COLORING, DRAWING, AND WATER COLORING TO LEARN PLANT STRUCTURES: EXPLORING PRE-SERVICE TEACHERS' PERCEPTIONS OF BOTANY LESSONS WITH ART INTERVENTIONS

by

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Chapter 1: Introduction

A major educational movement in the United States is to have all high school graduates 'college and career' ready (THECB, 2016). This requires educators, particularly science educators, to examine the pipeline for science readiness. Two science standards for college and career readiness emphasize an understanding of taxonomy: "D. Classification 1. Understand that scientists categorize things according to similarities and differences." (THECB, p. 17) and "E. Classification and taxonomy 1. Know ways in which living things can be classified based on each organism's internal and external structure, development, and relatedness of DNA sequences" (THECB, 2016, p. 18).

Statement of the Problem

Botany Education

Before an individual chooses a career path he/she is exposed to ideas in school that will help him/her discover interests, strengths, and talents. Beginning in K-12 education, there is lack of information about plant structure and taxonomy, which could prevent people from selecting botanical careers. The Next Generation Science Standards (NGSS, Lead State, 2013) state that the United States should "provide all students an international-benchmarked science education" (NGSS, home page). The standards include many mentions of plants in the context of evolution, genetics, and ecosystems throughout elementary grades and in specific middle and high school grades. However, basic information about plant structures is only detailed in first (1-LS1-1) and fourth grade (4-LS1-1) disciplinary core ideas. There is no mention of plant or animal taxonomy in the NGSS. This lack of in-depth information about plant structure and taxonomy may prevent students from pursuing advanced degrees in botany or from enrolling in a plant taxonomy classes because they are not well informed about plants.

Students wishing to apply their taxonomic knowledge in a botany college class may encounter difficulty finding a college or university that offers a botany or plant science program. Historically, biology departments have developed botany courses and degrees for both undergraduate and graduate students (Kramer, Zorn-Arnold, & Havens, 2013). However, colleges and universities have recently begun eliminating botany programs and courses (Kramer, Zorn-Arnold, & Havens, 2013). Statistics show that the number of botanists in the pipeline to fill botanical positions is decreasing in the United States (Drew, 2011). Kramer, Zorn-Arnold, and Havens (2013) state,

> These data [National Science Foundation] show that in 1988, 72% of the nation's top 50 most-funded universities offered advanced degree programs in botany. By 2009, more than half of these universities had eliminated their botany programs and many, if not all, had eliminated related courses. (p. 173)

One reason botany programs are being cut from college offerings is a lack of qualified people to fill available botany professor position. Other statistics indicate that when botany professors retire they are not replaced, and the position is filled by microbiologists (Kramer, Zorn-Arnold, & Havens, 2013). The elimination of botanical faculty positions will not only have a lasting impact on the academy, but the effects of this shift in academic interest could negatively impact the number of qualified people to fill botanical positions in both the private and public sectors.

Beyond K-12 and college education, recent graduates with botanical graduate degrees are not fully prepared to work in the government or the private sector. A study by Sundberg et al. (2011) found, that skill areas graduate students ranked as their greatest strengths were the same skill areas that potential employers ranked as needing the most improvement. Faculty, government agency staff, and private sector employers ranked plant identification and written communication skills as the top areas that recent graduates needed the most improvement in.

Botany Careers and Education

Because colleges are moving away from botanical education there is an increase in the need for well-educated botanist to fill job vacancies. The United States Department of Labor released the Occupational Outlook Book (Bureau of Labor Statistics, 2014-2015), which details hundreds of jobs and their projected growth over ten years (2012-2022). Botanical fields that require a high school level trainings are showing declines, and skilled botany related jobs show average to above average projected growth rates over ten years, and (Appendix A).

Botany occupations that require a high school education are showing projected declines. For example, Floral Designer, which requires a high school diploma, is projected to decrease 8%, which would eliminate 5,000 jobs. Logging Workers, also requiring a high school diploma, is projected to decline 9% and eliminate 3,800 jobs (Bureau of Labor Statistics, 2014-2015).

Two types of environmental science jobs that require different levels of education and the ability to identify plants are projected to increase faster than the national average. "Environmental Scientist and Specialists" are projected to have 15% new growth and 13,200 new positions (Bureau of Labor Statistics, 2014-15) while "Environmental Science and Protection Technicians" jobs are projected to increase 19% or by 6,200 new jobs (Bureau of Labor Statistics, 2014-15). On August 3, 2015 the private engineering and consulting company NV5 was hiring an environmental scientist to conduct phase one environmental site assessments (ESAs) (NV5, 2015). A phase 1 ESAs requires scientists to document the presence of wetlands and survey for endangered and threatened species in the field. To delineate a wetland, scientist must identify characteristic wetland plant species at a field site; the presence or absence of water does not meet the requirements for documenting a wetland. Endangered plant species are not limited to wetland, but can be present throughout a field site. Identifying wetland and endangered

plant species requires a strong understanding of plant structures and taxonomy. The data from Occupational Outlook Book (2014-15) appears to indicate that within the United States there is an increasing need for educated botanists with associates and bachelor's degrees.

The Importance of Taxonomic Training

Many non-academic, skilled botany positions necessitate the ability to recognize and/or identify plants, which requires botanical taxonomic training. Plants are identified using dichotomous keys in field guides and floras (list of, or key to identify plants in a particular region or area) because they are portable, accurate, and available for most areas. A dichotomous key presents two possible descriptions of morphological structures and the user selects the description that most accurately describes the plant s/he is trying to identify. The following example is a single couplet from a dichotomous key to the genus *Phacelia*,

> 41- Stem prostrate to ± ascending; corolla 1–2 mm; inflorescence axillary, partly hidden by leaves ..... *P. cookei*
>
> 41'- Stem generally ascending to erect; corolla >= 2 mm; inflorescence generally terminal, not hidden by leaves
>
> (Jepson & Hickman, 1993, p. 492)

If the plant has the characteristic of top statement the plant is *Phacelia cookei*, but if it more closely resembles the second description the person identifying the plant would have to move to the next descriptive couplet. This example demonstrates the level of technical knowledge required to identify a plant using a dichotomous key. A person using a dichotomous key must know hundreds of highly specific technical terms and be able to locate and describe the morphological structures on the plant. For example, leaf margin (outer edge of the leaf), pistil (reproductive structure present in flowers), and pericarp (ovary wall that surrounds the seeds in a fruit).

Several examples of non-academic positions that require post-high school education that necessitate the ability to identify plants are noted here. "Biological Technician" positions, which expect applicants to be able to identify plants, are projected to grow 10% creating 8,000 new jobs by the year 2022 (Bureau of Labor Statistics, 2014-15). The Federal job website (www.usajobs.org) had a posting on August 3, 2015 for Biological Technicians (plants) in 59 different cities across nine states. The duties described for this position include "documents occurrence and distribution of identified species" and "lead or conduct field searches for populations of sensitive, threatened or endangered plant species" (www.usajobs.gov, "Duties," para. 1). Both duties require the ability to identify plants in the field, which can be supported by sketching unknown plants in a field notebook and comparing them to line drawings in a fields guide.

Art as a Communication Tool in Science

Historically, botany and art have been intertwined. Botanical drawings are an essential component in field guides, floras, field notebooks, which serve as a communication tool for scientists, but art is not currently emphasized in K-12 or post-secondary science education. The NGSS (NGSS Lead States, 2013) recognizes the importance of sketches, drawings, and models as important forms of communication in science, however, that disciplinary core idea is only emphasized in Kindergarten (K-ESS3-3). This underemphasis on art as a scientific communication tool beyond kindergarten in K-12 and post-secondary education is not a new phenomenon. At the turn of the 20th Century, American educational researcher and philosopher John Dewey (1911) commented on the role of art in education.

> There has been a great loss in relegating the arts to the relatively trivial role which they finally assumed in schooling, and there is corresponding promise of gain in the efforts making in the last generation to restore these to a more important position. Viewed both

> psychologically and socially, the arts represent not luxuries, and superfluities, but fundamental force on development. (p. 96)

Art is an important scientific communication tool that can be used to support learning in post-secondary science and medical education (Ainsworth, Prain, & Tyler, 2011; Baldwin & Crawford, 2010; Naghshineh, et al., 2008; Phillips, 2000; Shapiro, Rucker, & Beck, 2006; Ting, Chen, Ho, & Gaufberg, 2012). A review of literature uncovered that drawing in science can enhance engagement, improve student scientific reasoning, and communicate and clarify ideas (Ainsworth et al., 2011). A hospital in China used art work hanging in the halls prompt medical students to hone close looking skills and personal reflection as part of their medical training (Ting et al., 2012). A study found that Pre-clinical medical students who participated in a life drawing class co-taught by an artist and an anatomy instructor improved their understanding of human anatomy (Philips 2000). It is possible that a similar process could be used in botanical education. One study hinted at this; Baldwin and Crawford (2010) studied student responses after bringing an art teacher into the class to support students' creation of botanical illustrations. However, they focused on the students' experience in the class, rather than the students' perception of leaning which would prepare the students develop the necessary taxonomic skills for eventual botanical employment.

Significance of the Study

Although there is evidence that art is an important communication tool in science, a thorough literature search did not find any research on the effectiveness (effectiveness- ability to transfer understanding to a job or real world situation) of various art interventions in college level botany courses. With the current trend of botany positions going unfilled, it is imperative to study pre-service elementary teachers to ensure colleges are training teachers to inspire the next

generation of botanists. This study is significant because it fills a gap in the pre-service teacher botany education literature by expanding it to include the United States.

Questions

The purpose of this research is to explore pre-service teacher's perceptions of three botany lesson that utilize art interventions to teach plant structures. The specific research questions were:

> Research Question 1: What were students past experiences with botany, art, and representations?
>
> Research Question 2: Which type of representation did students feel taught them the most about plant structures?
>
> Research Question 3: Which type of representation did students feel was the most enjoyable and the most stressful to create?
>
> Research Question 4: What changes did students notice, beyond the classroom, in how they view leaves, flowers, or fruits?

Definitions

For the purpose of this study, it is important to define the following terms *art, drawing, visual representation, scientific literacy,* and *taxonomy*. The terms are defined below:

Art- A tool for learning and communicating scientific ideas.

Drawing- A representation created with pencil, pen, markers, or other similar marking implements, not including paint, on paper or other surfaces.

Visual Representation- A detailed and accurate drawing or painting that symbolizes an object or phenomenon in the natural world without the addition of imagined structures.

Illustrations- "Explain or make something clear by using examples, charts, pictures, etc." (Oxford Dictionary Online)

Scientific literacy- An area of science education that includes writing, reading, speaking, listening, physical tasks, mathematics and the creating and interpreting visual representations related to science.

Taxonomy- The branch of science associated with the naming and describing of organisms.

Chapter 2: Review of Literature

Several areas of literature support and guide the present study. Within the field of botany, a historic perspective of visual representations is presented followed by discussion of the modes of science literacy, and an exploration of terminology used to describe representations, illustrations, or art. The limited literature on pre-service teacher botany education is reviewed. Followed by a close look at the ways that literature from educational psychology can inform this project including perceiving and processing visual images, student perceptions of learning, and the impact of emotions on learning.

Botany

A Historic Perspective of Botanical Visual Representation

Botanists have used visual representation to learn, teach, and communicate ideas about botany since the earliest of times. The use of representations in botany is not limited by location or gender. Examples can be found from the Middle East, Europe, Asia, and the Americas, and produced by both men and women (Egerton, 2012). There has been a high level of collaboration between artists and botanists as seen when artist illustrated field guides for scientists or artist drew plants and later botanist identified them out of context. These collaborations blurred the lines between art and botany.

Biological illustration first began at the Lyceum, which was established around 335 BCE by Aristotle and later headed by Theophrastos for thirty years (Egerton, 2012). Although Greeks had been drawing plants for thousands of years before the opening of The Lyceum, historians do not recognize it as biological illustration (Egerton, 2012). Theophrastos (ca. 371-ca. 287 BCE) is considered the founder of plant geography, the father of plant ecology, or simply the father of ecology (Egerton, 2012).

During the Renaissance period, European artists began to observe and accurately describe the world through visual representations. Leonardo Da Vinci (1452-1519) studied plants through the creation of visual representations before the discipline of botany was established as a science (Egerton, 2012; Morley, 1979). His drawings of plants are some of the earliest records of plant portraiture from nature, and were so accurate that the plant can be identified to the species level. His drawings and painting captures invasive species arriving in Italy, and the month in which a painting was created or the time of year it depicts can be speculated from plant species life cycles (Morley, 1979). Another botanical artist, Albrecht Dürer (1471-1528) from Germany, created detailed paintings of turf vegetation. Dürer is credited with painting the first ecological illustrations because his work depicted various species in an ecosystem, and inspired other artist to paint similar works (Egerton, 2012).

Another artist who contributed to the field of botany was Maria Sibylla Merian (1647-1717). She was a well-traveled botanical artist, also from Germany, who depicted insects with their host plants (Egerton, 2012). She traveled to South America to draw and paint new species unknown to Europeans. She was able to capture a high level of detail because she was inspired by Leeuwenhoek writings to study insects and plants with a magnifying glass (Egerton, 2012). Her visual representations and her notes were so detailed that Linnaeus used them to describe new species (Egerton, 2012).

During the 1800's, Walter Hood Fitch (1817-1892) was a prolific botanical illustrator from Scotland. He began his career by creating floral patterns for fabric in his father's shop. His artistic skills were noticed by William Jackson Hooker, a botany professor and editor of a botany magazine, who became his mentor and employer. Fitch went on to publish 12,000 illustrations utilizing drawings, wood cuts, lithographs, and watercolors. He worked by making direct

observation of plants (living or dried), used botanist's field notes, or drew from his memory to create representations. His contributions to botany were so significant a plant genus, *Fitichia*, was named for him (Lewis, 2004).

In the 1900's and early 2000's Nancy Adams (1926-2007) captured precise drawings and watercolors of plants in New Zealand. She studied Botany and Zoology in college and later became one of New Zealand's most important botanist and botanical artists. She co-authored several books on plants that appealed to hikers, botanists and teachers (*The New Zealand Herald*, 2007). Throughout history, botanical illustration has remained an important tool in scientific communication.

