teachers know how to integrate inquiry-based learning but are still in the habit of using a more traditional pedagogical approach when teaching common core content. More research is recommended to explore this question in a scientific manner.

Additional Research Opportunities

Once the recommended improvements to the curricular materials are completed, it would be of interest to conduct another STEM school to explore the following questions:

Are the audio/visual recordings effective in addressing the professional development needs of the teacher?

Are the audio/visual student records of the plant propagation activities effective in helping teachers with the science components in the classroom?

It would also be of interest to conduct the case study with predominately underprivileged student population to evaluate its effectiveness in sparking interest in STEM.

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APPENDIX I

Incentives and Barriers to Implementing Interdisciplinary, Standard and Inquiry Based Plant Science and Nutrition Literacy Curriculum into Common Core Elementary School Curriculum - Case Study Results

Barriers to Implementing Plant Science and Nutrition Materials 56 Occurrences		Incentives for Implementing the Edible Plant Curriculum 78 Occurrences	
Time Constraints 21 occurrences		**Inquiry Based Learning 20 occurrences**	
Lack of Time to Research Curricular Materials	6	Content fosters Collaboration	6
Time required to 'teach to test'	6	Content promotes self-directed learning	7
Lack of time to Prep for New Content	6	Hands-on Activity fostered Problem Solving	7
Class Management Issues	3		
Professional Development 17 occurrences		**Standard Based Materials 40 occurrences**	
Lack of Training in Plant Science		Math standards applied to activities	8
Lack of Confidence in Teaching Plant Science Content	5	Reading, Writing and Communicating Standards applied	8
Lack of Interest in Teaching Plan Science	4	Social Studies standards applied to activities	8
Plant Science is not part of 4th & 5th	1	Life Science standards applied to activities	8

Grade Science			
		Comprehensive Health and Nutrition	
Belief that Plant Science is not STEM	2 3	Standards applied	8
Curricular Materials - 18 occurrences		**Relevance of Material to STEM School Garden- 8 occurrences**	
Lack of Easily Downloaded Materials 5		Tomato Unit content was relevant to 3rd grade Pizza garden	8
Lack of Good Quality Standard Based Materials	5		
		Downloadable from Familiar Websites on the Internet – 5 occurrences	
Lack of Grade Specific and Progressive Materials	2		
Lack of Free Resources	6		
		Curriculum Resources were free - 5 occurrences	

APPENDIX II

FINDINGS

Teacher-Centered Systemic Reform (TCSR) Model Case Study