Abstract

The Plant Science Laboratory Manual Project was designed to accompany an already established plant science course curriculum at Denmark High School in Denmark, Wisconsin. The plant science course will now require a more hands on learning component because of the newly constructed greenhouse. The aim of the project was to provide a laboratory manual to each student enrolled in the plant science course, which will be used as an assessment tool for instructors and as a way for all instructors to ensure consistency between course sections. The project encompasses expanding the curriculum to provide more hands on learning opportunities within the greenhouse. The Curriculum for Agricultural Science Education (CASE) Institute offered a professional development workshop to train teachers for the instruction of plant sciences. Participants were provided with important background related to the pedagogy used in CASE curriculum and practice teaching lessons to prepare them for classroom and laboratory instruction. Participating in the CASE Institute was the beginning of compiling laboratory activities that work best for the course curriculum already established and the utilization of the greenhouse. The resulting laboratory curriculum of this project will be used to incorporate the laboratory component to the already established plant science course. The laboratory manual was compiled through time spent reviewing plant science laboratory resources and integrating them into the classroom curriculum. The curriculum is comprised on ten units with 26 individual labs for students to complete. Lab activities are taken from Biology and Earth science with Vernier, CASE Principles of Agriscience – Plant, and the Introductory to Horticulture Lab Manual. The laboratory curriculum will be used to compliment the high school plant science course and will be evaluated on an annual basis to improve laboratory activities.
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Introduction & Background

A Chinese Proverb states: “Tell me and I forget, show me and I remember, involve me and I understand.”

Agri-science educators are faced with opportunities and challenges each day they enter the classroom. The first time the above quote is heard, educators may begin to understand why agricultural education is so important. Beginning teachers can be faced with the challenges of just telling students concepts or showing students a concept, and then becoming frustrated when students do not remember. Time after time educators are faced with that same challenge. However, during teacher training and professional development opportunities teachers are continually reminded that if students are not involved in the learning process, they may not understand. According to the Benefits of Hands on Learning website (2011), “…it has been proven the students are going to have a lasting comprehension of things they do in comparison with the ones they only see or hear.” (¶ 2)

Local greenhouses in the Denmark community wanted to begin the training of students, potential future employees, in a school greenhouse through plant science courses and then potentially hire Co-op/Work Based learning students to work for them during their senior year. The School District of Denmark is located in a very strong agriculturally supported community. Agriculture industries include, but are not limited to, dairy production, crop production, and harvesting businesses and horticulture. The need for a school greenhouse was proven because of the horticulture industry that was present within the community.

The school greenhouse committee had the opportunity to show the school board the need for building a greenhouse. The need had to be supported by the local greenhouse industry, as well as, investigating other area school greenhouses: how they were originally built, how they
are sustained financially, and potential outside costs the district would be faced with if the greenhouse was not self-sustaining. The committee had no hesitation with proving the need for the greenhouse. At that point Denmark High School offered a plant science course, which was taught annually. The disadvantage students faced was that the course was lecture style only because there was not a greenhouse facility, not even grow lights in the classroom. After students took this course, most did not have an interest to pursue a career in plant sciences because they did not see the full potential of what could be offered.

Within the first month of the 2010 – 2011 school year, plans were underway for a school greenhouse. Initial designs were drawn, cost estimates for the structure and interior materials were developed, visits to several local school greenhouses were made to get an idea of what was needed. By February of 2011 the greenhouse proposal was made to the school board and approved. Ground breaking took place in April and the complete structure was built in August. Minor set backs with interior structures and materials were ongoing throughout the fall of 2011, but in January 2012 the greenhouse was functioning. In May of 2012 the community was welcomed to the greenhouse for a spring plant sale and open house.

The long range plans include expanding the production of the greenhouse and to have full hydroponic plants producing tomatoes and lettuce for the school lunch program, as well as partnering with other career and technical education programs to produce fresh herbs and other vegetables for the food service classes to use in cooking labs. With this in mind, it was a necessity to begin creating unique plant science laboratory lessons to engage students and to increase the interest of students in the plant science industry. With a greenhouse available for hands on learning experiences, the agriculture department is confident that student interest in the
plant science industry will increase because of the hands-on plant science education provided that will help prepare students for career success.

