Fall 12-10-2018

A Focus on Scientific Inquiry in CTE Through a Green Space

Emily Anderson
andersoe@dcmoboces.com

A Focus on Scientific Inquiry in CTE Through a Green Space

By

Emily Jane Anderson

A thesis submitted to the Department of Education of The College at Brockport, State University of New York, in partial fulfillment of the requirements for the degree of Master of Science.

November 27, 2018

A Focus on Scientific Inquiry in CTE Through a Green Space

By Emily Jane Anderson

APPROVED BY:

____

Abstract

Science education trends state that students and teachers should work to promote learning by making science relevant and meaningful. With a changing world, the way science is taught and learned needs to change too. There is an increasing push for Science, Technology, Engineering, and Mathematics (STEM) awareness and the engineering design process. Integrated science education in Career and Technical Education (CTE) is a trend and area of teaching that is needed and looked at as a way to make science more relevant and meaningful. Teachers are expected to engage students in meaningful and purposeful instruction that provided students with inquiry-based instruction. To assist CTE teachers with integrating science coaching, and working with a co-teacher can help mold students into thinking like scientist in their field of study.

Key words: Career and Technical Education, CTE, inquiry, science education

A Focus on Scientific Inquiry in CTE Through a Green Space

Table of Contents

Chapter I: Overview ... 5
Introduction ... 5
Project Design: ... 9
Significance: ... 10
Definition of Terms: ... 11
Chapter 2: Literature Review ... 12
CASE Curriculum ... 12
Getting non-science student to think like scientists ... 13
Making Science Worthwhile ... 15
Generalizing Science across disciplines ... 17
Feedback ... 22
Prior knowledge and memory ... 24
Too close for brain comfort ... 27
PCK ... 29
STEM pathways ... 36
Coaching ... 37
Green space and garden based learning ... 40
Career and Technical Education ... 55
Barriers for CTE ... 58
Barriers in teaching science in CTE ... 59
Co-teaching and integrated academics in CTE ... 63
The ideas of integrated academics ... 69
Inquiry in CTE ... 71
The Nature of Science in CTE ... 81
Reflection ... 88
Chapter 3: Project: Leading Lessons in the Greenhouse ... 89
Inspiration: ... 89

Curricular Justification: ... 90
CTE Conservation Science Lessons ... 90
How do nutrients effect the growth of a pea plant? ... 90
How does exposure to different wave lengths of light effect plant growth? ... 93
What are the effects of root growth hormone on plant propagation? ... 96
How does a change in pH effect the growth of seedlings? ... 100
How do plants reproduce to create seeds? ... 103
How can you tell if a seed is viable? ... 106
CTE Culinary Science Lessons ... 109
How do fresh herbs and spices compare to dried herbs and spices? ... 109
How sweet is the apple? ... 113
How does the color of the light effect the flower/fruit production? ... 116
What is sourdough? Are all sourdoughs the same? ... 119
Do microgreens like heat? ... 123
How fast to different sprouts grow? ... 126
CTE Computer Technology Science Lessons ... 129
What waters better: A human or automatic sprinkler system? ... 129
How much energy do the greenhouse lights use? ... 132
How can I create a database of the plants growing in the greenhouse? ... 135
How can I use a Raspberry Pi to control lights? ... 139
What does research say about exposure to cell phone and WiFi ER? ... 142
How can I engineer a hydroponics system to grow plants? ... 146
Chapter 4: Student Driven Inquiry Projects ... 149
CTE Conservation Inquiry Project Ideas ... 149
CTE Culinary Inquiry Project ... 150
CTE Computer Technology Project ... 150
Chapter 5: Reflective Commentary ... 151
Sample Agilix Buzz Lesson in Culinary ... 158
Sample Agilix Buzz Lesson in Conservation ... 165

Sample Agilix Buzz Lesson in Computer Technology.. 169
Closing Summary... 173
References.. 175

Chapter I: Overview

Introduction

Integrated science in career and technical education (CTE) should be a combination of inquiry-based lessons that are co-taught by both the science teacher and the CTE teacher. A truly inquiry-based classroom should include discussions, designing, and testing different ideas and thought processes to move towards a more coherent form of science where students are learning though inquiry and demonstrating understanding of their findings and what it means in relation to their CTE program area.

CTE works to use inquiry in the labs to prepare students for the workforce or furthering their training in the field. The ideas that students need to be able to apply various skills and apply thought processes in the scientific classroom has been central to science education for a long time. However, there are many challenges teachers face when they try to implement inquiry-based teaching methods into the classroom. It is difficult to measure the quality of inquiry, using discourse to improve inquiry, pursuing the goal of teaching science content through inquiry methods and learning how to effectively manage an inquiry-based classroom (Quigley, C., Marshall, J. C., & Deaton, C. C. M., 2011).

When a learner is inquiring he/she is engaging with a scientific question, participating in the design of the procedure, giving priority to evidence, formulating explanations, connecting the explanations to knowledge and finally communicating and justifying his/her explanations (Quigley, Marshall, Deaton, Cook & Padilla, 2011). However, teaching through inquiry varies greatly on how well the teacher understands the concepts and the process. On average 37.3% of time is spent on inquiry activities in K-12 science. This percentage becomes lower for high school teachers while the quality also tends to be activity centered. In these settings the teacher explains a phenomenon or concepts and then the students work with the concept through a guided activity which does not promote the learning of critical thinking skills (Quigley, Marshall, Deaton, Cook & Padilla, 2011). Teachers can improve the quality of their inquiry activities they are facilitating in the classroom when they are provided mechanisms to change and transform their teaching practice.

In the CTE classroom there are many levels of inquiry including confirmation, structured, guided and open inquiry. CTE easily allows for shop confirmation to happen naturally and is great for reinforcing a previous idea or covered material. Structured inquiry allows the instructor to determine the question and methods, but the students will generate the explanation based on their investigations. These two, confirmation and structured, tend to be lower levels of inquiry, but are important in the development of the students' skills and abilities (Schwartz, 2017). As the students' progress in their abilities though inquiry, then the higher levels of inquiry may be used to further inquiry development.

Research indicates that having students engage in more advanced inquiry practices, which involve posing questions, predicting outcomes, conducting observations and drawing conclusions, will create more effective learning motivation by increasing communication and interest in content. Currently, many activities in

CTE focused on structured inquiry which involves a step-by-step method to learning and results in a predetermined outcome (Schwartz, 2017). However, through incorporating higher-level guided and open inquiry within the classroom, students can experience a more rigorous and relevant learning experience.

In CTE the teacher can offer a very different learning experience for each learner based on prior knowledge and ability to teach students about inquiry and foster learning through inquiry. Some schools use co-teaching as a method to support and advance the understanding of academics in CTE. This process allows for students to gain academic credit while enrolled in a CTE course and graduate with skills necessary for success in furthering their education and/or entering the work force.

In the past CTE courses and programs have been considered separate from academic subjects like science, math, and English. The CTE programs have focused on curriculum and instruction that were based on the industry skills and technologies that were needed to enter the workforce as a skilled wage employee. However, following the 1990 Carl Perkins Act, which allowed vocation education monies to be spent on programs that "integrate academic and vocational education," it became essential for many CTE programs to integrate shop experiences with academic content and student learning activities (Spindler & Greiman 2013). To do this, guidelines were made in 2007 by the National Science Education Standards to promote learning through inquiry, use "hands on" learning, "minds-on" learning, and "science as process" (Pearson, Young, & Richardson, 2013). This in turn creates an opportunity for CTE teachers to construct many contextualized authentic learning opportunities. The learning activities then scaffold easily by the physical learning environment and allow for the propagation of knowledge construction, long term memory encoding, and the promotion of organization for memory recall of the information. When learning science in CTE, students do not need to construct artificial connections between what they are learning and how it works itself into the students' real world. The process of "slipping in some science where it fits" no longer works and will not meet the demands of industry and school based standards.

The Next Generation Science Standards (NGSS) and the New NYS p-12 Science Standards present a vision and an idea of science teaching and learning where science classrooms and students are given opportunities to generate, critique, and evaluate scientific evidence to develop and understand scientific explanation and arguments which in turn will support and further inquiry and understanding (Grooms, Enderle, & Sampson, 2015). A classroom with quality teaching and learning will need to begin to incorporate many different forms of instruction to achieve the benefits of all models. By implementing argument driven inquiry (ADI) teachers can help develop the robust pedagogical tools that are necessary for teaching the NGSS.

The design and focus of the following project will integrate science inquiry through coteaching in various CTE courses while focusing on using a green space located on the school's campus. The designing and implementing of carefully scaffolded lessons to build and support a more autonomous inquisitor will be developed along with the CTE teacher to ensure that the designed lessons fit into the CDOS, science, and industry standards.

Project Design:

This project will focus on the modifications of a CTE integrated science curriculum to develop a series of lesson plans incorporate the use of the greenhouse located on campus. These lesson plans will provide a unit which focuses on the design and implementation of inquiry into the CTE curriculum. Units consisting of at least 6 lessons will be developed for the following CTE courses: Culinary, Conservation and Computer Technology. The project will allow for science and CTE teachers to increase their use and comfort in both inquiry and the nature of science while exposing the students the greenhouse we have available to us at both DCMO BOCES campuses. The integrated science will be used to develop a better understanding of the natural world and plant biology while turning a greenhouse into a learning lab and opportunity for students to grow and learn more about the nature of science. All lessons will be aligned to the industry standards for the program area, the NYS Next Generation Science Standards, and the Learning Standards for Career Development and Occupational Studies (CDOS standards) for CTE.

Traditionally, only the Conservation program has used the attached greenhouse located on the DCMO BOCES Campus and this project will allow for additional programs to develop and find ownership in designing and performing inquiry within a productive teaching green space on campus. Each lesson will strongly support the building of students' inquiry and students understanding of the nature of science while incorporating NYS CDOS and NYS Next Generation Science standards into a co-teaching environment. Each lesson in each CTE course will build on the previous lesson in a way to move students from direct inquiry to self-guided inquiry.

This project will:

- Consist of a series of integrated science lessons (at least 6 lessons per unit) that will make up one science unit for 3 different CTE courses which focuses on building inquiry in a green space for a total of no less than 34 hours' worth of instruction
- Supply Links to each appropriate career and technical standards within the program area and make a connection between learning about science and performing science.
- Align to the New York State P-12 Science Learning Standards (Next Generation Science Standards) and CDOS standards
- Provide opportunities for co-teaching and extending the content and curriculum into the CTE classroom for each lesson.
- Supply materials necessary for each lesson/activity to take place
- Create lesson plans and all hand-outs/worksheets/assessments for each of the 6-2 hour based lessons in 3 different CTE courses. This will be done through Agilix Buzz, an on-line learning platform.
- Reflect on how the lesson motivated students to think more about the process and further their understanding. For each lesson that was taught a reflective component will be included.

Significance:

Co-taught, integrated science in CTE is most effective when the students and the teacher find the working meaningful and relevant. Additionally, the building of scientific inquiry can become a life-long skill involving the design and re-design cycles when troubleshooting problems one encounters. The current BOCES campus possesses a green space including an under-utilized greenhouse where conservation programs learn about the process of running a greenhouse. This project will aid in fully utilizing the green space to make science inquiry more relevant to Conservation, Culinary Arts and Computer Technology.

As a result of this project students will design, with minimal direction, an experiment where given a question to address they will, as a group, prepare materials list, procedures, data collection, and process to conduct an investigation which takes place in the green space.

Definition of Terms:

CTE- Career and Technical Education

CDOS- Career Development and Occupational Studies

NGSS- Next Generation Science Standards

Co-teaching- both the certified academic teacher and the CTE classroom teacher work together to develop and teach lessons which directly relate to the CTE program

Integrated Science in CTE- CTE in NYS requires a total of 110 hours of science curriculum to be incorporated into CTE for the student to receive a credit for science instruction upon the completion of the program

Chapter 2: Literature Review

CASE Curriculum

The Curriculum for Agricultural Science Education (CASE) is an instructional system that provides intensive professional development and curriculum. The idea is to change the cultural of agricultural education to include science, technology, engineering and technology in the classroom curriculum. CASE wanted to show the growth and development of the attendees before and after attending the training (Ulmer et al, 2013).

The post-then-pre method was used in this study to describe the response shift bias from the post-test and the pre-test due to the treatment of the concept being taught. In this case the treatment was the intense CASE training professional development. This training is typically a week long intensive training involving hands-on opportunities to learn and apply understanding throughout the training (Ulmer et al, 2013). A total of 71 teachers responded to the instrument in full and ranged in age from 21-62 and averaged 7.25 years of teaching experience. The majority (63.38%) of the participants attending the training participated because they wanted to attend the CASE training. While the majority of the attendees, 74.65%, were not certified to teach science (Ulmer et al, 2013).

Following this study researchers were able to identify that the efficacy remained high while their outcome expectancy returned back to the same levels they had before attending the professional development. The results from this study indicate that the CASE institute's model for professional development is impacting the science efficacy and outcome expectancies of their participants. The study was also able to determine that, following the training, the participants feel empowered and ready to take on a new task and as time continues on the participants assume a more realistic viewpoint (Ulmer et al, 2013).

Research suggested that CASE project staff can help participants after participating in the institute to gain mastery in their curriculum by continuing to break down the complex curriculum into sub-skills which would allow teachers to see and experience smaller but more frequent successes (Ulmer et al, 2013). It was also noted that following a large training the participants tend to feel empowered and ready to apply the skills learned with an action plan in place but as time passes the participants lose the optimistic view point and settle for a realistic point of view that is more practical for their teaching situation. Even with the change in attitude, the data showed that there was a statistically significant correlation between the science outcomes after the training having a higher expectation than before attending the training (Ulmer et al, 2013).

Getting non-science student to think like scientists

University and high school students not pursuing a STEM course of study demonstrate less developed scientific reasoning skills than that of their STEM-based peers. This study looked into differences between the two populations which included interest level, formal preparation, and prior development of scientific reasoning skills. It also looked into how to narrow the gap of scientific reasoning skills through evaluating prior literature. When evaluating scientific reasoning they looked at formal reasoning levels for STEM and non-STEM students, applied interventions to change metacognition. The study was then able to show demonstrated growth of understanding and development of scientific reasoning skills over time for the STEM and non-STEM students (Moore, 2012, p. 1-2).

Using the Lawson's Classroom Test of Scientific Reasoning (LCTSR) the study found that they were able to use the students' scores to classify the students into three categories: concrete operation, transitional, and formal operational. Over 50% of the students were classified as transitional in their reasoning. When students were exposed to the new curriculum which taught content on appropriate if, and, then (IAT) statements and provided more opportunities that involved context-rich activities and authentic research experiences they were are able to increase gains in student scientific reasoning abilities as well as move students to be more formal operational learners (Moore, 2012). The study points out many ideas regarding scientific reasoning and how scientific reasoning is more than just inductive inference. Scientific reasoning is more a process in which involves the coordination of both theory and evidence. The reasoning also notes that content gains are more difficult to achieve with less prepared students than with those with STEM prior knowledge (Moore, 2012). The study also noted that formal operational reasoners can begin to think like a scientist and for this reason can begin to develop strong hypothetico-deductive reasoning (Moore, 2012).

The LCTSR was able to classify students into three categories including: concrete operational, transitional and formal operational which was then used to improve scientific reasoning ability through explicit instruction where there was a lack in understanding and thinking patterns. An IAT statement was used to develop thinking patterns in the students and move the thinking towards a formal operational sequence (Moore, 2012). Within the activity the students were instructed to conduct testing of their hypothesis in different ways with different protocols to support and/or nullify the hypothesis. This allowed for a discussion to happen regarding "evidence does not constitute proof" (Moore, 2012). It was also interesting that when the students worked individually they struggled with a task regarding circuits and electrical theory, but found success while working in a group.

Making Science Worthwhile

There are many reasons why there has been little progress made in reversing gender inequalities in the last 35 years. A critique of Project Lily adds to what is already known and calls for a cultural change in the STEM fields allowing for minorities and women to be more comfortable in the fields. Sinnes and Loken also are noted as calling for a cultural change in STEM careers and gender representation in STEM related careers (Tonso, 2014).

The Sinnes and Loken's review points to a critique of the Project Lily mission of improving the gender representations in STEM careers. They looked into the feminism equality, difference, and cultural feminism in Project Lily to improve the recruitment and retention of gender equality in STEM educations and careers. Project Lily worked to improve gender inequalities in the STEM fields and, in looking at their project report, actually re-inscribed these gender stereotypes that it wished to change. The project lacked the ability to address the traditional roles and stereotypical roots of STEM practices (Tonso, 2014).

An additional review of *Women in engineering: A good place to be?* stated that until the culture and inequalities changed they could not advise women to enter the work force in the field of engineering. However, the 1998 *Woman's Science* looked at positions where there were larger numbers of women and found that they were successful in their fields. These fields included: environmental group door-to-door fundraising, conservation corporation work, biology classes, and college work in engineering. These tasks allowed for practices that were not perceived as masculine scientific practices and were thought to be more feminine in nature. The women in these roles were seen as women performing a more social and not scientific in nature of science with little room for advancements (Tonso, 2014). Following this research, one would reach the point that Project Lily and other projects like it does not remove the stereotypical roles from the minds of youth. Instead these types of initiatives tend to segregate the sex/gender into black and white ideals when in actuality there is a wide range of science expression for all humanity. The review of Sinnes and Lokens ideas also includes the idea that all classrooms should allow students a wide range of ways to engage in science and science-based expression allowing for more femininities and masculinities to become the norm in a scientific classroom (Tonso, 2014).

The study failed to address many initiatives and show if there were growth of self-identity of the individuals who partook in the projects. The study stated the obvious downsides and inequalities throughout STEM education. Tonso talks about an inclusive classroom but does inclusion allow for the best turn out for women to be successful in a STEM field? This review and study also fails to address the issue of women and girls performing better in science and math than their male counterparts, but still tend to enter the fields of biology and agricultural sciences when they choose a field of study in a STEM field. This in turn points females more to a nurturing, more social science studies than one of physical, chemical or engineering fields.

It would be interesting to see if there were points in development when a male or female decides if he/she is good enough for a field of science and at what age that feeling begins to fade.

Generalizing Science across disciplines

Relatively speaking, science education is a young discipline. It has been dominated by physicists and physics and there has been little research done to explore to what extent theoretical frameworks and construction developed in one discipline can be applied within another science discipline. This study looked at, “the relationship between science education and its separate disciplines, and what are the implications of this for the development of common theoretical frameworks?” (Lewis, L., 2009).

The models of science education typically follow three possible models: biology as a providence of science, biology as an autonomous science, and science disciplines as providences. These models provide useful perspectives for considering the relationships between the science disciplines and the potential development of common frameworks (Lewis, L., 2009). The perspective that biology education is a province of physics science education grants the ideas that biology has little to contribute unless it happens to address the rules, laws, and methodologies that fall within physics. In general this model does not work well for biological science education due to the nature in ways biology is different from physical science. Biology education as an autonomous discipline allows each science to be independent of the others and allow for its own set of rules, laws and methodologies. This means that there is no common ground and generalizing the body of knowledge loses all validity. The final idea that science disciplines are provinces of science education allows both a common core and discipline specific dimension in which all sciences are created equally (Lewis, L., 2009). This third perspective recognizes the differences in the sciences and also acknowledges the commonalities between the sciences.

Understanding learning demand is important to any science program. Learning demand can be the differences in the students' existing knowledge and understanding and the explanation the teacher wishes them to develop and the nature of the gap and the difficulty or ease in which that gap can be bridged. By understanding and recognizing this gap, teaching activities and goals can be created to aid in the developing of a conceptual understanding appropriate to what is to be understood scientifically by the student (Lewis, L., 2009).

When looking at learning demand for plant nutrition, a conceptual analysis of the school science explanation pointed out 10 concepts taught within 5 one hour sessions that were problematic to students for the age in which they were being taught. For this reason the learning demand was very large and the ideas should be simplified and reduced to allow for better bridging to be created. When identifying and defining the learning demand it allows the teacher to create teaching goals which focus on crucial aspects of the curriculum (Lewis, L., 2009). This in turn creates teaching goals that align to the curriculum but also take into consideration the time constraints for the curriculum and make adjustments as needed to improve learning outcomes. From this study it was clear at simplifying and making a strong emphasis on the communicative approach to teaching allowed identified goals to positively influence learning outcomes.

The ideas of learning demand have the possibility of applying to biological contexts and can be used to successfully inform the design of teaching. The process of learning demand construction may be applied across all science disciplines but this paper did not go into the process of applying it across all disciplines.

A fourth grade class took the initiative to develop and build a small native plant garden on a budget of $25. The students were responsible for planning and deciding all aspects of the garden along with researching native plant species and seeking out additional supplies and donations to help with their cause. The project allowed the students participating to gain valuable academic knowledge that was linked to the National Science Education Standards. Students were able to develop their abilities to solve problems and work together as a team.

The garden-based project was used to expand on learning resources that were already present in other previously established gardens throughout the school grounds. A tie into social studies was done to create a native plant learning garden. Fourth grade students were responsible for designing a layout, researching the garden elements and all of the prep work (Kirby, 2008). While working in the project, students were responsible for their research of non-fiction material on the garden elements and communicating with adults in the community to seek knowledge and additional materials for the garden beds. Each student in the process designed a section of the garden that they were to assigned for which they integrated the concepts of perimeter and area (Kirby, 2008). The area the students used was partially shaded which added an extra element into the design and plant selection process. The idea was that native plants that preferred shade and thrived in a small area would be discovered and used in the designing process.

When looking into additional funding and resources, the students and teachers word of mouth went a long way. Local businesses and community members were happy to help and donate to the cause. The department store Lowe’s was able to donate additional soil, and community field biologists donated several native plants along with the local nursery (Kriby, 2008). The students were able to spend their afternoon science lessons in the garden to build and research the best way to incorporate the plants into the garden. Some of these plants included: bleeding heart, serviceberry, sword fern, and the red osier dogwoods. Following the planting of the garden the students typed and laminated the plant identification tags and signs to keep the garden as a teaching center.

Throughout the lessons and project, discussions about native plants and their ethnobotanical uses were explored. This opened the students up into a more natural way of finding plants that fit the gardens' criteria and allowed the students to show how the plants could be used in medicinal and/or culinary applications (Kirby, 2008). With the additional research students were able to see the different uses of the plants they chose including their use as food, dyes, and health benefits and as a hunger suppressant. These discoveries allowed the students to better understand the importance to growing and using native plants in their garden.

Students were assessed in many different ways throughout their progress on the garden project. Research summaries were used to assess the students' ability to write clearly and accurately and explain their ideas clearly (Kriby, 2008). Mathematical understanding was assessed in the designing and layout portion of the project and self-reflective pieces were also used to assess student learning and understanding.

Overall the whole project allowed students to gain academic knowledge and the skills necessary to plant and maintain a garden. Students were able to further develop their skills in problem solving and working together as a team. Students being actively engaged in a project design process allow them the ability to work as a team to research and design a project that fits a need or an overall goal. Having plants possessing a more ethnobotanical use allowed students to experience and discover the importance of meeting the needs of native plants to be successful in a small shade garden and also provide the opportunity to offer the people planting them a use. With this project the community and local stakeholders were able to support learning and education and help build a garden from which students and visitors would benefit.

Feedback

Feedback is an important component to the learning process and makes it clear the difference between the desired knowledge and the actual knowledge. The information provided in the feedback procedure is important because it allows the learner to correct his/her understanding from what is wrong or misunderstood. Many studies find little or no benefit of providing feedback to the learner and just correcting the error. The research performed looked into feedback and the transfer of learning to new questions being asked. Two experiments were conducted where students read passages and then took an initial short answer test on the concepts learned. Following the test, students received correct answer feedback, explanation feedback, or no feedback. Two days later, test subjects took a final test that consisted of repeated questions and new inference questions. The results showed that correct answer and explanation feedback lead to the same performance on repeated questions but explanation feedback produced much higher performance on the newly introduced inference questions (Buttler, Godbole, & Marsh, 2013).

With the initial test, recall of information only, 60 subjects answered a little less than half the questions and there was no significant difference between the feedback conditions. When the questions were asked in a way that they would use new inference, the results showed that explanation feedback led to a much greater proportion of correct responses. When subjects received feedback on the initial test, results they were able to more successfully transfer their knowledge into an inference-based question with greater success than if they just received correct answer feedback. The additional information gained from the explanation feedback allowed for subjects to gain a better understanding of the material and concepts, and allowed them to transfer that understanding into answering new inference questions with greater success. The elaborative feedback may have allowed the test subjects to gain a deeper understanding of the concepts and given the subjects the ability to answer the inference questions more correctly (Buttler, Godbole, & Marsh, 2013). In summary, previous research and this study showed that elaborative feedback does not benefit learning when addressing correct answer assessments without allowing for inferences. Previous studies assessed retention and not a deeper understanding of the content material. When understanding was addressed the explanation feedback produced better performance than that of correct answer feedback (Buttler, Godbole, & Marsh, 2013).

The study looked into feedback as a form of retention and access to retention knowledge. However, retention does not equal understanding of the materials and content. It is difficult to fully assess understanding as a learning outcome and feedback may provide an essential role in building understanding and not retention of information. The mode of feedback may also aid in the transfer of information from just retention to a deeper understanding of the material.

The largest weakness in the study points to the ideas that feedback can promote the transfer of knowledge, but there was a lack of investigation into the differences between understanding as a learning outcome and retention as a learning outcome. This study points out that understanding as a learning outcome is improved with feedback that further explains the concept, but the retention of the material is not changed.

In the classroom, feedback includes correcting answers, explanation, or none at all. A simple multiple choice assessment allows for correction and explanation, if necessary. Students who search and want additional feedback are those who will often ask for furthering an explanation of why an answer is correct or not. This study points out that explicit feedback does not make a significant difference on definition-based questions, but when an inference is needed to answer an assessment question the type of feedback received previously does make a significant difference. Going over the answers on an assessment and providing more than just correct answers may allow for a better understanding of the content and information for future use.

Prior knowledge and memory

A review of research into developmental psychology and cognitive neuroscience looked into the effects of prior knowledge on memory processes. The idea that prior knowledge and drawing on prior knowledge to activate memories can foster knowledge acquisition has long held true. However, having prior knowledge can also hinder learning when there are inconsistencies between the known information and what is to be learned. The key reason for struggling while trying to memorize new information may be the role of prior knowledge (Shing & Brod, 2016).