Modes of Science Literacy

The modes of science literacy are the various ways people make meaning and communicate ideas about science. A multimodal approach to science literacy builds upon and expands the traditional modes of literacy (reading, writing, speaking, and listening) through the addition modes (ex. drawing, mathematical computation, manual technical, etc.). There is robust empirical evidence that college students and professors, regardless of gender or ethnicity, can improve their level of science literacy. Nuhfer et al. (2016) explain:

> Our analysis confirmed that women and men are equally adept at understanding science as a way of knowing. Likewise, every ethnic group seems equally capable of achieving higher-level reasoning afforded by understanding science's evidence-based way of knowing. (p.153)

However, there is no clear and concise definition of science literacy, although scientists, educators, and philosophers have been working towards one for most of the 20th and 21st centuries (Wenning, 2006). Traditional definitions of literacy include reading, writing, speaking and listening as the four modes of literacy. Thier (2002) states, "…good science and good science education are not possible without strong language skills" (p. 4). Miller (1983) presents a

broader definition by outlining three of components science literacy: understanding 1) the nature of science, 2) basic science constructs and 3) and the relationships of science technology and society. Developing an understanding of all three components outlined by Miller (1993) requires the use of one or more of the traditional modes of literacy (e.g. reading, writing, speaking, and listening).

Broad definitions of science literacy often overlook that scientists create graphs, diagrams, and representations as communication and meaning-making tools, so a definition of science literacy has specifically include engaging with visual representations (Ainsworth, Prain, & Tyler, 2011). Felton (2008) describes visual literacy as: "(T)the ability to understand, produce, and use culturally significant images, objects, and visible actions" (p. 60). Easton Kodak, best known for photography, coined the term "visual literacy" in the late 1960's and held the first conference on the subject (Felton, 2008). One could argue that visual literacy is important to foster in science students because professional scientists understand, produce, and use a wide variety of visual representations, graphs, photographs, and computer models.

Although there is little research on how scientists and students develop the ability to create and use these visual representations, there is a growing sense that these modes are a necessary part of the hybrid language of science (Lemke, 2004). Hybrid language consists of four modes: natural language, mathematical expressions, visual representations, and manual-technical operations. The four modes do not function in isolation but in various combinations. For example, when students are leaning about flowers they must listen and ask questions using natural language, dissect the flower to see its parts (manual-technical operation), and construct visual representations.

Hybrid language details only four possible modes of science literacy, in contrast, multimodal researchers explore numerous modes that people use to learn. Additional modes could include mathematics, gesture, images, tools, and activities (Airey & Linder, 2008). Multimodal researchers have empirical evidence to support the rejection of the Meshing Hypothesis, which posits that the instructional mode should be matched to a student preferred learning style (eg. visual, auditory, kinesthetic), and favors using different modes of instruction for different information (Pashler, McDaniel, Rohrer, & Bjork, 2008; Rogowsky, Calhoun, & Tallal, 2015).

One underused mode of science literacy is drawing to create visual representations. Researchers have found that creating a drawing enhances memory when compared to writing (Wammes, Meade, & Fernandes, 2016). After conducting seven experiments, the researchers proposed that memory is enhanced with drawing is due to the integration of semantic, visual, and motor aspects involved in creating a drawing. The authors refer to this phenomenon as the "drawing effect". Although there is empirical evidence to support the "drawing effect", will students intuitively perceive that drawing plant structures will improve their memory?

Exploring terminology. The construction and use of visual representation as components of science literacy raises the question: what should drawings and painting be called in the context of science? Typically, drawings and paintings are called art in most contexts. The Merriam- Webster Dictionary (Online) defines art as "Something that is created with imagination and skill and that is beautiful or expresses important ideas or feelings." The expression of important ideas could be interpreted as an essential characteristic of scientific representations. However, when drawing from a specimen in science the observer is trying to replicate its features without adding imagined structures.

Representation and illustration are two more specific terms, which could be used in place of art. The term representation is defined as "The depiction of someone or something in a work of art" or "A picture, model, or depiction of someone or something" (Oxford Dictionary Online). The most relevant definition of illustrate is "Explain or make something clear by using examples, charts, pictures, etc. " (Oxford Dictionary Online). The definitions for both representation and illustrate refer to aesthetics, but there is no mention of creativity in the construction or representations or illustrations.

Modeling is another possible way to describe scientific and botanical representations. The most relevant dictionary definition for a model is, "a description or analogy to visualize something (an atom) that cannot be observed" (Merriam-Webster dictionary Online). Lehrer and Schauble (2006) describe different types of models in order of increasing complexity: physical microcosms, representational systems, syntactic models, and emergent models. The latter three model types (representational systems, syntactic models, and emergent models) deal with representing complex systems with one or several variables. However, physical microcosms are representations that either increases the size of a system (e.g. a plastic model of a cell) or decreases the size of a system to help students visualize all components (e.g. terrarium model of an ecosystem). These types of models are typically the first scientific models' students engage with, but remain useful throughout school and into professional practice (e.g. scale models of airplane wings for testing). Another definition of a model is "a representation that abstracts and simplifies a system by focusing on key features to explain and predict scientific phenomena" (Schwarz et al., 2009, p. 633). This definition excludes many physical microcosm models because they do not always "explain and predict scientific phenomena" (p. 633).

Are botanical visual representations models? Plant structures depicted by botanical representations are scientific phenomena because they demonstrate different stages of growth, evolutionary relationships, and genetic diversity evident by phenotypic variation among members of the same population. However, botanical visual representations do not make predictions in the same way, for example, that a weather model can predict rain or a forest growth model can predict the density of vegetation ten years following a fire. The only prediction a person could make from a botanical representation is that plants that look similar to the representation will be members of the same species and have the same name. This may seem like a simplistic prediction compared to knowing when it will rain, but identifying a rare or endangered plant can halt construction and grant government protection to sensitive habitat areas.

The terms described above have been used in the literature to describe students' observation and creation of drawings and paintings in the context of science. To further explore the use of terminology, a review of both medical and science education literature that use art interventions uncover the way the terminology has been used in the literature.

Medical instructors have been using art to support their curriculum since the beginning of 21st century (Naghshineh et al., 2008, Phillips, 2000, Shapiro et al., 2006, Ting et al., 2012). Naghshineh et al. (2008) studied medical students observing art to see if it improved students' observation skills. The authors used the term "art" to describe abstract pieces, and "representational art" to describe realistic paintings of human anatomy and landscapes. Shapiro, Rucker, and Beck (2006) also researched medical students observing "art". The authors distinguished between "representation art" and "non-representational" art. Another study from the medical community, used the "art" hanging on walls of the hospital to improve medical

student's observation and reflection skills by making observations (Ting et al., 2012). The authors only use the word "art" and never mention "representation".

Unlike Naghshineh et al. (2008), Philips (2000) studied pre-clinical medical students who participated in a life drawing class co-taught by an artist and an anatomy instructor to support students' understanding of human anatomy. The author uses the term "art" much more frequently than "representation", however there are mentions of "aesthetic representations" and "representations of the human body" in regard to anatomical art history. The author writes more about the historical ties between anatomy and art than representations as a tool for scientific communication. In medical education research if something is observed it is "art" and if it is drawn by students it could be a "representation" or less commonly referred to as "art."

Similar to medical education, science education literature uses a variety of terminology to describe student drawings. In a review article titled "Drawing to Learn in Science", Ainsworth, Prain, and Tyler (2011) repeatedly use the word "drawing" to describe the process of creating "representations" in their article published in *Science*. The article never uses the word "art" to describe student's drawings.

Baldwin and Crawford (2010) brought in an art instructor to co-teach a botany course, and they consequently used three different terms to describe student work. The title uses the words "art instruction" to describe the collaboration with the art teacher. The example of student work is labeled "Example of illustrated learning journal pages…" (p. 27), which indicated that the students are creating illustrations. In the text of the article, the authors use the term "visual representations" consistently to describe student products. There are variations in terminology not only between articles, but also within a single article as well.

After exploring how other researchers have used terminology in their writing, the word representation is used in this study for several reasons to describe drawings and paintings in science. The definition of representation could include more artistic endeavors than the term "model" because representations do not require the drawing to make predictions. Representation is used because the word appears more prevalently, than illustration, in the literature. The term "art" implies a creative or imaginative aspect to the creation of a representation that could be intimidating to some students or give other students creative license to embellish their observations.

Representation in science. Engaging with visual representations requires a different way of thinking when compared to speaking, talking, reading, and writing. When learning about science, human beings are visualizing concepts even if they are learning science through reading, listening, and talking (Trumbo, 1999). Krantowitz (2012) stated, "The act of drawing can be understood as the creation of a physical space to play with our thoughts outside the confines of our minds, to see and manipulate our ideas and perceptions in visible form" (p. 3). Creating visual representations requires students to use their spatial mode of perception and methodical observations to perceive plant life and create botanical representations (Baldwin & Crawford, 2010).

The three types of visual representations used in this study to engage student's spatial mode of perception were labeled coloring pages, line drawings, and watercolors. The labeled coloring pages were copied from *The Botany Coloring Book* (Young, 1983). The coloring pages were selected because there are advanced science-coloring books for a variety of topics (e.g. human brain, zoology, periodic table, etc.), and have persisted in science education since the 1980's. Line drawings were utilized because they are common in botanical field guides and

scientists' field notes (Jepson & Hickman, 1993). Line drawings were also advantageous because of the low cost, and the limited supplies required to complete the activity. Watercolor was the third type of representation used in this study because of the transparent nature of the media. Layers of pigments produce the overall color of plants and fruits, and watercolors can be similarly layered. Watercolor also presents a greater challenge to students because they must draw, label, and color the representation, whereas with the coloring sheets they were only applying color or only creating line drawings.

Although observing and creating visual representations in a variety of different forms requires a different way of thinking, sometimes it is assumed that visual and language literacy are the same, and are learned the same way (Felton, 2008, Trumbo, 1999). However, Trumbo (1999) states that visual literacy and language literacy are not the same, but a complement to each other, which would indicate that different teaching methods are needed to learn how to create and interpret visual images.

Authentic experiences can teach an individual different information than a book or a lecture alone (Dewey, 1938; Gardner, 2011; Kantrowitz, 2012). Trumbo (1999) writes, "Written language must be cognitively processed, while the image is processed along the same perceptual pathway as direct experience" (p. 416). The creation and interpretation of visual images demands the same visual-spatial thinking required by both scientists' and science students' (Ainsworth, et al., 2011). Even the most abstract thoughts have their origin in physical experiences and interaction with the environment (Kantrowitz, 2012). Engaging with visual images provides science students an authentic experience similar to that of a scientist, and the knowledge they gain from that experience can be transferred to different disciplines and different contexts (Baldwin & Crawford, 2010).

Drawing can provide students with a different worldview that they may not have contemplated before and an experience with representations and science (Philips, 2000). Baldwin and Crawford (2010) found that science students drawing from observation better understand the structures and details of what they are observing. The students believed that visual representations were important because they received instruction from an art teacher during class time (Baldwin & Crawford, 2010). The authors felt that the purpose of drawing was to better equip their students to be learners and observers. Students begin to see differences and similarities in what they observe when they draw what they see instead of what they expect to see. A medical educator found that the creation of visual representations as part of an anatomy class changed the image of human anatomy from a dry subject that requires memorization and no thinking to a more interactive and stimulating discipline (Phillips, 2000). Another strength of engaging students with visual representations is that it supports individual learning differences by making them visible in the students' work (Ainsworth, et al., 2011). As an educator, seeing students' thoughts can be a valuable tool for assessment and a space for discussing visible misconceptions.

In contrast to the positive learning experiences students have with art and science education, Phillips (2000) states, "Using art cannot take the place of learning but increases student interests and provides new points of view" (p. 1024). Contrary to Philips (2000), there are several studies that indicate that with enough interaction with representations students can improve their scores on observation tests and overall course grades. Naghsineh et al. (2008), found that the more art session students attended, the higher their scores were on post-observation test in a medical school class. A weak positive correlation was found between the

number of extra credit coloring pages students completed in a botany coloring book and their final course grade (Tibbetts, 2009).

Pre-Service Teacher Botany Education

Only two studies were found that address pre-service teacher botany education. A study was conducted on pre-service teachers which utilized a porphyrios tree to help correct mislearnings about plant classification (Yangin, 2013). Another study on pre-service teacher plant classification misconceptions found that after four years of teacher preparation students were graduating with misconceptions about plants (Yangin, Sidekli, and, Gokbulut, 2014). However, pervious literature does not explore students' perceptions of using art interventions to increases pre-service teachers content knowledge of leaf, flower, and fruit structures. Both of the aforementioned studies (Yangin, 2013; Yangin, Sidekli, and, Gokbulut, 2014) were conducted in Turkey, so this study geographically expands on the location of earlier research on pre-service teachers botany education to the United States.

Educational Psychology

Literature from educational psychology can shed light on how visual images are perceived and processed, and what occurs when visual processing is damaged. Additional literature is reviewed relevant to spatial reasoning, intelligence, mental rotation, and gender differences. This section concludes with an overview of learning and a discussion of the developmental process for drawing skills.

Perceiving and Processing Visual Images

Visual processing is an essential component in perceiving and creating representations. An image must first travel though the eye and nervous system, before it can be processed in the

brain. Malfunctions can occur during both the perceiving and processing phases, which can impact a person's understanding of the visual world.

Perceiving. To perceive the world through sight requires several organs and a multistep process before meaning can be derived from the surrounding world. To begin, light must be reflected off surfaces for the human eyes to be able to detect objects. In humans, the eyes detect both fields of vision at the same time. The temporal side of the retina senses images in the opposite field of vision (ex. left eye, right field of vision) and nasal side of the retina detects images in the same field of vision (ex. left eye, left field of vision). The lens in the eye inverts the image before it reaches the retina. Once it reaches the retina, located on the back of the eye, it is detected by light sensing cells called rods and cones. Rods detect lower intensity light and cones need a higher intensity of light to activate (Stenberg & Williams, 2010).