**Literature Review**

“…, show me and I remember,…” As teachers, it is important to remember the entire quote because of the diverse ways students learn. In most cases students must be taught, shown how to do something and be involved to fully grasp the entire concept. In most cases students will comprehend concepts more fully if given the opportunity to learn by doing. So as teachers, it is vital to show students that learning by doing if not just for students, it is for the teacher as well, which would be to create a curriculum for students to learn by doing. Being that example to students not only shows them that the teacher took initiative to enhance their learning experience, but also that learning is lifelong and teachers are willing to continue to learn and improve curriculum. In the research associated with this project, the main focus was placed on answering the following questions: What is hands-on learning and its limitations? Why use hands-on learning in plant science education?

**What is hands-on learning and its limitations?**

As teachers, it is a goal to inspire students to see more, do more, and be more. When creating laboratory curriculum, the intent is to fully engage students in plant science education. For too long in the School District of Denmark, students were learning about plants in the classroom without ever working with plants. As teachers it must be first, why would teachers want to learn about plants if there was never an application component to actual plants, so why should students care? Additionally, teachers need to keep in mind the variety of learning styles that are present in the classroom (Felder & Brent, 2005). Some students can learn everything they need to know about plants, without ever touching a plant. Still further, some students need
to see demonstrations about plants to begin to understand the concepts, and then there are students who need to be physically engaged in ‘hands-on’ activities (Miller, 2000). As teachers, it is important to keep in mind all the learning styles that are present in the classroom. To ensure student successes, concepts must be taught in a way that encourages all styles.

Hands-on learning is a common phrase used in education, but what is hands-on learning? Hands-on learning is learning by doing (Haury & Rillero, 1994). A hands-on teaching approach requires the students to become more active participants in the learning process and not passive learners who listen to only lectures and videos. Hands-on learning not only allows students to be active learners, it also increases positive attitudes about hands-on learning, and enables students to become critical thinkers, as well, to apply what they have learned to real life situations (“Benefits of hands on learning,” 2011).

For example, if one tried to explain to a child how to ride a bike, without ever allowing the child to sit on a bike, the child may not be as successful in learning how to ride an actual bike. Getting students physically engaged in projects is very important for their individual success. Performing a project successfully from start to finish gives the students an important sense of achievement. The hands-on learning environment also provides the students the opportunity to get used to handling equipment and materials better because of the experience (“Benefits of hands on learning,” 2011).

**Why use hands-on learning in plant science education?**

Hands-on learning is not a new approach in teaching. An emphasis on actively involving students in learning has influenced American Education since the 1860s. However, the term ‘hands-on’ learning seems to have emerged during the 1960s (Ash, 2009). This approach has long been used in Career and Technical Education classes and will continue to be used. The
ability to teach according to the learning styles of students are vital to the success they have to understand and the ability to apply the concepts they are learning about.

The school greenhouse is a terrific example of a way to create positive attitudes toward plant science education, but there are still some limitations to hands-on learning. Those limitations can cause the entire hands-on experience of students to fail. If a teacher is not prepared to teach using a hands-on approach, students will not benefit from the experience (Ferreria, 2004, p. 106). Hands-on learning application is time consuming and is a major obstacle facing educators. Teachers sometime are not given adequate time to prepare proper activities which will enable students to learn the specific objectives needed.

Furthermore, not all students exposed to hands-on learning will be successful because of their learning style. However, research has indicated that students with varying learning experiences will have an overall better experience. Heins-Rothenberger and Stewart (1995) point out, “…recent studies in education have documented that specialized treatment that creates a real world context will produce achievement gains equal to or greater than just the traditional instructional methods” (p. 24). This approach can also foster the development of problem-solving skills, which educators try to help students develop.

So why use hands-on learning when teaching plant science education? Plant science is becoming increasingly more important in our lives because of the need to know how to survive from day to day. People need to understand that daily life requires food, shelter, clothes, and energy, which all depend on plants (Lettice, 2011). Additionally, young people need to be encouraged to pursue careers in plant research and horticulture. Plant scientists and horticulturalists play an important role in maintaining the nation’s food supply by ensuring agricultural productivity and food safety. These scientists study farm crops and develop ways to
improve quantity and quality. Plant scientists look for ways to improve crop yield with less labor, control pests and weeds more safely and effectively, and to conserve soil and water. Some plant scientists look for ways to use agricultural products for fuels. Careers in plant science and horticulture are predicted to increase at a steady rate to meet the needs of the growing world population ("Science careers: plant scientist," 2012).

One way this can be accomplished is through hands-on learning experiences at the secondary level which show students that plant sciences are important.