Accessing prior knowledge depends on memory processes that include encoding, consolidation, and retrieval of new information. The idea that prior knowledge facilitates the memory for incoming information is apparent because it provides both a location and structure in which the information should be stored and integrated. Secondly, is the idea that knowledge needs to be activated to benefit from the memory processing of new information. It also is clear that simply accessing prior knowledge is not enough to activate and encode the information to create a strong memory (Shing & Brod, 2016). If the prior knowledge is not accessed appropriately, there is no benefit of making the attempted linkages to prior knowledge in the memory process.

Understanding what prior knowledge is and how to access it is important for students to accommodate and assimilate information. Accommodation is defined by the process in which people update a schema where new information conflicts with existing knowledge. Assimilation is when people integrate the properties into their existing schemas (Shing & Brod, 2016). These two ways of processing information and storing information into memory makes accessing prior knowledge that is relevant difficult for the person who is trying to make the linkage. The activation of prior knowledge needs to be activated properly to facilitate the memory trace between new knowledge and previous understandings of the same concept. If this is not matched the memory benefit is less likely (Shing & Brod, 2016).

As teachers trying to access prior knowledge, it is difficult to find a common ground of where the class stands. An example of downhill skiing may work for one student who has experienced this, but for the student who has not a non-linkage may mean that he/she is not gaining the same benefits from the example and accessing the benefits of prior knowledge. However, this linkage can also result in retrieving incorrect or inaccurate knowledge which will refute information that is not congruent to previous knowledge on the subject. If this happens there is no longer a benefit from accessing prior knowledge and instead there is a non-service to the student learner.

As teachers and students it is important to address misconceptions and use experimentally-induced knowledge to improve understanding and clarify differences between what is thought to be true and what is actually true. It was interesting that the study pointed out a difference in accessing prior knowledge and its link to the age of the students. The younger students express immaturity of the prefrontal and hippocampal processing areas and therefore school age children's link to accessing prior knowledge is different from that of high school students. A high school student profits from a highly structured learning environment, while a college student benefits from a more low coherent activation of prior knowledge which allows them to self-organize the information better than high school students (Shing & Brod, 2016). The implications may base accessing prior knowledge in the younger grades to more concrete known truths. In the middle grades we could allow for structured learning where truths are "discovered" and these matters are assisted for categorizing the materials for later retrieval.

Too close for brain comfort

An investigation into teaching strategies for the retention of science vocabulary was done to look into the similarities and differences between scientific vocabulary in the middle school grades. Word morphology and memory, degradation over time and task similarities, were researched and a field study was conducted to see if active and engaging instructional strategies centered on vocabulary development would increase the retention and understanding of terminology. The study involved improving vocabulary using different strategies to see if there were improvements. A total of 334 students was the final sampling size and the data collected was analyzed to see if there were a difference in understanding of the terms with different strategies applied (Shore, Ray, & Goolkasian, 2013).

Students were separated by classes and were given an order of strategy to practice the vocabulary terms. Groups were given strategies: drawing a picture, talking to a neighbor and copying the definition from the glossary. Students were then given quizzes on the vocabulary words. There was a noticeable difference especially for struggling readers when it came to the outcomes of the quizzes. Seven total vocabulary words were tested and errors made were not evenly distributed throughout the seven tested words. Words beginning with an anti-prefix were missed the most and the highest missed words were antibody, antigen, and antibiotic no matter which strategy for learning the terms was used (Shore, Ray, & Goolkasian, 2013).

The study aimed to identify the best strategy for studying new language acquisition and three forms were addressed: talking about the new word, copying a definition, and drawing a picture. However, in analyzing of the results a larger problem was found: the confusion of closely related words which were too close for memorization and correct recall of what the terms actually mean. Although one would think that a middle school student has already been exposed to words such as antibiotic, but it did not ease the confusion when learning and producing answers later on a quiz (Shore, Ray, & Goolkasian, 2013). In this study it would have been helpful to see a separation of more vocabulary terms and a longer study of units so that one could have a better understanding of the findings and how different strategies allow for memory acquisition of new vocabulary terms. The study pointed out that, "we learned that different learning strategies can make a difference in word retention, particularly with struggling readers," but it never addressed which learning strategies worked best for the struggling readers (Shore, Ray, & Goolkasian, 2013, p. 19). Additionally, the figures and data tables also fail to show the similarities and differences of how students performed under the different strategies tested.

This study points to strong implications for students and teachers when thinking about language and vocabulary learning. Thinking about the way words sound, look and their associated meanings allows one to further the understanding and success of students learning targeted vocabulary in a unit or lesson. "Morphemic awareness" may be an area for study in the future to help students notice and identify the similarities and differences in words and a way to improve reading performance (Shore, Ray, & Goolkasian, 2013). In a science classroom the understanding of curriculum and literature centers on learning new vocabulary. Giving students their best chance at learning and remembering scientific vocabulary accurately is improving their success rates. As a student is able to decipher and commit to memory more vocabulary, they in turn are able to process and synthesize information more quickly.

The issue of encoding after learning was addressed in the research and suggested that after new learning takes place the brain needs a period of rest to consolidate that learning. This consolidation process usually takes place in a deep sleep cycle. However, if a student is asked to practice a second skill that is similar to the first skill it may interfere with mastery of the first skill. Which in turn results in the child not being able to perform either skill well (Shore, Ray, & Goolkasian, 2013). It was later implied that a teacher should compare the similarities and differences in the learning tasks and decide if the two concepts were different enough to not cause problems with the encoding process.

PCK

Learner-centered classrooms work well for teachers that have a large amount of topic specific pedagogical content knowledge (TSPCK) which is a version of pedagogical content knowledge (PCK). The relationship between TSPCK and the teachers' beliefs were tracked following an intervention plan that was designed to target improvements of teachers TSPCK in the area of chemical equilibrium content in a South African teacher prep school. 16 teachers were exposed to training to increase their TSPCK and better the teachers for transforming their content understanding to increase student learning. In this study written pre-and-post tests were used along with recorded discussions to show growth in understanding of the materials (Mavhunga & Rollnick, 2016). Findings stated that furthering the development of TSPCK was linked to science teacher beliefs when it came to student-centered learning over teacher-centered learning and for some there was a shift in the TSPCK, but with no shift in teacher-centered to a student-centered based science learning.

Pedagogical content knowledge (PCK) allows teachers to build a bridge between difficult content and student understanding. Using PCK teachers scaffold understanding for students so they can learn something new. In this study they defined topic specific pedagogical content knowledge (TSPCK) as a version of PCK. However, TSPCK is typically displayed by pre-service teachers because they lack experience in the classroom and working with teaching specific content to students. When a new teacher enters the classroom they also tend to present knowledge in the form of teacher-centered practice rather than learner-centered practice (Mavhunga & Rollnick, 2016). While working in the study with pre-service teachers the researchers wanted to see what shifts can be made with a TSPCK-focused intervention and what the relationship between TSPCK and science teacher beliefs were. An extensive literature review allowed the researchers to look into how they were going to define TSPCK. TSPCK is the “knowledge that enables teachers to transform their understanding of content knowledge of a topic” (Mavhunga & Rollnick, 2016, p. 834).

When it comes to teacher beliefs there tends to be some consistencies and some inconsistencies between teachers' beliefs and practices. Generally, teachers with traditional pedagogical beliefs had teacher-centered classrooms and those who had constructivist beliefs did not always have learner-centered classrooms.

The study was conducted with 16 pre-service teachers in their last year of study before qualifying as a teacher in South Africa. Following the study it was observed that teachers experienced an improvement in the quality of TSPCK for the topic involved with the study, chemical equilibrium, and improved their thinking about the concepts involved in teaching chemical equilibriums. At the beginning of the intervention the teachers has a limited level of TSPCK and their quality improved to a developing level after the post-topic-specific PCK interventions. This allowed the research to state that there is convincing evidence that the improvement in the context even with the small sampling size was not just by chance (Mavhunga & Rollnick, 2016). Putting the concepts and curriculum behind chemical equilibriums allowed teachers involved to search for answers on how to explain concepts like indicator color change and other concepts. In turn this allowed for not only the development of TSPCK, but also the interactions of all components within the TSPCK.

When it came to teacher beliefs pre-and-post test data was collected and compared to determine the teachers' beliefs. About 50% of their pre-service teachers experienced a shift from traditional towards the responsive/reform-based teacher science beliefs and 18% experienced alternative shifts (Mavhunga & Rollnick, 2016).

The study pointed out the shift of thinking and understanding of the teachers involved in the small sampling size. It would have been interesting to see if the pre-service teachers followed and implemented their beliefs that shifted to a more learner-centered belief system after being in their own classroom. The research was short lived and if the study was able to be more longitudinal, we would have been able to see the shift in understanding of the students about the concepts being taught. Chemical equilibrium is a difficult topic for students to fully understand in the classroom and having a deep TSPCK about the subject. Any entry level teacher who did have a deep understanding would have large impact on the way the students perceived the information and were able to apply it in the classroom.

Research was done to examine the effect of the amount and quality of content knowledge on pedagogical content knowledge for the biological content of photosynthesis and plant growth. 10 primary and 10 secondary (biology) student-teachers were used in the study. Questionnaires, lesson preparation tasks and interviews were all used to collect and analyze data. In the findings neither group had clear knowledge on suitable experiments and demonstrations that should be done at the 6th grade learning level and this indicates that some PCK should be taught explicitly (Käpylä, Heikkinen, & Asunta, 2009).

Teachers' thinking while making and implementing lessons include planning, implementing and all of the theories behind these phases was studied. Pedagogical content knowledge (PCK) stresses the idea that much of teacher knowledge is content specific and results in limited transfer to other learning situations. A teacher's practical theory or knowledge includes a teachers personal beliefs about the goals, values and principals of education, a script of how and what to teach and classroom interaction with short-term decision-making. The phase of teacher cognition and teaching actions contain five aspects of PCK which include understanding the conceptual problems of the students, core content in teaching, teaching methods, assessment methods and orientations to teaching science (Käpylä, Heikkinen, & Asunta, 2009).

The effect of content knowledge (CK) on PCK was used to compare how student teachers who differ in the amount of CK would design and implement a lesson on photosynthesis. An expert teacher has a wide collection of alternative teaching methods and can modify and change his/her teaching to help students better understand content knowledge of the course. Being an expert in CK generally improves teaching and these teachers have a better understanding of what is most important to stress in the curriculum. The primary teachers and secondary teachers in the study had about the same amount of pedagogical studies and only differed on the amount of subject area content studies. A lesson preparation method was used and followed up with an interview to gain better insight to teacher thinking and understanding. Teachers were given 1 hour to write a 2 hour lesson plan focusing on photosynthesis and plant growth for grade 6 students. Grade 6 was used due to the fact that in Finland primary teachers teach grades 1-6 and subject area teachers begin in grade 7 (Käpylä, Heikkinen, & Asunta, 2009).

As a result of the study it was clear that many primary teachers did not fully understand photosynthesis and many had misconceptions and shortcomings in understanding the process. Four teachers failed to mention that carbon dioxide was necessary for the process to take place, three did not mention that sugar was a product and three forgot that oxygen was released in the reaction. As for content, only two did not mention that oxygen was released in the process (Käpylä, Heikkinen, & Asunta, 2009). The connection between photosynthesis and plant growth was an area that was missing for primary teachers, while nine content teachers mentioned the connection. Of these teachers nine content area teachers understood that carbon dioxide was the main contributor to increasing the plant's mass and only one primary teacher demonstrated this concept (Käpylä, Heikkinen, & Asunta, 2009).

When examining the conceptual difficulties students may face, primary teachers failed to identify any while 8 of 10 content area teachers identified at least one area of difficulty students may have. However, most were able to identify that the important topic was the ideas of basic ecological understanding. When addressing the activities chosen by the primary teachers in order of choice were as follows:

- examining the plant structure (4)
- searching for information and presenting it (4)
- plant growing and observations (3)
- drama (2)
- experimental work (2)
- small group discussion (2)

- manuscript for animation (1)

Content area teachers decided on the following:

- experimental work (6)
- plant growing (4)
- fieldwork (2)
- watching a video (2)
- searching for information and presenting it (1)
- small group discussion (1) (Käpylä, Heikkinen, & Asunta, 2009).

In general the content area teachers tended to use more direct activities than the primary teachers. The primary teachers selected more creative activities than the content area teachers.

The most common difficulty expressed by the primary teachers was the lack of CK and the difficulty this would have when actually teaching the content. For content area teachers the most common difficulty was the insufficient knowledge of the students' scientific understanding and how to address what prior knowledge the students may have. The most common problem across all the teachers was the fragmented and insufficient knowledge of the concepts. Although the biology content area teachers had fewer misconceptions and inaccuracies than the primary teachers, they still had misconceptions and inaccuracies on the subject matter they would be teaching (Käpylä, Heikkinen, & Asunta, 2009). Throughout the study the most common need mentioned was the idea of CK and content-specific teaching methods to help students better understand the content and science.

STEM pathways

In the USA is it important for schools to provide a robust STEM workforce to continue to be competitive globally. To do this, policy makers are seeking effective interventions in STEM education throughout K-12 to stimulate an interest in the STEM fields for all students (Ashford, S., Lanehart, R., Kersaint, G., Lee, R., & Kromrey, J., 2016). The initial assumption is that programs like ePEP will help facilitate a successful navigation through educational and career pathways and a way to facilitate career exploration. This created ‘plan of record’ would allow students to define and tract their academic career towards a desired path and outcome. The pathways also include various pathways and levels of rigor for the science and math courses offered to students based on their intended goal. Students in Florida had the option of enrolling in general high school or STEM-focused career and technical education (CTE) courses where science and mathematics were fully integrated.

Early research points to the ideas that students who show an interest in STEM, as soon as eighth grade, are most likely to achieve an undergraduate degree in a STEM field and the students who participated in rigorous courses continue to develop stronger interest in STEM careers (Ashford, S., Lanehart, R., Kersaint, G., Lee, R., & Kromrey, J., 2016). In this study a benchmark of Algebra 1 was used to map trajectory along the mathematics pipeline. In the science pipeline the rigor of student’s experience in STEM used biology as an indicator. In high school only 25% of student complete chemistry or physics 1 and only 12.2% complete both physics and chemistry to obtain level 5. Only 7.1% of students move on to chemistry 2 or physics (Ashford, S., Lanehart, R., Kersaint, G., Lee, R., & Kromrey, J., 2016). This being said, CTE courses are designed to prepare students for postsecondary STEM career pathways through the integration of science and math throughout the CTE STEM course. In this study STEM interested students were identified as STEM capable if they completed algebra 1 geometry or physical science by eighth grade.

Following the study, results indicated that STEM CTE students were, on average, 7% less likely to persist in STEM courses than their counterparts as STEM high school students. With regards to survival probabilities of STEM-capable students, they were higher for students enrolled in public high school than those of students enrolled in STEM CTE courses by grade 11 and lower than the national sample from STEM high school students (Ashford, S., Lanehart, R., Kersaint, G., Lee, R., & Kromrey, J., 2016). This study was able to examine and explore the adequate preparation of students to enter a STEM workforce through career tools like ePEP and CTE in high school. The STEM-capable high school students in Florida had lower persistence in rigorous mathematics and science course taking than similar students in a national cohort, regardless of gender, race or ethnicity. But, interestingly, were the female students who entered ninth grade with lower probabilities of persistence often complete eleventh grade with higher probabilities of persistence.

Coaching

Coaching can help teachers transfer knowledge and learning from professional development trainings to the classrooms of other teachers. The process of coaching can also promote collaboration and reflection within teacher groups (Anderson, R., Feldman, S., & Minstrell, J., 2014). This study looked at what causes coaching to ‘work’ when it does and what causes it to break down. The study lasted for five years and uses a mixed methods approach in a single school district. Surveys, interviews, classroom observations and coaching logs were used to determine a strong correlation between teacher practice and the time the teacher and coach spent together.

The process of coaching promotes a deeper professional reflection and with at least 20 hours of quality professional teacher-coaching hours spent together and a meaningful relationship produced a strong correlation with the improvements of teacher practice. In the study participants consisted of full and part time science coaches who were experienced science teachers with instructional and content knowledge expertise with many having 10-20 years of experience in the field. Approximately 180 elementary and secondary education science teachers participated at different ‘tiers’ where they were asked to participate in surveys, classroom observations and interviews. Other participants included building administrators and non-science instructional coaches, un-coached teachers and various other district personnel. The data was collected and analyzed for each school within the district (Anderson, R., Feldman, S., & Minstrell, J., 2014).

For data collection, observations were made at coaching meetings, during facilitation and shadowing. An online coaching log was also developed to track work and coaching. Surveys were used to check on the perception of teachers and coaches experience throughout the process. For interview data collection, semi-structured interviews were used for the science coaches and the researchers on a yearly basis throughout the study. The data analysis through coding allowed the researchers to show and trace the changing appearance of relationships and possible causes and conditions (Anderson, R., Feldman, S., & Minstrell, J., 2014).

In terms of relationships there were a lot of ups and downs which seemed to be a result of the *situated interaction between the coach and teacher* (Anderson, R., Feldman, S., & Minstrell, J., 2014). Both the coaches and teachers were aware of the classroom space which would be asked to remain open for an ‘outsider’ to look at their practice with a critical lens. The teacher-coach relations were equal with the notion of trust. Throughout the study rational trust increased and diminished in each reaction as there were demonstrations of concern or not in key components involving personal regard, respect, competency and integrity. Personal regard was the most commonly used attribute by teachers describing their relationship with their coach. However, there were no explicit times where a coach and teacher did not demonstrate personal regard, but it was touched upon when teachers talked about trusting their coaches (Anderson, R., Feldman, S., & Minstrell, J., 2014).

Respect was observed when coaches listened to the teacher’s concerns and found ways to make the coaching work and develop goals. This trait was also demonstrated when coaches allowed teachers to be autonomous and worked with the teacher’s schedule and preferences. Competence appeared to be connected to the coach's science content knowledge and the classroom teaching experience. Teachers across all grade levels said that the coache's requisites for coaching effectively rested on their ability to be a proven master teacher. Science content experts with teachers in high school focused on pedagogical expertise and not the specific science subject matter (Anderson, R., Feldman, S., & Minstrell, J., 2014). While looking at the data, integrity seemed to be illusive but this may have been because it was difficult to separate it out from role synchrony. When there was role synchrony, coaching was most likely to be initiated and continued throughout and when the coaching broke down it often was due to poor synchrony and trust issues.

All members involved in the research also were able to show a role shift in the coach from a teacher to administrator with regard to the function and feedback the coach played in the teachers' classroom (Anderson, R., Feldman, S., & Minstrell, J., 2014). Coaches were continuously shifting their role to meet their teachers' expectations and worked to build a professional community. Coaches were able to foster trustworthy environments and allow teachers and themselves to be vulnerable as they worked with the teachers coaching. In some cases the coaches ended up co-teaching without warning and modeling a teaching style by request or without warning.

Green space and garden based learning

Garden-based learning (GBL) local initiatives are more common in today's schools than previously. In a GBL environment the garden serves as a real-world focus point for integrated learning (Carver, & Wasserman, 2012). However, many of these programs are often short lived due to the fact resources are limited and sometimes a natural water supply is low or difficult to manage within the green space. Hydroponics is a way to overcome these problems and use water and nutrients in a more efficient way with a smaller footprint. Hydroponics is a process in which plants are grown in nutrient-rich water instead of soil, thus maximizing the total use of water and nutrients by the plants. This way of growing plants can also ensure that crops grown are free from contaminants like *E.coli* and *Salmonella* (Carver, & Wasserman, 2012).

When students build and grow in their own hydroponics systems they experience true hands on experience. The following study used inquiry-based hydroponics lessons in biology classes in a West Virginia high school to improve 21st-century learning skills. This process allowed students to experience the 5Es of engage, explore, explain, elaborate, and evaluate to build an instruction model heavy in content and processing skills. The project was implemented in a biology classroom but is easily envisioned in a technology education course involving plant experiments, math classes to analyze data and even language arts to write up reports and analysis (Carver, & Wasserman, 2012).

Engaging students in the lesson allowed students to access prior knowledge of NASA’s work on sustainable living. The ideas from NASA and the need to grow large amounts of food in a small space was an ideal setting for the goals and plans of the lesson. Sustainable practices and biological concepts are easily linked to what plants need to survive. This provides students the opportunity to get into additional factors limiting plant growth such as pH, stress, nitrogen fixation, salinity and other factors (Carver, & Wasserman, 2012). Students throughout the project are able to control variables for optimal growth and consider possibilities of independent variables for experimental design. Students can also discuss experimental design and determine what type of study should be done.

While exploring, the experiment has been decided on and students are able to build the hydroponics set up, plant medium and types of plants to grow. In groups, students take on specific tasks to carry out the experiment and collect meaningful data. In the pilot version of the lesson students used identical units except for temperature which allowed students to easily see the independent variable in the study (Carver, & Wasserman, 2012). Students were responsible for the experiment for three weeks and collected data in the first 10 minutes of class. After collecting data and analyzing the data the students needed to find an overall measurement of the plants' growth and document their conclusions. Support for the conclusions generated was easily found in root growth, overall biomass and shoot length and students were able to discuss their findings and the importance of their findings.

Finally in evaluation, student learning and motivation was assessed through concept maps, pre- and post-tests and class surveys. With the small sample size used there can be no definitive conclusions made but there was a 13% increase in overall understanding of the material covered and an instructional gain of 0.30 (Hake, 1998) with an increase in motivation and more positive outlook towards science (Carver, & Wasserman, 2012).

The Next Generation Science Standards encourages the engagement of students in more authentic forms of science activities and is more focused on research and instruction efforts. However, creating and orchestrating this in a scientific classroom presents challenges for researchers, teachers, and curriculum designers. It is not easily seen how the practices that are introduced to students should resemble and mirror those of the experts in the science fields and how to best initiate beginning science students into these practices (Manz, 2015). The “Mangle of Practice” can be a tool used to support and aid in the design of teaching practices that would support the learning environment in a way that provides context for the development of content knowledge through the process of mangling or pushing back from the world to better understand practices and understanding by reconsidering their ideas and theories.

The mangle supports how science practice and ideas are continuously developed and revised in the professional activity of studying and doing science. When experiments do not go as expected, scientists step back and re-examine their materials, procedures and conceptual accounts and understanding of what happened and why. The scientists then can better understand the phenomenon of what happened and how their experiment better represents that phenomenon (Manz, 2015). The goal of mangling allows participants “to interact and communicate better with uncertain and resistant phenomena. It is argued that when students engage with the complexity of the scientific practice and the pushback they can begin to perceive problems with their own approaches and better make adjustments to adapt and change their understanding accordingly.”

The study was a multiyear design conducted with third grade students at an urban school where the majority of the students (70%) were on free and reduced lunch. The teacher had 30 years experience teaching elementary students at the time of the study and was participating in her fifth year of a larger research project. The researcher actively participated in the seventeen lessons that were conducted in the study. A total of 18 students participated in the overall study to engage and develop an understanding of the “wild backyard” where there were complex shade and growing conditions that students would have to overcome and understand to design a better backyard. Video recordings, field notes, student work, and interviews were used to collect and compile data. The classroom based experiments involved growing Wisconsin Fast Plants to develop explanation of differential success and the understanding of a plant’s lifecycle (Manz, 2015). Four design features were developed to build this understanding: an experiment to represent the backyard; building uncertainty into the experiment; having students construct and critique the experiment; and providing tools and information to focus their activity on without constraining it (Manz, 2015).

In the process students had to decide how their experiment they designed would represent the conditions in the backyard. They needed to discuss and collect information about the backyard and use that to inform their design and procedure. To aid in the mangle, students created the experiment, the data models and explanations in order to figure out and explain all of the resistances that would proceed throughout the experiment. Students were asked to tell what they were thinking and why they thought that way. Students used restatements and the posing of questions to clarify their ideas and rationales and reasoning behind why they agreed or disagreed with something being said (Manz, 2015).

Throughout the study episodes showed that a resistance caused a destabilization of the students' thinking and students discussed how their plants were changing and not reacting as predicted. This aided in the development of better understanding of the plant lifecycles and turned into a relation to each other to develop definitions and context of plant growth and development (Manz, 2015). The continued resistance supported the interrelated development of practices and allowed students to map the classroom to the backyard and relate the two processes and understandings regarding shadowing, soil type, etc. The destabilized ideas allowed the students to develop a better understanding and explanation of what happened and why. This in turn allowed students to develop and call on new ideas and understandings to support or refute their claims and findings. Overall the study showed three main ways students made progress in their conceptualization of science: they differentiated ideas, related ideas, and used ideas as a mechanism to predict and account for what they were experiencing and seeing (Manz, 2015).

Students' socioeconomic status has a significant effect on the number of species that were named. The students who attended state schools (mostly of a lower socioeconomic status) listed more species and more native species than those students who attended private schools. Additionally, the species that were listed tended to have big brightly-colored flowers and have inodorous to medium intensity scents (Bermudez, Díaz, & De Longhi, 2018).

Research in science education has shown that when teachers teach botany they find many hurdles to overcome that interfere with learning. One of the major hurdles is that children are typically disinterested in plants and fail to recognize them. Teachers spend more time focusing on the animal and other kingdoms and therefore may contribute to additional plant misconceptions such as plants are not living organisms or that they are the least important to preserve (Bermudez, Díaz, & De Longhi, 2018). Biology curriculum may also make the teaching of botany “dull, lifeless, and boring.” Although biodiversity and the need for conservation is stressed, often times the true importance of native species and their role in the natural environment are missed. This form of “plant blindness” can be attributed to the ideas that people either: fail to see or focus on common plants; think of plants as a backdrop for animal life; overlook the importance of plants; lack hands-on experience with plants in their region; are insensitive to the plants qualities and the misunderstandings of what a plant needs to stay alive (Bermudez, Díaz, & De Longhi, 2018).

As a consequence to plant blindness people tend to ignore plants and show disinterest towards them and tend not to want to learn more about them. In Argentina, when a similar study was done on having students name native plants only 3 out of 10 plants named were native. In Switzerland most children named garden and decorative plants the most (Bermudez, Díaz, & De Longhi, 2018). Categorizing plants in the native or non-native bunch involves much more than just knowing the name of the plants. You also need to know more about the living environment and how the plant interacts with the environment.