After reflected light travels through the eye, it is then converted into electric impulses that travel along the optic nerve (Chatterjee, 2014). Because both eyes detect images from both the left and right fields of vision, the optic nerves must cross in the optic chiasm before the impulse travels to the back of the brain to a region called the occipital lobe where processing begins (Chatterjee, 2014).

Processing. Light information enters the eyes and travels to the occipital lobe, and is then distributed throughout the rest of the brain for further processing (Chatterjee, 2014). After visual information is dismantled into its different attributes (e.g. light intensity, movement, shape, color, etc.) the brain pulls images back together in different areas of the brain that specialize in the images they assemble (e.g. faces (fusiform face area), places (parahippocampal place area), or objects (lateral occipital complex), etc. (Chatterjee, 2014). This is called parallel distributed processing.

Early research supporting the parallel distributed processing model began after World War I when Gordon Holmes studied the effects of head injuries on solders' ability to process visual images (Chatterjee, 2014). Some soldiers lost the ability to see color, form, or movement depending on the precise location of their brain injury, so Holmes was able to correlate the distinct attribute of sight that was lost with the location of the brain injury to map how vision is processed in the brain

Building upon head injury studies, the parallel-distributed processing frameworks are the current set of models used to describe how human brains process various inputs. Specifically, a paradigm-shifting framework developed by Rumelhart, McCelland and thirteen other writers in 1986, unifies various parallel-distributed processing models (Rumelhart et al., 1986; Sampson, 1987). This model posits that everything in the brain is connected, but the various connections are given different weights that determine the likelihood of processing information a certain way. If the connections in the brain are disrupted, then a person's ability to produce drawings can be impaired. Understanding how images are processed provides background information to support an understanding of students' perceptions of learning.

Visual Processing and Disability

In MRI studies, representational art has been found to activate more wide spread areas of the brain when compared to the restrictive activation found when viewing abstract art (Zeki and Nash, 1999). Moreover, perceiving and creating arts require two different cognitive skill sets. The specific neural basis of drawing has been overlooked when compared to other skills (Makuuchi, Kaminaga, & Sugishita, 2003). To learn about the cognitive processes utilized in creating a drawing, cognitive psychologists look to individuals with brain injuries or assess brain function or the location of brain injuries of individuals who demonstrate deficits in drawing

(much like the WWI studies described earlier). Hemispatial neglect occurs after one hemisphere of the brain is damaged (Parton, Malhotra, & Husain 2004). Most commonly, the damage is a result of a stroke or hemorrhage, although, hemispatial neglect can also be the product of a variety medical conditions or injuries (Parton, et al., 2004). Patients who have hemispatial neglect only attend to objects on the same side as their brain damage, which can be evident in self-care (e.g. dressing and grooming), limb use, and in drawing. When asked to copy an image patients typically only reproduce half of the image provided (Parton, Malhotra, & Husain 2004, Gardner, 1983). Hemispatial neglect provides evidence that both sides of the brain are used when an individual constructs a drawing.

Similar to, and often comorbid with, hemispatial neglect, patients with constructional apraxia demonstrate drawing impairment due to brain damage. However, the change in drawing ability occurs without general impairments to their visual, motor abilities, or intelligence, and the brain damage is localized to the parietal lobe in one or both hemispheres (Makuuchi, Kaminaga & Sugishita, 2003). Drawings produced by patients have either the left or the right side missing, or one side of the drawing appears distorted. Guerin, Ska, and Belleville (1999) review several models and/or theories of the components of the process of drawing, and van Sommer's 1998 model (as cited by Guerin, Ska, and Belleville, 1999) was the only "global cognitive model of drawing abilities" (p. 467). Van Sommers's model has a visual perception system and a graphic production system. When drawing from memory or copying an object the drawer must make *depiction decisions* (e.g. dimension and amount of detail), *production strategy* (e.g. Segmenting the drawing into parts), and *contingent planning* (e.g. Planning the order that segmented parts should be drawn) decisions before executing the drawing. Unlike like hemispatial neglect,

researchers believe the planning component of producing a drawing is impaired in individuals with constructional apraxia (Guerin, Ska, & Belleville, 1999).

Intelligence and Visual-Spatial Ability

Similar to people with cognitive impairment from injury and illness, people who are nureo-typical can also shed light on visual-spatial ability. Charles Spearman is well known for discovering the positive manifold in human intelligence, which is a well-documented phenomenon in which people who excel or do poorly in one subject will also have a similar level of performance in other areas (Kaufman, 2013). To explain this correlation Spearman describes the *g* factor or "general intelligence" as the underlying cause. Visual-spatial abilities are included as a skill in the positive manifold tests and are impacted by *g*. Some intelligence tests include visual tasks or questions while others do not, but the positive manifold and *g* emerges from an analysis regardless of its inclusion (Kaufman, 2013).

In contrast to the belief that intelligence is single entity *g* that can be measured, Gardner (1983) believes that intelligence is a combination of six different intelligences including: 1) linguistic, 2) musical, 3) logical-mathematical, 4) spatial 5) bodily-kinesthetic 6) personal. Spatial intelligence is a combination of abilities, but a person does not have to demonstrate a high ability in all areas to be successful spatial tasks. Researchers did however, analyze people tested in each of Gardner's proposed intelligences and the positive manifold emerged and they were related to *g* (Kaufman, 2013).

The five capacities that contribute to spatial intelligence are, recognizing similarities, recognize transformation of an object, creating mental images, transforming mental images, and producing representation of spatial information. Each capacity is independent and can break down separately, but they often work together and reinforce one another. It is important to note

that spatial intelligence is not a privilege of the sighted, but people who are blind can also demonstrate a high level of spatial intelligence. Gardner (1983) includes several instances where spatial intelligence aided in the discovery or explanation of science. He discusses Darwin's tree of life, John Dalton's view of the atom like a tiny solar system, and Lewis Thomas's analogy of micro-organisms and human society.

Gender Differences in Visual Processing

Unlike *g,* which has similar trends across all genders, there are noted differences in visual processing skills between males and females. All of the participants in the present study are female, so exploring gender differences in visual processing could give insight into the study participants. If this study included male participant's differences in visual processing may be more evident. However, even without the presence of male students', gender may have an impact on the female students' participation and perception of the three lessons.

There are well-documented sex differences in the brain; for example, women are more prone to depression and Alzheimer's and men are more likely to be on the autism spectrum (Jarrett, 2015). It is well documented that men have physically larger brains than women (Jarrett, 2015; Hines, 2004). Historically, brain size differences have been used to discriminate against people based on age, nationality, race, and gender (Hines, 2004). However, the differences in brain size have not shown a significant difference in intelligence (Hines, 2004). Hines (2004) states, "…compared to the male brain, the female brain has a higher percentage of grey matter, greater cortical volume, and increased glucose metabolism, thought to reflect increased functional activity" (p.187). Although researchers have presented evidence reverse previous conceptions about brain size, intelligence, and gender, there may be lasting effects on society that negatively impact male and female perceptions of intelligence and learning.

Regardless of size and overall functional activity, researchers have found differences in visual-spatial cognitive ability between males and females. Sex differences in mental rotation first appear around four years of age and are more evident in middle and upper socioeconomic classes than in lower economic groups (Newcombe & Stieff, 2012). Garner (1983) posits that men may have evolved more highly developed visual-spatial abilities than woman because historically they were hunters band needed visual-spatial skills to return home and not die lost in the wilderness. Another possible cause of this sex difference could be the 'spatial stereotype threat', which negatively impacts a woman's performance on visual-spatial tasks when she is told to reflect on her gender before preforming the task (McGlone & Aronson, 2006; Newcombe & Stieff, 2012).

With training, both men and woman can improve their mental rotation ability, but this training does not close the gender gap (Terlechi, Newcombe, & Little, 2008). More recent studies have demonstrated that the gap in spatial thinking has been closing, but there is a specific component, three-dimensional mental rotations, that is stable (Hines, 2004) or widening (Newcombe & Stieff, 2012) between genders. Differences in mental rotation ability may be an underlying cause for the lack of woman in science and mathematical professions because there is a link between mental rotation ability and career choice (Newcombe & Stieff, 2012; Shea, Lubinski, & Benbow, 2001; Wai, Lubinski, & Benbow, 2009).

In conclusion, understanding how visual input, processing, deficits and gender differences can inform a deeper understanding of student perceptions of learning from representations in science. Visual processing has many different physical and neurological processes that must be coordinated for a person to perceive, make meaning from, and create visual information. Some aspects are well understood, like the anatomy of the eye, while other

aspects of visual cognition are more cryptic like the biological or social causes of gender differences in mental rotation. Science seeks to better understand the underlying mechanisms that contribute to visual literacy. Understanding and improving visual processing skills could possibly support student's comprehension of science and increase the number of women working in science fields.

Learning

Learning is a difficult concept for which to create a single definition because it is presented and defined in many different disciplines (Barron et al., 2015). Barron et al. (2015) state: "…most contemporary theoretical considerations of learning view it as a structured updating of system properties based on processing new information" (p. 405). Learning is often described as a change in behavior, which is a functional approach because behaviors can more easily be observed or reported than a change in the brain can be seen (Barron et al., 2015; De Houwer, Barnes-Holmes, & Moors, 2013). There are limitations that challenge the idea of learning as a change in behavior, for example, altered motivation, physiological considerations, and biological changes. For a change in behavior to be considered learning, it most commonly has to be tied to an experience (Barron et al., 2015; De Houwer, Barnes-Holmes, & Moors, 2013). For example, if person's behavior changes due to Alzheimer's it would not be considered learning but a symptom of a disease. However, if a person watches people play chess, asks questions, and is then able to play the game it would be considered learning because they experienced other people modeling how they game is played.

Perceptions of learning. Researchers have investigated student perceptions of learning in several different countries, subjects, and learning environments (e.g. online learning, tutoring, and classroom). Students' perceptions of learning can be quantified using surveys (Spronkrn-

Smith, Walker, Batcher, O'steen & Angelo, 2012), explored qualitatively using interviews (Herrmann, 2014; Seylani, Negarandeh, & Mohammadi, 2012), or explored through mixed methods (Koretsky, Kelly, & Gummer 2011; Lumpkin, Achen, & Dodd, 2015). Understanding students' perception of learning is important to creating a student-centered learning environments where students believe the activity or the environment is helping them understand the course material (Lumpkin, Achen, & Dodd, 2015).

The literature demonstrates how exploring students' perceptions of learning can inform college teaching practice. By comparing groups of college students' responses on a questionnaire, researchers found that creating student-centered lessons that are both engaging and enjoyable increased both undergraduate and graduate students' perceptions of learning in nine different courses related to sports and recreation (Lumpkin, Achen, & Dodd, 2015). One study found that instructional strategies that addressed students as whole people helped Iranian nursing students broaden their perception of what can be learned during their college training (Seylani, Negarandeh, & Mohammadi, 2012). Exploring students' perceptions of learning can help educators understand the depth and breadth of what their students believe they are learning.

Emotions and learning. Emotions overlap with nearly all cognitive thought, except for high reason/rational thought, which indicates that emotions play an important role in learning (Immorodino-Yang & Damasio, 2007). Researchers found that when eighth grade students, who participated in a science unit on energy, experienced strong positive emotions, their focus on the assignment increased, they recalled the lesson positively, and the students indicated increased interest and engagement in science (King, Ritchie, Sandhu, & Henderson, 2015). The importance of emotion in education is not limited to children but extends to adult learners as well. A study, that focused on positive emotions in college and university education, found that students who

reported love, joy, and happiness after completing a task demonstrated a state of flow and increased engagement during the task (Rowe, Fitness, & Wood, 2015). The emotions professors' display during a lesson also contribute to learning.

> The enthusiastic delivery of curricula was not, on its own, sufficient to engage all students – the emotion had to be genuine. It was important for students that teachers genuinely enjoyed, were excited by, and were interested in teaching their discipline. For students, teachers' behaviour in this regard reflected how they felt about teaching them. (Rowe, et al., 2015 p.10)

All emotions that both the teachers and students feel in the classroom can have a negative or positive effect on learning.

Drawing and Development

Some scholars believe that art is an integral part of human nature because it is evident in very young children and has persisted throughout human history (Blatt-Gross, 2011; Carroll, 2004). Before the age of four, childrens' drawings progress from scribbles to lines and they begin to realize that their scribbles resemble objects (Kellogg, 1969 as cited by Gardner, 1973; Golomb, 1994). At about age four, children begin drawing representation; this is called the design phase (Kellogg, 1969 as cited by Gardner, 1973).

> "…early drawings of children appear to follow a regular sequence that leads, seemingly ineluctably, to the production of representations. And once the child begins to represent, even his purely geometrical figures take on a referential meaning of some sort for him. "(Gardner, 1973, p. 215-216)

Beyond the age of 5 or 6, children's artwork becomes influenced by their gender, culture, and education (Toku, 2001). Typically, children's art becomes more sophisticated until they enter pre-adolescence when there is a regression in sophistication or cessation of creating art all together (Kellogg, 1969 as cited by Gardner, 1973). Pre-adolescents may also stop drawing when they become aware that their representation does not accurately match the model, or when they compare their artistic efforts to peers (Gardner, 1973). Art and representations can become

suddenly more demanding as pre-adolescents become overwhelmed by the fear of failure, which overrides their desire to create (Gardner, 1973).

Baldwin and Crawford (2010), write, "The greatest impediment to incorporating visual representation into [college] curricula is that most individuals have little experience beyond early childhood in using visual representations" (p. 28). The NGSS (NGSS Lead States, 2013), a document which aims to create research based standards for science education in the United States, outlines the importance of sketches, drawings, and models as forms of communication in science, however, drawing is only emphasized in Kindergarten (K-ESS3-3). Despite this limited requirement of including drawing in K-12 science education, working scientists create scientific drawings as adults in spite of the possible lack of training beyond kindergarten.