Lettice (2011) message posted to Communicate Science:

Plant scientists are tackling many of the most important challenges facing humanity in the twenty-first century, including climate change, food security, and fossil fuel replacement. Making the best possible progress will require exceptional people. We need to radically change our culture so that ‘plant scientist’ can join ‘doctor’, ‘vet’ and ‘lawyer’ in the list of top professions to which our most capable young people aspire.

Heins-Rothenberger and Stewert (1995) found, “Overall, the positive knowledge gained with the laboratory instruction supports the emphasis in agricultural education on experimental learning. The greenhouse should be used to provide ‘hands-on’ contextual experiences for students studying horticulture” (p. 28). Since building the greenhouse at Denmark, students have had the opportunity to participate in some hands-on learning activities, which should increase their attitudes toward learning through hands-on techniques (Bicknell, 2000).

Methods & Timetable

The development of my plant science laboratory curriculum project was the result of the implementation of the components detailed below.
Part I: Expanding the Plant Science Laboratory Experience at the High School

The undertaking of a new greenhouse can be extremely intimidating for a teacher just beginning at a new school. Staying positive and focused has helped me to stay on track and begin the undertaking of creating a plant science laboratory curriculum. It was not a matter of when, we knew with the support of the administration in building a greenhouse for our program that the expectations were now. The base classroom curriculum was set, so it was a matter of creating the laboratory activities for students.

The greenhouse is a 35’ x 60’ free standing structure, with in floor heating; an environmental control station controls vents, shade cloth, and heat. The excitement of having a greenhouse was noticeable among all students. They were all very curious on how it would be used and how they could be involved in using it. With the greenhouse built and student interest increasing about plant science education, we were ready to begin teaching more hands-on learning activities. My responsibilities included creating the initial laboratory manual for students to use and a teacher laboratory resource binder.

Part II: Engaging in Professional Development

Being a part of the agricultural education family in Wisconsin, has allowed me to participate in numerous professional development opportunities over the past ten years of my teaching career. My beginning plant science curriculum began during my student teaching experience, but continued after because whenever I have had questions through the years I would meet with DeWayne Fossum. At anytime he would sit down with me to explain new resources he was using that were beneficial or give me new activity handouts I could utilize in my plant science classes. His knowledge and expertise in the plant science area has been an asset to me.
Continuing the past couple of years I have participated in workshops through the Wisconsin Association of Agricultural Educators Professional Development Conference. Some of the workshops I have attended include pesticide applicators certification, teaching inquiry based curriculum, and plant identification. These workshops have proved very useful even when not teaching plant science in a greenhouse setting.

During the summer of 2010 I had the opportunity to attend the nine day Curriculum for Agricultural Science Education – Plant (CASE) Institute held on the Oregon State University campus. This experience was phenomenal. The program was intensive and at times mind draining. The benefit of being trained in the CASE curriculum is that the workshop was not just listening about what the curriculum was about, but we actually were the students learning how to set up the labs, completed the labs, and then learned techniques on how to teach the labs. This professional development opportunity inspired me to pursue teaching a more hands-on learning plant science curriculum.

In August of 2010, I accepted a new teaching position with the Denmark School District. Upon arriving in Denmark, I was immediately put on the school greenhouse initiative committee, which included the current high school agri-science instructor, several FFA alumni members, a local greenhouse manager, and a local greenhouse owner. During this short experience I toured and learned about several school greenhouses in our area. We talked with instructors on how they utilize the greenhouse, how it is funded and future plans for using the greenhouse. This experience was insightful because I was able to talk to agriculture instructors one on one to discuss their experiences, likes, dislikes, and ways they would change how they use it.
Part III: Creating a Baseline Laboratory Curriculum

The purpose of organizing a baseline laboratory curriculum was to have a starting point to develop a set of useful labs in plant science. My initial step was to go through plant science lab resources on file from both instructors. The lab resources on file were then organized according to the units we covered in the course. These resources were kept in a separate 3-ring binder to refer back too. Next, both agri-science instructors discussed what types of labs we were looking to incorporate in the class. We took into account the time we had, as well as this was the first time the class would be taught utilizing the greenhouse and as a semester long block class, so labs would be enhanced or eliminated as the course would be taught. In reviewing the resources we had, we ensured that the lab activities selected aligned to the standards and objectives already set up in the classroom portion. The lab activities were selected to enhance the class curriculum. District approval of the lab activities (enhanced plant science curriculum) will be done at the end of the summer of 2012.