In Argentina there are considerable differences in the schools that are private and public. There are noticeable differences among the students' socioeconomic status and the quality of materials and resources the students have access to. Families also influence a student's learning experience by sharing their conceptual and physical resources with the student. Access to movies, trips and talking about shared experiences all provide a different experience for those students attending private and public schools. Additionally this may also provide a disconnect between the people and their immediate biological environment (Bermudez, Díaz, & De Longhi, 2018).

Classrooms where high-school teachers had taught biodiversity in the year of the study were chosen to collect data about student knowledge of native plants and the influence of the students' socioeconomic status on their ability to name native plants. A total of 321 students were selected to complete a questioner survey in 8 state schools and 6 private schools (Bermudez, Díaz, & De Longhi, 2018). It was assumed that if a student wrote down a plant name they 'knew' the plant they listed.

All species listed were recorded as native, exotic and mixed species. Additionally the color size and scent were also coded to gain a better understanding of the plants selected by the students. Each species named by the students had a rank for its floral trait examined and this was used to code the attributes of the plant and how often it was listed. For each species there was a combination of the inflorescent size, color, and scent variables.

Of the total 165 different categories of plant names 6.8 species of plants on average were listed. However, many of these plants listed were exotic and more native species were listed by students attending a state school. Therefore, the students' socioeconomic status had a large influence on what species were listed by the students (Bermudez, Díaz, & De Longhi, 2018). The most common plant names were trees and shrubs and the majority of the species named showed floral traits of low to medium value.

Following the research it is clear that the concept of nativeness is abstract to many students and needs to be better defined to what is natural. The ideas that willows were often grouped together and that grouping contained both exotic and native species in Cordoba. The idea that graminoids and other underestimated forms of plants are not often considered and the idea of favoring the local flora to increase the people's connection to the local environment should be used to help remove 'plant blindness' (Bermudez, Díaz, & De Longhi, 2018).

The integration of STEM into the classroom allows for a learning environment that improves the student's motivation and also can improve the learning of specific content knowledge. The idea of design-based thinking and scientific inquiry based learning are models of thinking that are critical to the engineering/technology and scientific communities. The relationship between design thinking and scientific inquiry was examined in the context of an Engineering byDesign unit to support the leverage of the relationships used throughout the lesson and then generalize the concepts learned into other lessons (Johns, & Mentzer, 2016).

When allowing for students to practice the design process there are trade-offs and constraints that can arise. When trade-offs and constraints are tied to scientific phenomenon the opportunity arises for students to analyze their findings based on experimentations. The methods and content of scientific experimentation and inquiry can be integrated into the engineering design-based activities (Johns, & Mentzer, 2016). The idea of scientific inquiry includes the processes of which scientific knowledge is acquired. A typical science class experiment does not typically do this since there is usually a focus on establishing a verification of knowledge through given procedures. The true implementation of inquiry requires giving the students opportunities for ideation and the redesign of experiments without solely focusing on getting the right result (Johns, & Mentzer, 2016).

The ability to have knowledge of the science content and the scientific inquiry are not the same. The development of inquiry skills involves the opportunity to engage in inquiry and have the freedom to try different processes and further ones understanding of how to learn knowledge from inquiry. The engineering design tasks allow students the opportunity to partake in open-ended scientific inquiry when there is no perfect design (Johns, & Mentzer, 2016). Each design will have its trade-offs in regards to its constraints and knowledge available.

When delivering the “Lunar Plant Growth Chamber” lesson there was the opportunity for open-ended scientific experimentation included with its course materials. The goal of the unit was to design and build a growth chamber that can fully protect and allow the growth of plants of the student's choosing. Lessons 1 and 2 discuss the advantages and drawbacks of students' choices and involve research into the plants being chosen. In lesson 3 the students begin designing their growth chamber and enrichment is used to compare trade-offs. The testing and re-designing of prototypes allows students to conduct a scientific experiment while learning the process (Johns, & Mentzer, 2016).

In choosing experiments it is important to keep in mind that not every experiment needs to be comprehensive and the experiments can be tailored for the students to explore subsystems of the overall experiment. The process of scientific inquiry is encouraged throughout the process and does not just include conducting an experiment to verify knowledge. It involves learning how to gain knowledge from experimentation and focuses on student growth and understanding of the scientific process (Johns, & Mentzer, 2016). Students need to try out, evaluate and redesign their experiments through self-discovery. Well-designed experiments can still be scaffolded with allowing for design choices within the experiment. Students need to foster and develop the ability to develop a focus using their creative and analytical skills.

The connection between engineering and science holds true in the abilities of students to: plan and carry out investigations, analyze and interpret data, engage in argumentation from evidence and obtaining, evaluating and communicating information (Johns, & Mentzer, 2016). Within a single design project students can be exposed to common scientific inquiry practices and have the opportunity to plan investigations at many different levels. This process of including scientific inquiry in the design process allows for design-based thinking and ability to include decision-making process across the STEM fields. The model has different goals in each content area but integrated activities can allow for the reinforcement of ideas through engineering and scientific practices.

Aquaponics has the potential of being a great education tool due to the fact that it can incorporate an interdisciplinary nature of science and technological skills into the classroom. With aquaponics students can learn and conduct activities that involve chemistry, physics, biology and sustainability, and help support their learning and understanding of scientific theories (Hart, Webb & Danylchuck, 2013). Incorporating aquaponics into the classroom also has its challenges. In this study 10 teachers were interviewed through phone interviews about their experiences using aquaponics systems into their classroom. Participants reported two main challenges: the technical difficulties as a result of aquaponics and the restrictions in the school setting. Solutions given by these teachers included the physical system modifications and the development of community connections and support along with a passion for aquaponics and more expertise.

Aquaponics combines aquaculture and hydroponics as a symbiotic relationship to grow and produce food (usually fish and vegetables). The use of aquaponics in schools can also enhance the interdisciplinary nature of science education. The combination of hydroponics and aquaculture allows chemical nutrients needed by plants to be produced and replaced by the fish waste that may otherwise be discharged and cause environmental degradation. This form of a balanced system can increase the availability of nutrients in the plants being grown and the use of medium to small systems can take up a relatively small amount of space (Hart, Webb & Danylchuck, 2013). This can be easily implemented into schools, homes, backyards rooftops and balconies.

The highly technical nature of the system itself is sometimes overlooked. A balanced system must match the demands of the plants being grown and the fish species. Additionally, the physics of water flow, testing and troubleshooting the water's chemical properties and the biology of the fish and plants is important to fully understand to maintain and sustain a system long-term. The use of the systems may allow for the enhancement of active learning and be used to actively engage students into the learning community (Hart, Webb & Danylchuck, 2013).

In the late 1990s the AgriScience Education Project at the University of Arkansas allowed for 38 classrooms to participte in Aquaponics in the Classroom project which provided the classrooms with systems to enhance learning. The teachers participating in the project showed positive perceptions of the project but more information was needed on how the systems were actually used (Hart, Webb & Danylchuck, 2013). In 2003 Cornell Science Inquiry Partnerships Program allowed for a simpler and smaller system to be adapted and they were able to focus on nitrogen cycle while providing a teaching guide aligned to specific learning objectives.

The study focused on three questions: Why are educators choosing to use aquaponics systems, what challenges are they facing and how do they overcome these, and what advice do they have for others? A qualitative research method was used to collect data from 10 participants in the study. In depth semi-structured phone interviews were used to collect and analyze data as a “conversation with a purpose” (Hart, Webb & Danylchuck, 2013). Most interviews lasted between 20 and 45 minutes and 4 were between 5 and 20 minutes.

Reasoning on using the systems contained the opportunity to practice hands on learning, flexibility, food concepts, and STEM concepts. 83 times participants mentioned challenges and 34% of these related to technical difficulties while 17% mentioned space and location difficulties with the remaining 12% mentioning time constraints and other challenges (Hart, Webb & Danylchuck, 2013). Participants discussed the time it takes to implement and maintain the aquaponics systems as a challenge throughout the time they used them. Caring for the system over the summer and holidays provided a challenged in 8% of the excerpts. The lack of knowledge in aquaponics was also a challenge for some. To overcome these challenges many strategies broke into two groups: technical solutions (13%) and nontechnical solutions (84%).

The modifications that were mentioned to make the systems better included the idea of changing the physical components involved in the system and the fish themselves so they would stop eating the roots of the plants involved. Many times the passion of the system and for aquaponics itself lead to the teachers being driven to find solutions despite the time commitment the systems required (Hart, Webb & Danylchuck, 2013). An expert of aquaculture was frequently mentioned as a solution to overcoming the challenges, especially when it came to the technical difficulties with the systems themselves. As for the size of the system, two educators said that starting small and growing was very successful while one stated that starting too small reduced the potential for learning while increasing the technical difficulties (Hart, Webb & Danylchuck, 2013).

The challenges and solutions that were reported related to technical difficulties with systems and included the nitrogen cycling, creating a well-functioning set up and long-term maintenance on the systems. School space for the larger systems presented a challenge along with time constraints in their schedules to take care of the systems fully. The implementation of aquaponics in the classroom or school setting presented challenges not foreseen and encountered by hobbyist and aqua culturists that have the systems set up as a profession. Taking care of the systems over school breaks and summers was also a challenge. Sometimes the teachers came in over their breaks and some were able to have maintenance and custodians help. However, this matter was still a challenge yet to be overcome (Hart, Webb & Danylchuck, 2013).

Overall recommendations included the ideas that teachers should reflect on their own passion in regards to their own motivation with aquaponics systems, the ability to reach out and develop a community for support from local businesses, administration, other teachers and people within the aquaponics community. It was recommended that the cultivation of aquaponics expertise through community connections was necessary to build a successful system and the process of building a plan with goals for implementing the plan was needed along with the need to remain flexible. Finally, a solution for holiday breaks and the summer session were needed to maintain the system (Hart, Webb & Danylchuck, 2013).

Career and Technical Education

In American schools, meeting the needs of employers and the economy is important for career and technical education centers to keep their students up to speed in the industry. However, American students are failing to keep pace with our international counterparts and this continues to create a gap and a justification for educational reform movements. This newer modernization of career and technical education (CTE) will support a strong economic competitiveness by: increasing student engagement, improving math, science and literacy skills, meeting America's workforce needs and meeting employer needs for highly skilled workers (Drage, 2009). The students involved in CTE programs are usually students from lower-income areas and minorities, and have little to no desire to enter college following graduation from high school. Throughout the nation more than two-thirds of the high schools have CTE programs (Packard, Gagnon & Morin-Parris, 2010). CTE students are not typically looked at as contributors to the science workforce and are often overlooked. Additionally, if CTE students decide to enter college they often do not have the prerequisites to do so and are then entered into remedial classes before entering college. However, a push for preparing students by integrating science and mathematics concepts in CTE may be a way to broaden postsecondary options for students in CTE.

The students involved in CTE programs are usually students from lower-income areas, minorities and have little to no desire to enter college following graduation from high school. Throughout the nation more than two-thirds of the high schools have CTE programs (Packard, Gagnon & Morin-Parris, 2010). CTE students are not typically looked at as contributors to the science workforce and are often overlooked. Additionally, if CTE students decide to enter college they often do not have the prerequisites to do so and are then entered into remedial classes before entering college. However, a push for preparing students by integrating science and mathematics concepts in CTE may be a way to broaden postsecondary options for students in CTE.

In 2006 the No Child Left Behind Act ignored CTE but the president noted that investments in CTE were necessary to meeting the educational goals of our future workforce. Any education should provide students with the foundation for future study and inquiry in the technical subjects (Drage 2009). Today's CTE programs expose students to future career opportunities and provide technical skills and training at a time when it is critical to get students interested in STEM-related occupations. The jobs of tomorrow will require more technical skills, knowledge and flexibility than the jobs of today.

Knowing that today's schools will need to align their education reform with the technological advances, partnerships between states, schools, employers, industry and other stakeholders have been created to offer new curriculum guidelines, academic and technical standards and professional development materials for 16 career clusters. Theses clusters also offer a STEM pathway where there are two groups: the knowledge and the skills required to prepare students in STEM (Drage 2009). CTE is the foundation of STEM in many middle and high schools and programs like Project Lead the Way (PLTW) helps provide real-world approaches to hands-on learning. This curriculum allows students to experience the value in how the classroom lessons are tools for everyday life.

CTE needs to stay in front of the curve and encourage and expand its reach into emerging fields in technology. Biometrics is one of these new technologies and CTE programs could use to promote learning and interest in STEM. Many industries and businesses will be seeking qualified individuals that have prior knowledge, experience and skills in technologies such as biometrics. A CTE course can attract and serve all populations who can serve in such technology heavy sectors of industry. To reinvent the high schools of tomorrow educators and schools need to meet the needs of the students and change the familiar structures and practices in a way that is in the best interest of our students (Drage 2009). A whole school redesign will prepare students for the future. CTE can narrow and close the gap between China and the United States in terms of technological advancement and STEM fields. A proactive approach to curriculum development is ideal in reaching this goal instead of the traditional reactive approach.

CTE is set apart by its use of the application of knowledge and the ability to encourage in depth understanding to solve problems. The use of real-world problem solving allows for the delivery of high-value education in the classroom. The ability to use curiosity-provoking situations, problems and questions, allow teachers to captivate and keep the interest of the students.

This form of investigative learning or applied learning that CTE uses is most beneficial to minority students and students with disabilities, and allows students to explore and experience areas of learning that they would not otherwise meet and experience (Drage 2009). CTE is rich in the investigative learning methodologies and is good at serving all types of learners at different learning levels and styles.

Following the No Child Left Behind Act (NCLB) states are required to measure student progress in science at least four times between the students third and twelfth grades. The goal was to strengthen the scientific rigor as a whole throughout the schools. Due to this ruling, career and technical education programs needed to justify their curriculum contribution into science, math and reading areas (Myers, & Washburn, 2008). Many researchers believe that agriculture education has many natural ties to the science disciplines and has many meaningful learning contexts for applied scientific principles. However, just knowing that there are ties is not enough.

Barriers for CTE

Career and technical education (CTE) has been undergoing changes in response to the low student work readiness and preparedness for furthering their education upon completion of CTE programs. Many administrators have been implementing more relevant and meaningful curriculum with the idea that students will be more career and college ready at the time of graduation. However, currently the way this is being done is not helping prepare the students fully with the necessary skills (Schwartz, 2017). Due to this factor additional curriculum delivery methods should be considered in order to better prepare students for their futures.

Research indicates that having students engage in more advanced inquiry practices which involve posing questions, predicting outcomes, conducting observations and drawing conclusions will create more effective learning motivation by increasing communication and interest in content. Currently, many activities in CTE focused on structured inquiry which involves a step-by-step method to learning and results in a predetermined outcome (Schwartz, 2017). However, through incorporating higher-leveled guided and open inquiry within the classroom, students can experience a more rigorous and relevant learning experience.

Barriers in teaching science in CTE

Teachers have long been asked to integrate technology into their classrooms to better explain and support the ideas of science education. This increase in the use of learning technology (LT) allows for teachers to deliver scientific knowledge throughout courses in vocational education pedagogy. Theoretical concepts of pedagogical knowledge and how technology influences learning was used to investigate how technology can be used in the teaching of scientific concepts in vocational context (Hobley, 2016). Throughout the research what emerged is that what is lacking with the integration of LT is strong ‘bodies of knowledge’ within the curriculum and how to create these linkages.

Vocational pedagogies were also examined to see how flipped classrooms can be applied in vocational education and how traditionally vocational education has resulted in a dislocation of knowledge from the frameworks that gives knowledge its meaning. For this reason students trained in a traditional fashion are lead in courses that ‘face one way’ which results in students struggling with relocating knowledge within context. This leads to tensions between academic and vocational educations in areas such as vocabulary. The study points out the “teaching of science” as an important and neglected component to vocational pedagogy (Hobley, 2016).

As teachers we are increasingly pushed to use iPads and Chromebooks in the classroom and are trained in a one-size-fits-all fashion. However, this form of training does not work for all individuals. In order to help students navigate through the use of new technology we need to be better trained ourselves and have a better grasp on how to help our students make effective use of technology in the classroom. Technology tools are expensive and many schools have moved into a one-to-one classroom setting. But we see Chromebooks/technology sitting on the shelf and not being used in a way that would supplement the learning in the classroom. Training and ideas for implementation of these technologies are needed to make them highly effective in supporting and furthering learning.

Inquiry-based science education (IBSE) is used to teach science content as well as used to foster scientific skills. IBSE is rarely adopted and used in schools due to barriers that teachers face. One of these barriers is the struggle for teachers to teach science as inquiry. The goal of this research was to examine the problems that teachers face when having to teach through inquiry. Three different view-points were used to develop the research question of: “What problems regarding IBSE do teachers have from an objective, a subjective, and a self-reflective perspective?” (Kramer, Nessler & Schluter, 2015). Video recordings and other observation tools were used as well as questioners to collect data. The overall outcome was that each of the perspectives provided plenty of problems, which sometimes overlapped, complemented each other and sometimes partially revealed completely new problems. This conclusion supports the ideas that teachers using IBSE need to consider all of these perspectives to better their own teaching with IBSE (Kramer, Nessler & Schluter, 2015).

The idea of IBSE allows for the following of the scientific process as much as possible in the classroom. Students carry out phases including the diagnosis of problems, critiquing experiments, planning investigations, and searching for information. The ability for students to work in IBSE allows for student freedom to explore and develop the skills of scientific content, science skills and literacy within science. The form of IBSE may also allow for the fostering of understanding, critical thinking, and a positive attitude towards science (Kramer, Nessler & Schluter, 2015). However, IBSE is rarely adopted because even good teachers struggle to teach science as inquiry.

When teaching inquiry, teachers want their students to experience the scientific process by doing and developing their own experiments. The teachers who do this consider the experiments important to pushing the students into testing their ideas and hypothesis to collect and analyze data. Even with the teachers who practice inquiry have issues. These include classroom management, the abilities of all to understand the instruction format and the constraints that have come from their educational training and previous teaching experience (Kramer, Nessler & Schluter, 2015).

The study was conducted with 24 teachers finishing their completion of a teacher preparation program at the University of Cologne, Germany. All of the students involved in the study had also completed a course in using IBSE techniques to teach. A questionnaire given found that student teachers had problems while building their students' ideas and the observers were able to identify 10 of the 29 criteria for IBSE that were absent in at least six of the seven lessons that were analyzed. The observers were able to identify 10 of the 29 criteria for IBSE that were present in six lessons (Kramer, Nessler & Schluter, 2015).

In all 16 problems were categorized through data and related to the concepts of teacher abilities, pupils' abilities, differentiated instruction and the schools condition. 38% of the student teachers evaluated that their own pedagogical and content knowledge as insufficient. The student teachers also believed that the pupils' abilities caused problems with inquiry-based instruction. 52% of the student teachers worried that the pupils lacked the experience with IBSE. There was concern from

48% that the rooms and materials would be missing and 34% feel that the preparation and follow-up work is too time consuming. Additionally there was concern in creating differentiated instruction for those students who needed it (Kramer, Nessler & Schluter, 2015).

While self-reflecting 75% of the student teachers realized that they taught in a teacher-centered fashion and did not establish an inquiry-based situation. 63% realized they predetermined the problem, the question and the hypothesis, and 46% realized that they preset the planning and the accomplishment of the investigation. While thinking about problems 75% state that the students were neither focused or disciplined or didn't pay attention while additionally 65% realized that the students were inactive without a given activity (Kramer, Nessler & Schluter, 2015).

The student teachers could not make the distinction between non-IBSE affiliated problems and IBSE problems like well-practiced teachers can. When the student teachers asked for a specific IBSE problem could not distinguish the difference. For this reason, new teachers need to be aware that on top of typical classroom problems they will have additional issues while using IBSE (Kramer, Nessler & Schluter, 2015).

Co-teaching and integrated academics in CTE

Career and Technical Education (CTE) teachers integrate science content relevant to their programs in which they teach, and this integration of science content is very different than how it was done before the process of integration began. In this study CTE teachers were interviewed to show the evolution that within the grounded theories of connection and the future CTE science integration (Spindler, & Greiman, 2013). The process of science integration into CTE has been complex for CTE teachers and often that process involved connecting to others, putting their ideas into action, and always looking to the future.

In the past CTE courses and programs have been considered separate from academic subjects like science, math, and English. The CTE programs focused on curriculum and instruction based on industry skills and technologies that were needed to for a skilled workforce. However, following the 1990 Carl Perkins Act which allowed vocation education monies to be spent on programs that "integrate academic and vocational education," it became essential for many CTE programs to integrate shop experiences with academic content and student learning activities (Spindler, & Greiman, 2013).

Continuing with the Perkins Act it became clear that CTE and science education was being advanced by policy decisions and these decisions were being driven by the needs for improvements in science education which were influenced by many stakeholders (Spindler, & Greiman, 2013). Stakeholders such as researchers, practitioners, and business and industry leaders all recognized that college and career ready students should be able to use the science content knowledge as a tool for reasoning, decision-making and problem-solving in the future. Increasingly the importance of science education in CTE would allow students in the United States to keep up with other global competitors.

The use of co-teaching in the classroom also reduced the number of disturbances associated with assessment and other issues that came about (Milne, C., Scantlebury, K., Blonstein, J., & Gleason, S., 2011). Co-teachers were able to build and re-explain concepts and messages by using signals like “may I jump in,” which allowed the co-teachers to feed off one another and support learning by framing questions and answers differently for the students. The researchers pointed out that, in a reframing situation in a classroom with one teacher, this disturbance may have been ignored and therefore the students would not gain the same amount of knowledge and understanding of the context.

When learning is nested in interactions and the natural environment of the learner, the learner seeks meaning throughout the interpretations of the contextual interactions. This in turn creates an opportunity for CTE teachers to construct many contextualized authentic learning opportunities. The learning activities then scaffold easily by the physical learning environment and allow for the propagation of knowledge construction, long-term memory encoding, and the promotion of organization for memory recall of the information. When learning science in CTE, students do not need to construct artificial connections between what they are learning and how it works itself into the students’ real world.

However, even within CTE science integration there are questions about how teachers can optimize the learning experiences of today’s students and there seems to be little research in the field of CTE and science content integration as a process. The research for how teachers begin to integrate and process science standards into CTE at the secondary level is relatively undeveloped and little information exist in the literature for how CTE teachers can make sense of the science content and how it is best integrated into their CTE courses (Spindler, & Greiman, 2013).

The integration of academics into CTE curriculum was part of the Perkins IV Act of 2006 which linked professional development to improve teaching practices and student outcomes to promote the integration of rigorous academic content standards and CTE curricula (Pearson, Young, & Richardson, 2013). In regards to science instruction in context, teachers and researchers were noticing that students do not know how to connect the isolated facts in science and give meaning to what they have learned, and students fail to solve problems that closely mirror the ways they have been taught. However, a context-based science course will motivate students and help them feel more positive about science and help them see the importance of what they are studying.

The process of metacognitive instruction could be helpful for students by helping them the science behind the tasks and by improving the fundamental knowledge of science. To do this, guidelines were made in 2007 by the National Science Education Standards to promote learning through inquiry, use “hands on” learning, “minds-on” learning, and “science as process” (Pearson, Young, & Richardson, 2013). In the science in CTE pilot study teachers were asked to draw on situated cognition. In situated cognition there is a complex interplay between the physical and social context, the authenticity of experience, and personal construction of knowledge (Pearson, Young, & Richardson, 2013). This model required the CTE teachers to change their way of teaching to allow students to actively engage in thinking as scientists. In this study CTE concepts within the curriculum dictated the academic content to be integrated into the course. Seven elements were used to guide teachers' development of integrated lessons and the instruction. These included the introduction of the CTE lesson, assessing the students' science awareness, working through the CTE lesson, working through related, contextual science-in-CTE examples, working through explicit science examples, students demonstrating understanding and, finally, a formal assessment (Pearson, Young, & Richardson, 2013). In these CTE lessons students not only learned the factual information, but engaged in the complex interactions of scientific inquiry and skills.

The results of the study showed that science-in-CTE study, for agriculture education, supports a contextualized learning approach. The science-in-CTE also reflects the theoretical work in the areas of situated cognition and experimental learning to better understand science skills and knowledge (Pearson, Young, & Richardson, 2013). All results in the study concluded that, relative to the control group, those participating in the science-in-CTE intervention showed a significant positive improvement in students' achievement (Pearson, Young, & Richardson, 2013).

When looking at the attitudes, barriers, impacts on enrollment and support from stakeholders of the responding teachers in a Flordia based agricultural CTE program, 94% agreed that science concepts are easier to understand when the science curriculum is integrated fully into the program. Out of these teachers two-thirds reported that there was insufficient time and support to plan for integration of the science concepts and that the lack of materials and funding will be a barrier. Additionally, over half the teachers (53%) felt their lack of experience in science would be a barrier for integration (Myers, & Washburn, 2008). With the integration of the science curriculum and the ability for students to gain science credit, teachers felt that an increase in enrollment would evident. About half the teachers felt that they did not believe that they integrate enough science, and 75% said they plan on increasing the amount of science integrated into the agricultural classes. When looking at the perceived amount of support for integration and where it would come from, the surveys provided the ideas that most support would come from science teachers (76%), followed by administrators, school counselors, parents and other teachers (Myers, & Washburn, 2008).

Vocational pedagogies were also examined to see how flipped classrooms can be applied in vocational education and how traditionally vocational education has resulted in a dislocation of knowledge from the frameworks that gives knowledge its meaning. For this reason students trained in a traditional fashion are lead in courses, where prerequisites must be met to enter the next course. When science is being presented in a traditional format or forms these results in students struggling with relocating knowledge within context and applying it fully in the vocational setting. This leads to tensions between academic and vocational educators in areas such as vocabulary. The study points out the “teaching of science” as an important and neglected component to vocational pedagogy (Hobley, 2016).

The ideas of integrated academics

Co-teaching is a strategy used in elementary and secondary schools. Some universities are beginning to implement co-teaching, but there is little research done in this area. The effects of co-teaching in a university science education course were used to analyze the disturbances in the work and preparation of science teachers. It was observed that the presence of an extra instructor provided an increase in the opportunities for student learning and offered expanded opportunities for the progression of the activity system when preparing science teachers (Milne, C., Scantlebury, K., Blonstein, J., & Gleason, S., 2011).