Conclusion

In conclusion, several different fields provide support for the present study. Representations are present in art and science throughout history and support a student's understanding of science literacy. There is limited research on pre-service teacher botany education, and this study will help fill the gap in the literature. Education psychology literature provides a background on perceiving, processing, and learning from visual images, which could inform students perception of learning.

Chapter 3: Methods

The purpose of this study is to gain a better understanding of college students' past experiences with art and botany, gain insight into their perceptions of learning, and explore their feelings when they engaged with three different types of botanical representations presented within the context of a science content for elementary educator's course. All students enter the classrooms with past experiences that inform their current thinking and actions (Piaget, 1951), so it is important to understand a student's past and present experiences with art, science, and representations to provide the most appropriate individualized instruction because each student may be at a different level of understanding. The scope and intent of this study is not to evaluate students' short or long-term memory of plant structures, but to gain an understanding of the students' perceptions of learning plant structures and possible future application of art interventions in college science classrooms through exploring students' classroom experience.

Methodology

The proposed research questions can be best addressed through qualitative methodologies because such methodologies allow the researcher to deeply explore one classroom of student's perceptions as opposed to gaining a less in depth information from many students across a campus or nation. The qualitative research methodologies emerged as a push back from quantitative ways of thinking. Unlike quantitative research, qualitative research values the individual and his/her complicated, often messy personal experience (Denzin & Lincoln, 2011). This shift in thinking is reflected by the change in terminology used to describe people in a study. Quantitative researchers typically refer to people being studied as "subjects" or collectively as a "population" (van den Hoonaard, 2008). The terms "subject" and "population" are also used in biological science research to describe plants and animals (I recognize that

humans are animals, but will risk seeming anthropocentric to demonstrate the change in terminology that accompanied the emergence of qualitative research). Qualitative researchers call the people involved in their research "participants". This term indicates they have an active role and are not powerless and passive as the term "subject" implies.

Qualitative research is often focused on one or a few participants, so it may not be directly generalizable to larger populations. However, limitations on generalizability should not deter researchers from conducting qualitative research studies. Dewey (1929) believed that education researchers should consider doing non-generalizable qualitative research because there are too many variables to control. He further asserts that teachers should be aware of educational research to enrich their practice rather than to directly control what they do in the classroom. Qualitative research holds value in the classroom and in education as a whole by enhancing the way teachers and administrators view educational experiences, instead of providing educators with prescriptive generalizable methods that are often implemented too quickly and broadly. Although, qualitative research is not generalizable, it is valuable because it uncovers instead of overlooking complexities.

There are many different methodologies within the qualitative paradigm (e.g., design experiment, action research, ethnography, autoethnography, grounded theory, and case study) (Denzin & Lincoln, 2011). This study utilizes Qualitative Data Analysis (QDA) to guide this research study (Glaser & Holton, 2007). There are several different modes of thinking that can support QDA, including: categorical, narrative, dialectical, poetical, diagrammatical (Freeman, 2017).

Personal Bias

The *etic* issues I bring with me into this research study are from my experience as an adjunct professor when I was a member of a team teaching the same plant science course. During that time I was required to assign my students coloring pages from Paul Young's Botany Coloring Book (Young, 1982) and use pre-drawn coloring sheets in the botany lab. Outsiders to the classroom determined what my students and I were doing and not giving my students voice in the learning process, or giving me the authority to respond to my students' needs. Although I no longer teach at that community college, I still wonder how college students think and feel about creating botanical representation, which is the *emic* issue, or the issue from the insider's perspective, in this case study (Handcock & Algozzine, 2006; Stake, 1995).

Methods

Participants

All participants were enrolled in a science for elementary teacher's course, which aimed to provide pre-service teachers with a wide variety of science content appropriate for early childhood through sixth grade. The course took place at a private teaching and research university associated with the Disciples of Christ in the southwest United States during the spring of 2016. The students enrolled in the course were primarily in their first or second year: 22 sophomores, three freshmen and one senior. They ranged in age from 18-26 with an average age of 20, were all female, and intended to major in elementary education. The course included three lessons on plant structures as part of a unit on ecology. All of the students selected for the study participated in all three lessons, except Gwynn who was absent during the first lesson on leaves. To create anonymity the students were assigned pseudonyms.

All students in the class filled in a personal information questionnaire. They provided their classification, hometown, age, and type of education (public, private, charter, homeschool etc.) she received in elementary, middle school, and high school. There were seven different tables in the classroom, however, this study only focuses on three tables with a total of 11 participants. The three tables were chosen to give the study more depth by limiting breadth, and to explore the three lessons with a variety of students.

Table 1. Table one was located at the front right side of the room almost touching the instructor's desk. The group of students sitting at this table group were silly, upbeat, but not consistently interested in the course content. Out of the three tables included in this study, students at this table had the lowest end of course grade average. The students would draw pictures on each other's hands, sing songs, and giggle during class. During the semester group members commented to me that they were obviously elementary education majors because of their behavior. Two of the students were from out of state, one was international (UK and Jordan), and one was from a city an hour away from the university. Three of the four students were 20 years old. The fourth student at the table, Claire, was the oldest student in the entire class at 26 years old.

Table 3. Table three was in the center of the classroom and was the last to fill up on the first day of class when the students self-selected their seats for the rest of the semester. The three women who sat at this table did not appear to be friends outside of class or have any close friendships with other students in the class. They were polite to one another and collaborated well together. Their impersonal relationships seemed to help this group focus more on course content, rather than their personal lives. Two of the students were from nearby cities and one, Delany, had moved all over the United States and attended high school in Italy. Beth appeared to

be shy, quiet, and did not always make eye contact with me. Frequently her tablemates encouraged her to answer questions and speak while the audio recorder was on. Faith self-disclosed that she is dyslexic while responding to the reflection questions.

Table 7. Table 7 was located in the back-left corner of the classroom and was the closest to the door. The women at this table were high achieving and had the highest end of course grade average out of the three tables, and the youngest average age. Kendall was one of four freshmen in the class and had the highest end of course grade out of all the students in the class. Gwynn did not normally sit at this table, but after missing the first lesson on leaves, she was assigned to this table to evenly distribute the students. One student in this group was from out of state and the other three were from the same state where the university was located.

Recruitment

Students enrolled in a science content for elementary educator's course were asked to sign a Human Subjects consent form during the first week of class to participate in any research on teaching methods used during the entire semester. It was made explicitly clear that their participation would not require extra work for the students or affect their grade. All 28 students enrolled in the course consented to participate in course related research.

Lesson Location

The lessons were conducted in a traditional classroom, as opposed to the outdoors, for two reasons. First, the classroom environment was selected to minimize students' perceived anxiety about being outdoors (Davis-Berman & Berman, 2002). Second, the classroom context is easily replicated by other educators interested in implementing representation generating activities to support students understanding of plant structures. However, learning about plants indoors could negatively affect students' recollection on tests conducted in the classroom due to

the principle of encoding specificity, which highlights the importance of the environment in which a person learns information because it impacts how a person remembers information in the future (Sternberg & Williams, 2010; Tulving & Thompson, 1973).

Data Collection

The four data sources used in this study were: audio recording during student work sessions, small group discussions, student artifacts, and end-of-course reflections. The audio recording did not include the lecture portion of class, but captured student dialogues while creating representations and their small group discussions. After the lecture, I handed out audio recorders. I asked them to introduce themselves to the recorders by stating, "Hello audio recorder, today is 3/31/16, and my name is _____ _____.", to capture the date, each student's voice, and name to help with transcribing. After the students introduced themselves, they began creating botanical representations and talking in their small groups.

During the last 20 minutes of class, students were asked to finish their representation (eg. coloring sheets, drawings, or water colors) and respond to an instructor-generated list of questions in their small groups to address the research questions proposed in Chapter 1. The questions were identical, but asked in a different order for each of the seven groups to prevent students from listening to other groups, repeating classmates' answers, or speeding up to keep pace with other groups' progression through the questions. The discussion questions are found in Appendix B. The researcher transcribed all the audio recordings from both the work session and the small group discussion.

The student artifacts were collected at the end of each lesson and included leaf structure coloring sheets, flower diagrammatic drawings, and water colorings of fruit structures. The student artifacts were scanned and returned to the students the next class meeting.

The end-of-course reflection, a short in-class assignment conducted during week 12 of a 13-week course, asked students to write half to a whole page about their experience during the entire course and their attitude towards science. While the students wrote their reflections', I left the room and a colleague facilitated the assignment and collected the assignments electronically through email. I did not read the assignments until after course grades were submitted to encourage the students to write honest responses. Although the assignment prompt did not ask students to write specifically about their experience during the plant lessons, nine of the 27 students who completed the assignment included some comments about the lessons.

Analysis

To analyze the small group discussions, I used qualitative data analysis. I began by transcribing the conversations students had while creating representations and in their small group discussion questions. I worked through the recordings by group (e.g. Table 1 Lesson 1, 2, 3) to hone in on the participants' different voices on the recoding and begin to note the differences between the lessons. I physically cut the transcripts into individual responses or brief conversations to be sorted.

Student Products. Researchers have used student products to gain insight into student learning, creativity, and feelings. Schmeck, Mayer, Opfermann, Pfeiffer, and Leutner, (2014) evaluated students' drawings and compared the test scores of a control and experimental group to determine the effect drawing had on their comprehension of biology texts. Because this study takes place in one classroom, there was not a control and an experimental group to compare, so students' perceptions of learning were more important than scoring their artifacts for accuracy. In another study, children and college-aged adults in China were given a fantasy drawing task and visual-artistic judged their drawings for creativity (Chan & Zhao, 2010). Since the participants

in this study were asked to make accurate representations their creativity will not be assessed. The student's artifacts will not be used to gain insight into the student's emotional state during the activity or toward plant structures because student products are not reliable indicators of emotion (Thomas & Jolly, 1998). However, student products were used to support or illustrate student discourse.

Student activity participation. To describe and uncover themes in the students' discussions while creating three representations, I listened to the recording of each group's discussions and typed notes for each group, supplemented my notes with quotes from the transcripts, and then compared the notes from each table for each lesson to uncover similarities and differences in their conversations (e.g. all three tables had off topic conversations during lesson one). After completing all three groups and all three lessons I analyzed the lessons to see if there were reoccurring themes that were present in each lesson (eg. table one had difficulty understanding the instructions for all three activities).

Research question 1. To analyze the data for question one, I utilized a chart that had all the participants listed in the first column and the next two columns were headed with "art" and "botany". I sorted through the participants' responses to research question 1 (RQ#1) focus group responses from all three lessons to fill in the chart.

Research question 2. To address the second research question, I sorted through the participants' responses to research question 2 (RQ#2) focus group responses into a coloring, drawing, and watercolor piles. I then proceeded to sort the three piles into themes related to what the students perceived they had learned during the lessons.

Research question 3. I began by soring the student's responses to research question 3 into two piles, cards that discussed their feelings and off topic cards. The cards that addressed the

students feeling were sorted into three piles, positive, negative, and mixed feelings. The three feeling piles (positive, negative, and mixed) were then sorted into three sub-piles one for each lesson.

Research question 4. First, I sorted the cards into to piles, those that addressed sharing and noticing plant structures outside of the classroom and those that were off topic. Next, I divided the cards by lesson, and then within each lesson sorted the cards into themes.

Emergent themes. To further analyzes the students' perceptions of the activity, science, art, and botany. I open coded the cards that were not used to address that four research questions (Thornberg, 2012).

Chapter 4: Results

This chapter provides descriptions of the three lessons: coloring leaf worksheets, drawing flowers, water coloring fruits. The descriptions are followed by an analysis of student discussions while creating three different botanical representations and their responses to scripted question during small group discussions to address the four proposed research questions. The chapter concludes with an exploration of emergent themes that were not addressed by the research questions but emerged from the data.

Description of the Three Lessons and Student Engagement

Lesson one

The windows which line one wall of the classroom showed the signs of the impending dramatic shift in the weather. The sky was dark, the air hung heavy with humidity, and the weather stations warned of strong thunderstorms and possible hail. The students entered the classroom excited, complaining, and anxious about the coming storm. Before the lecture began I numbered the tables and passed out media release forms and reminded the students that the next three classes would be recorded.

The class began with announcements about the test they took during the last meeting and the new unit we were beginning called “Our Big World” that covered ecology and space. The start of the lesson consisted of a 19 instructional PowerPoint slide lecture that began with the question and discussion of “Why do leaves change color in the fall?” and continued with one slide on the function of leaves and four slides describing the variety of leaf sizes and shapes. The students were very interested in a picture of infants sitting on Amazonian water lilies to demonstrate their gargantuan size. The last eight slides explained the structure of leaves and each slide had images from Paul Young’s *Botany Coloring Book* (1983) to explain the terms

(Appendix C). During this portion of the lecture I brought in fresh cuttings of local vegetation to demonstrate locating the structures in live plants. The students were very quiet during the section on leaf structure and did not verbally respond to whole class questions. For example, questions such as: “Does that make sense?”, “Do you have any questions?”, “Do you know what a serrated bread knife looks like [in reference to serrated leaf margins]?”, “Do you know what irises are?” were all met with silence (M. Patterson, Personal communication, April 6, 2016).

To conclude the section on leaf structure I passed out a small cutting of ornamental boxwood and asked the students to use the new terminology to describe the leaves. To scaffold the students’ discussion, I went back through the slides on leaf structure and again displayed leaf arrangement, margin, venation, and simple/compound leaves to help them describe the live specimen. The whole class readily and correctly responded to arrangement, margin, and venation. The slide about simple and compound leaves stumped the class. The students believed it was pinnately compound, but after locating the axillary bud, the students correctly concluded it was a simple leaf.

Finally, I quickly went through the last five slides, which gave few examples of interesting specialized leaves including carnivorous plants, which the students showed the most interest in. The students then signed media consent forms and I passed out the recorders.

Many of the students changed the tone and cadence of their voices to mimic a radio announcer when they spoke into the recorder, and giggling filled the classroom. One student seemed to alter her voice to be more like and NPR radio host; soft, monotone, and thoughtful. In contrast, some students were shyer when interacting with the recorders for the first time, but politely complied with my request to introduce themselves to the recorder following a script posted on a PowerPoint slide.