Part IV: Reflecting

Ten years of being in the education field has increased my ability to reflect on everything I do, not only at school, but personally as well. Part of being an educator is to reflect upon what we do in the classroom, which in turn makes us realize what to change to make it better and make us a better teacher so we meet the needs of students. Before and after every formal observation I have had as a teacher, I have needed to reflect on what I would be doing, as well as how the lesson went. Reflection has been a key in building my awareness of what the needs of my students really are, individually and as a whole.

Even reflecting after compiling this project, I can see that more work is still needed to make it better, and realize it will be a forever changing project. Since reflection has been such an
important part of my career, I include as much reflection in my classes as I can. This in turn helps me understand how students view what we are doing and in some cases a short reflection will help me assess if they completely understand the concepts addressed in class. These reflections are then used to re-teach concepts in new ways to ensure students understand what is being taught. The review portion of this project is just more proof of the importance of reflection and the ability for an individual to reflect on what is being done, but take it to the next step and change it according to the needs of the student, lesson or activity.

**Part V: Gathering Resources**

The gathering of resources and possible laboratory activities has been ongoing since beginning teaching in 2002. Reviewing all collected materials over the last decade has allowed me to select and prepare activities that are meaningful to students, as well as, serve as a tool to engage the students to the fullest. The resources that initially make up this manual will be updated as the class is taught because of the changes occurring with materials and student needs.

The initial laboratories are a combination of materials found in the Introductory Horticulture textbook and lab manual, Plant & Soil Science Fundamentals and Applications textbook, CASE Plant Science Curriculum, and teacher sharing sessions from various FFA Leadership Conferences. My goal during this process was to find laboratories that not only had students completing one activity and be finished, but starting an activity and over several days or weeks compile results so they could see the effects certain environmental conditions have on plants over a period of time.

Additionally, my goal was to incorporate activities that would increase my students’ ability to think critically. A district goal in Denmark is for all teachers to focus on giving as
many opportunities for students in increase critical thinking skills and relate it to real world experiences so they can begin to connect what they are doing in school with future careers.

Part VI: Assembling Plant Science Laboratory Curriculum

Laboratory lesson plans and activities are aligned to the National Agriculture, Food and Natural Resources (AFNR) Career Cluster Content Standards by Mary Handrich. The teacher portion of the laboratory manual contains lesson outlines, materials lists, student handouts, and assessment options. The student laboratory manual contains student laboratory hand outs, which contain objectives, standards, materials list, set-up procedures, and assessments. The steps discussed above helped prepare the project for review.

Results

This lab manual project is meant to accompany an already established plant science course curriculum. The plant science course now requires a more hands-on learning component because of the newly constructed greenhouse the district built over the summer/fall of 2011. The result of my plant science laboratory manual project is a three-ring binder of laboratory assessment sheets which correspond to the classroom portion of the course. One binder will be the teacher’s guide, which contains laboratory lesson plans, organized in chronological order within the defined units below. The laboratory lessons indicate the lesson name, objectives, materials needed, standards, lesson outline and student handouts. A second binder will be used as the student plant science laboratory manual, which each student will use while in class. This manual will contain all student hand outs needed for laboratory exercises. Handouts will contains laboratory objectives, materials needed, lab procedures, and assessment questions. The following is the table of contents for the plant science laboratory/activity manual project. The teacher’s resource manual will contain full lessons and additional resources. Student manuals will contain
student activity sheets with information needed for students to set-up labs, record findings and assessments.

**Introduction to Plant Science Laboratory Manual**
- 18 week Course
- Block Scheduling

**Unit 1 – Worlds of Opportunity**
*Lab 1.1 The World of Agricultural Education* (Principals of Agricultural Science – Plant, 2010)
*Lab 1.2 A World Without Enough Plants* (Principals of Agricultural Science – Plant, 2010)

**Unit 2 – Mineral Soils**
*Lab 2.1 Starting from the Ground Up* (Lab Manual Introductory Horticulture, 1997)
*Lab 2.2 Understanding Soil Properties* (Lab Manual Introductory Horticulture, 1997)
*Lab 2.3 Soil Chemistry* (Lab Manual Introductory Horticulture, 1997)

**Unit 3 – Soilless Systems**
*Lab 3.1 Mixing Media* (Lab Manual Introductory Horticulture, 1997)
*Lab 3.2 Hydroponics* (Lab Manual Introductory Horticulture, 1997)