Co-teaching involves two or more teachers working together on a given content. Co-teaching is becoming more common in science education programs as a pedagogical strategy when an experienced elementary or secondary teacher is paired with a university professor to teach a science methods course (Milne, C., Scantlebury, K., Blonstein, J., & Gleason, S., 2011). This research examined the ideas of what co-teaching methods brought to a science methods course at two different U.S. universities. The observational study focused on whether co-teaching at the university level replicated identified co-teaching models at the K-12 levels. While examining the classroom data it was easily seen that identifying disturbances were clearly seen. Disturbances were described as the ripples in the smooth ongoing communication which interrupted the flow of the system and disrupted learning and communication (Milne, C., Scantlebury, K., Blonstein, J., & Gleason, S., 2011).

The ideas of co-teaching is a relatively new tool that uses old rules of teaching and can be seen as a way to better support the learning of pre-service teachers in science methods courses. In a science methods course, all participants expect the conversation will help support the outcomes of preparing pre-service teachers to teach science. The idea of co-teaching could also be seen as a disturbance because co-teaching was outside the norms of a typical science methods course. However, the research also identified the idea that having more than one professor may expand the possibilities of identifying other disturbances in the activity system while learning how to teach science (Milne, C., Scantlebury, K., Blonstein, J., & Gleason, S., 2011). The researchers pointed out that in a reframing situation in a classroom with one teacher this disturbance may have been ignored and therefore the students would not gain the same amount of knowledge and understanding of the context. The co-teaching tool allowed each co-teacher to bring their assets into the classroom and build a sense of community and additional insight into learning.

Through the research of science integration done with 16 CTE teachers, three different strategies of integrating science emerged: full-preventative problem-solving; and partial prevention and selective preventative which pointed towards one core category of evolutionizing and three other categories such as; connecting, enacting and futuring of CTE science integration (Spindler, & Greiman, 2013). Through interviews many related ideas became apparent. These were the ideas of taking action, adapting, transforming, selecting, creating and guiding towards evolutionizing the ideas of CTE science integration.

All CTE teachers participating gave emphasis to not “slipping some science in where it fit” and many of the teachers said that the process of CTE and science integration involved a complete adaptation into the program content. This process allowed the CTE teacher to redesign student experiences for an increased allocation for flexibility and learner centered “ah ha” moments (Spindler, & Greiman, 2013). Using and working with science integration allowed the CTE teachers to construct the future of their program of study.

Inquiry in CTE

In the CTE classroom there are many levels of inquiry including confirmation, structured, guided and open inquiry. When in the classroom, confirmation is great for reinforcing previous ideas or covered material. Structured inquiry allows the instructor to determine the question and methods, but the students will generate the explanation based on their investigations. These two, confirmation and structured, tend to be lower levels of inquiry but are important in the development of student skill and ability (Schwartz, 2017). As the students progress in their abilities though inquiry, then the higher levels of inquiry may be used to further inquiry development.

When the instructor provides the students with a question and the students are responsible for making predictions, building a procedure, carrying out an experiment, and generating an explanation based on their findings, the students are working towards guided inquiry (Schwartz, 2017). Finally, open inquiry has students posing questions, making predictions, designing an experiment and sharing their results.

These more advanced forms of inquiry encourage students to think more about a problem and question their own assumptions. The higher levels of inquiry along with collaboration allow the students to sharpen their soft skills and interpersonal skills which are essential in any job (Schwartz, 2017). As students are exposed to more opportunities and levels of inquiry they will develop skills, understanding, and mature as a whole person. Constant opportunity and practice in inquiry will allow students to develop a deeper understanding of the course content.

When looking at shifting the way in which teachers teach science, moving from a thinking that is ‘science through education’ to one which is ‘education through science’ requires a large revision of the teaching-learning approach. The paradigm shift in educational philosophy is intended to change science curriculum to see the nature of science and base learning on an appreciation of the nature of science, student development in intellect, attitude and aptitudes and making relationships to make informed socio-scientific decisions within society (Holbrook, Rannikmae, & Valdmann, 2014). This way of teaching encompasses key learning competences for education and provides a focus for the needs of the students in learning “how to learn” with a strong emphasis on the interrelations of science, math, and technology competences.

The study looked deeply into the shift in teaching styles and the support needed to make that shift. Changing the way teachers approach science education takes time and there was little data collected on how teachers feel students will respond to the shift and how long/what continuing support the teachers would need following the initial professional development training. In order to guide professional development for teachers the undertaking of the change in thinking of a science classroom from “science through education” to “education through science” is needed (Holbrook, Rannikmae, & Valdmann, 2014). However, the support needed to make that shift is great. The teachers felt that they were confident in handling aspects such as classroom learning environment, motivation, and the nature of science, but they still wanted to continue to enhance their competences in these areas. Teachers generally held low confidence in their theories of education, self-reflection, inquiry-based learning and assessment and felt a high need in continuing professional development in these areas (Holbrook, Rannikmae, & Valdmann, 2014). Interviews pointed to the ideas that teacher’s evaluations of their skills were unrelated to their requests for further training. The request of professional development was based on teacher interest. This seems to lead to the idea that teachers lack the ability to effectively plan their own professional development. Teachers also shared that they expect support from scientists to keep up on the latest advancements in science to enrich their students’ education and keep it current. Overall teachers felt that support was needed in the areas of: inquiry-based teaching, assessment, self-reflection and familiarity with educational theories (Holbrook, Rannikmae, & Valdmann, 2014).

Using argumentation theory can help students engage in science practices that enhance their science content knowledge. The Next Generation Science Standards (NGSS) emphasizes argumentation skills, and teachers need to use productive approaches to engage their students in the practice of science to promote and increase science proficiency (Grooms, Enderle, & Sampson, 2015). By using argument driven inquiry theory teachers can structure laboratory activities that support student engagement in scientific argumentation and emphasize the core ideas while cross cutting the concepts of science.

The use of scientific argumentation has a goal of teasing out the relationships between ideas and the evidence that is presented (Grooms, Enderle, & Sampson, 2015). The process of scientific argumentation develops and refines knowledge and uses rationales and justifications which are critiqued and evaluated by other scientists. This cyclical process of critique, refinement, and evaluation eventually leads to scientific argument supported by scientific evidence. The NGSS support the role of scientific argumentation and reflects that it should play a role in the science classroom (Grooms, Enderle, & Sampson, 2015). The addition of the science and engineering curriculum includes eight areas that are essential to the k12 science practice: asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations, engaging in argument form evidence and obtaining, evaluating and communicating information (Grooms, Enderle, & Sampson, 2015).

Scientific argumentation is central to the coordination and bridging of ideas between scientists and engineers and helps build a better understanding of the world. The idea of being able to engage in argument from evidence presents itself in many phases throughout the NGSS. It is used in evaluating claims, constructing arguments, presenting arguments using evidence, analyzing data to support a claim and in various other phrases throughout the NGSS (Grooms, Enderle, & Sampson, 2015).

Moving forward with NGSS, students will be expected to be proficient in science through changing instruction to enhance student opportunity to engage in the practices of science in order to learn better. When thinking about proficiency of science there are four important strands: knowing the content, using and interpreting scientific explanations, generating and evaluating scientific evidence, understanding the nature of science and science knowledge, and participation in scientific practices and discourse (Grooms, Enderle, & Sampson, 2015). An argument driven inquiry (ADI) is one that allows and is designed to foster the development of the four aspects of scientific proficiency. Classroom activities and labs are designed to engage students in data collection, analysis, argumentation generation, group argumentation, scientific writing, and double blind peer review. The model of ADI can serve as a template for teachers to restructure their laboratory activities and allow for a more realistic and authentic experience in the science classroom for students.

In the ADI model, stage 4 is the argumentation stage. Research in this stage suggests that learning is enhanced when students are exposed to ideas of their peers and are asked to evaluate and argue competing ideas. Following this stage of ADI students may want to collect additional data to better support or refute an idea and build deeper understanding. The whole ADI process allows students to undergo several opportunities to engage in scientific argumentation and critique to provide better evidence to support claims (Grooms, Enderle, & Sampson, 2015).

Additional support and evidence on the success of ADI has been seen by studying learning gains in students enrolled in an ADI chemistry course. Students exposed to the ADI investigations showed learning gains that were significant in science content, scientific writing and performance tasks. The results of this study suggest that ADI instructional use in laboratory investigations has the potential of increasing learning gains within the strands of science proficiency (Grooms, Enderle, & Sampson, 2015).

The NGSS present enhanced vision and ideas of science teaching and learning where science classrooms and students are given opportunities to generate, critique, and evaluate scientific evidence to develop and understand scientific explanation and arguments (Grooms, Enderle, & Sampson, 2015). A classroom with quality teaching and learning will need to begin to incorporate many different forms of instruction to achieve the benefits of all models. By implementing ADI teachers can help develop the robust pedagogical tools that are necessary for teaching the NGSS.

However, there are many challenges teachers face when they try to implement inquiry-based teaching methods into the classroom. It is difficult to measure the quality of inquiry, using discourse to improve inquiry, pursuing the goal of teaching science content through inquiry methods, and learning how to effectively manage an inquiry based classroom (Quigley, C., Marshall, J. C., & Deaton, C. C. M., 2011).

The traditional teaching and learning of the sciences does not always offer direct experience and confrontation of the sciences until a more professional level is reached. Even at this point some scientists still do not fully understand how complex and uncertain their knowledge is. The teaching of scientific process skills can be difficult for secondary science education teachers and adhering to a linear scientific method that is written in many textbooks allows knowledge to be generated only in a fixed manner. For this reason students tend to think that science is fixed and unchanging instead of thinking of it as a dynamic structure that evolves over time (Seraphin, K. D., Philippoff, J., Kaupp, L., & Vallin, L. M., 2012).

Becoming more aware of their thinking, teachers and students can help further understand their own thinking of the complex nature of the scientific process. In the process of the TSI professional development teachers are taught to help students evaluate and decided which inquiry techniques to use during their investigations and scaffold metacognitive strategies to facilitate the process of teaching and learning. Metacognition is thinking about your thinking and often involves the awareness and control of one's cognitive processes (Seraphin, K. D., Philippoff, J., Kaupp, L., & Vallin, L. M., 2012). The TSI cycle uses both instruction and learning and is reflected in the phases of initiation, invention, investigation, interpretation and instruction. Unlike other learning cycles the TSI promotes fluidity between the phases and creates an open environment where the teacher acts as the research director and not the sole source of knowledge in the classroom.

When a learner is inquiring they are engaging with a scientific question, participating in the design of the procedure, giving priority to evidence, formulating explanations, connecting the explanations to knowledge and finally communicating and justifying their explanations (Quigley, Marshall, Deaton, Cook & Padilla, 2011).

However, teaching through inquiry varies greatly on how well the teacher understands the concepts and the process. On average 37.3% of time is spent on inquiry activities in K-12 science. This percentage becomes lower for high school teachers while the quality tends to be activity centered. The teacher explains a phenomenon or concepts and then the students work with the concept through a guided activity which does not promote the learning of critical thinking skills. Teachers can improve the quality of their inquiry activities they are facilitating in the classroom when they are provided mechanisms to change and transform their teaching practice.

To improve inquiry in the classroom teachers can examine their questioning techniques and move from a teacher initiated-student-response-teacher-evaluation (IRE) format to more of a feedback format. Instead of evaluation, making IRF will mimic a conversation that is more related to everyday and continue conversation in the classroom (Quigley, C., Marshall, J. C., & Deaton, C. C. M., 2011). Using IRF teachers can also move to provide more follow up information and highlight student ideas and contributions to make connections to other experiences and support the student in learning scientific inquiry. These forms of communication can serve as non-evaluative functions and allow the teacher and students to construct knowledge.

When thinking about science content and inquiry a teacher must teach inquiry within the science standards and not separate the two from one another. Students can engage in combining process and critical reasoning skills in an effort to develop understanding of scientific concepts. To help and encourage students to develop scientific explanations based on data, teachers can push students into a three-step process where students develop scientific questions or problems to be investigated, collect evidence to support or refute their claim and then make connections between their claims and the evidence they collected. In this way students are analyzing relationships and making evaluations about their own evidence and conclusions.

In regards to assessment, traditional assessments like tests and quizzes allow teachers to gain insight to what their students know in a contextual area, but a performance based assessment allows students to engage in their research and provides the teacher time to examine students in action and scaffold them into thinking critically about science investigations.

Many teachers feel a classroom that involves a lot of inquiry lack classroom management but with developing “withitness” a classroom can operate safely and respectfully allowing for learning to take place (Quigley, C., Marshall, J. C., & Deaton, C. C. M., 2011). This also allows the teacher time to treat all students with equity when addressing individual needs of each learner in the classroom. A classroom that is functioning with high levels of mutual respect can additionally lead students and teachers into setting higher expectations. This will in turn result in classrooms that are student centered and have quality inquiry happening at a more frequent rate.

Changing a science teacher’s perception of his/her work is a difficult task. Many pre-service teachers have had the socializations and experiences of inquiry that has acted on most teachers since their first science lesson that happened in elementary school. A reform in science education is not just the teachers gaining knowledge and skills in science that support inquiry but the additional skills necessary to build a new professional identity to promote inquiry within the classroom (Melville, Bartley, Fazio, 2013).

The ideas of active engagement could allow the pre-service teacher to build and develop a framework for their professional lives. The more active participants allow for continued professional growth, the construction of new knowledge, and thus become agents of change and growth. When thinking about pre-service teachers one should consider them students of science and teachers of science. In this way eventually pre-service teachers will be able to conceptualize and create a shift in their cognition. However, if the teachers begin with limited experience with inquiry and their own educational biographies it leads to pre-service teachers tending to lack an adequate understanding of science content and the aspects of the nature of science along with an underdeveloped understanding of inquiry and its needed skills in the classroom (Melville, Bartley, Fazio, 2013).

The unit that provided the structure of inquiry allowed the pre-service teachers to explore the possibilities of inquiry and develop a better understanding of the discourses, experiences, and emotions around the unit. The ability to learn more about open inquiry allowed the pre-service teachers to consider how an open inquiry process related to their own understanding of science and classroom teaching (Melville, Bartley, Fazio, 2013). Of the 31 interviews conducted, 29 pre-service teachers said that “the open inquiry gave them a greater appreciation of the inquiry continuum” (Melville, Bartley, Fazio, 2013, p. 1269).

The Nature of Science in CTE

The ideas behind understanding the nature of science (NOS) is expected to improve science content learning by helping students make connections and relate to scientific concepts. However, there is a lack of direct systematic investigations that can justify this claim and provide a clarified relationship between the NOS and science content learning. A total of 82 sixth and seventh grade students participated in a summer camp study where they received instruction on energy. 41 of the students received generic NOS instruction beforehand and the rest did not (Michel & Neumann, 2016). The NOS instruction did not impact their results in a pre/post NOS instrument used. However, with the conclusion of the camp and study students with higher NOS understanding seemed to be more able to learn how to relate different energy forms to each other and justifies their answers. Lastly, an understanding of NOS may also be related to student approach towards the concept of energy degradation, but it does not seem to have an impact on learning gain.

Much literature points to the ideas that a better understanding of NOS allows students to perform better with problem-solving strategies. A good understanding of the NOS also allows students to show higher levels of metacognitive skills instead of more rote-like learning strategies (Michel & Neumann, 2016). Before this study the researchers found a lack of research on the relationship between students’ NOS and their ability to understand specific scientific concepts. This study aimed at determining the relationship between the two. The concept of energy is important at all science levels and often difficult to understand. The students conceptualize energy in very different ways and sometimes their ideas do not represent a scientifically accurate view. When thinking about energy a student should understand that energy is a universal concept and that it is theoretical. If students grasp a strong understanding of NOS, it may influence the way in which they process the concepts of energy. The study used pre/post-tests to explore student learning gains with exposure to pre-teaching NOS concepts.

For this study a stepwise analysis was conducted to investigate student learning gains with regards to understanding the nature of energy as a theoretical concept and also how this understanding related their NOS understanding. When it came to investigating the nature of energy as a theoretical concept (NETC), there were significant gains in students' NETC understanding from both groups regardless if the students were exposed to NOS content (Michel & Neumann, 2016). An interaction effect was used to determine if the gains in the NETC could be related to the students differing in the understanding of NOS and it was determined that students with lower NOS scores appeared to have a much lower learning gain. With regards to content knowledge about energy there was a significant learning gain seen after the instruction of the first units of energy and a smaller learning gain in the later units on energy (unties V-VII). The analysis also points out that the student learning gain does not have a strong relation to their students NOS understanding. Following the conclusions of the study it was found that the NOS instruction did not result in students performing better on the NOS instrument, but the study did find that that students with naïve view of the NOS seem to process their understanding of the NETC much slower than the students with experience of the NOS (Michel & Neumann, 2016). This may mean that students are able to perceive the concepts of NETC differently when they are exposed to NOS beforehand. This interrelationship shows that the two factors may be independent of each other but the NOS understanding is related to the learning of science content.

The study pointed out some weaknesses of the study including the fact that the NOS instruction time of 270 minutes may have been too little to see a shift in the understanding and students performance on the NOS measurement for pre and post-tests. Additionally, the measurement used may not have been sensitive enough to perform analysis of the gains in student thinking and understanding of the NOS. Being that the study took place at a science camp, time was limited and the students used throughout the study may have resulted in a bias due to the fact the camp took place over holiday, not general school time, and students signed up or were signed up for the camp. This may imply that the students attending actually wanted to participate in the learning because they had a general interest in science beforehand. Finally, the scoring of assessments counted a missing response as no answer which limited open-ended questions and the number of missing answers may be an indicator that the assessment was too difficult or a lack in student motivation to provide answers (Michel & Neumann, 2016).

The idea that the NOS can impact student understanding and the ability to make connections allows teachers to address not only content matter in the classroom, but the process of science and its nature. Fully understanding NOS may help struggling learners connect concepts and make sense of the world around them. The Next Generation Science Standards incorporates some of the NOS ideas and teachers should be encouraged to teach these concepts and ideas to students at a much younger age. A push to understand the nature of science may encourage youths to think about science reasoning with a more holistic approach. In the classroom, the first weeks of instruction may benefit from teaching about the NOS and how it works. By teaching students and helping them to understand the NOS teachers may also be able to encourage students to think outside the box, not take everything as a given truth and encourage students to search for answers. This shift in thinking in the science classroom may help students gain confidence in content knowledge and further their overall understanding.

A case study was performed to gain insight into how science inquiry is implemented in an agriscience classroom. The tenet of the nature of science (NOS) was also observed and noted on how it reflected in the students' experiments. An agrisciecne teacher and her class of 15 students were used in the case study to gain insight into how inquiry was being implemented into the classroom. The students were observed and participated in conversations and interviews as well as the teacher (Grady, Dolan, & Glasson, 2010). The data found that the teacher viewed scientific inquiry as a mechanical process and put little emphasis on the overall reasoning that inquiry happens. The experiments conducted focused on the procedural aspects of the inquiry and there was little attention paid to scientific reasoning. The little to no attention paid to the nature of science implied sometimes correct, incorrect, and underdeveloped conceptions of the nature of science. This suggests a much needed collaboration between agriscience and the science teachers to design and participate in professional development focused on scientific inquiry and the NOS for both pre-service and practicing teachers (Grady, Dolan, & Glasson, 2010).

In addition to allowing for the understanding of science concepts and applying them in formal and informal education, it is also important that the education emphasizes the learning about the processes and NOS. Due to this notion many agriscience and science teachers have become partners in their commitment to building scientifically literate students who have a basic understanding of the principals of science and how they relate to their everyday lives (Grady, Dolan, & Glasson, 2010). The approach to classroom and laboratory experiments can help unintentionally contribute to student understanding of how science works and reduce the distance of authentic science from classroom science. In recent times the agriscience education research has expanded to include the investigation of how the integration of science reasoning skills in agriscience experiments can help build more science-orientated thinking skills. However, there is little research in the actual classroom where the learning is being done and how the inquiry is being presented along with the NOS.

Most often scientific inquiry (SI) is referred to as the scientific method. However, this is incorrect and there is not one format for scientists to follow while investigating the natural world. The NOS focuses on the ideas that science education should include the idea that, scientific knowledge can be generated through empirical practices, scientific knowledge is theory-laden and subjective and scientific knowledge is socially and culturally embedded because there established norms for the scientific work being done (Grady, Dolan, & Glasson, 2010).

In this qualitative case study an investigation of how SI and NOS are used and shaped in the agriscience classroom. This was used to allow for a compressive picture to be created in order to inform educators of their own teachings and research in the matters. The experiments observed were supported by the Partnership for Research and Education in Plants (PREP) and involved the students to study a plant of *Arabidosis thaliana* to design and conduct an original experiment to gain insight to the disabled gene's role in the plant's response to the environment (Grady, Dolan, & Glasson, 2010). Data collection for the study included classroom observations, in class conversations, face to face interviews, and observations of students work. In total 10 classes were observed and the teacher, Sara, participated in six semi-structured interviews. The collected field notes and student work was then analyzed to identify references to the NOS and SI.

When looking at the mechanical features of inquiry the teacher, Sara, did not mention any of the complex cognitive processes of SI. Her primary focus was on the mechanics of SI and centered on routine and not the reasoning involved in the experimentation. Students throughout the experiments did not turn to other sources of information to gather additional information about the plants and what solutions to use with the plants. In the planning of the experiment, Sara had done everything in advance while the students engaged in a few, brief teacher-led discussions about their experiments which focused on logistics and methods (Grady, Dolan, & Glasson, 2010). The students worked in teams but did not discuss their experiments with their teammates or other students. Student talking was discouraged and therefore students did not have the opportunity to explain and defend their thinking and processes as they conducted their experiments. In summary of the final day the students work was quickly summarized and the meaning of the observations made throughout the experiment were quickly discussed. Students finished the unit with a quick fill-in-the-blank, pre-formatted paragraph for the final write up. There were no class discussions about their experimental evidence and conclusions that could be drawn based on the evidence (Grady, Dolan, & Glasson, 2010).

In regard to the NOS there was no evidence found in the interviews or observations that there was explicit attention drawn to the NOS and its practices. Students inquiries were reinforced with a combination of accepted, underdeveloped and relatively incorrect NOS conceptions. The overall linear format of the cause-and-effect controlled design supported the notion that there is a single, carved in stone, procedure for conducting scientific work (Grady, Dolan, & Glasson, 2010). Students, while designing and performing their experiments, did not base their designs on previous efforts and did not share their findings and conclusions to build SI or NOS skills. Instead, students recorded data in a traditionally structured format that was provided and failed to make connections to what the data meant and how it could be interpreted. Much of the experiment was superficial and not based on students prior knowledge, experiences or trainings and was a “we just picked it” experience. Due to these factors students did not address the NOS and there was no follow up discussion about the way scientists conduct their work (Grady, Dolan, & Glasson, 2010).

Overall, the mechanical process of inquiry was empathized but the NOS and the opportunities for discussion and reasoning was minimized throughout the study. It is likely that students inquiry only minimally contributed, if any, to the development of students understanding of the NOS and the scientific process (Grady, Dolan, & Glasson, 2010). To assist and help educators design and implement better practices in regard to inquiry and the NOS, continued professional development and collaboration is needed between agriscience teachers and science teachers where experiences will allow the teachers to engage in their own authentic inquiries and promote the learning of the NOS and science reasoning strategies. This in turn will help the students and the teachers better promote the learning of the NOS and SI in the classroom. To be better prepared to teach the NOS and SI, teachers and educators need to participate in explicit SI and NOS professional development to implement this into their classrooms effectively.

Reflection

Co-teaching science in CTE is a difficult task. The process of “slipping in” some science does not and will not work. Professionals in the field need to work together to develop and implement science lessons and curriculum that fits the CTE program by enhancing the learning. Currently New York BOCES have different models for implementing the integration of academics into the CTE programs. Some BOCES use the co-teaching model, while others pull out students who need the academic credit for meeting state requirements and still others use consultant teachers to guide the practice of the CTE teachers into integrating more academics into their curriculum.

Science in CTE will change as the future of jobs in STEM and industry change. However, implementing more inquiry, performance-based learning, and curriculum that allows students to think about the nature of science and the scientific process will help teachers provide students ready to enter the field with more knowledge and critical thinking skills than before.

Chapter 3: Project: Leading Lessons in the Greenhouse

Inspiration:

10 years ago an extensive project went underway to upgrade the greenhouse on the DCMO BOCES Harrold Campus with the goal in mind that the greenhouse and Conservation program could provide some foods to the Culinary program at the BOCES. After ten years and many conservation teachers later, the greenhouse is underused and often does not provide high enough quality produce to be used by the culinary program. The goal of the project is to better provide high quality inquiry-based science education in the greenhouse which in turn will result in more meaningful use of the greenhouse and green space on campus. In the end this project

will build new innovative science lessons in CTE where the focus is learning and developing scientific inquiry in the greenhouse that can be shared with both the CTE staff and science teachers throughout the BOCES and other schools.

Curricular Justification:

Being enrolled and participating in CTE programs at the high school level allows students to receive academic credit in science, math, and English upon completion of the program. Each program area has their own industry and CDO standards to meet along with specific science, math, and English standards that are met throughout the two-year CTE program at the BOCES.

For these reasons science curriculum must be fully integrated into the program area to make it meaningful and relevant to the students participating in the activity. Currently the Conservation Program already has a strong section dedicated to greenhouse Technology and the Culinary Program consists of food exploration and picking high quality produce for culinary dishes. As for computer technology this project will tie in the experimental design and redesign process to develop and help students foster experimental design and inquiry skills throughout the unit.

CTE Conservation Science Lessons

How do nutrients effect the growth of a pea plant?