When the students finished their introductions, I gave the following instructions:

> Today you're going to do coloring pages to practice leaf structures. They have all the terms and pictures from the PowerPoint. They have instructions and explanations, further explanations, and more notes on this page, and this page [shows class instruction pages]. You will notice that the letters are kinda hollow. That means you um gotta color those in too. That's why you have a pencil sharpener and a cup so you can put you pencil shavings in your cup so you don't have to run to the trash can and make a mess so that's helpful. (students at table 1 laughing) So your recorder does not go in the cup [to table 1]. Um, alright so let's get this started. (M. Patterson, Personal communication, March 30, 2016)

After I gave the instructions, the students were instructed to get colored pencils from a box in the back of the classroom. One student from each table hurried to the back of the classroom to get the pencils from the box. Some groups felt that they did not get the best colors because they did not get to the box fast enough.

Lesson one, student engagement. The three tables approached their introductions to their recorders differently. Although the introductions were intended to simply give me a record of who was present in each group, the students' introductions seemed to set the tone for their interaction with the recorder and participation in the assignments. Students at table one were very excited to interact with an audio recorder. They introduced themselves with silly-dramatic voices and laughed uncontrollably. Emily, Jenna, and Annie then sang a song about a snowman from the Disney movie Frozen and quoted the movie Elf. The presence of the audio recorder seemed to have inspired this group to put on a performance.

In contrast to table one's introductions, both table three and seven were more subdued. At table three, Delany and Faith quickly introduced themselves using the recorder without any dramatics or silly voices, and then encouraged Beth to introduce herself to the recorder because she was reluctant to speak. They repeated their introductions, this time holding the recorder close to their mouths. Beth's introductions were the only time she spoke with her tablemates. Although

slightly more enthusiastic and giggly than table three, students at table seven introduced themselves without the theatrics demonstrated by table one.

After the introductions, all three groups had some difficulty with the assignment's instructions and getting started on their coloring sheet assignment. Table one continued to talk while I gave verbal instructions to the whole class. After the instructions, Jenna said, "I suggest you do not listen to table one's recording" possibly because the students were not focused (Jenna, Personal communication, March 30, 2016). It took about ten minutes for the students to figure out the labeling on the coloring sheets, they discussed if the structures were labeled for them or if they need to label the structures, and complained that I did not give the class instructions. They began coloring before they understood the labeling. After a few minutes of coloring, Claire exclaimed, "Oh it tells you what they are! ...Okay this makes more sense now." Emily replied, "We are basically just coloring." (Personal communication, March 30, 2016). They said, "I'm confused" several times throughout the activity, and not just at the beginning when they struggled to determine how to start coloring in the worksheet.

Both tables three and seven were silent during the verbal instructions, and tried to understand the activity by reading the instructions. To better understand the instructions, Faith at table three, immediately read the first three sentences of the instruction page out loud verbatim as soon as they got the worksheet. Delany and Faith seemed to understand the instructions and got to work discussing the structures, locating the letter labels on the representations, and assigning colors:

> Delany: I'm sharpening the pencils as fast as I can
> Faith: How about A will be green, then… (coloring sounds)
> Delany: So for all the A's in the whole entire thing, we are supposed to color it one color?
> Faith: Yes

> Delany: (talking to herself) …Major morphological regions A is the petiole and B is the stem…So A and B don't matter…oh no wait they are different… (Delany, Faith, Personal communication, March 30, 2016)

They were the quickest group out of the three to understand the assignment and start coloring. They also used correct botanical terminology in addition to letter labels and colors when they were discussing botanical structures.

Parallel to table three, students at table seven tried to clear up their confusion by reading the instructions. However, after reading the first three lines on the handout twice, they were still confused. Imogen read aloud to the group, "Color the leaf A its major morphological regions the lamina and the petiole and the stem and axillary bud the three diagrams at the top of the plate. Leaves come…" (Imogen, Personal communication, March 30, 2016). She did not read the letters that were present in the original text "…lamina (B), petiole (C), and stem (D) and axillary bud (E)…" (Young, 1983, p. 68), which may have helped the students see that the structures were already labeled for them to color. In response to the instructions that Imogen read aloud, Kendall said, "I don't understand", and Imogen echoed her confusion "I don't really either" (Kendall, Imogen, Personal communication, March 30, 2016). The students wondered aloud about what they should color, how it should be colored, and then decided they were "just going to color" (Imogen, Personal communication, March 30, 2016). The three groups demonstrated that the verbal instructions were not clear enough, and that the written instructions were only helpful to students who read them verbatim.

While the students at tables three and seven worked, they discussed the presence of the audio recorder. Table one did not directly acknowledge the presence of the recorder, but spoke directly to it and seemed to perform for it. Table three was very aware of the recorder in the

center of their table. Delany suggested they name it. The idea may have originated from students at a neighboring table that also named their recorder.

> Delany: Do you think we should give the recorder a name?
> Faith: What kind of name does the recorder need?
> Delany: What's a good name for a recorder?
> Faith: Renaldo?
> Delany: I'm thinking more of like a reporter recorder name.
> Faith: Clark Kent? (giggling) Anderson Cooper?
> Delany: A part of me loves it though; a part of me loves Clark Kent.
> Faith: We can call it Clark.
> Delany: Hello Clark. (Faith, Delany, Personal communication, March 30, 2016)

Table seven was also very aware of the audio recorder, and that what they said would be transcribed. After coloring a leaf blue, Imogen asked "Audio recorder, how do you feel about that?" Later the table discussed the presence of the audio recorder:

> Kendall: It would a funny way to like let's see, to play this back and listen to what you say, like how you talk
> Imogen: I wish I didn't know
> Kendall: I wasn't asking for your opinion I was just stating it
> Imogen: I wish didn't know I was being recorded
> Holly: What?
> Imogen: I wish I didn't know I was being recorded. It would be more natural…
> Holly: How do you feel about that?
> Imogen: It's weird! .... right in front of you
> Holly: So does she have to transcribe everything we say?
> Imogen: Ok that's what I was thinking, so what these things are on for like thirty minutes and there are like 3 6 7 or 8 groups. That's a lot. (Kendall, Imogen, Holly, Personal communication, March 30, 2016)

This awareness may have impacted what the students discussed while they were coloring in the leaf worksheet and what they said during the small group discussion.

In addition to discussing the recorder, the students discussed the leaf structures, colors they were using, and the art intervention. Table one was mostly on topic throughout out the activity possibly due to the prevailing confusion about the instructions. Students at this table used both the botanical terms and the letters used to label the structures in their discussions. The

whole group sang the alphabet song because they were chatting about the letters used to label the structures so much. Then PG announced to the recorder, "that was the original ABC's by table one, our next CD will be out by August 14th of next year we hope you buy it" which was more evidence of the students performing for the audio recorder (Jenna, Personal communication, March 30, 2016). They discussed adult coloring books, which Jenna and Emily enjoyed coloring, Annie thought they were boring and threw hers away, and Claire did not weigh in on the topic, but clarified that they were *adult* coloring books.

At table three, Faith and Delany discussed the letters that labeled structures, colors available, and used correct terminology when pointing out the structures to one another.

> Faith: Lamina right here is B
> Delany: The lamina is yeah, that's the lamina because the petiole is different
> Faith: Just checking (Faith, Delany, Personal communication, March 30, 2016)

Beth did not participate in the conversation. Their on-topic conversation only lasted approximately nine minutes, but was more focused and quicker paced than the other two tables, so they covered many of the structures on the first page of the coloring worksheets.

At table seven, students discussed the colors they were using, and only mentioned the structures they were coloring a few times. "I'm going to make mine blue!" Holly exclaimed with a laugh (Holly, Personal communication, March 30, 2016). Imogen described both the color and the structure. "I think I am going to make the axillary bud orange, you know like on this thing [boxwood cutting on the table] it's kinda orange" and about a minute later Kendall chimed in "God, I can't believe you colored it orange, it looks like poop" (Kendall, Imogen, Personal communication, March 30, 2016). The colors used seemed more important than the structures at this table. After coloring for roughly nine minutes Kendall exclaimed:

> Kendall: You know what? I'm not coloring it for accuracy.
> Imogen: Why not?

> Kendall: Because I hate coloring! (Kendall, Imogen, Personal communication, March 30, 2016)

Two minutes later Kendall says, "I don't want to color anymore!" (Kendall, Personal communication, March 30, 2016). The two other tablemates did not indicate frustration about coloring.

While the students worked, I walked around the classroom to answer questions. I answered group one's questions twice during the activity time. The first time came from the whole group about how to color the venation patterns. I concluded with "It's really to help you learn, so if you don't follow the rules exactly but you learn from it then you know…" they said "okay", but seemed frustrated that I would not give them black and white instructions. The second question came from Jenna, she asked "why is this labeled A?" I explain that the blade and the petiole together make the leaf and that its ok to color the petiole a different color because that is still correct, just more detailed than the way the worksheet had it labeled.

At table three, when I asked Beth if she had finished coloring the first page, she responded by saying she was still working on it. Aside from her brief introduction this was the only time she spoke during class time. Table three did not ask me any questions during the activity time.

Before table seven started coloring, the students complained to me about their colored pencil selection, and I told them to think of them as fall colors because they had some red, orange, and yellow pencils. They did not ask questions after that, and I did not interact with table seven while they were coloring because they seem focused, on task, and engaged. However, after listening to the recording, it seems their hands were on task but their thoughts were elsewhere.

At all three tables the students had off topic conversations. Table one used their activity time singing, laughing, and talking to the recorder. At table three, after naming their recorder, Delany and Faith spent about a third of their coloring time discussing superhero movies, but only did so after they had figured out the assignment and were actively coloring while they talked. During the activity time table seven spent approximately half of their activity time discussing the museum school and assignments from other classes.

Lesson two

Before the start of lesson two I placed the leaf coloring sheets from lesson one on the students' tables and explained that they were not graded, but they were scanned. The students saw the fresh flowers on my desk and talked about when, as children, they pulled out flower petals one by one saying "he loves me, he loves me not". I began the shorter eight slide PowerPoint lecture right at the beginning of class to try and give the students more time to create representations of flowers. The lecture began with a one slide explanation of the reproductive function of flowers, and continued with one slide defining and illustrating accessory parts of a flower (e.g. petals, sepals, receptacle, and their collective terms), followed by three slides on reproductive structures (e.g. androecium, gynoecium, etc.), and concluded with four slides on influence types (e.g. spike, panicle, corymb, etc.) including one slide that focused on the specific structures of a head inflorescence typical of the asteracea (daisy) plant family. All slides were illustrated with instructor generated labeled line drawing diagrams (Appendix D); except one slide that introduced asteracea inflorescences and had a photograph of a sunflower.

During the lecture, I used fresh flowers to point to structures and asked questions to elicit whole class responses. The majority of students quietly mumbled their responses to the whole class questions. While I was discussing the flower structures, a student asked if she would be

required to label diagrams that were similar to the ones in the PowerPointon the upcoming test. I informed all the students that they would be labeling photographs of plants on the test. To transition from simple flowers to a discussion of inflorescences, I used a photograph of a sunflower on a slide and asked the students "How many flowers do you see here?". After a long silence I asked, "Does anyone see one flower?" and one student spoke up and said, "I feel like this is a trick question, I see one flower…".

The lesson concluded with an explanation of several inflorescence types and spontaneous short discussion about pollination without a corresponding PowerPoint slide. The students were much calmer and quieter during this lesson. At the end of the short lecture I passed out the recorders. The students began whispering and slowly the volume in the classroom increased as they began to introduce themselves with a marked decrease in theatrics from their first introductions. I then gave the class the following instructions:

> Today our activity is to draw the flowers we talked about. These are the terms (gestures towards a PowerPoint slide of terms) you will use, so you are going to draw simplistic diagrams kinda like the ones that were in the PowerPoint. You can only use pencil and paper to create your drawing so even if you have fancy markers, or you know, fun colored pens at your desk, pencil and paper only. And you will want to draw enough pictures, simplistic diagrams, so that you can label them with all of these terms, except for the inflorescences… (M. Patterson, Personal communication, April 4, 2016)

After the instructions were given, students began to draw and label the flower examples.

Lesson two, student engagement. Overall the mood in the classroom was much quieter and subdued compared to lesson one. It was a beautiful spring day towards the end of the semester, and it was clear that the students were tired and not keen on being confined to a classroom. The students at table one were whispering so quietly I could not transcribe what they were saying when the recorders were first distributed. Their performance for the recorder had

ended at the conclusion of lesson one, during lesson two they were less animated and more focused on the assignment.

Table three was silent for the majority of the activity. Consistent with lesson one's activity, Beth did not participate in any conversations during the entire time. Delany mentioned needing to start over on a new piece of paper at the beginning of the lesson and said, "I'm like not even wanting to do this…" (Delany, Personal communication, April 4, 2016).

Gwynn joined table three for the first time during lesson two. During the introductions to the recorder, Kendall mentioned, "This is a very stressful day in my life.", and after the introductions she had a hushed conversation with her tablemates about being asked to be a bridesmaid.

Consistent with lesson one, most of the groups struggled with the instructions. Table one was confused about the instructions thought the activity time. Immediately after I gave verbal instructions the students asked each other:

> Claire: Are we doing one flower?
> Emily: We are doing a whole bunch of flowers….you have to label the whole left side [terms on the PowerPoint slide], on different big flowers or little flowers?
> Jenna: Do you think I can just copy this picture I found on the Internet?
> Emily: Are we doing this individually or as a group?
> Annie: I think individually
> Emily: Okay (Claire, Jenna, Emily, Annie, Personal communication, April 4, 2016)

However, they started drawing sooner than they had started coloring during lesson one. Although they may have used a flower diagram they found online, they applied the labels to the live flower species I brought to the class. After 15 minutes into the activity the students at table one were still uncertain about what to draw.

> PG: I'm like, really confused.
> Claire: Me too.
> Emily: I don't think I really understand…I don't understand…we only have four flowers, right?

Claire: Indeed. (Claire, Jenna, Emily, Personal communication, April 4, 2016)

Despite their confusion, they successfully completed the activity by drawing and labeling flower structures correctly.