**Unit 4 – Anatomy and Physiology**
*Lab 4.1 Cells: Life’s Smallest Units* (Earth science with Vernier, 2007)
*Lab 4.2 The Radicle Root* (Lab Manual Introductory Horticulture, 1997)
*Lab 4.3 Stems, Stalks, and Trunks* (Lab Manual Introductory Horticulture, 1997)
*Lab 4.4 Leave it to Leaves* (Lab Manual Introductory Horticulture, 1997)
*Lab 4.5 Flower Power* (Principals of Agricultural Science – Plant, 2010)

**Unit 5 – Taxonomy**
*Lab 5.1 Sorting Out Plants* (Biology with Vernier, 2007)
*Lab 5.2 Plant Names* (Principals of Agricultural Science – Plant, 2010)

**Unit 6 – The Growing Environment**
*Lab 6.1 Plant Food* (Principals of Agricultural Science – Plant, 2010)
*Lab 6.2 All Wet* (Principals of Agricultural Science – Plant, 2010)
*Lab 6.3 Lighting it Up* (Principals of Agricultural Science – Plant, 2010)
*Lab 6.4 Chilly Lilies* (Principals of Agricultural Science – Plant, 2010)

**Unit 7 – Sexual Reproduction**
*Lab 7.1 Kernels of Life* (Principals of Agricultural Science – Plant, 2010)
*Lab 7.2 Pollination and Fertilization* (Principals of Agricultural Science – Plant, 2010)

**Unit 8 – Asexual Reproduction**
*Lab 8.1 Plant Multiplication* (Principals of Agricultural Science – Plant, 2010)
Unit 9 – Surviving a Harsh Environment
Lab 9.1 Pesky Bugs and Plants (Lab Manual Introductory Horticulture, 1997)
Lab 9.2 Diving into Diseases (Lab Manual Introductory Horticulture, 1997)

Unit 10 – Crop Production and Marketing
Lab 10.1 Tools of Plant Production (Principals of Agricultural Science – Plant, 2010)
Lab 10.1 Planting Seeds of Fortune (Principals of Agricultural Science – Plant, 2010)

The following is a list of resources that were used in creating the plant science laboratory manual. Actual laboratory lessons are not included in this paper because of copyright. All materials were taken from the resources listed below and compiled together for classroom use.

Examples of Helpful Resources:


The plant science lab manual is divided into ten units, which follows a logical approach to plant science. The course also focuses on student implementation of SAE plans and maintaining records throughout the semester. In the manual there is a section for students to keep SAE records. Each unit contains a basic unit plan which outlines why each lesson/lab will be taught, lesson concepts, performance objectives, and what labs are going to be completed. The
unit is then broken down into lesson format which gives the background information about the lab. The Agriculture Food and Natural Resources Standards and the National Science Standards are also indicated on the lesson. Further standards will be added as the course is taught to address the common core standards. Lesson plans also contain essential questions and the estimated amount of time planned for the lesson. Each lab gives the purpose of the lab so students know why the lab is being conducted, materials needed, the procedure to be followed, and conclusion questions for students to answer. Rubrics for certain labs or projects are also included so students know how they will be graded.

Since the course has not been taught as a full semester block course, more updating will take place because it is a work in progress. As well, not all labs included in the manual will be conducted in the greenhouse. Some will be done within the classroom or outside and some of the labs will require students to research before they conduct the actual lab. The labs were intended to address all learning styles and not just give all the information students’ need, some information students must find on their own. The intent of this course was to encourage students to come to class prepared, organized, and ready to learn, as well as, to become more critical thinkers and be career ready or further their education.

The manual begins with an introduction to plant science unit. This unit focuses on preparing students for the semester, which addresses the requirements of the course, establishes their SAE’s and begins their work on a semester long project, “Your Grower’s Handbook” which is also a section in the manual where students will record data and include information about research completed on specific plants. This information will eventually be used in their final lab project of a ‘School Farm Proposal.” The manual then continues with a soils unit where students will conduct labs utilizing some Lab-Aids kits, gathering soil samples, setting up their lab
stations, and going on site to analyze a soil horizon. This unit is included to show students how soils are important not only to growing plants, but also to building structures.