Teacher: Anderson	**Grade:** 11-12	**Date(s):** 09/12/2018
Unit Title: Creating a green space in Conservation	**Corresponding Unit Task:** Greenhouse plant properties	
Essential Question(s): How do nutrients effect the growth of a pea plant?		
Materials/Resources		Essential Vocabulary

<table>
<tr>
<td>Teacher:
*you may want to start the bean plants in Dixie cups a week or two in advance and then alter the exposure to available nutrients to allow for more clear differences
• https://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=237</td>
<td>Student:
• Bean/pea seeds
• Dixi cups/small cups
• Cotton string
• 2 liter bottles
• Tap water
• Miracle Grow
• Epsom salt
• Fish emulsion
• Potting mix with no nutrients added</td>
<td>Macronutrients
Micronutrients
Nitrogen
Phosphorous
Potassium
Independent variable
Dependent variable</td>
</tr>
<tr>
<td colspan="3">Learning Experience</td>
</tr>
<tr>
<td>Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds on instructional strategies
☐ Use of Process</td>
<td colspan="2">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy
HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.
CDOS 1: Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their</td>
</tr>
</table>

skills in context-predict, observe, measure, classify, infer, communicate □ Peer Discussion – scientific arguments and explanations □ Use appropriate tools accurately □ Focus on detail - precision & accuracy in observations and measurements □ Use of collaboration for learning	potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 1 Natural and Agricultural Sciences:** Basic agriculture foundation development
	I Can Statement(s): I can begin to develop an experiment to determine how nutrients effect plant growth
	Engage: Activating Strategy/Hook: • What are essential nutrients that plants need? • What do you think happens to plants when all their needs for nutrients are not met? • Do you think we can measure and test what would happen when a plants needs are not met? • How can we do this with the given materials?
	Explore: Learning Experiences • Have students work in groups to develop a plan for manipulating the test with an independent variable. • Guide students in designing a test and a control for the pea plants • Have students conduct an experiment where they manipulate the plants exposure to different fertilizers and nutrients.
	Explain: Learning Experiences **Expected results** • Over time (1-2 wks) plants only provided water will stunt their growth while the other pea plants will accelerate their growth.
	Elaborate: Extending & Defining • Have students develop a conclusion to why they observed what was observed.

<table>
<tr><td></td><td>

- Open a discussion about replication size and uncontrolled variables for each experiment
- Explore ways a greenhouse manages nutrients and fertilization

</td></tr>
<tr><td></td><td>

Evaluate: Summarizing Strategy

- Students will complete a written assignment which includes vocabulary matching and short answers about what they feel the results will be
- Students will measure and record data throughout the following two weeks and then begin to develop a conclusion
- Students will turn in their data table and observations after the two weeks

</td></tr>
</table>

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop another study to conduct an investigation of what would happen if a plant did not have a specific nutrient available such as calcium.		

Assessment(s):
Short answers, matching
Group work participation
Development of a conclusion

Teacher Reflection:

How does exposure to different wave lengths of light effect plant growth?

Teacher: Anderson	**Grade:** 11-12	**Date(s)**: 09/12/2018
Unit Title: Creating a green space in Conservation	**Corresponding Unit Task:** Greenhouse plant properties	
Essential Question(s): How does exposure to different wave lengths of light effect plant growth?		

<table>
<tr><th colspan="2">Materials/Resources</th><th>Essential Vocabulary</th></tr>
<tr><td>Teacher:
*you may want to start the seeds a week or two in advance of this lesson</td><td>Student:
• lettuce seeds
• flats
• watering wells
• T9 bulbs or LEDs of different color spectrums and their corresponding balusters (at least three different kinds)
• An apparatus to hold lights- PVC works well
• water
• seedling mix or grow mix</td><td>Lumens
Chlorophyll
UV spectrum
DGH- daylight growing hours
Procedure</td></tr>
<tr><th colspan="3">Learning Experience</th></tr>
<tr><td>Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds on instructional strategies
☐ Use of Process skills in context-</td><td colspan="2">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy
HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.
CDOS 1: Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work.
CDOS 3a-2 Thinking Skills: Thinking skills lead to</td></tr>
</table>

predict, observe, measure, classify, infer, communicate Peer Discussion – scientific arguments and explanations Use appropriate tools accurately Focus on detail - precision & accuracy in observations and measurements Use of collaboration for learning	problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 1 Natural and Agricultural Sciences:** Basic agriculture foundation development
	I Can Statement(s): I can determine the procedure to conduct an experiment where plants are exposed to different light sources and collect data.
	Engage: Activating Strategy/Hook: • What is an experimental procedure? • What do you think a good procedure looks like? • If given a list of materials and a question could you come up with a procedure? • How can we do this with the given materials?
	Explore: Learning Experiences • Have students work in groups to investigate the materials and needed set up to address the essential question. • Guide students in designing a procedure including all steps • Have students conduct an experiment where they manipulate the plants exposure to different light sources using their procedure they developed.
	Explain: Learning Experiences **Expected results** • Over time (1-2 wks) plant growth may vary.
	Elaborate: Extending & Defining • Have students develop a conclusion to why they observed what was observed. • Open a discussion about replication size and uncontrolled variables for each experiment • Explore ways a greenhouse manages lighting and analyze the cost of each lighting option for

<table>
<tr><td></td><td colspan="2">the greenhouse we have.</td></tr>
<tr><td></td><td colspan="2">Evaluate: Summarizing Strategy
• Students will complete a written assignment which includes vocabulary matching and short answers about what they feel the results will be
• Students will measure and record data throughout the following six weeks and then begin to develop a conclusion
• Students will turn in their data table and observations after the six weeks</td></tr>
<tr><th colspan="3">Differentiation Strategies</th></tr>
<tr><th>Extension</th><th>Intervention</th><th>Language Development</th></tr>
<tr><td>Develop another study to conduct an investigation of what would happen if a plant did not have a specific nutrient available such as calcium.</td><td></td><td></td></tr>
<tr><td colspan="3">Assessment(s):
Short answers, matching
Group work participation
Development of a conclusion</td></tr>
<tr><td colspan="3">Teacher Reflection: This lab went fairly well. The PVC apparatus worked well so the height of the lights could be moves to where they should be as the lettuce plants grow. There was a clear difference between the low lumen bulb that was a fluorescent and the full spectrum LED. If you had resources to purchase Wisconsin Fast Grass I would. The lettuce doesn't grow fast enough to keep the students entertained with the experiment. With this experiment we also had access to a LUX scale and could quantify the amount of light being released from each bulb. We did not analyze the spectrum but it would have been nice if we could have done this.</td></tr>
</table>

What are the effects of root growth hormone on plant propagation?

Teacher: Anderson	**Grade:** 11-12	**Date(s)**: 09/12/2018

<table>
<tr><td colspan="2">Unit Title: Creating a green space in Conservation</td><td colspan="2">Corresponding Unit Task: Greenhouse plant properties</td></tr>
<tr><td colspan="4">Essential Question(s): What are the effects of root growth hormone on plant propagation?</td></tr>
<tr><td colspan="3">Materials/Resources</td><td>Essential Vocabulary</td></tr>
<tr><td>Teacher:
*you may want to start the bean plants in Dixie cups a week or two in advance and then alter the exposure to available nutrients to allow for more clear differences</td><td colspan="2">Student:
• Plants to be propagated (Christmas cactus, snake plants, jade, grapes)
• Rooting hormone
• Willow water
• Propagation medium (vermiculite or perlite)
• water</td><td>Asexual reproduction
Cuttings
propagation</td></tr>
<tr><td colspan="4">Learning Experience</td></tr>
<tr><td>Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds on instructional strategies
☐ Use of Process skills in context-</td><td colspan="3">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy
HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.
CDOS 1: Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work.
CDOS 3a-2 Thinking Skills: Thinking skills lead to</td></tr>
</table>

<table>
<tr>
<td rowspan="6">predict, observe, measure, classify, infer, communicate
□ Peer Discussion – scientific arguments and explanations
□ Use appropriate tools accurately
□ Focus on detail - precision & accuracy in observations and measurements
□ Use of collaboration for learning</td>
<td>problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations.
CDOS 3a-3 Personal Qualities: Personal qualities generally include the ability to plan, organize, and take independent action.
CDOS 3a- 8 Systems: System skills include the understanding of and ability to work within natural and constructed systems.
CDOS 3b- 1 Natural and Agricultural Sciences: Basic agriculture foundation development</td>
</tr>
<tr>
<td>I Can Statement(s): I can make observations of root development, document the data and write a conclusion.</td>
</tr>
<tr>
<td>Engage: Activating Strategy/Hook:
• How can we clone plants?
• What plants sendoff clones naturally?
• Why do plants clone?
• How can we study the effects of root growth hormone on propagated plants?</td>
</tr>
<tr>
<td>Explore: Learning Experiences
• Demonstrate proper procedure for plant propagation
• Have students develop a set up for both plants being tested with the hormone, willow water and no additional substances
• Have students decide and work in groups to determine what plants and how many they will use for each test
• Examine growth and development of the plants roots weekly until the plants are able to be transplanted</td>
</tr>
<tr>
<td>Explain: Learning Experiences
Expected results
• Over time (1-6 wks) plants provided the willow water and root hormone will develop and show better signs of root growth</td>
</tr>
<tr>
<td>Elaborate: Extending & Defining
• Have students develop a conclusion and research what the root growth hormone does to the plants cells to make them grow roots</td>
</tr>
</table>

	• Open a discussion about replication size and variables • Explore ways a greenhouse/nursery manages propagation • Discover the genetic advantages to being able to clone specific plants
	Evaluate: Summarizing Strategy • Students will complete a written assignment explaining their set up and replication size • Students will answer short answer questions to show understanding of the process and vocabulary development • Students will measure and record data throughout the following 6 weeks and then begin to develop a conclusion • Students will turn in their observations and conclusions

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop another study to conduct an investigation of what would happen if a plant did not have a specific nutrient available such as calcium.		

Assessment(s):
Short answers, matching
Group work participation
Development of the set-up, replications and conclusion

Teacher Reflection:
Students were able to document root growth on both Christmas cactus and strawberry plants. Students observed that the Christmas cactus and the strawberry plants that we just placed in soil tended to do well also with the rooting hormone. The students want to carry out a further experiment with rooting hormone and soil and how much of the Christmas cactus you should propagate to get good root growth. We realized that if you are able to cut off at least 5 leaves of the cactus the success rate and the speed at which roots begin to develop is much better. Following the experiments the students were able to successfully pot a number of Christmas cacti and strawberry

plants.

How does a change in pH effect the growth of seedlings?

Teacher: Anderson		**Grade:** 11-12	**Date(s):** 09/12/2018
Unit Title: Creating a green space in Conservation	**Corresponding Unit Task:** Greenhouse plant properties		
Essential Question(s): How does a change in pH effect the growth of seedlings?			
Materials/Resources			Essential Vocabulary
Teacher: *start seeds at least 3 weeks prior to lesson - pre mix soils with vinegar and potassium hydroxide or sodium hydroxide to make the pHs different -Use the "What's Your pH?" lesson guide for help https://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=317 https://www.youtube.com/watch?v=zQowljL8	**Student:** • soil • white vinegar • potassium hydroxide • pH meter • pH testing kit • water • seedlings • seedling flats • 3" pots for transplant • labels for each pot • large tub for creating soils with different pHs		Seedlings pH basic acidic alkaline amendment

<table>
<tr><td>e5E</td><td></td><td></td></tr>
<tr><td colspan="3">Learning Experience</td></tr>
<tr><td rowspan="3">Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds on instructional strategies
☐ Use of Process skills in context-predict, observe, measure, classify, infer, communicate
☐ Peer Discussion – scientific arguments and explanations
☐ Use appropriate tools</td><td colspan="2">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-PS 1-11: Plan and conduct an investigation to compare properties of acids and bases.
HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules.
CDOS 1: Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work.
CDOS 3a-2 Thinking Skills: Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations.
CDOS 3a-3 Personal Qualities: Personal qualities generally include the ability to plan, organize, and take independent action.
CDOS 3a- 8 Systems: System skills include the understanding of and ability to work within natural and constructed systems.
CDOS 3b- 1 Natural and Agricultural Sciences: Basic agriculture foundation development</td></tr>
<tr><td colspan="2">I Can Statement(s): I can measure the pH of a soil and make predictions about how the soils pH will affect seedling success.</td></tr>
<tr><td colspan="2">Engage: Activating Strategy/Hook:
• How can we clone plants?
• What plants sendoff clones naturally?
• Why do plants clone?</td></tr>
</table>

<table>
<tr><td rowspan="5">accurately
□ Focus on detail - precision & accuracy in observations and measurements
□ Use of collaboration for learning</td><td>How can we study the effects of root growth hormone on propagated plants?</td></tr>
<tr><td>Explore: Learning Experiences
Demonstrate proper procedure for plant propagation
Have students develop a set up for both plants being tested with the hormone, willow water and no additional substances
Have students decide and work in groups to determine what plants and how many they will use for each test
Examine growth and development of the plants roots weekly until the plants are able to be transplanted</td></tr>
<tr><td>Explain: Learning Experiences
Expected results
Over time (1-6 wks) plants provided the willow water and root hormone will develop and show better signs of root growth</td></tr>
<tr><td>Elaborate: Extending & Defining
Have students develop a conclusion and research what the root growth hormone does to the plants cells to make them grow roots
Open a discussion about replication size and variables
Explore ways a greenhouse/nursery manages propagation
Discover the genetic advantages to being able to clone specific plants</td></tr>
<tr><td>Evaluate: Summarizing Strategy
Students will complete a written assignment explaining their set up and replication size
Students will answer short answer questions to show understanding of the process and vocabulary development
Students will measure and record data throughout the following 6 weeks and then begin to develop a conclusion
Students will turn in their observations and conclusions</td></tr>
<tr><td colspan="2">Differentiation Strategies</td></tr>
</table>

Extension	Intervention	Language Development
Develop another study to conduct an investigation of what would happen if a plant did not have a specific nutrient available such as calcium.		
Assessment(s): Short answers, matching Group work participation Development of the set-up, replications and conclusion		
Teacher Reflection: With this lab we developed a pH of 7, 7.9 and 6.5. The pH of the soil was so much of a drastic change for the seedlings that they died within a day. All seedlings were transplanted and I think the stress of the transplant and the shock ended up killing the seedlings. In the future I think using altered water or a larger plant would help prolong the study and allow for students to see the effects of pH over time. The use of a soil pH probe helped while testing the soils and allowed the students another opportunity to practice determining the pH of a soil.		

How do plants reproduce to create seeds?

Teacher: Anderson		**Grade:** 11-12	**Date(s):** 09/12/2018
Unit Title: Creating a green space in Conservation	**Corresponding Unit Task:** Greenhouse plant properties/Horticulture		
Essential Question(s): How do plants reproduce to create seeds?			
Materials/Resources			Essential Vocabulary
Teacher: *you may want to ask your local florist for day old flowers. You will also need grasses in flower stage and other	**Student:** • Various compound flowers • Grass species • Dissecting microscopes • Post it notes or tape • Dissection kit		Gymnosperm Angiosperm Petal Pollen Sepal Pistil Ovary Style Stigma

<table>
<tr><td>seeds
https://biologywise.com/parts-of-flower-their-functions</td><td colspan="2">Fruits
Pine cones</td><td>Seed
Ovule
Perfect flower
Imperfect flower</td></tr>
<tr><td colspan="4">Learning Experience</td></tr>
<tr><td rowspan="3">Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds on instructional strategies
☐ Use of Process skills in context-predict, observe, measure, classify, infer, communicate
☐ Peer Discussion – scientific arguments and</td><td colspan="3">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis
CDOS 1: Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work.
CDOS 3a-2 Thinking Skills: Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations.
CDOS 3a-3 Personal Qualities: Personal qualities generally include the ability to plan, organize, and take independent action.
CDOS 3a- 8 Systems: System skills include the understanding of and ability to work within natural and constructed systems.
CDOS 3b- 1 Natural and Agricultural Sciences: Basic agriculture foundation development</td></tr>
<tr><td colspan="3">I Can Statement(s): I can dissect a flower and begin to understand the process of fertilization. I can recognize similarities and differences between different flower types.</td></tr>
<tr><td colspan="3">Engage: Activating Strategy/Hook:
How is an apple created? What is an apple?
What is the difference between angiosperms and gymnosperms?</td></tr>
</table>

<table>
<tr>
<td rowspan="5">explanations
□ Use appropriate tools accurately
□ Focus on detail - precision & accuracy in observations and measurements
□ Use of collaboration for learning</td>
<td>How do different flowers look different/similar?
How can we look closely at a flower and identify the different components involved in the creation of a seed?</td>
</tr>
<tr>
<td>Explore: Learning Experiences
Have students work in pairs to recognize and explore the different parts of the flower.
Have students match given definitions (without photos) to what they are seeing.
Have students divide the flower to explore where the seeds would be developed.</td>
</tr>
<tr>
<td>Explain: Learning Experiences
Expected results
Students will explore the reproductive components of a flower and use this to explain the development of a seed.</td>
</tr>
<tr>
<td>Elaborate: Extending & Defining
Have students develop a conclusion to why flowers look so different but provide the same function
Discuss the similarities and differences found in the different flower structures
Describe the benefits to reproducing using a flower</td>
</tr>
<tr>
<td>Evaluate: Summarizing Strategy
Students will complete a dissection
Students will match and identify the different parts of a flower with their definitions and functions
Students will better understand terms used while thinking of the flowers reproductive functions</td>
</tr>
</table>

<table>
<tr><th colspan="3">Differentiation Strategies</th></tr>
<tr><th>Extension</th><th>Intervention</th><th>Language Development</th></tr>
<tr><td>Students can find plants in the greenhouse that have both complete and incomplete flowers</td><td></td><td></td></tr>
<tr><td colspan="3">Assessment(s):
Short answers, matching, working skills while using a microscope and correct identification of all flower parts in the dissection</td></tr>
</table>

Teacher Reflection:
Students were really engaged in taking apart flowers and identifying the components and their functions. In the future I think having walnut fruits; pine cones and other items present would be helpful to demonstrate the importance of fruits and their jobs in see transportation. For this lesson fruits and pine cones were added to the list of materials so students as an extension can dissect these flowering bodies.

In this photo you can see the students' results of pulling apart the flowering body to examine each flower's components. On the left there is also the remnants of the matching activity that was done before the lab began.

How can you tell if a seed is viable?

Teacher: Anderson	**Grade:** 11	**Date(s):** 09/12/2018
Unit Title: Creating a green space in conservation	**Corresponding Unit Task:** Greenhouse plant properties/Horticulture	
Essential Question(s): How can you tell if a seed is viable?		
Materials/Resources		Essential Vocabulary

Teacher: Oregon State Unversity https://extension.oregonstate.edu/node/81411 Seed Savers https://www.seedsavers.org/site/pdf/HomeGermTests_LAFrevised.pdf	**Student:** • Various seeds (at least 10 per test) • Marker • Ziplock bags or petri dishes • Water • Paper towels • Graduated cylinder • heat mat or a warm place • digital camera (to document)	Viable seeds Seed coat Germination Germination percentage
Learning Experience		
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context-predict, observe, measure, classify, infer, communi	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS-LS1-3:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 1 Natural and Agricultural Sciences:** Basic agriculture foundation development	

<table>
<tr><td rowspan="6">cate
□ Peer Discussion – scientific arguments and explanations
□ Use appropriate tools accurately
□ Focus on detail - precision & accuracy in observations and measurements
□ Use of collaboration for learning</td><td>I Can Statement(s): I can measure and calculate the germination rate of seeds.</td></tr>
<tr><td>Engage: Activating Strategy/Hook:
• Discuss with students what they think a viable seed is
• Discuss the process of conducting an investigation and measuring data
• Group discuss what a could be done to perform a sound germination test
• Talk about the number of seeds that should be tested to calculate the germination rate</td></tr>
<tr><td>Explore: Learning Experiences
• Materials to students including bags, seeds and heating mat and paper towels
• Go over what students in groups talked about for a possible idea of how to test the germination rate
• Hand out directions for the experiment from activity sheet. Introduce the calculations for percent germination rate
• Have students measure and track the germination while monitoring temperature and other conditions</td></tr>
<tr><td>Explain: Learning Experiences
Expected results
• Seeds will sprout with various percent germination rates</td></tr>
<tr><td>Elaborate: Extending & Defining
• Students will describe and investigate why the seeds all had different germination rates
• Students will continue a discussion of seed viability and what makes a seed viable
• Students will discuss the advantages to having a higher seed germination rate both from a monetary standpoint and an advantage in the natural environment</td></tr>
<tr><td>Evaluate: Summarizing Strategy
• Students will complete daily images to record data and record observations about each seed viability/germination test daily in a chart.</td></tr>
</table>

	• Students will conduct essay questions and multiple choice questions individually to check for understanding of introduced vocabulary and observations made throughout the five days.

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Incorporate the germination test into furthering understanding of how seeds germinate and grow		
Assessment(s): Agilix Buzz quiz Summary of findings and data table		
Teacher Reflection: This was the first lesson I did with conservation. Although the concept is very easy to grasp the students struggled to discuss why the findings from each seed used were so different. The germination rates from the older seeds varied from 10% to 100% and students couldn't understand why. We looked into this from a more economical perspective with planting crops and why would you want a higher germination rate but some of the discussion turned into what makes a seed viable for a longer period of time. I think this experiment is typically done in elementary school as a way to show that seeds produce plants. However, in this case it opened more advanced discussions about seed choice, planting amounts, and the time needed for different seeds to germinate.		

CTE Culinary Science Lessons

How do fresh herbs and spices compare to dried herbs and spices?

Teacher: Anderson	**Grade:** 11-12	**Date(s)**: 09/12/2018
Unit Title: Creating a green space in Culinary	**Corresponding Unit Task:** Seasonings and flavorings	
Essential Question(s): How do fresh herbs and spices compare to dried herbs and spices?		

Materials/Resources		Essential Vocabulary
Teacher: You will need to have access to fresh herbs • http://extension.illinois.edu/herbs/directory.cfm • https://www.youtube.com/watch?v=qtbnkihsc-4 • https://www.marthastewart.com/270213/ratio-of-fresh-herbs-to-dry-herbs	**Student:** • Various fresh herbs • Various dried herbs • Butter • Light olive oil • Bread • Chicken stock • Pots • Spoons • Access to a stove	Herb Spice Taste Fragrance Herbaceous

Learning Experience	
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS-LS1-5:** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy **HS-LS1-6:** Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules. **CDOS 1:** Integrated learning encourages students to

instructional strategies ☐ Use of Process skills in context- predict, observe, measure, classify, infer, communicate ☐ Peer Discussion – scientific arguments and explanations ☐ Use appropriate tools accurately ☐ Focus on detail - precision & accuracy in observations and measurements ☐ Use of collaboration for learning	use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 1 Natural and Agricultural Sciences:** Basic agriculture foundation development
	I Can Statement(s): I can compare the taste of both fresh herbs and dried herbs.
	Engage: Activating Strategy/Hook: • What makes a dish taste better and more flavorful? • What is the difference between a herb and a spice? • Is black pepper a spice or herb?
	Explore: Learning Experiences • Have students work in pairs to discuss how they could test the similarities and differences of different herbs (dried vs fresh) • Guide students in creating a collection data chart for their test • Have students conduct an experiment where they collect qualitative data regarding the flavoring of different herbs (limit the numbers for each group) • Have the students come up with ideas of how the herbs are used in culinary dishes.
	Explain: Learning Experiences **Expected results**

	• Students will create a data chart that allows them to explore and taste various herbs and explain the flavor, texture and look of the herbs.
	Elaborate: Extending & Defining • Have students grow a collection of herbs in their classroom to provide fresh herbs at arms reach • Have students use both fresh herbs and dried herbs in a favorite dish and provide feedback with the overall taste
	Evaluate: Summarizing Strategy • Students will complete a written assignment which includes vocabulary matching and short answers • Students will measure and record data for the taste test using qualitative observations • Students will turn in their data table and overall thoughts of the herbs at the end of class

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop another study to conduct an investigation of what would happen if a plant did not have a specific nutrient available such as calcium.		

Assessment(s):
Short answers, matching
Group work participation
Development of a conclusion

Teacher Reflection:
For this lab hot chicken stock worked best for expressing the herbs and spices used. Students cut fresh herbs and found that their flavor for some of them was milder than the dried herbs. Students also found that the finer you chopped the herbs the more of the aroma was released. The observations about dried sage were interesting. Saying that sage smells like grandma's house. However, they did not have the same observation about the herb when it was fresh. I think this may have been because of the intensity of the herb when dried. The classroom teacher was able to follow up this lesson with an

identification of herbs and spices lab and classroom activity that is normally done.

Here you can see the fresh herbs being placed in chicken broth as the taste test is being completed. Students recorded data in their data charts for both smell and taste for both dried and fresh herbs.

How sweet is the apple?

Teacher: Anderson		**Grade:** 11-12	**Date(s)**: 09/12/2018
Unit Title: Creating a green space in Culinary	**Corresponding Unit Task:** Pies Pastries and Cookies		
Essential Question(s): How sweet is the apple?			
Materials/Resources			Essential Vocabulary
Teacher: • https://www.youtube.com/watch?v=lij4oawWONg • http://usapple.org/the-	**Student:** • Fresh apples of different colors and varieties • Refractometer • Knife • Cutting board		Refractometer Brix scale

industry/ apple-varieties/		
Learning Experience		
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context- predict, observe, measure, classify, infer, communicate ☐ Peer Discussion – scientific arguments and explanations ☐ Use	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS-LS1-5:** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy **HS-LS1-6:** Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements such as nitrogen, sulfur, and phosphorus to form amino acids and other carbon-based molecules. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 1 Natural and Agricultural Sciences:** Basic agriculture foundation development **I Can Statement(s):** I can examine apples and determine how sweet they using a refractometer. **Engage: Activating Strategy/Hook:** • What makes an apple sweet? • Does redness determine ripeness and	

appropriate tools accurately □ Focus on detail - precision & accuracy in observations and measurements □ Use of collaboration for learning	sweetness? • What is a measure of sweetness?
	Explore: Learning Experiences • Have students work in groups to discuss how they could test the apples and determine their sweetness • Guide students in creating a collection data chart for their test • Have students conduct an experiment where they collect qualitative data regarding the sweetness of the apples • Have the students determine the actual sweetness using the refractometer
	Explain: Learning Experiences **Expected results** • Students will create a data chart that allows them to explore and taste various apples and then gather quantitate measurements using brix.
	Elaborate: Extending & Defining • Have students compare other fruits and vegetables to determine their perceived sweetness verses their actual brix score
	Evaluate: Summarizing Strategy • Students will complete a written assignment which includes vocabulary matching and short answers • Students will measure and record data for the taste test using qualitative and quantitative observations • Students will turn in their data table and complete the exit ticket evaluation

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop another study to conduct an investigation of different fruits and vegetables sweetness.		