Tables three and seven did not struggle with the instructions as much as table one. However, Delany needed a new piece of paper at the beginning of the lesson to start over, which indicated that there might have been some confusion about the instructions. Students at table seven became upset towards the end of the lesson because I asked them to draw an inflorescence, which indicates that they were not clear on which flowers to draw.

All tables spent more time silently working and discussing flower structures than engaging in off topic conversation. Table one's conversation only strayed off topic once to discuss dinner plans for less than one minute. Table one spent the entire time drawing, silently sketching, asking each other questions about flower structures, or discussing what they should draw and label. Below is a conversation that all four students at the table had about flower structures:

> Claire: What's the name for these?
> Annie: Those are disk, yeah disk flowers.
> Jenna: What's the pistil?
> Emily: It's just the female parts, like the collective part, like the sigma style and ovary.
> (Claire, Annie, Jenna, Emily, Personal communication, April 4, 2016)

The students could correctly answer each other's questions throughout the drawing time.

The limited dialogue at table three was primarily between Delany and me, but occasionally between Delany and Faith. Delany helped Faith with the activity by correctly repeating the information I had given her.

The students at table seven were the most off topic, however, they asked and answered each other's questions about the plant structures during most of the activity time. Their

conversation strayed off to baseball games, springtime weather, high school senior skip day, and last year's prom.

Unlike lesson one, some of the students at tables three and seven complained about participating in the drawing activity and their artistic ability. Delany complained throughout the lesson about the tiny structures that made her eyes hurt and gave her a headache. She stated, "oh this is hurting my eyes oww…", "The tiny ones are giving me a headache because they are so tiny.", and "…I'm getting a big headache from this, it hurts" (Delany, Personal communication, April, 4, 2016). Delany did not seem to enjoy the activity.

Students at table seven made frustrated comments about their perceived level of artistic skill. Holly exclaimed defeated, "Uh I'm just not such an artist.", and Imogen replies, "Holly, stop it." to encourage her. Holly ends the exchange by lamenting, "I used to be good at drawing but not anymore." Kendall complained and apologized to me for her perceived lack of drawing skills.

> Kendall: Uh I'm not very artistic
> MEP: It looks like you are doing a fine job to me, all the parts are labeled and that's the important part.
> Kendall: I apologize.
> MEP: No, it's good. (Kendall, MEP, Personal communication, April 4, 2016)

Students at this table were very self-deprecating when it came to their own artistic abilities, but always encouraged and complemented each other's drawings.

While the students drew, I walked around the classroom passing out flowers, hand lenses, and answering student's questions. I spent the most time talking to students about the daisy, which is a complicated inflorescence. I interacted with table one twice, once to answer questions about which flowers to draw, and to explain the daisy inflorescence with its disk and ray flowers. The second time I came to their table I saw over their shoulders that they had not labeled their

disk and ray flowers in detail, so I initiated the conversation. I encouraged them to use the hand lenses I passed out to look closely at the disk and ray flowers so they would beable to label the reproductive structures. Their final drawings were correctly labeled.

At table three I primarily discussed how to label the daisy with Delany, while Beth and Faith listened in on our conversation.

> MEP: So that's a flower, and that's a flower,
> Delany: So would these be considered its petals?
> MEP: Yeah that's an asymmetrical petal. Instead of going around it goes longer one-way.
> Delany: So if you take it apart…
> MEP: Yeah unroll it a little you can see …see that tiny little string?
> Delany: That's the stamen?
> (Delany, M. Patterson, Personal communication, April 4, 2016)

After our conversation, Delany and Faith continued to discuss and label the structures found in a rose while the started to clean up their table.

I overheard that the conversation at table seven had strayed off topic, so I came by their table and noticed they did not diagram the daisy. I told them that they still had a flower left to diagram, and explained how to find all the tiny structures with a hand lens. The students struggled with their last flower and said, with aggravation in their voices, that I didn't tell them they had to do it at the beginning of the activity time.

Lesson 3

The morning before I taught this lesson I spent some time water coloring to be more empathetic to the students when they were water coloring. Before class started, I purchased and cut fruit in half for the students to draw, label and watercolor. The ten example fruits available to the students were: tomatoes, zucchini, peaches, jalapenos, blackberries, peanuts, apples, oranges, bananas, and fresh garbanzo bean pods.

To begin the 13 slide PowerPoint lecture on fruits, I informed students that they had been taught about fruits by nutritionists and not by botanists, so they should try and keep an open mind, because some of the information in the lesson was contrary to what they had learned in the past. I had taught students about fruit several times in the past and I learned it is better to prepare them for new terminology than to shock them with the information. I started with a slide containing the botanical definition of a fruit (a mature ovary) and seed (mature ovule), the next slide covered the general structure of fruits, followed by a slide displaying a diagram of broad categories for types of fruit. The students quietly took notes during this introductory portion of the lecture.

The next seven slides described specific types of fleshy fruits and their botanically accurate names. Each slide was illustrated with an instructor-generated, labeled watercolor to demonstrate what the students would create during the activity time (Appendix E). Surprisingly, the students were very receptive to learn botanical terminology and were shouting various fruits types to learn the botanically correct term to describe the fruit, or to provide additional examples of the fruit type we were discussing. The students shouted: “Grapes!”, “Cucumbers!”, “What about bananas?”, “Watermelon?”, “What kind of fruit are blueberries?” the classroom volume rose with students talking amongst themselves at their tables, with an occasional student shouting a question, or a possible example of a fruit to me. I continued lecturing over the chatter because I was glad the students were engaged and on-topic. The students came up with several exotic fruits, for example, dragon fruit, papaya, and figs, which we disused as a class. To allow the students more time to watercolor, I briefly went over the last three slides that covered several dried fruits, which I did not have examples of for the students to draw and watercolor in the back of the classroom. To begin the watercolor activity, I gave the following instructions:

> So today, the first day we colored in worksheets, right? The second day we drew simplistic diagrams. Today we are going to draw accurate pictures of fruits and watercolor them [Emily: "awww" and some chatter from the class] so we are upping the level. So I want you to draw as accurately as possible. I want you to count the sections inside the fruit, I want you to look at how many seeds there are, like an apple has like five little um exocarps that hold the seeds you need to count them to make sure there is five. Count them and try to make them as accurate as possible. Please remove the stickers, don't draw complicated Chiquita banana stickers like we don't need that, so take the stickers off, we don't need those, so try to draw and label as accurately as possible. When we did the flowers we said just make it simple just make them diagrams, but today we want it to look like your fruit. I should be able to go back there and find the exact tomato that you drew. (M.Patterson, Personal communication, April 6, 2016)

After the instructions, the students introduced themselves to the recorders and started the activity.

Lesson three, student engagement. Once again, the students at table one were performing for the recorder. Jenna narrated the activity to the recorder in an announcer voice. She explained the activity and narrated the student's movements if they left the table to get supplies. For example, she stated:

> Jenna: We have just learned about all the different parts of fruits and what they are called, and next comes the artistic creative piece of the day where we will draw our fruit, and try and make it look as realistic as possible and then, wait for it, we will watercolor it in with these water colors. If I could show you a picture I would but you are recorded and not a camera. (Jenna, Personal communication, April 6, 2016)

The other students at the table occasionally chimed in during Jenna's narration. Similar to lesson two, table three worked in silence for most of the activity time.

Consistent with lessons one and two, group one was confused by the instruction during this lesson. Emily was the most confused and her tablemates tried to help explain the instructions.

> Emily: I'm kinda confused.
> Jenna: Do we have to get a fruit? Or do we each get one? Or do we all get the same one?
> Annie: I think we are just playing [referring to the play space at the top of the page]
> Emily: What's on the right column?
> Annie: The other fruit.

Emily: Why are there two columns? Oh, is that the top and the inside.
Annie: I think so.
Emily: I understand.
Jenna: Woooow deistar deister, beauuutiful (silly sounds and words).
Emily: What are we doing in the top?
Jenna: We color. (Emily, Jenna, Annie, Personal communication, April 6, 2016)

The students at table one were the last of the three groups to start on the activity because they were preoccupied trying to figure out the directions, using the botanical term "juice sac" as a replacement for a curse word, and singing the backpack song from Dora the Explorer for about five minutes before Jenna exclaimed "Hey guys we need to get a fruit!" (Jenna, Personal communication, April 6, 2016). A minute later, with the example fruit at their table, the students started drawing their representations.

Groups three and seven were not confused by the instructions and got to work quickly. When group three was deciding on which fruit to choose they picked an orange because they believed the cross section would be easy to draw and water color.

Faith: Apples, pears, oranges.
Delany: Yeah do an orange.
Faith: These are easy to cross-section.
Delany: Oh yeah!
(Faith, Delany, Personal communication, April 6, 2016)

When the students at table seven decided which fruits they wanted to watercolor, they chose what they perceived to be the easiest. Gwynn said, "I think an apple would be easy." and another student exclaimed "let's do the easiest!" and table seven chanted "Apple, apple, apple, apple…" (Gwynn, Kendall, Imogen, Holly, Personal communication, April 6, 2016). During most of the activity time, Imogen narrated what she was painting out loud to herself, "here we go that's not bad, I'm not the worst artist in the world…ok I gotta hurry." (Imogen, Personal communication, April 6, 2016).

After they figured out the instructions, all three tables spent some time discussing the plant structures during the lesson. As the students at table one worked they asked each other if their drawings and watercolors looked good and complemented each other's work. After five minutes of drawing and painting, approximately 12 minutes into the activity time, the students discussed the fruit structures and terminology for the first time.

> Jenna: What's a receptacle again?
> Annie: That's a great question though.
> Emily: We are all like uuuuuuuu.
> (Jenna, Annie, Emily, Personal communication, April 6, 2016)

The term receptacle was introduced during the flower lesson earlier that week. The receptacle on a flower looks completely different than the swollen receptacle that is part of a fruit, however, the students did not seem to recall the term at all. They asked each other and all agreed they did not know what a receptacle was three times before Jenna asked me:

> Annie: What's the receptacle? (mispronouncing receptacle)
> M. Patterson: The receptacle? Did I spell it right? (looks at the overhead screen with the terms on it) I was like oh no.
> Jenna: Would it be the stem?
> M. Patterson: Um, well is that an apple that you did? [Jenna: yeah] it would be most of this yellow part.
> Jenna: What is the definition of a receptacle?
> M. Patterson: It's the um flower part where the petals and sepals connect, do you remember? It's like the base of the flower where the stem and the flower meet.
> Annie: Would it be here?
> M. Patterson: That one doesn't have it, so…
> Jenna: So a peach doesn't have it?
> M. Patterson: Those don't have it so apples and pears and strawberries are going to be the ones that have the receptacle. (Annie, M. Patterson, Jenna, Personal communication, April 6,2016)

I continued to explain the layers within the fruit to the students and pointed them out on their representations. Right before cleanup, Emily and Jenna discussed the location receptacle again:

> Emily: Ok so the outside the red part is the receptacle.
> Jenna: No, ok yeah, I know the yellow part is the receptacle, but I don't know if the skin is included in that.

> Emily: So the skin is the receptacle, oh no, I mean the white stuff is the receptacle.
> Jenna: Yeah. (Emily, Jenna, Personal communication, April 6, 2016)

This time Jenna demonstrated more understanding, but not a complete confident understanding of a receptacle, and Emily still struggled with the structure.

Although table one was the last to start the activity, students at this table were the first to discuss fruit structures. Both tables three and seven did not discuss fruit structures until after I gave the class a ten-minute warning. Towards the end of class Beth spoke during the activity for the first time during the three lessons.

> Beth: Which one is the exocarp? The outside.
> Delany: Yeah, the very outside.
> Beth: So it's just four parts for each of them? Good, then all I need to do is color it. (Delany, Beth, Personal Communication, April 6, 2016)

A few minutes later she asked for advice on water coloring:

> Beth: I'm trying to make this a more vibrant red and not darker.
> Delany: Add a little bit more orange tint.
> Beth: Its true, it makes it more vibrant.
> Delany: Mmhum…
> Beth: I accidently mixed the real orange pulp with the paint, on accident, so it looks weird. So, like I did this and it surrounded, so now it literally smells like orange. (Delany, Beth, Personal communication, April 6, 2016)

Perhaps it was the difficulty of identifying the fruit structures to be labeled, the struggle of water coloring, or the familiarity with the audio recorder that prompted Beth to interact with her tablemates.

After I instructed the class to start cleaning up their tables, Delany exclaimed, "Awwwww this was fun!", disappointed that she had to stop water coloring. Faith assures Beth who was still working, "I think yours is good, Beth." to help her find a stopping point, and Beth replied, "Ok now we are good." (Delany, Faith, Beth, Personal communication, April 6, 2016).

After the ten-minute warning, table seven began labeling their fruit water colorings. Because they drew, water colored, and then labeled, they found it difficult to write the labels on the wet paper. Gwynn noted, "It's hard to write on this" Imogen commiserated "It kinda broke my paper a little" (Gwynn, Imogen, Personal communication, April 6, 2016). Imogen also lamented not drawing pictures in her notes to help her label her fruit structures, "um…I didn't draw the pictures, I don't know what I was thinking…" (Imogen, Personal communication, April 6, 2016). Right before the students cleaned up, I came over and pointed out the location of the structures they were struggling with. After I walked away Imogen applied what I told them to her representation, "endocarp is the crunchy part, and wait this is…the mesocarp…this is the exocarp. I think I got it? I think I got it?" her labels were correct (Appendix F), but her questioning tone did not indicate that she confidently knew the structures she was labeling.

During the activity time, the students engaged in off topic discussions and singing. All students at table one sang throughout the lesson. The two songs they sang the most were "Backpack" from Dora The Explorer and "Lollypop" by The Chordettes. Students at table three worked silently and did not have any off-topic conversations. At table seven, Kendall was excited there were roasted, salted peanuts in their shells, so she snuck some. Later, I gave her the rest of the peanuts. Kendall sang "Take Me Out to The Ballgame" because the peanuts reminded her of baseball.