The third unit focuses on the different types of media used in a greenhouse setting and addressing the differences between soil and media and why growing media is preferred when growing plants in a greenhouse. The media labs allow students to use graduated cylinders, beakers, pipettes, electronic balances, the different greenhouse medias such as vermiculite, perlite, peat moss, potting mix and compare that to sand, silt and, clay soils. During the media unit hydroponics will also be discussed. The Denmark greenhouse has an ebb and flow hydroponics system, but additional research will be done on other systems as well as allowing students to build the hydroponics systems. This section allows students to set up their own lab to determine how plants will grow in the hydroponics system of their choosing.

Next, unit four covers anatomy and physiology of plants. During this unit, students will break down the structure of a plant to the cellular level, make analogies of cell parts and examine the cell structure, roots, leaves, and stems under a microscope. Students will learn how to properly prepare slides for the microscope or utilize the skills learned in other science courses to do this as well use LabQuests to conduct respiration labs. This unit focuses on students application of the materials covered in the class. They will be responsible for conducting each lab according to the procedures in their manual and recording their results. Unit five focuses on plant taxonomy and why it is important to understand how plants are classified. The growing requirements of plants are discussed in unit six. During this unit students will conduct labs focused on testing soils for nitrogen, phosphorus, and potassium, determining the type of fertilizers to apply and in what amounts; and how to detect and treat nutrient deficiencies. Further labs will be conducted on water loss and water, light, and temperature requirements.
Units seven and eight delve into sexual and asexual reproduction of plants. Sexual reproduction is learned through planting seeds and understanding the needs of seeds. Students will learn the differences between monocots and dicots where they will be able to see the differences when seeds begin to germinate and grow. Further investigation will give students the opportunity to dissect flowers locating the eggs and learning about how pollination is required for seed development. Unit eight focuses on asexual reproduction methods, why it is done, why it is important for the plant industry and how to asexually reproduce a plant. Students will learn the proper techniques on how to take cuttings from a variety of house plants, as well as, how to divide plants properly for replanting, basic grafting techniques along with why grafting is used greatly in fruit tree production.

The final two units include unit nine environmental factors and unit ten plant uses. In unit nine students will conduct labs to learn about pests and the effects pests (weeds, insects, mollusks, vertebrate animals) have on plants, as well as the prevention and treatments methods to use. Additional labs will be completed to learn about potential plant diseases, how diseases are spread, prevented and treated. The final unit addresses plant uses where students will learn about common tools and equipment used in crop production and irrigation methods, as well as students will complete final work on their school farm proposal lab project. This lab project will allow students to use the information gathered throughout the semester about specific plants and store this information under the grower’s handbook section of their lab manuals. The school farm proposal allows students to develop a basic business plan to show the financial side of producing crops, taking into consideration growing requirements of each type of plant and environmental factors.
The created plant science laboratory curriculum has the potential to be utilized in numerous ways. For example, it will provide a uniform laboratory manual for all students at Denmark High School who enroll in the Plant Science course. This course is taught by myself and the other agri-science instructor and will provide consistency between the sections that are offered and instructors’ assessment techniques.

This laboratory manual project has truly opened my eyes. I always knew the importance of providing laboratory experiences to my students, but have sometimes put off incorporating those opportunities because of the amount of time it takes to set up labs and organize materials. I have learned that this is not the time to sit back and see if the lab manual will work, but a way for me to continue to learn and change the manual to better meet the needs of the students. It will be an ever changing manual; however I am not going to be discouraged because it will challenge me to continue to provide the best learning environment for my students.

**Conclusion**

“…involve me, and I understand.” Each time a student has the opportunity to apply classroom knowledge to hands-on learning activities, the more likelihood of them retaining the information. A teacher must be able to provide their students with a hands-on experience even for several minutes of a class period, where the student can feel, hear, see, and act on the subject that will be taught during the rest of the period. This can make the class period more fun and interactive, where students are less bored and the learning more effective.

Students want and need to be involved in laboratory experiences so they retain information taught in the classroom. They do not always need information to be ‘given’ to them; they need to be a part of the system, part of the process of acquiring knowledge and seeking to
further their knowledge. Students are not bottles to be filled up, they are learners, competent to learn, curious to experiment and all different.

During this project I was trying to make a true connection that plant science education is truly more effective with hands-on laboratory experiences. Then I remembered back to my student teaching experience at Bloomer High School. When walking into their high school, you will see the Chinese proverb, “Tell me and I forget, show me and I remember, involve me and I understand” painted on their wall. This is a reminder to me that one of the best ways for me to reach my students is to have them participate in hands-on laboratory experiences.
References


Lettice, E. (2011, September 8). Plant science has never been more important. Message posted to http://www.communicatescience.eu