Assessment(s):
Short answers, matching

Group work participation Development of a conclusion
Teacher Reflection: Results from this experiment were interesting. Many of the students thought the granny smith apples tasted sweeter than they were. The use of the refractometer allowed students to compare their taste results to an actual brix scale and then opened a discussion about taste and flavor. Students were also able to explore what apples would be best used in their apple pies that they were making next week for class. The students then were able to see how the apples altered the flavors and textures in the pies they created.

How does the color of the light effect the flower/fruit production?

Teacher: Anderson	Grade: 11-12	**Date(s): 09/12/2018**
Unit Title: Creating a green space in Culinary	**Corresponding Unit Task:** Fruits, Vegetables and Legumes	
Essential Question(s): How does the color of the light effect the flower/fruit production?		
Materials/Resources		Essential Vocabulary
Teacher: • https://www.lumigrow.com/application/floriculture/ • Start plants a least four weeks before beginning the experiment	**Student:** • various pea plants almost to maturity • access to different types of light or LEDs of different colors or colored film plastic to filter the incoming light • water • soil	Light spectrum Fruit (from a botanist perspective) Harvest time ripe
Learning Experience		
Inquiry Based Learning:	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into	

☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context- predict, observe, measure, classify, infer, communicate ☐ Peer Discussion – scientific arguments and explanations ☐ Use appropriate tools accurately ☐ Focus on detail - precision	smaller, more manageable problems that can be solved through engineering. **HS-LS1-5:** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems.
	I Can Statement(s): I can build a test to observe the effects of lighting color on flower production.
	Engage: Activating Strategy/Hook: • What do you know plants need to grow? • Why is light important? • Can plants produce fruit under different light conditions?
	Explore: Learning Experiences • Have students work in groups to create an apparatus and experiment where they can collect data on how color effects plants flowering • Guide students in creating a collection data chart for their test • Have students conduct an experiment where they collect qualitative data on the amount of flowers being produced
	Explain: Learning Experiences **Expected results** • Students will develop a plan to expose plants to

<table>
<tr><td rowspan="3">& accuracy in observations and measurements
Use of collaboration for learning</td><td colspan="3">different wavelengths of light and observe how it influences flower production.</td></tr>
<tr><td colspan="3">Elaborate: Extending & Defining
• Have students compare other plants and their flower/fruit production while exposed to different light sources.</td></tr>
<tr><td colspan="3">Evaluate: Summarizing Strategy
• Students will complete a written assignment which includes vocabulary matching and short answers
• Students will measure and record data for the development of flowers on different plants
• Students will turn in their data table and complete the exit ticket evaluation</td></tr>
<tr><td colspan="4">Differentiation Strategies</td></tr>
<tr><td colspan="2">Extension</td><td>Intervention</td><td>Language Development</td></tr>
<tr><td colspan="2">Develop another study to conduct an investigation of different fruits and vegetables and their flower production while exposed to different lighting</td><td></td><td></td></tr>
<tr><td colspan="4">Assessment(s):
Short answers, matching
Group work participation
Development of a conclusion</td></tr>
<tr><td colspan="4">Teacher Reflection:
In this experiment students used pea plants to see if red light effected the flower production. One group decided to use colored tents over the plants to act as a filter on lighting. This method tended to work. We were not able the plants exposed to the red filter produced one more flower than the plant not exposed to the red filter throughout the two weeks we did this study. This would have worked better if we were also able to have different colors reflecting back to the plant so we could have tried to encourage some plants to flower more in the greenhouse.</td></tr>
</table>

This is an image of one group's solution to the filter being placed over the control and the test. The colored bag idea was not the best aesthetically but it functioned in a way the group wanted it to.

What is sourdough? Are all sourdoughs the same?

Teacher: Anderson	Grade: 11-12	**Date(s): 09/12/2018**
Unit Title: Creating a green space in Culinary	**Corresponding Unit Task:** Yeast Breads	
Essential Question(s): What is sourdough? Are all sourdoughs the same?		
Materials/Resources		Essential Vocabulary
Teacher: You will need to prepare a starter or have one on hand before the	**Student:** • Sourdough starter for a few different flours • Recipe for sourdough	Yeast Sourdough Starter Bacteria

class. Make a loaf of each bread beforehand also • http://studentsdiscover.org/wp-content/uploads/Lesson_v2.pdf • https://www.npr.org/sections/thesalt/2016/10/28/499363379/discovering-the-science-secrets-of-sourdough-you-can-help • https://scistarter.com/project/19378-Sourdough-for-Science	• Ingredients to make your best sourdough bread • Rye, wheat, barley, etc. that are not bleached • Non-chlorinated water	

Learning Experience	
Inquiry Based Learning: ☐ Use of scientific investigati	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS-PS1-4:** Develop a model to illustrate that the

on, problem solving or engineering design □ Hands on–minds on instructional strategies □ Use of Process skills in context- predict, observe, measure, classify, infer, communicate □ Peer Discussion – scientific arguments and explanations □ Use appropriate tools accurately □ Focus on detail - precision & accuracy in	release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy **HS-LS1-7:** Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems.
	I Can Statement(s): I can determine the differences in taste and chemistry behind a traditional sourdough and traditional yeast bread.
	Engage: Activating Strategy/Hook: • What makes sourdough bread taste sour? • Why are all sourdoughs different? • How does one make sourdough bread?
	Explore: Learning Experiences • Have students work in pairs to discuss what items they would like to use to create their sourdough • Have them explore how to create a starter • Have students measure the rise and fall of the starter each day for at least two different grains

<table>
<tr><td>observations and measurements
□ Use of collaboration for learning</td><td colspan="2">Explain: Learning Experiences
Expected results
Students will examine the growth of the bacterial and yeast colonies within the starter
Students will feed the starter daily to ensure proper colony growths
Students will create a data chart that allows them to explore and taste of the breads after the starter is created.
Elaborate: Extending & Defining
Have students explore yeast and bacteria and how they are essential components to sourdough breads
Evaluate: Summarizing Strategy
Students will complete a written assignment which includes vocabulary matching and short answers
Students will measure and record data for the taste test using qualitative observations
Students will turn in their data table and overall thoughts of the sourdough experiments</td></tr>
<tr><td colspan="3">Differentiation Strategies</td></tr>
<tr><td>Extension</td><td>Intervention</td><td>Language Development</td></tr>
<tr><td>Develop another study to conduct an investigation of what would happen if you used a grain like rye for the starter</td><td></td><td></td></tr>
<tr><td colspan="3">Assessment(s):
Short answers, matching
Group work participation
Development of a conclusion</td></tr>
<tr><td colspan="3">Teacher Reflection:</td></tr>
</table>

Do microgreens like heat?

<table>
<tr><td colspan="2">Teacher: Anderson</td><td>Grade: 11-12</td><td>Date(s): 09/12/2018</td></tr>
<tr><td colspan="2">Unit Title: Creating a green space in Culinary</td><td colspan="2">Corresponding Unit Task: Fruits, vegetables, and legumes</td></tr>
<tr><td colspan="4">Essential Question(s): Do microgreens like heat?</td></tr>
<tr><td colspan="3">Materials/Resources</td><td>Essential Vocabulary</td></tr>
<tr><td>Teacher:
Begin growing the microgreens in a dark area to get them to germinate two weeks before the lab</td><td colspan="2">Student:
• Microgreen seeds
• Soil
• 1040 flats
• Heat mat
• Lighting apparatus or the greenhouse
• water</td><td>Microgreens
Harvest
Available nutrients</td></tr>
<tr><td colspan="4">Learning Experience</td></tr>
<tr><td>Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds on instructional strategies
☐ Use of Process skills in context- predict, observe, measure, classify,</td><td colspan="3">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy
HS-LS1-7: Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food
molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net
transfer of energy
CDOS 1: Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work.
CDOS 3a-2 Thinking Skills: Thinking skills lead to problem solving, experimenting, and focused</td></tr>
</table>

<table>
<tr>
<td rowspan="7">infer, communicate
☐ Peer Discussion – scientific arguments and explanations
☐ Use appropriate tools accurately
☐ Focus on detail - precision & accuracy in observations and measurements
☐ Use of collaboration for learning</td>
<td>observations and allow the application of knowledge to new and unfamiliar situations.
CDOS 3a-3 Personal Qualities: Personal qualities generally include the ability to plan, organize, and take independent action.
CDOS 3a- 8 Systems: System skills include the understanding of and ability to work within natural and constructed systems.</td>
</tr>
<tr>
<td>I Can Statement(s): I can create an experiment with an independent variable.</td>
</tr>
<tr>
<td>Engage: Activating Strategy/Hook:
• What are microgreens?
• Why do we grow them?
• How can they be used in culinary?</td>
</tr>
<tr>
<td>Explore: Learning Experiences
• Have students work in groups to discuss how they could test the best way to grow microgreens
• Have students design an apparatus to execute their test
• Have students conduct an experiment to see how heat effects the growth of microgreens</td>
</tr>
<tr>
<td>Explain: Learning Experiences
Expected results
• Students will create a data chart that measures the growth of the microgreens until they reach harvest height (approximately 4 weeks)
• Students will care and maintain their experiments</td>
</tr>
<tr>
<td>Elaborate: Extending & Defining
• Have students look up the best temperatures and reasons why greenhouse grow microgreens in the winter</td>
</tr>
<tr>
<td>Evaluate: Summarizing Strategy
• Students will complete a written assignment which includes vocabulary matching and short answers
• Students will measure and record data on the growth of the microgreens under two different conditions, heat and no heat</td>
</tr>
<tr>
<td colspan="2">Differentiation Strategies</td>
</tr>
</table>

Extension	Intervention	Language Development
Develop another study to conduct with regards to heat and seedling growth (peppers would be interesting)		

Assessment(s):
Short answers, matching
Group work participation
Graphical representation of data
Development of a conclusion

Teacher Reflection:
Results from this experiment were interesting. We all thought that the microgreens would continue to survive but many of the microgreens on the heat mat died. It was difficult to keep the soil moisture the same between the control and the test due to the heat mat evaporating off some of the moisture. The students were easily able to see stunted growth within the first week and a half. Following the lab we were able to harvest the microgreens for the salad bar.

This image shows the apparatus the students in culinary built for their effects of heat on microgreens. The students wanted to test the felt mats and soil to see if there were differences The microgreens planted were the same amount initially but through shifting while moving things the seeds tended to cluster. The heat mat is located on the right side of this image and as you can tell more than 50% of

the plants died. It was difficult to keep the soils moist over the weekends.

How fast to different sprouts grow?

<table>
<tr><td>Teacher: Anderson</td><td colspan="2">Grade: 11</td><td>Date(s): 09/12/2018</td></tr>
<tr><td>Unit Title: Creating a green space in culinary</td><td colspan="3">Corresponding Unit Task: Fruits, vegetables and legumes</td></tr>
<tr><td colspan="4">Essential Question(s): How fast do different sprouts grow?</td></tr>
<tr><td colspan="3">Materials/Resources</td><td>Essential Vocabulary</td></tr>
<tr><td>Teacher:
Sprout-Ease Sprouting Instructions

Johnny's seeds information on sprouts: http://www.johnnyseeds.com/growers-library/vegetables/sprouts-growing-instructions.html</td><td colspan="2">Student:
• Various seeds for sprouts (broccoli, lentil, bean, alfalfa)
• 1 mason jar per sprout variety
• water
• mason jar top for sprouts
• heat mat
• digital camera (to document)</td><td>Viable seeds
Germination time
Harvest
sprouts</td></tr>
<tr><td colspan="4">Learning Experience</td></tr>
<tr><td>Inquiry Based Learning:
☐ Use of scientific investigation, problem solving or engineering design
☐ Hands on–minds</td><td colspan="3">Essential Standards: K-PS2-4: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy
HS-LS1-7: Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food
molecules and oxygen molecules are broken and the</td></tr>
</table>

on instructional strategies ☐ Use of Process skills in context- predict, observe, measure, classify, infer, communicate ☐ Peer Discussion – scientific arguments and explanations ☐ Use appropriate tools accurately ☐ Focus on detail - precision & accuracy in observations and measurements ☐ Use of collaboration for	bonds in new compounds are formed resulting in a net transfer of energy **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems.
	I Can Statement(s): I can measure and observe sprouts germinate and grow and determine length to harvest.
	Engage: Activating Strategy/Hook: • Discuss with students and ask who has tried mung beans or sprouts? • Discuss the process of conducting an investigation and measuring data • Look into what constitutes as a micro green and why someone would be interested in eating them • Give students time to investigate micro greens more
	Explore: Learning Experiences • Materials to students including jars, seeds and heating mat • Go over directions for the experiment from activity sheet. Introduce the measuring we will be doing on the time to harvest for each variety of sprouts

<table>
<tr><td rowspan="4">learning</td><td colspan="3">
Have students measure and track the growth of each one of the sprouts for 5 days.
</td></tr>
<tr><td colspan="3">Explain: Learning Experiences
Expected results
Seeds will grow to harvest length in 3-5 days and will vary according to temperature and available light
</td></tr>
<tr><td colspan="3">Elaborate: Extending & Defining
Students will taste and describe/make observations of the taste and texture of the micro greens.
Students will find a recipe to incorporate the sprouts into and explore the nutritional value of each of the sprouts grown.
</td></tr>
<tr><td colspan="3">Evaluate: Summarizing Strategy
Students will complete daily images to record data and record observations about each micro green daily in a chart.
Students will conduct essay questions and multiple choice questions individually to check for understanding of introduced vocabulary and observations made throughout the five days.
</td></tr>
<tr><td colspan="4">Differentiation Strategies</td></tr>
<tr><td colspan="2">Extension</td><td>Intervention</td><td>Language Development</td></tr>
<tr><td colspan="2">Incorporate micro greens into a recipe/ design a taste test</td><td></td><td></td></tr>
<tr><td colspan="4">Assessment(s):
Agilix Buzz quiz
Summary of findings and data table</td></tr>
</table>

Teacher Reflection: The sprout lab was initially a fail. Students did not keep the jars in a dark warm place and the air conditioner/ too much light caused the experiment to fail. After a second try students

were able to see mung beans sprout. The seeds all sprouted and reached maturity a few days apart. Students were surprised that you were able to see growth so quickly after providing moisture to the seeds.
To the left is an image of the alfalfa growth after 3 days.

CTE Computer Technology Science Lessons

What waters better: A human or automatic sprinkler system?

Teacher: Anderson	**Grade:** 11-12	**Date(s)**: 09/12/2018
Unit Title: Working in a Green Space with Computer Technology	**Corresponding Unit Task:** Artificial Intelligence	
Essential Question(s): What waters better? A human or automatic sprinkler system		
Materials/Resources		Essential Vocabulary
Teacher:	**Student:** • Green house map • Rain gauges or graduated cylinders • Hose and sprinkler system set up	Soil moisture Computer aided greenhouse
Learning Experience		

Inquiry Based Learning: □ Use of scientific investigation, problem solving or engineering design □ Hands on–minds on instructional strategies □ Use of Process skills in context- predict, observe, measure, classify, infer, communicate □ Peer Discussion – scientific arguments and explanations □ Use appropriate tools accurately	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **K-PS2-5:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 3 Business/Information Systems:** prepare, maintain, interpret/analyze, and transmit/distribute information in a variety of formats while demonstrating the oral, nonverbal, and written communication skills essential for working in today's international service-/information-/technological-based economy.
	I Can Statement(s): I can address a need, and design a solution for a problem.
	Engage: Activating Strategy/Hook: • Why is it important for the green house to have equal distribution of water? • Which system do you think is more accurate, a human or the automatic system? • How can we determine which method of watering

☐ Focus on detail - precision & accuracy in observations and measurements ☐ Use of collaboration for learning	is more accurate with just the given supplies?
	Explore: Learning Experiences • Have students work in groups to build a t-chart showing the pros and cons of each type of watering system • Have students begin to design a test to determine if a human or the sprinkler system is better? • Have students conduct the test they developed over the next few days to collect data.
	Explain: Learning Experiences **Expected results** • Students will observe how uneven the sprinkler system waters. In the greenhouse there are three different sprinkler heads being used and some that drip continuous.
	Elaborate: Extending & Defining • Have students develop a conclusion to why they observed what was observed. • Have students think of ways to make the system better.
	Evaluate: Summarizing Strategy • Students will complete a written assignment which includes vocabulary matching and short answers about what they feel the results will be • Students will measure and record data throughout the following two weeks and then begin to develop a conclusion • Students will turn in their data table and observations after the two weeks

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop another study to conduct an investigation of what would happen if a plant did receive too much or too little water.		

Assessment(s): Short answers, matching Group work participation Development of a conclusion
Teacher Reflection: After collecting data and having students analyze the data set we were able to determine that there was a large difference in the sprinkler system. In zone one student observed 0 mL to 200 mL being measured. After the week of collecting data the student decided that one or more of the watering heads must be broken or dripping over time into the collection unit. The students advised the greenhouse technician that the sprinklers should be observed to see if any are not working properly and some of the plants should be moved to gain a better, more equal, amount of water. In zone two, water was observed to be much higher in some spots than others. Upon further investigation the students learned that when the watering system was turned on the hanging plant basket sprinklers were also on but there were no hanging plants. The students advised the greenhouse technician that these should be shut off. Throughout the experiment students also were able to notice how humid and wet the soils were. At the end of the experiment students wanted to try to have the system water every other day and collect data after the systems adjustments had been made.

How much energy do the greenhouse lights use?

<table>
<tr><td colspan="2">Teacher: Anderson</td><td>Grade: 11-12</td><td>Date(s): 09/12/2018</td></tr>
<tr><td colspan="2">Unit Title: Working in a Green Space with Computer Technology</td><td colspan="2">Corresponding Unit Task: Artificial Intelligence</td></tr>
<tr><td colspan="4">Essential Question(s): How much energy do the green house lights use?</td></tr>
<tr><td colspan="3">Materials/Resources</td><td>Essential Vocabulary</td></tr>
<tr><td>Teacher:
Familiarize yourself with using the kilowatt meter and the lumen</td><td colspan="2">Student:
• Green house map
• Kilowatt meter
• Lumen meter
• FLIR Camera (optional)</td><td>Kilowatt
Energy
Lumens
volts
Computer aided greenhouse</td></tr>
</table>

meter. You may also want to use an FLIR camera to show the heat energy being produced		Daylight growing hours

Learning Experience	
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context-predict, observe, measure, classify, infer, communicate ☐ Peer Discussion – scientific argument	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **K-PS2-5:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 3 Business/Information Systems:** prepare, maintain, interpret/analyze, and transmit/distribute information in a variety of formats while demonstrating the oral, nonverbal, and written communication skills essential for working in today's international service-/information-/technological-

s and explanations □ Use appropriate tools accurately □ Focus on detail - precision & accuracy in observations and measurements □ Use of collaboration for learning	based economy.
	I Can Statement(s): I can measure and calculate energy use and work to plan for energy conservation
	Engage: Activating Strategy/Hook: • What is energy conservation? • How do we measure energy use? • How do we know how much energy a plant needs to grow? • How would we measure how much energy the greenhouse lights use?
	Explore: Learning Experiences • Have student explore ways to measure and calculate energy use. • Have students decide on the method for determine how much energy the lights use. • Have students measure the amount of energy the lights use • Have students determine how many lumens the lights produce and the amount of light naturally occurring • Have students research how many lumens are necessary for proper plant growth • Determine the total amount of energy used
	Explain: Learning Experiences **Expected results** • Students will decide to test exactly how much energy each light uses and then use that number to determine the total amount of energy used in the green house • Students will compare the produced lumens to natural sunlight levels
	Elaborate: Extending & Defining • Have students develop an energy use chart and determine under what conditions the supplemental lights would need to be used • Research solutions on how to save energy in the greenhouse
	Evaluate: Summarizing Strategy • Students will participate in activities in the greenhouse and in their group.

<table>
<tr><td></td><td colspan="2">Students will engage one another in meaningful discussions to build understanding and promote problem solving
Students will present a summary of their findings regarding greenhouse lighting energy use.</td></tr>
<tr><td colspan="3">Differentiation Strategies</td></tr>
<tr><td>Extension</td><td>Intervention</td><td>Language Development</td></tr>
<tr><td>Develop a way to implement energy saving measures in the greenhouse.
Extend the learning into energy savings throughout the building.</td><td></td><td></td></tr>
<tr><td colspan="3">Assessment(s):
Short answers, matching
Group work participation
Development of a conclusion</td></tr>
<tr><td colspan="3">Teacher Reflection: Students were able to easily collect data. It was difficult to decide how much heat loss the greenhouse had due to the warm day that we had. Student had exposure to using scientific instruments to assess and gather data from the greenhouse. The most shocking findings were how different the LUX scores for outside the greenhouse and inside the greenhouse with the lights on were. Students asked why the shades were closed and the lights on which made me think the same thing. Natural light is always best light, so why weren't we using it? After investigating this matter the students recieved the answer that the shades tend to break while opening and closing them and having the shades drawn at night tends to trap in more heat.

This lesson allowed the students to have an open discussion about green technology and energy use while producing food. We were also able to discuss how computer monitoring and AI can help address these overuses of energy when the plants do not need them.</td></tr>
</table>

How can I create a database of the plants growing in the greenhouse?

Teacher: Anderson	**Grade:** 11-12	**Date(s)**: 09/12/2018

Unit Title: Working in a Green Space with Computer Technology	**Corresponding Unit Task:** Fundamentals of operating systems	
Essential Question(s): How can I create a database of the plants growing in the greenhouse?		
Materials/Resources		Essential Vocabulary
Teacher: • Familiarize yourself with using Accesses program and creating GUIs • https://www.youtube.com/watch?v=i2zmedYhM40 • https://ocw.mit.edu/courses/sloan-school-of-management/15-564-information-technology-i-spring-2003/lecture-notes/lec9.pdf • https://su	**Student:** • computer with Access • list of greenhouse plants and their general locations • photos of greenhouse plants	GUI Database Macros If statements

pport.office.com/en-us/article/create-a-user-interface-ui-macro-12590d3b-b326-4207-bfe5-19234f53f08b		

Learning Experience	
Inquiry Based Learning: □ Use of scientific investigation, problem solving or engineering design □ Hands on–minds on instructional strategies □ Use of Process skills in context- predict, observe, measure, classify, infer, communi	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **K-PS2-5:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems.

<table>
<tr>
<td rowspan="7">cate
□ Peer Discussion – scientific arguments and explanations
□ Use appropriate tools accurately
□ Focus on detail - precision & accuracy in observations and measurements
□ Use of collaboration for learning</td>
<td>CDOS 3b- 3 Business/Information Systems: prepare, maintain, interpret/analyze, and transmit/distribute information in a variety of formats while demonstrating the oral, nonverbal, and written communication skills essential for working in today's international service-/information-/technological-based economy.</td>
</tr>
<tr>
<td>I Can Statement(s): I can create an inventory and build a home screen that is user friendly.</td>
</tr>
<tr>
<td>Engage: Activating Strategy/Hook:
• What is an inventory?
• What programs can help build inventories?
• What is a GUI?
• How are GUIs use to help make interfaces more user friendly?</td>
</tr>
<tr>
<td>Explore: Learning Experiences
• Have student's modify a given database to create an inventory that is easy to use.
• Have students create GUIs in Access to assist with navigation of the database.
• Have students add graphics and information about each plant to assist in learning more about the plants contained in the greenhouse.</td>
</tr>
<tr>
<td>Explain: Learning Experiences
Expected results
• This project will take considerable amounts of time. Students better versed in programming will be able to quickly design the database while other groups may need more guidance.
• All students will design and create a functioning interface for plants in the greenhouse.</td>
</tr>
<tr>
<td>Elaborate: Extending & Defining
• Students will use their databases to check accuracy of the greenhouses inventory and test how user friendly the databases are.</td>
</tr>
<tr>
<td>Evaluate: Summarizing Strategy
• Students will complete a written assignment which includes vocabulary matching and short answers about the process of building a database with a GUI.
• Students will work in their pairs and work</td>
</tr>
</table>

	through the steps to build a database. Successful completion of the database will be part of project along with a successful GUI implemented.		
Differentiation Strategies			
Extension	**Intervention**	**Language Development**	
Develop an app. to be used which would serve the same function as the inventory database			
Assessment(s): Short answers, matching Group work participation Development of a GUI interfaced system			
Teacher Reflection:			

How can I use a Raspberry Pi to control lights?

Teacher: Anderson	**Grade:** 11-12	**Date(s):** 09/12/2018
Unit Title: Working in a Green Space with Computer Technology	**Corresponding Unit Task:** Programming	
Essential Question(s): How can I use a Raspberry Pi to control lights?		
Materials/Resources		Essential Vocabulary
Teacher: • Familiarize yourself with using Raspberry Pi and programming them • Be sure to understand circuit	**Student:** • Cardboard • LEDs • Raspberry Pi • Computer • Wire jumpers • Bread board	LED UV light Resister Circuit delay

boards before beginning this project • https://tutorials-raspberrypi.com/build-your-own-automatic-raspberry-pi-greenhouse/		

Learning Experience	
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context-predict, observe, measure,	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **K-PS2-5:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action.

<table>
<tr>
<td rowspan="6">classify, infer, communicate
☐ Peer Discussion – scientific arguments and explanations
☐ Use appropriate tools accurately
☐ Focus on detail - precision & accuracy in observations and measurements
☐ Use of collaboration for learning</td>
<td>CDOS 3a- 8 Systems: System skills include the understanding of and ability to work within natural and constructed systems.
CDOS 3b- 3 Business/Information Systems: prepare, maintain, interpret/analyze, and transmit/distribute information in a variety of formats while demonstrating the oral, nonverbal, and written communication skills essential for working in today’s international service-/information-/technological-based economy.</td>
</tr>
<tr>
<td>I Can Statement(s): I can use an Raspberry Pi to control the lights in a “green space”</td>
</tr>
<tr>
<td>Engage: Activating Strategy/Hook:
• Why is it important for plants to be exposed to different colors of LED lights?
• Which light wavelengths do plants grow best under?
• How can we build a model of a greenhouse to allow for the plants to receive the best light and promote the best growth?</td>
</tr>
<tr>
<td>Explore: Learning Experiences
• Have students work in pairs to design a breadboard to mimic alternating LED lights using the Raspberry Pi
• Have students use the engineering design process to code the lights and create a model mimicking the light control system they designed
• Have students share their designs and have classmates offer suggestions for improvements</td>
</tr>
<tr>
<td>Explain: Learning Experiences
Expected results
• This project will take considerable amounts of time. Students better versed in programming will be able to quickly design light functions while other groups may need more guidance.
• All students will design and create a functioning circuit board and model.</td>
</tr>
<tr>
<td>Elaborate: Extending & Defining
• Have students implement the suggestions for improvements to better their design</td>
</tr>
</table>

	Evaluate: Summarizing Strategy • Students will complete a written assignment which includes vocabulary matching and short answers about the engineering design process • Students will work in their pairs and work through the process to complete the project. Students will share their results and their project to the class.