Research Questions

After the students completed the botanical representation activity, the students at each table asked each other scripted questions during small group discussions (Appendix B). The scripted questions related to both that day's activity and the four research questions proposed in

chapter one. The students' conversations during the activity provided context for the student's responses to the scripted questions.

Research Question 1: What are students' past experiences with botany, art, and representations?

The students' experiences with art varied much more widely than their familiarity with and knowledge of plants. Only seven students discussed their experiences with plants because Gwynn was absent and three students at table one did not answer the question. Two students considered themselves artistic and had taken art classes in high school, and the other nine students did not consider themselves very artistic. The students at table one had experience with botanical art (drawings and leaf rubbings) in elementary school.

Experiences with art. Holly and Faith considered themselves artistic and had taken art classes in high school. In addition to taking high school art classes, Holly participated in art competitions. She received a considerable amount of positive feedback about her art from friends and family, but believes her art teacher thought she was average. Holly said she did not like to draw as much now because she has not done it in a long time.

Faith's interest in art was motivated by her struggles with numbers and letters in school.

> Faith: …I had severe dyslexia for, when, well I still have it but it was a lot harder when I was younger so the outlet that I always did was art because it wasn't confusing letters and numbers, um so I always enjoyed art… (Faith, Personal communication, April 4, 2016)

Her past experience with art was different than the representations she produced during the flower lesson. Having drawn roses in the past, she said the lesson was "A bit more scientific…a bit less artistic interpretation" (Faith, Personal communication, April 4, 2016). Both Faith and Holly continue to create their own art and art with children.

Some students enjoyed certain forms of art activity, but did not consider themselves artistic. Unlike the two students who considered themselves artists, all the students who fell in

this group mentioned coloring inside the lines in a coloring book. Gwynn liked to draw when she was younger, but not anymore. She felt confident in her coloring skills because she can stay inside the lines. Emily never declared herself an artist and has not received training, but enjoys doodling, coloring inside the lines, and water coloring and painting for fun. After the first lesson, Jenna said she did not consider herself artistic, but after lesson two she said she did not like to draw but enjoys doodling. Claire also never declared herself an artist. She could not remember the last time she water colored, but remembered liking it, and thought she was good at coloring in the lines.

Almost half of the participants were adamant that they were not artistic at all. Delany described herself as "the least artistic person in the world." (Delany, Personal communication, April 4, 2016). Both Beth and Delany had siblings whom they perceived to be more artistically talented than themselves, and Annie had been encouraged to draw by her parents but discouraged by her siblings. Annie likes to color but did not think she was good at it. Beth said, "my biggest fear is that I would not be drawing it accurately or depicting it as accurately as I should.", which may hint at her perfectionist tendencies that I observed during the semester (Beth, Personal communication, April 4, 2016). Kendall cites her perfectionism and lack of training as the reasons she has never liked to draw. Imogen got in trouble in school for not being neat and not coloring inside the lines, and said she is not good at drawing. She explicitly stated, "…I am not artistic at all, I have very bad handwriting, and I'm not very creative." (Imogen, Personal communication, March 30, 2016).

Many of the students noted that they used adult or children's coloring books recently. Adult coloring books are a recent popular trend; coloring book manufacturers allege that they have a calming meditative effect on the adults who use them (Barrett, 2015). Delany and Kendall

used the coloring books to pass time on planes. Kendall reported that it is relaxing unless you color outside the lines, and if she does color outside the lines she starts a new page. Annie threw her adult coloring book away because she "grew very bored with it" (HA, Personal communication, March 30, 2016). Not all the students used adult coloring books, Holly colored a Disney Princess coloring book that a relative gave her as a gift to entertain herself while recovering from surgery.

Because this is a course for pre-service teachers, many of the students interact with children as babysitters and mentors. Two of the students recently participated in art activities with children. Imogen colored in coloring books and water colored with the children she babysat. Faith mentored elementary students and colored and water colored with the children.

The last time many students remembered engaging in art was during elementary or junior high school when it was a required course. Both Kendall and Gwynn did not specifically remember that last time they water colored, but believe it was sometime in sixth grade or junior high. Both Jenna and Beth had very specific memories of the last time they water colored. Jenna remembers that the last time she water colored was at a local community center in fourth grade. Beth recalled water coloring detailed self-portraits in elementary school to learn about "facial structure and composition" (Beth, Personal communication, April 6, 2016). Several students either did art projects with young children when babysitting, mentoring, or remembered doing art as a child.

Experiences with plants. All students who responded to the question about plants gave brief answers which expressed that it had been a long time since they had learned about plants and that they did not know very much about them. Both Beth and Faith use technical terms (e.g. chlorophyll, chloroplasts, photosynthesis) without explaining the terms. Holly confided that she

is “not a plant person”, but gardens with her mother occasionally (Holly, Personal communication, March 30, 2016). Jenna and Imogen said they knew there were different kinds of plants and they had stems and leaves, but did not know botanical terminology. Delany stated, “I have not learned about plants since fourth grade” (Delany, Personal communication, March 30, 2016). Kendall said she knew a lot about cacti, with a laugh, but did not know their structures.

Experience with botany and art. As mentioned previously, the students at table one had used art to learn about leaves and flowers in the past. Jenna described going to the school yard in third or fourth grade and selecting a leaf then “we did the little thing where you shade the leaf so you can see the veins.” (Jenna, Personal communication, March 30, 2016). Jenna also believes she may have drawn pictures of flowers in high school. Emily, Annie and Claire said that they had also drawn pictures of flowers in the past to learn about their parts.

To conclude, the participants’ self-perception of their artistic skill varied widely. In contrast, they lacked in botanical knowledge and experience. Only three students commented on experience using art during a botany lesson.

Research Question 2: Which type of representation do students feel taught them the most about plant structures?

The students indicated that all three lessons helped them see details in leaves, flowers, and fruits that they had not noticed before. They also indicated that the activities would help them remember the plant structures. At the end of all three lessons the students made suggestions to improve the lessons.

Lesson one: coloring leaves. Three out of four students at table one believed that the first lesson taught them the most about plant structures. Annie said coloring was the most helpful because it was easy to distinguish the structures. Regarding lesson one she stated, “…we could

figure out what everything was easier like it should be, and today [water coloring/fruits] was not very easy" (HA, Personal communication, April 6, 2016). Jenna pointed out that using the coloring sheets made it consistent for each student in the classroom, they would all learn the same thing, and have the same materials to use to study for the test. Emily liked the structured nature of the coloring sheets. At the conclusion of the three lessons she said:

> Um, I think the first one [was most helpful] when we colored in a diagram that was already labeled I think that one was the most helpful. Because for the other two we were just kinda doing our own thing and we didn't have much to go off of. (Emily, Personal communication, April 6, 2016)

The students at the other two tables were not as overwhelmingly positive about their perception of learning during lesson one.

Only one student at table three indicated that lesson one taught her the most about plant structures after participating in all three lessons. At the conclusion of lesson one Delany said this would be a good activity for kids, but it was "really, really, really boring…" for her (Delany, Personal communication, March 30, 2016). However, after participating in lessons two and three, she indicated that lesson one taught her the most because she is not artistic. At the same table, Faith disagreed with Delany and said, "I'm not really sure but I believe the one that taught us the *least* about plant structure was probably the first lesson", but thought it was good practice for visual learners (Faith, Personal communication, April 6, 2016). Beth also mentioned that this activity would be good for kids because the parts are easy to distinguish, but did not indicate that it taught her the most out of the three lessons.

At table seven, none of the students indicated that coloring in the leaf work sheets taught them the most about plant structures when compared to the other two lessons. However, Holly said, "Seeing all of the leaves mapped out with different parts helped me understand which parts were the parts on the leaf" (Holly, Personal communication, March 30, 2016).

The students at tables one and seven demonstrated what they had learned when they indicated that the coloring activity prompted them to see differences in the leaves and the different parts that they did not know about before. Emily at table one said, "I think I noticed differences, I obviously noticed there are different types of leaves, but now I think there is clarification and identification of what those differences are and what they look like." (Emily, Personal communication, March 30, 2016). At table seven Imogen said,

> I think this lesson was very good because I guess I never like stopped to think about the different shapes and margins and the different veins and stuff on the leaves so I think it was good to notice that. (Imogen, Personal communication, March 30, 2016)

At the same table, Kendall agreed with Imogen by saying, "…it helped me see the different parts of the leaves that I never knew about…" (Kendall, Personal communication, March 30, 2016). The other participants did not comment on any specifics of what they learned or saw differently after completing the first activity.

Although students could see many advantages to using the coloring sheets, some students indicated ways to improve the lesson. After lesson one both Jenna (table 1) and Kendall (table 7) indicated that the coloring instructions were unclear and it was difficult to know what to color. Delany suggested that in the future the instructor should use coloring sheets with unlabeled diagrams so students that are not artistic would not have to draw, but could practice labeling.

The majority of participants indicated that they would not be able recall all of the leaf structures a year from now after completing the coloring sheets. Students at table three and seven recognized the need to practice structures in order to remember them. At table seven Imogen said, "Um, I don't think I would remember it [leaf structures] perfectly I think I would need a bit more practice for that, but I definitely think I would remember the leaf and stem which I already knew…" (Imogen, Personal communication, March 30, 2016). At table three, Faith commented

on practice as well, "It's not something I do daily [identify leaf structures], so I think if it is something I did daily on a daily basis It would be something I could remember" (Faith, Personal communication, March 30, 2016).

Lesson two: drawing flowers. Over half of the participants (Annie, Jenna, Faith, Beth, Holly, Imogen) across all three tables indicated that drawing the flowers helped them understand their structures better. Holly said, "I actually got to draw the different um elements of the plant and write down and just label every single part, so it helped me get it into my brain" (Holly, Personal communication, April 4, 2016). At the same table, Imogen also found that drawing flowers helped her understand the structures better, "I do think that drawing the flowers kinda helped because you get to emphasize the parts that you are trying to label and so that helps make it stick out a little more and help you understand" (Imogen, Personal communication, April 4, 2016). At table one Jenna explained, "I feel like drawing them [flowers] helped me understand them, because in order to draw them you have to understand what they look like, and where they are located, you can't just guess." (Jenna, Personal communication, April 4, 2016).

In addition to understanding the structures, several students thought drawing could help them remember the flower structures. Beth said, "I find that this has really helped me understand the structure better because like the activity when we were drawing it I feel like it helped me picture it better, I feel like I will remember it better" (Beth, Personal communication, April 4, 2016). Kendall believed that drawing the flowers would help her short-term memory,

> …I don't know if I could say I would remember it any longer because I don't know if I have ever even had a lesson like this before, but I certainly think that drawing it will help me short term. (Kendall, Personal communication, April 4, 2016)

Both Holly and Gwynn believe that they would remember the flower structures in the future if they saw a flower cut in half or taken apart. Several students mentioned that they would

remember the larger more visible structures, (e.g. petals and sepals) as opposed to the smaller structures found in inflorescences.

Congruent with lesson one, the students noticed differences in the structures. Kendall and Gwynn at table seven noticed differences in flower petals (e.g. size, shape, and color), a structure they were already familiar with. Delany noted that she noticed the differences in rose, lily, and tulip stamens.

Unlike lesson one, at the conclusion of lesson two, the students saw more than just differences in the flowers they drew. In addition to differences, Faith noticed similarities. She noted, "…drawing really helped, I can see the similarities between the stamens and the ovaries but you can also see the differences between those." (Faith, Personal communication, April 4, 2016). Beth commented on the complexity she observed during the second lesson, "...I didn't realize it was way more complex than I thought it was. I was fascinated to see all of the parts that make up a flower…" (Beth, Personal communication, April 4, 2016). At table seven Imogen described not only the form of the flower, but its function as well.

> I thought the structure was the most interesting was the stigma because it was the female part that was sticky that got the pollen and I didn't know that, so, I thought that was very interesting that was kinda that the plants uh that bugs would come and pollinate and that they actually moving the pollen around, so that was cool. (Imogen, Personal communication, April 4, 2016).

Table one also had a conversation about form and function of flower structures. Annie cleared up Jenna and Emily's confusion about the function of botanical reproductive structures.

> Jenna: I thought that the most interesting were the sigma style and ovary collectively known as the pistil because …
> Emily: Why Jenna?
> Jenna: It's cool how they can produce the pollen (laughing).
> Annie: They can't produce the pollen…they make babies, the anthers produce the pollen.
> Emily: The anther catches the pollen.
> Annie: No, it's the other way around.

> Jenna: Ooooh then we messed up ok maybe they don't produce the pollen (laughing). (Jenna, Emily, Annie, Personal communication, April 4, 2016).

Lesson two prompted a much broader discussion of plant structures than the leaf coloring sheet.

At table three, Delany and Faith believed that drawing flowers would be a good lesson for children, and discussed the age appropriateness of the content. Delany said, "I would do like, the tiny inflorescence daisy with the older kids" (Delany, Personal communication, April 4, 2016). This may indicate that they perceived that they learned from this lesson, and that children may benefit from it too.

The students brought up learning styles during the small group reflections after lesson two. Kendall is a self-described hands-on learner who said,

> …like I said earlier I'm very hands on and that just kinda helps me just see things in my own writing in my own work it is easier than just looking at a picture on a screen and just to have to try and visualize what it is within a flower. (Kendall, Personal communication, April 4, 2016)"

After reflecting on all three lessons Holly says she liked drawing flowers because it was a hands-on activity.

Similar to lesson one, there was confusion about the activity and its instructions. All four students at table one wished that they were given a diagram to help them know what they were supposed to be drawing and labeling. The confusion during the lesson may have decreased the amount of information the students learned or provided a greater challenge to understand the assignment, which inspired more on-topic discussion of the activity.

Lesson three: water coloring fruits. Several students commented on how they were more focused during the watercolor activity. Claire at table one said, "…once we started using the water colors we were a lot more focused on, you know, pinpointing the exact structures…"

(Claire, Personal communication, April 6, 2016). That focus helped the students notice structures they had not seen before. Imogen explained:

> I definitely think that water coloring the fruit structures helped me notice things I didn't notice before especially in the apple and how it was labeled and how the part that I thought would be the mesocarp was actually called the receptacle. So, I don't think I would have gotten that, probably if I had not only just drawn it. (Imogen, Personal communication, April 6, 2016).