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop other ways to program the Raspberry Pi in ways that would assist accomplishing or monitoring in the greenhouse		

Assessment(s):
Short answers, matching
Group work participation
Presentation
Development of a summary of findings

Teacher Reflection: Having students work on this took a lot longer than expected. The computer networking/technology class is rather large and students were ability paired to help guide learning between stronger students and weaker ones. Before the science lessons for this project the computer networking/technology teacher had students work on programing and using the Raspberry Pi. Students struggled with coming up with a design and an idea right off the back however, using the engineer design process was encouraged for students to work though their problems they encountered themselves. In the future I would recommend working through programming lights with the Raspberry Pi as a class modeling the actions and then have the students modify the design to suit the needs of the task and choose LEDs that meet the needs of the plants.

What does research say about exposure to cell phone and WiFi ER?

Teacher: Anderson	**Grade:** 11	**Date(s)**: 09/12/2018

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>Unit Title: Creating a green space in Computer Technology</td><td colspan="2">Corresponding Unit Task: Wireless Technology</td></tr>
<tr><td colspan="3">Essential Question(s): What does research say about exposure to cell phone and WiFi ER?</td></tr>
<tr><td colspan="2">Materials/Resources</td><td>Essential Vocabulary</td></tr>
<tr><td>Teacher:
https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet
https://www.psychologytoday.com/us/blog/the-resilient-brain/201509/cell-phones-and-brain-injury
https://www.sciencealert.com/cellphone-radiation-effects-study-human-health-mixed-results
https://www.consumerreports.org/cell-phones/what-the-cell-phone-brain-cancer-study-means-for-you/</td><td>Student:
• Access to computer search engines
• markers
• flip charts
• two lighting set ups that are exactly the same
• two filled 1040 flats with soil and cells
• various seeds
• lighting timer
• water</td><td>Electromagnetic radiation
Frequency
Cancer
Credible source</td></tr>
</table>

Learning Experience	
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context- predict, observe, measure, classify, infer, communicate ☐ Peer Discussion – scientific arguments and explanations ☐ Use appropriate tools accurately	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **K-PS2-5:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities generally include the ability to plan, organize, and take independent action. **CDOS 3a- 8 Systems:** System skills include the understanding of and ability to work within natural and constructed systems. **CDOS 3b- 3 Business/Information Systems:** prepare, maintain, interpret/analyze, and transmit/distribute information in a variety of formats while demonstrating the oral, nonverbal, and written communication skills essential for working in today's international service-/information-/technological-based economy.
	I Can Statement(s): I can locate and use credible information to develop a hypothesis.
	Engage: Activating Strategy/Hook: • Discuss with students if they know what electromagnetic radiation is • Show students two statements from journals that contradict one another regarding exposure to

☐ Focus on detail - precision & accuracy in observations and measurements ☐ Use of collaboration for learning	cell phone or wifi routers • Have students think pair share what they think the statements mean
	Explore: Learning Experiences • Have students research and provide research regarding exposure to electromagnetic radiation • Discuss findings and create a t-chart to track findings • Have students write a few paragraphs about their findings including terms such as "according to…" or have citations included • Have students conduct an experiment exposing plants to WiFi and no WiFi and record observations on their growth over time
	Explain: Learning Experiences **Expected results** • Students will find information that states cell phones cause brain cancer and others will find that there is no effect from being exposed to electromagnetic radiation • Students will conduct a test to begin to make conclusions about how WiFi effects plant development and growth.
	Elaborate: Extending & Defining • Have students begin to think of ways to test the inconclusive findings for themselves • Begin to write a question that could be testable regarding their findings
	Evaluate: Summarizing Strategy • Students will complete a written assignment in paragraph form and submit it • Students will develop a testable question • Students will conduct a test as a class exposing plants to WiFi and no WiFi

Differentiation Strategies		
Extension	**Intervention**	**Language Development**
Develop another testable hypothesis for exposure to electromagnetic		

radiation Measure or quantify the amount of electromagnetic radiation being given off from a WiFi router		
Assessment(s): Written paragraph Group discussion and t-chart development Observations based on the test		
Teacher Reflection: This lab takes a number of class periods to complete. In CTE, the English teacher is also pulled into to help students annotate and build their argument for or against the research they are finding regarding electromagnetic radiation. After conducting the test the students developed we found no conclusive results. The sampling size the students used was too small but some strange things did happen. The students wanted to plant strawberries. We did and the ones exposed to a WiFi router became very long and spindly. I thought maybe the lights were different so I used a lux meter to test them and they were not. The same thing happened with the bean plants. In the future we will expose more seeds and plants to the router to see if the same results are seen. This did raise a lot of questions for the students to explore.		

How can I engineer a hydroponics system to grow plants?

Teacher: Anderson		**Grade:** 11	**Date(s)**: 09/12/2018
Unit Title: Creating a green space in Computer Technology		**Corresponding Unit Task:** Engineering Design	
Essential Question(s): How can I engineer a hydroponics system to grow plants?			
Materials/Resources			Essential Vocabulary
Teacher: Research various hydroponics systems and gather	**Student:** • Access to computer search engines • PVC various sizes and at least 3" in		Hydroponics Engineering design process Flow rate System Test

materials to help students with their design • https://curriculum.vexrobotics.com/curriculum/intro-to-engineering/what-is-the-engineering-design-process.html •	diameter • Totes • Water pump • Gutters • Styrofoam • Growing medium (clay pellets) • Grow baskets • 5 gallon buckets • Tubes for transporting water in the same size as the water pumps input and output	

Learning Experience	
Inquiry Based Learning: ☐ Use of scientific investigation, problem solving or engineering design ☐ Hands on–minds on instructional strategies ☐ Use of Process skills in context- predict,	**Essential Standards: K-PS2-4:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **K-PS2-5:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **CDOS 1:** Integrated learning encourages students to use essential academic concepts, facts, and procedures in applications related to life skills and the world of work. This approach allows the students to see the usefulness of the concepts that there are being asked to learning and to understand their potential application in the world of work. **CDOS 3a-2 Thinking Skills:** Thinking skills lead to problem solving, experimenting, and focused observations and allow the application of knowledge to new and unfamiliar situations. **CDOS 3a-3 Personal Qualities:** Personal qualities

<table>
<tr><td rowspan="7">observe, measure, classify, infer, communicate
□ Peer Discussion – scientific arguments and explanations
□ Use appropriate tools accurately
□ Focus on detail - precision & accuracy in observations and measurements
□ Use of collaboration for learning</td><td>generally include the ability to plan, organize, and take independent action.
CDOS 3a- 8 Systems: System skills include the understanding of and ability to work within natural and constructed systems.
CDOS 3b- 3 Business/Information Systems: prepare, maintain, interpret/analyze, and transmit/distribute information in a variety of formats while demonstrating the oral, nonverbal, and written communication skills essential for working in today's international service-/information-/technological-based economy.</td></tr>
<tr><td>I Can Statement(s): I can design and re-design a system to allow for it to function as a grow system for plants.</td></tr>
<tr><td>Engage: Activating Strategy/Hook:
• Discuss with students if they understand the term hydroponics
• Talk about the engineer design process
• Have students think of things they would need to build their own system from things at home</td></tr>
<tr><td>Explore: Learning Experiences
• Have students research and explore systems that work as hydroponic systems
• Discuss the differences between constant flow systems and ebb and flow systems
• Have students develop a plan and a list of materials for building their system
• Build what they come up with and test the system</td></tr>
<tr><td>Explain: Learning Experiences
Expected results
• Students will find various systems and design, test and redesign until their group can create a system that functions properly.
• If students begin to struggle give them advice on how they can make improvements.</td></tr>
<tr><td>Elaborate: Extending & Defining
• Have students begin to think of ways to make their peers systems better
• Test the systems by growing plants in them</td></tr>
</table>

<table>
<tr><td colspan="2"></td><td colspan="2">Evaluate: Summarizing Strategy
Students will complete a written assignment in paragraph form and submit it
Students will develop a design which can be build with available mateirals.</td></tr>
<tr><td colspan="4">Differentiation Strategies</td></tr>
<tr><td colspan="2">Extension</td><td>Intervention</td><td>Language Development</td></tr>
<tr><td colspan="2">Develop a different hydroponics system that is more energy efficient or cost less than the first one.</td><td></td><td></td></tr>
<tr><td colspan="4">Assessment(s):
Written paragraph
Group discussion/development of a plan
Participation in the group</td></tr>
<tr><td colspan="4">Teacher Reflection:</td></tr>
</table>

Chapter 4: Student Driven Inquiry Projects

CTE Conservation Inquiry Project Ideas

Conservation is a program where they have full access to the greenhouse at any time. The goal of a student driven inquiry project in conservation may involve many different ideas. Below is one idea for a student driven inquiry project.

- What happens to plant growth when water is restricted?
- How can we use the greenhouse to better support plant growth?
- How can I create a micro climate in the greenhouse for tropical plants?
- How can we develop an integrated pest management plan that works for our greenhouse?
- What happens when you cross a pumpkin and a zucchini flower?

- Can we successfully propagate a cutting of a tomato to a potato plant? Why does this work?
- How can we better use the space in the greenhouse for agricultural production?

CTE Culinary Inquiry Project

Culinary programs may want to allow students to extend the learning from the green space into the kitchen. For culinary many additional projects can be created and performed. Students in culinary are chemists by nature and can open the doors to much more food science than what is currently being explored. As for green space inquiry ideas for culinary one can suggest the following:

- How can we decide what foods grow best in the greenhouse on campus?
- Which is better a Rutgers tomato or a heirloom variety?
- Why do genetics in the greenhouse matter?
- How can we get a continuous harvest of tomatoes or peppers?
- How does a farm to table meal compare to a grocery purchased meal in terms of cost and taste?

CTE Computer Technology Project

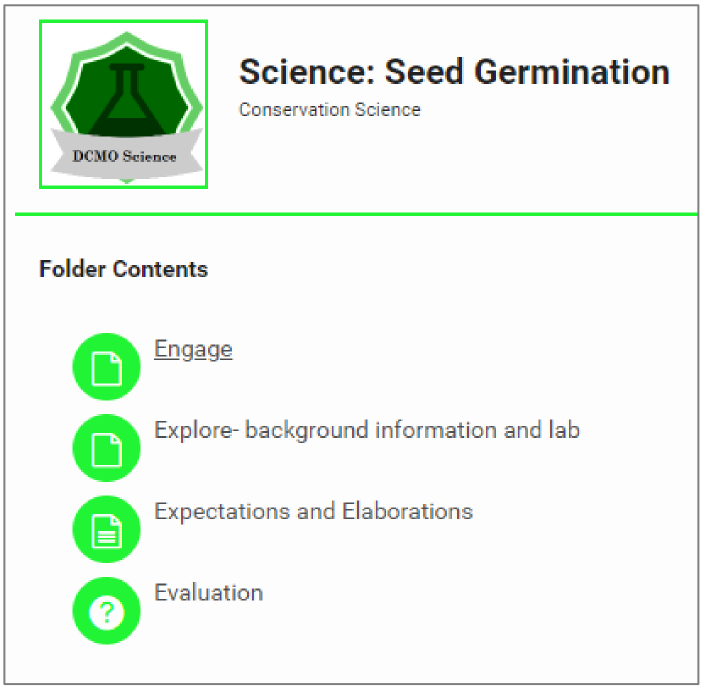
As faming systems become more advanced and need to produce more food in the same amount of space is needed more and more computer technology and AI is integrated into the field. With AI agriculturalists can watch a field for irrigation from an application on his/her phone and can make a decision to harvest based on a computers analysis of the health and production of the plants. As a field that is rising and needing more people to enter finding a student driven inquiry project should not prove to be difficult. Below are options that a student may be interested in pursuing.

- How can I simulate AI for sensing the hydration level in the soil?
- How can I build my own system for watering plants?
- How can the temperature control system in the greenhouse be made more automatic?
- Can I program the automatic watering system to function better than what was observed?
- What is the effect of the shade system in controlling the temperature of the greenhouse on a sunny day?
- How does a AI system work to identify the maturity of a fruiting plant?

Chapter 5: Reflective Commentary

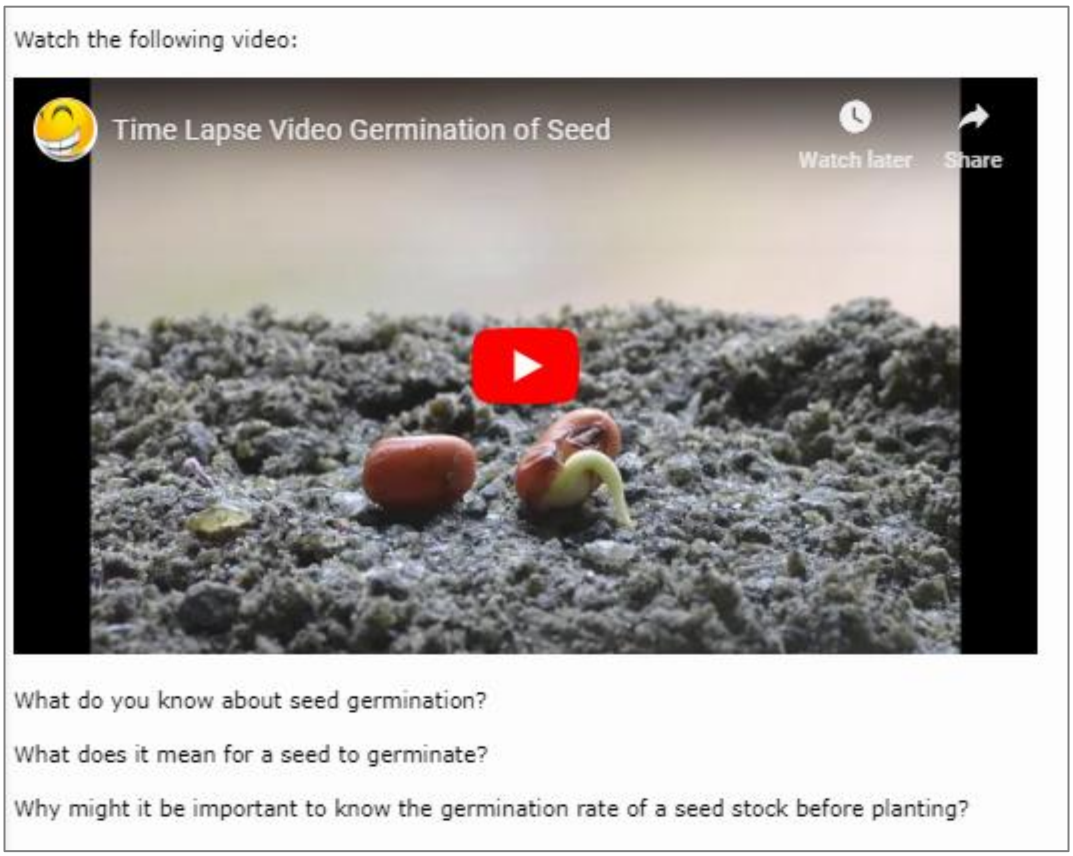
Throughout this project lessons were built and expanded into a platform called Agilix Buzz. Students and teachers have access to this platform any time there is access to internet. Agilix Buzz is an online learning platform that DCMO BOCES uses for integrating course materials and content into a more blended learning environment. The platform allows for teacher directed instruction, individual instruction, and allows for absent students to still engage in the lesson at their own pace. Agilix Buzz serves as a platform for collaboration of lessons and allows both the classroom CTE teacher to work with the academic teachers to align grading, modify lessons, and pull curriculum from other collaborators within the platform.

Lessons for the following project were placed into Buzz to allow the science and CTE teachers at both DCMO BOCES campuses to easily access and modify content, assessments and see what the lessons align to regarding NYS NGSS and CDOS.



The ability to use Agilix Buzz allows me to track and monitor student progress and also help engage students in a more technology based learning platform. In each of the Agilix Buzz lessons the 5 E inquiry method is clearly defined by each of the areas used in Agilix Buzz. As you can see below the lesson designed for conservation shows that students will be engaging, exploring, elaborating and being evaluated on their findings. You can also observe that students are also given what their expectations for the project are too.

As students click through the content they are able to access information that is student paced. The teacher then has the option of guiding students through the lesson or having them go at their own speed. For the majority of the lessons there is an associated video or hook to draw in the student’s attention to the topic. For all lessons designed this hook was included in the engage section of the lesson. Below you can see the embedded YouTube video regarding a time lapse of seed germination. You will also see that there are some guiding questions to engage thinking about the topic and what is to come next. In the situation where this lesson is teacher led these questions will be addressed to the whole class. In a situation where the student is learning on their own these questions act as guides to what they should be thinking about. The engage section also includes vocabulary for the lesson and the essential question.



The explore section provides additional background information and the lab or task that students are asked to complete. In a lesson on the effects of rooting hormones the following information was given to the students to begin their experimental design.

Explore- background information and lab Conservation Science > Science: The Effects of Rooting Hormone

How can we increase the chances of a cutting or clones to be successful?

What is rooting hormone?

Rooting hormones are sometimes called auxin hormones. These types of hormones allow for switching of plant cells to produce root cells instead of stem cells. People who propagate plants use rooting hormones to speed up the process of root development and also allow for a more successful plant.

Caution: Rooting hormones can sometimes inhibit plant growth and should not be used on petunias or inpatients.

Can cuttings/clones be grown without rooting hormone?

When strawberry plants grow they send off horizontal shoots called runners or stolons which have clones or daughter plants on them. The goal of sending off runner plants is to increase the overall reproductive success of the plant and increase its colonial size.

Some plants, like strawberries are really good at propagating and cloning themselves. Plants like willow and raspberries are also well adopted for cloning. Some plants produce specific hormones that activate the change of stem cells into root cells while conditions are just right and allow for daughter plants to quickly emerge off from runners.

How can we determine if rooting hormone is the best method for promoting root growth?

Materials

1. vermiculite/perlite
2. 1040 flats with drainage
3. willow water
4. rooting hormone
5. cinamon
6. water
7. cuttings
8. strawberry runners with clones

Procedure

1. Work with your group to decide what the proper procedure should be for the test.
2. Determine a method to collect data and observe changes. How long will the test last for? How often will you check on the tests?
3. Discuss your independent variable to test and what will be the dependent variable.
4. Set up and prepare your cuttings and clones for your test. Carefully follow your procedure throughout the set up and the continuing time period.
5. Measure and record data for the determined sampling time for both the test and the control.

How Long Do I Collect Data For?

Determining how long to collect data is difficult. You want to have enough information to gain an understanding of what is happening and any trends that may be present. For some experiments this can be years and for others it could be a few minuets. You will need to determine the time span to collect data for.

How to Interpret Test Results

All cuttings will appear differently. With this experiment you are gaining knowledge about cuttings, clones, and hormonal use in a greenhouse application. With time there should be a noticeable difference in root development between the test and the control.

After completing reading this information or going over it as a group the students move on to designing and implementing a procedure or experiment to answer the given question. In the case from above that question would be, “How can we determine if rooting hormone is the best method for promoting root growth?” The students have access to all materials and work in groups or by themselves to decide what they want to do and how long they want to collect data for. The guidelines for grading and participation are outlined in the next section below for the rooting hormone lab. Students also have access at any time to the grading rubric that is given for all practical based work. The practical based work rubric is also aligned to CDOS standards with regard to standards 2 and 3a for integrated learning and universal foundation skills.

Explain: Learning Experiences

Expected results

- Root development data will vary from group to group.
- Students will check on their designs for data collection, collect and analyze data.
- Students will better understand a control and a test and be able to compare results.

Elaborate: Extending & Defining

- Students will design and implement their test with regards to rooting hormone application and the control.
- Students will analyze and discuss their findings after conducting their experiments.

Rubric for practical skills:

Student Performance in Lab	
5	You assumed a leadership role in the lab and/or were instrumental in the group effort toward a successful completion of the project. Evidence backed statements and understanding of key concepts were generated. The experimental design process was used and supports the objective of the lab. Multiple data points have been collected and some thought is given as to the number of points needed to increase the validity of the results. The analysis of the data may include a graphical/table representation. Results were used to support a conclusion. You are able to explain your thoughts and findings in a way that indicates a superior understanding of the concepts and/or a deeper thought process than was required in the completion of the activity.
4	You were a full and active participant in the lab. Statements were generated. The experimental design process was used and supports the objective of the lab. Multiple data points have been collected. The analysis of the data may include a graphical/table representation. Data analysis is used to support the objective and to explain how the objectives were met. The conclusion includes a discussion of other factors which may have influenced the data. Each of these factors is fully explained and the possible effect is evaluated.
3	You participated fully in the lab. The objective is partially understood. An experimental design process was used sometimes. A sufficient amount of data was collected to perform an analysis. The analysis was partially

	completed. The data was weakly used to form a conclusion that responds to the objective. You show some general understanding of the concepts involved and may be able to answer any analysis questions.
2	You participated fully in the lab. The objective is not addressed completely. Data is recorded on the data table and some attempt is made at analyzing the data. You made weak or unsupported conclusion statements.
1	The student was present for the lab, participated, and recorded data but did not participate fully.

For all projects 50% of the total science grade is based on the practical application and the "doing" of the lab. Agilix Buzz allows for the students to see their grades in real time and see where they stand throughout the process. For each one of the lessons designed there are two grading areas. One is found under the expectations and elaborations and the other under the evaluation. Below is an example of an assessment placed in Agilix Buzz to monitor student understanding after completion of the project. The evaluation assessment is typically done after the project is completed.

For culinary students after looking and monitoring microgreens reaction to heat the following short evaluation was submitted. Here you can see the point value of each of the questions and the score that the student was given. Remember that this evaluation is to check progress and understanding.

Questions

X 1. Microgreens grow fairly quickly. We tested the addition of heat to see how it would effect the microgreens growth. What were your overall results?

The microgreens under the heat in the soil lived, while the microgreens on the mat died.

8 / 10

✓ 2. Determine one issue or problem you experienced while collecting data?

the water in the microgreens with the mat dried out faster than the water with the microgreens and soil.

10 / 10

✓ 3. What is the process in which your group collected data? How did you set up your experiment?

we set up the experiment by putting microgreens in soil and on mats, gave them all equal water and heat. we collected data by checking the mesurments of how tall each microgreen grew.

10 / 10

✓ 4. Microgreens are very nutritious. What are four nutrients they provide?

The nutrients found the most in micro greens are potassium, iron, zinc, magnesium and copper.

8 / 8

For computer technology's energy audit of the greenhouse a matching for vocabulary was also included.

X 4. We talked about energy use in the greenhouse. Match the following energy related terms to their definitions.

✓ 1.	a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour	kilowatt-hour
✓ 2.	a tool typically used on military and civilian aircraft that uses a thermographic camera and senses infrared radiation	FLIR
X 3.	a unit of difference in electrical potential	watt
X 4.	measurement of electrical current	volt
✓ 5.	unit of illuminance, equal to one lumen per square meter	lux
✓ 6.	the power in an electric circuit in which the potential difference is one volt and the current one ampere	watt
✓ 7.	electromagnetic radiation having a wavelength just greater than that of the red end of the visible light spectrum	infrared

10 / 14

Below is a series of samples of a full Agilix Buzz lesson that helped guide the students through the learning process with the 5 E inquiry method. You will see that students are able to easily navigate through the lesson if they happened to be absent or missed information. When used in the classroom Agilix Buzz is able to be used in a way that it is an interactive and imbedded slide show. Instead of having students take notes, Agilix Buzz allows students to work through multiple ways of learning. In each lesson notes and background information are provided but so are interactive videos. Agilix Buzz has the ability to track student engagement and learning and also allows for discussion boards and assessments all to be in one place.

Sample Agilix Buzz Lesson in Culinary

In the lesson below students in Culinary were asked to look into if micro-greens grow best with or without heat. Students were asked to prepare an experiment to test this idea and were responsible for tracking data and collecting evident to support or disprove a hypothesis. By the end of this lesson it was clear that the micro-greens selected grew best without heat.

Science: Do micro-greens like heat?

Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Culinary in a Green Space

Folder Contents

- Engage
- Explore- background information and lab
- Expectations and Elaborations
- Evaluation

Engage Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Culinary in a Gree…

By the end of this lesson you will be able to better design an experiment, collect data and make suggestions for how micro-greens should be grown in the greenhouse.

Introduction to Problem Solving

Watch the following videos:

Questions to Consider:

Have you ever hear of or eaten micro-greens?

What are micro-greens?

How can you use them for a nutritional boost?

What are the benefits to using micro-greens?

Can you think of a dish that you could use micro-greens in?

Explore- background information and lab Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Culinary in a Green Space >..

Do micro-greens prefer warmer or cooler temperatures?

How much warmth do micro-greens prefer?

Micro-greens can be grown year round in a greenhouse with the right temperatures and conditions. Micro--greens do not require as much light as other vegetables so they are a healthy alternative in the winter months. However, what is the perfect temperature for growing a micro-green mix? All seeds prefer warmth to germinate and most like a temperature around 70 degrees Fahrenheit.

How can we determine which temperature micro-greens like the best?

Materials

1. heat mats
2. lighting racks
3. 2 micro-green trays or 1020 trays that do not leak
4. soil or grow fiber
5. water
6. tool to measure water
7. micro-green seeds that were germinated before the start of the lab
8. digital camera
9. data log

Procedure

1. Work with your group to determine a method of testing what temperature micro-greens prefer to grow in using the materials provided. Remember when designing a test all conditions need to remain the same except the independent variable
2. Determine a method to collect data and design a data collection chart with your group.
3. determine the time to collect data.
4. Analyze your data and draw a conclusion with discussion of why you believe the micro-greens grew the way they did.

How Long Do I Collect Data For?

Determining how long to collect data is difficult. You want to have enough information to gain an understanding of what is happening and any trends that may be present. For some experiments this can be years and for others it could be a few minuets. You will need to determine the time span to collect data for.

How to Interpret Test Results

All experiments work differently. In this lab we want to see how temperature effects the growth of micro-greens. Specifically we are looking at how we can increase the speed in which micro-greens grow. Draw conclusions based on what your data shows.

Expectations and Elaborations Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capsto

Application Task

Explain: Learning Experiences

Expected results

- Experimental design will vary for each group. However, there should only be one independent variable, the heat.
- Students will check on their designs for data collection, collect and analyze data
- Students may document the micro-greens growth with a digital camera

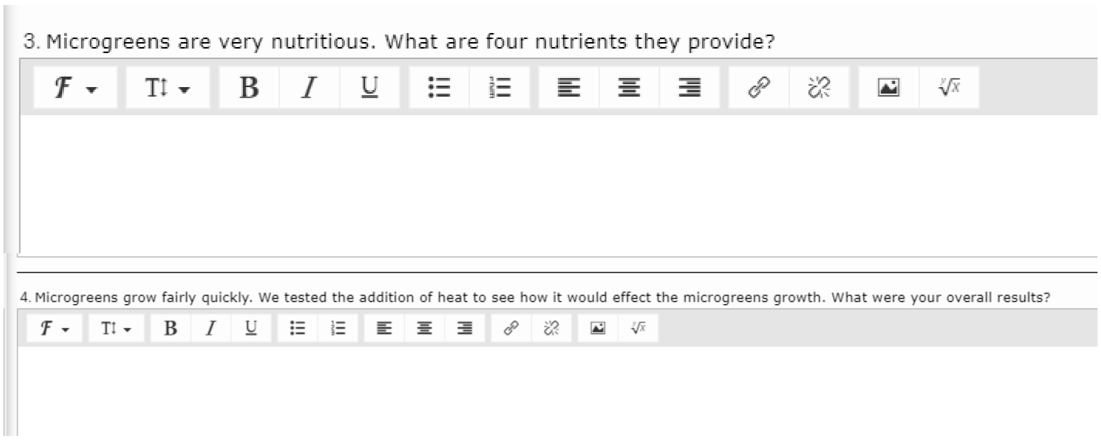
Elaborate: Extending & Defining

- Students will design and implement their experiments.
- Students will analyze and discuss their findings after conducting a mini study on how temperature effects the growth of micro-greens and harvest time.

Student Performance in Lab Rubric for Expectations	
5	You assumed a leadership role in the lab and/or were instrumental in the group effort toward a successful completion of the project. Evidence backed statements and understanding of key concepts were generated. The experimental design process was used and supports the objective of the lab. Multiple data points have been collected and some thought is given as to the number of points needed to increase the validity of the results. The analysis of the data may include a graphical/table representation. Results were used to support a conclusion. You are able to explain your thoughts and findings in a way that indicates a superior understanding of the concepts and/or a deeper thought process than was required in the completion of the activity.
4	You were a full and active participant in the lab. Statements were generated. The experimental design process was used and supports the objective of the lab. Multiple data points have been collected. The analysis of the data may include a graphical/table representation. Data analysis is used to support the objective and to explain how the objectives were met. The conclusion includes a discussion of other factors which may have influenced the data. Each of these factors is fully explained and the possible effect is evaluated.
3	You participated fully in the lab. The objective is partially understood. An experimental design process was used sometimes. A sufficient amount of data was collected to perform an analysis. The analysis was partially completed. The data was weakly used to form a conclusion that responds to the objective. You show some general understanding of the concepts involved and may be able to answer any analysis questions.
2	You participated fully in the lab. The objective is not addressed completely. Data is recorded on the data table and some attempt is made at analyzing the data. You made weak or unsupported conclusion statements.
1	The student was present for the lab, participated, and recorded data but did not participate fully.

1. Determine one issue or problem you experienced while collecting data?

2. What is the process in which your group collected data? How did you set up your experiment?



Sample Agilix Buzz Lesson in Conservation

In conservation students looked into the effects of auxin (rooting hormone) with regards to cloning plants. Students decided to test both strawberry plants and Christmas cacti at the same time. In the lesson below students are able to make decisions about the time of the study, the procedure and what data they want to collect. The results from this experiment were interesting. Initially the students wanted to continue the study for only three weeks and collect data. This worked well due to rotations in their schedules but having not cleaned up the experiment and not transplanted the propagated plants allowed the study to continue for 6 weeks. In the additional weeks of the study students observed that the control's root growth caught up to the root growth of the treated cuttings. With inquiry like this students are able to track data, observe changes and make recommendations for what should be done next.

DCMO Science

Science: The Effects of Rooting Hormone

Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Conservation in a Green Space

Folder Contents

- Engage
- Explore- background information and lab
- Expectations and Elaborations
- Evaluation

Engage Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Conservation in a Green Space > Science: The Effects of Rooting Hormone

By the end of this lesson you will be able to better understand the effects of rooting hormone and discover which rooting hormone promotes the most root growth.

Introduction to Problem Solving

Watch the following video:

Questions to Consider:

How do you think we can best promote root growth in a plant while making a cutting?

What does root growth hormone do to the plant?

Can willow water or cinnamon be used as rooting hormone?

Do you have to use rooting hormone to promote root development?

Vocabulary:

- rooting hormone
- axillary bud
- auxin hormone

How can we increase the chances of a cutting or clones to be successful?

What is rooting hormone?

Rooting hormones are sometimes called auxin hormones. These types of hormones allow for switching of plant cells to produce root cells instead of stem cells. People who propagate plants use rooting hormones to speed up the process of root development and also allow for a more successful plant.

Caution: Rooting hormones can sometimes inhibit plant growth and should not be used on petunias or inpatients.

Can cuttings/clones be grown without rooting hormone?

When strawberry plants grow they send off horizontal shoots called runners or stolons which have clones or daughter plants on them. The goal of sending off runner plants is to increase the overall reproductive success of the plant and increase its colonial size.

Some plants, like strawberries are really good at propagating and cloning themselves. Plants like willow and raspberries are also well adopted for cloning. Some plants produce specific hormones that activate the change of stem cells into root cells while conditions are just right and allow for daughter plants to quickly emerge off from runners.

How can we determine if rooting hormone is the best method for promoting root growth?

Materials

1. vermiculite/perlite
2. 1040 flats with drainage
3. willow water
4. rooting hormone
5. cinamon
6. water
7. cuttings
8. strawberry runners with clones

Procedure

1. Work with your group to decide what the proper procedure should be for the test.
2. Determine a method to collect data and observe changes. How long will the test last for? How often will you check on the tests?
3. Discuss your independent variable to test and what will be the dependent variable.
4. Set up and prepare your cuttings and clones for your test. Carefully follow your procedure throughout the set up and the continuing time period.
5. Measure and record data for the determined sampling time for both the test and the control.

How Long Do I Collect Data For?

Determining how long to collect data is difficult. You want to have enough information to gain an understanding of what is happening and any trends that may be present. For some experiments this can be years and for others it could be a few minuets. You will need to determine the time span to collect data for.

How to Interpret Test Results

All cuttings will appear differently. With this experiment you are gaining knowledge about cuttings, clones, and hormonal use in a greenhouse application. With time there should be a noticeable difference in root development between the test and the control.

Expectations and Elaborations Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Conservation in a Green Spa

Application Task

Explain: Learning Experiences

Expected results

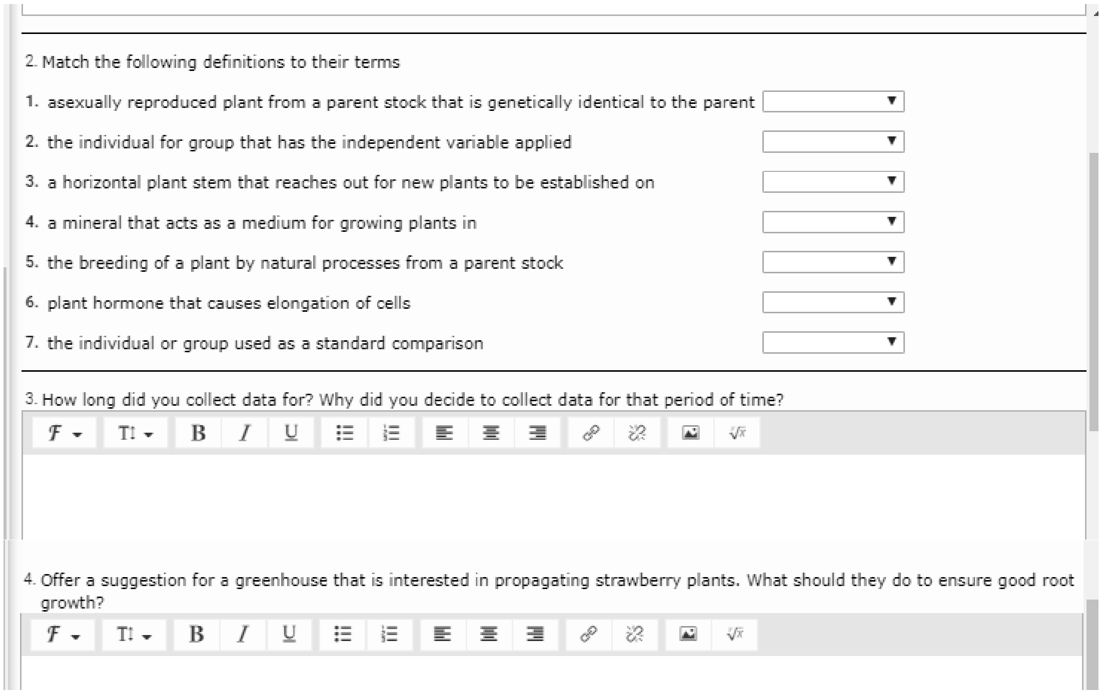
- Root development data will vary from group to group.
- Students will check on their designs for data collection, collect and analyze data.
- Students will better understand a control and a test and be able to compare results.

Elaborate: Extending & Defining

- Students will design and implement their test with regards to rooting hormone application and the control.
- Students will analyze and discuss their findings after conducting their experiments.

Evaluation Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Conservation in a Green Space > Science: The Effects of Rooting Hormone

1. Based on your results, which method worked the best for promoting root growth?



2. Match the following definitions to their terms

1. asexually reproduced plant from a parent stock that is genetically identical to the parent
2. the individual for group that has the independent variable applied
3. a horizontal plant stem that reaches out for new plants to be established on
4. a mineral that acts as a medium for growing plants in
5. the breeding of a plant by natural processes from a parent stock
6. plant hormone that causes elongation of cells
7. the individual or group used as a standard comparison

3. How long did you collect data for? Why did you decide to collect data for that period of time?

4. Offer a suggestion for a greenhouse that is interested in propagating strawberry plants. What should they do to ensure good root growth?

Sample Agilix Buzz Lesson in Computer Technology

Computer technology opened the doors for many studies and observations to be made in regard to the function of the greenhouse. In the following lesson computer technology students decided to gather information about the energy consumption used in the greenhouse. They collected and analyzed data on energy use with the lighting, air sealing, energy loss and also potential areas for conserving energy. Students engaged in finding out more about the greenhouse and how it functions as a system while learning about energy and how to conserve energy too.

Science: Energy Audit of the Greenhouse

Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Computer Networking/Technology in a Green Space

Folder Contents

- Engage
- Explore- background information and lab
- Expectations and Elaborations
- Evaluation

Engage Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Computer Networking/Technology in a Green Space > Science: Energy Audit of t

By the end of this lesson you will be able to better understand energy use in the greenhouse and identify ways in which energy can be conserved while working in the greenhouse.

Introduction to Problem Solving

Watch the following videos:

Questions to Consider:

What types of energy are being used in the greenhouse?

What is the energy consumed in the greenhouse being used to do?

How could an analysis of the energy use and consumption in the greenhouse be used to make informed decisions of how the greenhouse functions?

Can an energy audit save you money? How and where?

Vocabulary:

- Artificial intelligence (AI)
- energy
- audit
- lumens
- kilowatt hours

Explore- background information and lab Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Computer Netwc

Why it important for greenhouses to have equal and appropriate distribution of water?

How much water do plants need?

Watering plants in a greenhouse is often a judgment call. There are no fast and hard rules to proper watering and a lot is dependent on the environment and conditions surrounding the plants. For example on a hot day a lot of the water will evaporate into the environment. To determine how much water plants need you need to check the pots they are in and see how much water is already present before watering. You want the soil to be moist and you want the water to be absorbed by the roots to help with plant growth, which means you need to water slowly.

What happens when plants are over watered?

When plants are over watered they show signs of stress. The roots need oxygen to grow and saturated soil does not allow the roots oxygen. Sometimes over watering will present with stunted growth, yellowing leaves, leaf burn or even root rot.

What happens when plants are under watered?

Under watered plants tend to wilt and stunt their growth to conserve energy. Under watering can also stress the plants. Signs of stress may be wilting, limp leaves, or even not produce fruit. In severe cases you could even have dried leaves and dead leaves at starting at the base of the plant or the plants roots may begin to show.

How can we determine what waters better: a human or the automatic watering system?

Materials

1. greenhouse map
2. rain gauges or graduated cylinders
3. hoses and sprinkler system set up

Procedure

1. Work with your group to fill in the greenhouse map and determine where the watering systems are and what type they are.
2. Determine a method to collect water and measure the accuracy of the automatic watering system throughout the greenhouse.
3. Measure and record data for the determined sampling time for both the automatic watering and the human based watering.

How Long Do I Collect Data For?

Determining how long to collect data is difficult. You want to have enough information to gain an understanding of what is happening and any trends that may be present. For some experiments this can be years and for others it could be a few minuets. You will need to determine the time span to collect data for.

How to Interpret Test Results

All watering systems work differently. In this lab we want to see how accurate and how much water is placed on the plants throughout the greenhouse. Does a human do a better job or the automatic system? Draw conclusions based on what your data shows.

Expectations and Elaborations Extras- Conservation and Culinary > Anderson- Greenhouse Curriculum for Capstone > Computer Networking/Te

Application Task

Explain: Learning Experiences

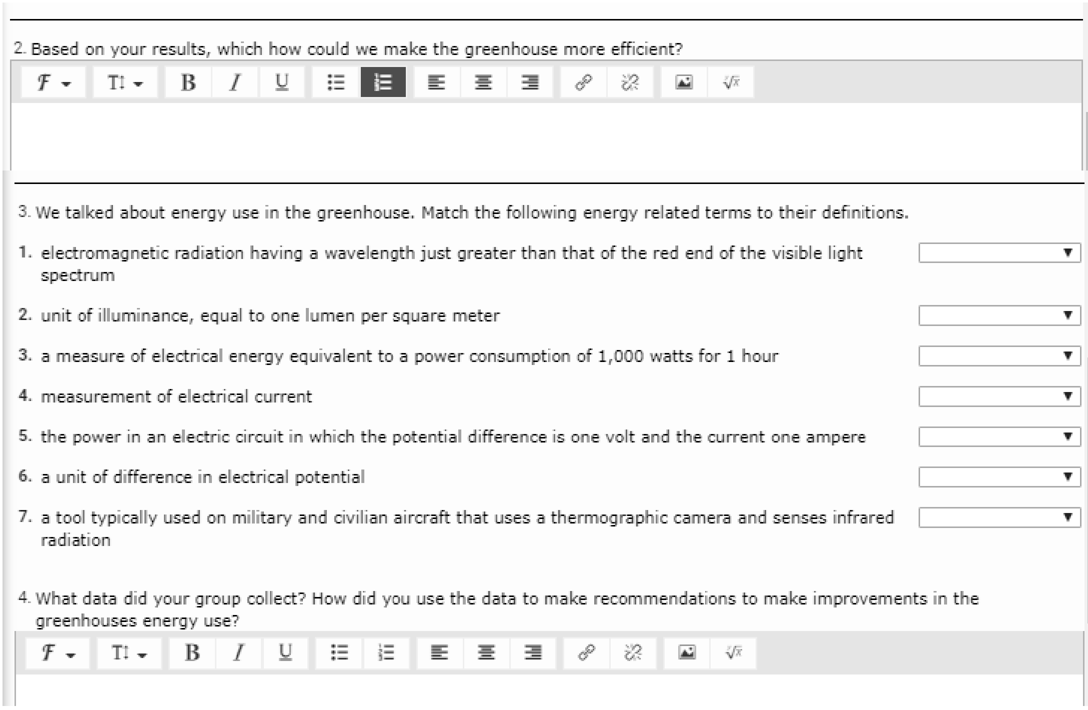
Expected results

- watering system data will vary for each group
- Students will check on their designs for data collection, collect and analyze data

Elaborate: Extending & Defining

- Students will design and implement their test into the greenhouse watering system.
- Students will analyze and discuss their findings after conducting a mini study on the accuracy and amount of watering performed by hand and by the automatic watering system.

1. Determine one issue or problem you were able to identify regarding the greenhouses energy use. How could the greenhouse have been re-designed to overcome this problem?



2. Based on your results, which how could we make the greenhouse more efficient?

3. We talked about energy use in the greenhouse. Match the following energy related terms to their definitions.

1. electromagnetic radiation having a wavelength just greater than that of the red end of the visible light spectrum
2. unit of illuminance, equal to one lumen per square meter
3. a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour
4. measurement of electrical current
5. the power in an electric circuit in which the potential difference is one volt and the current one ampere
6. a unit of difference in electrical potential
7. a tool typically used on military and civilian aircraft that uses a thermographic camera and senses infrared radiation

4. What data did your group collect? How did you use the data to make recommendations to make improvements in the greenhouses energy use?

Closing Summary

Career and Technical Education requires the integration of science education to build a successful program that is supported by the Perkins Act. Students who attend a CTE program learn by doing and are able to easily apply what is learned out in the shop into the classroom with guidance and leading lessons to help students better their understanding of scientific practices. Throughout this project the 5 E Inquiry Method was used to guide the building of content students could work with in Agilix Buzz. Inquiry which is student centered allows the teacher to be a facilitator of learning. By having non-science students engage in learning where they will be asked to think more like a scientist the students are able to build their scientific reasoning skills. Providing content-rich activities that are authentic will allow students to gain scientific reasoning skills and move toward being a more formal operational learner which was the goal of the lessons designed in this project.

The lessons developed allow for continued co-teaching opportunities for the science teacher to work with the content area teacher in a way where lessons can be extended on. For example, with regards to the data collection students were asked to use time outside of the typical science lesson to extend their own learning through data collection and asking questions about what they were observing. In conservation students were expected to continue their study and observations for approximately three weeks. In this time the co-teachers worked together to tract student progress and assess the students on their ability to work as a group, use time wisely and continue to their projects into a period in which conclusions could be made. Before integrating the greenhouse lessons into the curriculum students tended to apply learning in a more scientific setting and perform an assessment aligned to the specific lesson. For these more long term lessons students were expected to extend their learning beyond the designated science time.

The final result of this project provided both the DCMO BOCES Harrold Campus and the Norwich Campus with additional curriculum to better utilize a green space which was underutilized at the time. By working closely with the CTE teachers, the science teachers can easily implement and use the developed curriculum across the shared Agilix Buzz platform. The provided lessons clearly link program units to NYS NGSS and CDOS standards and allows for students to better their understanding of the nature of science and science process skills.

References

Anderson, R., Feldman, S., & Minstrell, J. (2014). Understanding relationship: maximizing the effects of science coaching. *Comprendiendo Relaciones: Maximizando Los Efectos de Los Entrenamientos/Coaching En Ciencias.*, *22*(50–57), 1–25. https://doi.org/10.14507/epaa.v22n54.2014

Ashford, S., Lanehart, R., Kersaint, G., Lee, R., & Kromrey, J. (2016). STEM pathways: examining persistence in rigorous math and science course taking. *Journal of Science Education & Technology*, *25*(6), 961–975. https://doi.org/10.1007/s10956-016-9654-0

Bermudez, G. M. A., Díaz, S., & De Longhi, A. L. (2018). Native plant naming by high-school students of different socioeconomic status: implications for botany education. *International Journal of Science Education*, *40*(1), 46–66. https://doi.org/10.1080/09500693.2017.1397297

Butler, A. C., Godbole, N., & Marsh, E. J. (2013). Explanation feedback is better than correct answer feedback for promoting transfer of learning. *Journal of Educational Psychology*, *105*(2), 290–298. https://doi.org/10.1037/a0031026

Carver, J., & Wasserman, B. (2012). Hands-on hydroponics. *Science Teacher, 79*(4), 44–48.

Drage, K. (2009). Modernizing career and technical education programs. *Part of a Special Section Entitled The Future of CTE*, *84*(5), 32–34.

Grady, J. R., Dolan, E. L., & Glasson, G. E. (2010). Agriscience student engagement in scientific inquiry: representations of scientific processes and nature of science. *Journal of Agricultural Education*, *51*(4), 10–19. https://doi.org/10.5032/jae.2010.04010

Grooms, J., Enderle, P., & Sampson, V. (2015). Coordinating scientific argumentation and the next generation science standards through argument driven inquiry. *Science Educator, 24*(1), 45–50.

Hart, E. R., Webb, J. B., & Danylchuk, A. J. (2013). Implementation of aquaponics in education: an assessment of challenges and solutions. *Science Education International*, *24*(4), 460–480.

Hobley, J. (2016). 'Here's the iPad'. The BTEC philosophy: how not to teach science to vocational students. *Research in Post-Compulsory Education*, *21*(4), 434–446.

Holbrook, J., Rannikmäe, M., & Valdmann, A. (2014). Identifying teacher needs for promoting Education through Science as a paradigm shift in Science Education. *Science Education International*, *25*(2), 4–42.

Jenny, L. (2009). Can theoretical constructs in science be generalized across disciplines? *Journal of Biological Education (Society of Biology)*, *44*(1), 5–11.

Johns, G., & Mentzer, N. (2016). STEM integration through design and inquiry. *Technology & Engineering Teacher*, *76*(3), 13–17.

Käpylä, M., Heikkinen, J., & Asunta, T. (2009). Influence of content knowledge on pedagogical content knowledge: the case of teaching photosynthesis and plant growth. *International Journal of Science Education*, *31*(10), 1395–1415. https://doi.org/10.1080/09500690802082168

Kirby, T. (2008). A garden of learning. *Science & Children*, *45*(9), 28–31.

Krämer, P., Nessler, S. H., & Schlüter, K. (2015). Teacher students' dilemmas when teaching science through inquiry. *Research in Science & Technological Education*, *33*(3), 325–343. https://doi.org/10.1080/02635143.2015.1047446

Manz, E. (2015). Resistance and the development of scientific practice: designing the mangle into science instruction. *Cognition and Instruction*, *33*(2), 89–124. https://doi.org/10.1080/07370008.2014.1000490

Mavhunga, E., & Rollnick, M. (2016). Teacher- or learner-centred? Science teacher beliefs related to topic specific pedagogical content knowledge: a South African case study. *Research in Science Education*, *46*(6), 831–855. https://doi.org/10.1007/s11165-015-9483-9

Melville, W., Bartley, A., & Fazio, X. (2013). Scaffolding the inquiry continuum and the constitution of identity. *International Journal of Science & Mathematics Education*, *11*(5), 1255–1273. https://doi.org/10.1007/s10763-012-9375-7

Milne, C., Scantlebury, K., Blonstein, J., & Gleason, S. (2011). Co-teaching and disturbances: building a better system for learning to teach science. *Research in Science Education*, *41*(3), 413–440. https://doi.org/10.1007/s11165-010-9172-7

Michel, H., & Neumann, I. (2016). Nature of science and science content learning. *Science & Education*, *25*(9/10), 951–975. https://doi.org/10.1007/s11191-016-9860-4

Moore, C. J. (2012). Transitional to formal operational: using authentic research experiences to get non-science students to think more like scientists. *European Journal of Physics Education*, *3*(4), 1–12.

Myers, B., & Washburn, S. (2008). Integrating Science in the Agriculture Curriculum: Agriculture Teacher Perceptions of the Opportunities, Barriers, and Impact on Student Enrollment. *Journal of Agricultural Education*, *49*(2), 27–37.

Packard, B. W.-L., Gagnon, J. L., & Moring-Parris, R. (2010). Investing in academic science for allied health students: challenges and possibilities. *Career & Technical Education Research*, *35*(3), 137–156. https://doi.org/10.5328/cter35.311

Pearson, D., Young, R. B., & Richardson, G. B. (2013). Exploring the technical expression of academic knowledge: the science-in-CTE pilot study. *Journal of Agricultural Education*, *54*(4), 162–179. https://doi.org/10.5032/jae.2013.04162

Quigley, C., Marshall, J. C., & Deaton, C. C. M. (2011). Challenges to inquiry teaching and suggestions for how to meet them. *Science Educator*, *20*(1), 55–61.

Schwartz, J. (2017). Incorporating guided and open inquiry into the CTE classroom. *Techniques: Connecting Education & Careers*, *92*(6), 46–49.

Seraphin, K. D., Philippoff, J., Kaupp, L., & Vallin, L. M. (2012). Metacognition as means to increase the effectiveness of inquiry-based science education. *Science Education International*, *23*(4), 366–382.

Shing, Y. L., & Brod, G. (2016). Effects of prior knowledge on memory: implications for education. *Mind, Brain & Education*, *10*(3), 153–161. https://doi.org/10.1111/mbe.12110

Shore, R., Ray, J., & Goolkasian, P. (2013). Too close for (brain) comfort: improving science vocabulary learning in the middle grades. *Middle School Journal*, *44*(5), 16–21.

Spindler, M., & Greiman, B. C. (2013). CTE teachers and the process of CTE and science content integration. *Career & Technical Education Research*, *38*(2), 125–146. https://doi.org/10.5328/cter38.2.125

Tonso, K. (2014). Making science worthwhile: still seeking critical, not cosmetic, changes. *Cultural Studies of Science Education*, *9*(2), 365–368. https://doi.org/10.1007/s11422-012-9448-5

Ulmer, J. D., Velez, J. J., Lambert, M. D., Thompson, G. W., Burris, S., & Witt, P. A. (2013). Exploring Science Teaching Efficacy of CASE Curriculum Teachers: A Post-Then-Pre Assessment. *Journal of Agricultural Education*, *54*(4), 121–133. https://doi.org/10.5032/jae.2013.04121