Beth and Faith at table one, also felt that water coloring helped them notice more details. Faith Said "…it's not a quick look at it, you're actually looking at the structures…" and Beth added "…I feel like drawing and water coloring made me pay attention to more details that I was looking over. I feel like it helped me pay more attention to details" (Faith, Beth, Personal communication, April 6, 2016). All the students at table seven agreed that water coloring fruit structures helped them prepare for the upcoming test at the end of the unit.

Students at tables one and seven commented that water coloring fruits was the easiest of the three lessons. Claire mentioned that it was easier to relate to fruit because she has more experience with it. At table seven Imogen, Kendall, and Gwynn said it was easier because there were fewer structures to label. Imogen agreed with Gwynn and added, "…like Gwynn said um it had less parts to label so it is easier to process the information. With leaves and flowers there is so much information it is harder to digest" (Imogen, Personal communication, April 6, 2016). The students believed you could learn more by focusing on fewer structures.

Some students did not feel water coloring helped them learn the fruit structures. Delany noted that it was not the water coloring that helped her learn, but drawing the fruit before water coloring. It helped her learn about the structures. At table one Emily and Annie agreed that water coloring made it harder to find structures because the structures are similar in colors and it was difficult to replicate the exact color with watercolors. Holly, at table seven, recommended using

colored pencils rather than water colors because they dry faster and they could get more than two fruits done. Jenna at table one, would prefer to look at a diagram instead of creating a watercolor, "…I think I will learn more looking at an already made diagram and just studying that than like doing the watercolor and then trying to label it" (Personal communication, April 6, 2016).

The amount of time it took students to watercolor was also perceived as a detriment to learning during this lesson. Because water coloring takes more time than drawing, the students only had time to complete two fruits. Students at all three tables commented on the limited number of representations they created. Imogen summed up table seven's response by saying,

> I think I might be able to remember the names and the different categories of the fruit but kinda like everyone else said I think it would be harder to recall the information of the fruits I didn't draw. (Imogen, Personal communication, April 6, 2016)

The students also drew, water colored, and then labeled so they did not spend much time on working on the labels and felt rushed. Claire at table one said,

> I don't think we had enough time to really do the watercolor, so um I didn't have enough time to practice the names of the different structures, so probably not as much. I think I have some studying to do. (Claire, Personal communication, April 6, 2016)

Also at table one, Emily commented, "…we were all trying to get to colors right because we were trying to have an accurate picture, and like the last two minutes we spent labeling because we didn't know which parts were which…" (Emily, Personal communication, April 6, 2016).

Suggestions for improving lessons. After the three lessons, the students reflected on various ways the lesson supported learning or ways that the lessons could be improved to increase student learning. The students at table three valued the variety of art interventions so that all students, regardless of their strengths and weaknesses, could do an activity at which they could excel. Gwynn requested a physical model that could be taken apart for students who are not good at art. The students at tables three and seven requested diagrams of all the flowers and

fruits, so they could know what to draw and watercolor and have something to study from other than their own activity artifact.

In conclusion, the students' background played an important role in their perceptions of learning. Some students enjoyed the variety of art interventions because they could support learning for all the students in the class not just the artistic or self-described non-artistic students. There was no clear best practice when it comes to teaching botanical structures using art interventions.

Research Question 3: Which type of representation do students feel was the most enjoyable and the most stressful to create?

Lesson 1. When the participants discussed how coloring in the coloring sheets made them feel, they used words like "calm", "relaxed", "fun", and "enjoyed". Claire at table one said, "I felt very relaxed and really enjoyed coloring different sections and structures of the leaves…" (Claire, Personal communication, March 30, 2016). At table three Beth said, "…I felt calm and like I was able to concentrate, it helps me with my concentration…" (Beth, Personal communication, March 30, 2016). At table seven, Holly was the only student to express positive emotions about the coloring activity. She said, "…it was very enjoyable and fun to color the leaves it brings us back to our childhood." (Holly, Personal communication, March 30, 2016).

However, several students at table seven did not find the coloring activity very relaxing due to confusion about the instructions and limited colored pencil options. Kendall expressed her frustration by saying,

> …I was actually a little confused because I wasn't sure if I was supposed to color different parts of the leaves different colors or if it was all supposed to be the same color, and also, I was a little sad because we got really bad colors, so I felt limited by the colors we were coloring with. (Kendall, Personal communication, March 30, 2016)

Imogen and Holly also expressed confusion and hesitation to start the assignment. Imogen said, "…I was just kinda hesitant to start working on the paper because I wasn't sure what to do." (Imogen, Personal communication, March 30, 2016). Confusion and hesitation are not overtly negative emotions. They indicated some discomfort with the assignment, but not the act of coloring in the worksheets.

Lesson 2. The two students with previous artistic training commented that they like drawing better than coloring because it helped them learn and that drawing was better suited to flower structures. Faith, at table three, said,

> Personally I think it would have been better for this subject because with leaf structures it is a little bit more uh general and a little bit more of the same, but with flowers it is more diverse…so it's probably better drawing different types of flowers. (Faith, Personal communication, April 4, 2016)

The other participant with art training, Holly, told her table mates, "I actually like it better this time because it helps me learn because I was actually drawing out the different structures" (Holly, Personal communication, April 4, 2016).

The students who described themselves as not artistic found drawing to be a more difficult experience. At table one Annie commented "Um, so I'm not a very good draw-er, so it was hard…to draw." (Annie, Personal communication, April 4, 2016). Beth at table three describes her personal fears related to drawing flowers, "My biggest fear was that I was not drawing it accurately enough sometimes…" (Beth, Personal communication, April 4, 2016). Imogen and Kendall at table seven both noted an increase in anxiety. "I felt a little more anxiety than I did last week because when you're coloring a worksheet you can color between the lines and when you're drawing you kinda just have to free hand" (Kendall, Personal communication, April 4, 2016). Imogen agreed, "…It caused me more anxiety I wasn't really sure what I was

doing even more so. I was a little frustrated but I got myself together towards the end." (Imogen, Personal communication, April 4, 2016).

Unlike the other self-described non-artists, Delany at table three had made peace with her perceived abilities and expressed neutral emotions, "I have accepted the fact that it is not my strong suite [drawing] so I'm like, eh'" (Delany, Personal communication, April 4, 2016). However, upon first hearing that we were drawing flowers during the lesson she did feel scared, "Personally, I was a little scared when we said that we were drawing flowers because I don't draw and I don't like drawing but other than that I thought it was a lot better than the leaf." (Delany, Personal communication, April 4, 2016).

Lesson 3. "Excited" was the word most students used to describe how they felt when the learned that we were water coloring fruits. At table one Claire exclaimed, "I was excited I really like watercolors so, um, it was very interesting" (Claire, Personal communication, April 6, 2016). Jenna echoed Claire, "I was really excited because it was going to be something new and different from what we had done the past two days." (Jenna, Personal communication, April 6, 2016). Faith at table three explained, "I was kinda excited, but I like painting and doing craftier activities especially with kids, that's my thing…" (Faith, Personal communication, April 6, 2016). Both Holly and Imogen, at table seven, noted that water coloring made them feel calm and that it relieved stress. Gwynn at table seven was excited to watercolor for different reasons, "I was very excited for this because it was a lot easier to draw and it's fun to paint and fruit is not too difficult to do." (Gwynn, Personal communication, April 6, 2016).

Three students expressed conflicting feelings about the watercolor activity. Emily at table one was both excited and nervous to watercolor, "I was excited because I like watercolors, but also nervous because watercolors aren't always realistic because they are free flowing and flow

fast." Beth also had mixed feelings, "I was terrified, I was like 'oh my goodness what if I draw it wrong?', and I was like 'I think this activity helps me pay attention to details, to pay more attention to the structure of the fruit'" (Beth, Personal communication, April 6, 2016). Kendall at table seven did not like creating art but found water coloring exciting, "When I found out we were drawing again I was a little bummed because I'm not crazy about art or doing art I guess, but the watercolor was exciting" (Kendall, Personal communication, April 6, 2016).

Only Delany, at table three, did not enjoy water coloring at all. She used the word "terrified" twice when talking about water coloring. She stated, "Definitely a terrifying experience to have to do it realistically than if it is a general cartoon.", and "Personally I was terrified especially with this [water coloring]." (Delany, Personal communication, April 6, 2016).

To conclude, all students regardless of their artistic ability enjoyed the act of coloring, however, they did not like the confusion about the coloring instructions. When students were asked to draw, there was a clear divide in emotional response between students who had art training and responded positively and students who perceived a personal lack of artistic skills and indicated a negative emotional perception of the lesson. Water coloring a realistic looking fruit elicited excitement, mixed feelings from most students, and terror in one.

Research Question 4: What changes do students notice, beyond the classroom, in how they view leaves, flowers, or fruits?

Lesson 1. The students were asked if they would show friends and family leaf structures that they had learned in class. Both Imogen and Delany said they would point out an interesting shaped leaf to a friend. Imogen was more enthusiastic and certain she would share what she learned,

> Um, I would say yes, I think I definitely would appreciate the different shapes and all of their variations of leaves I think it's interesting, so if I saw a cool shaped leaf I would point it out to a friend. (Imogen, Personal communication, March 30, 2016)

Whereas Delany seemed more reluctant to point out an interesting leaf to a friend,

> I mean I guess if we saw a really interesting leaf then I guess I might be like, 'we learned about this in that class'. I wouldn't go into full detail about it because I don't spend my days looking at leaves I'm not a big nature person at all. (Delany, Personal communication, March 30, 2016)

Holly, Kendall, and Delany were eager to share information about the axillary bud because it was new information that they had learned in class, easy to remember, and is often overlooked in nature. At table seven Holly and Kendall commented on the axillary bud, "…I would show them the axillary bud because …I hadn't noticed the axillary bud but now I will keep my eyes open." (Holly, Personal communication, March 30, 2016). Kendall believed the axillary bud was easy to remember, and therefore something she would share, "Um, I would probably would try to point out the axillary bud because it's easy to remember, but I don't think I would point out much more beyond that if I didn't remember" (Kendall, Personal communication, March 30, 2016). Delany wanted to point out the axillary bud because it was something people do not notice. "…like I don't know why, I would show them the axillary bud, I don't know why…something they wouldn't really notice" (Delany, Personal communication, March 30, 2016).

Two students commented that they would not show friends, but maybe children they babysat. Both Faith and Delany agreed that showing leaf structures to kids would be a fun and informative activity. Faith said, "…when I'm babysitting a kid or something, that might be a fun activity, like, hey that's a perforated leaf that's and entire leaf, maybe a little fun fact to keep them interested" (Faith, Personal communication, March 30, 2016).

Claire commented that she would share botanical information with friends after she had time to practice and study the structures more.

> Yes, once I leave class I will probably walk out the door and (laughing) look at the leaves and identify their structures, I don't know if I will necessarily be able to point to all of the

> structures to friends yet, but maybe in the future once I get more practice I will be able to point out the features and sound like I know what I'm identifying when I point out a leaf…I will be practicing this by looking at my coloring book (laughing) studying my notes of course (laughing) and real leaves…real leaves….and I believe that is all (Claire , Personal communication, March 30, 2016)

The amount of laughing in her response may indicate she does not intend to share information about leaf structures after the class has ended. However, her response indicated the lesson did not help her reach a full understanding and additional studying will be necessary before she will feel comfortable with the material. However, during the four days between the first a second lessons Claire, did not take time to study real leaves. "…I have just noticed more leaves, but I have not looked at the structure." (Claire, Personal communication, April 4, 2016).

Five other students, (Emily, Annie, Jenna, Faith, and Delany) mentioned that they had not looked at leaves differently during the four days between lessons one and two. Delany and Faith do not like to go outside; Delany cited that she "is not a nature person" and Faith said, "I'm basically allergic to the sun", so they do not go outside very often. At table one Emily, Annie, and Jenna all confirmed that they did not look at leaves differently between lessons one and two. Only Beth said that she showed her, science and nature loving, brother leaf structures and he thought it was "pretty interesting".

Lesson 2. After participating in lesson two, the students at table three and Holly from table seven said that they would view flowers outside of the classroom differently because they would see them as more complex. Beth said, "…I would definitely see them differently I mean I always saw flowers but I never paid attention to…how complex they were like their structure and how they are made..." (Beth, Personal communication, April 4, 2016). Faith and Delany both mentioned looking at flowers to see if they were an inflorescence or a single flower. Faith commented, "…I definitely think I will go and look at them [flowers] differently and be like 'oh

is this an inflorescence or is that a simple flower?'" (Faith, Personal communication, April 4, 2016). Holly said she would look at flowers differently because she learned what the insides look like.

Three students said they would look at flowers differently in specific ways. Both Jenna and Emily at table one said they would have to look at flowers up close and dissect them to see them differently. Jenna said, "I won't look at them differently unless I see them up close then I will be able to see the parts we learned about." (Jenna, personal communication, April 4, 2016). Emily agreed with her tablemate, "I agree, if I'm ever pulling the parts of a flower apart I will look at them differently." (Emily, Personal communication, April 4, 2016). Kendall said that she would not look at flowers differently, but think of them as a reproductive structure with a function. Kendall said, "I mean, I might look at it and I might be able to identify things, but I don't think I will see flowers any differently. Maybe just like see them like reproductive things because I never knew that…" (Kendall, Personal communication, April 4, 2016).

Four students indicated that they would not look at flowers differently. Claire indicated that she would not see them for anything beyond a pretty part of the landscape. Annie said, "I don't really notice the flowers on campus, I know there are a lot. I don't consider them something I like to stare at." (Annie, Personal communication, April 4, 2016) Both Gwynn and Imogen will not see flowers differently outside of the classroom, but gained a better understanding of their structure and function in academic settings. Imogen said, "I definitely think that I will just be able to label flowers better and have a better understanding of their function" (Imogen, Personal communication, April 4, 2016).

Lesson 3. Table one was the most hesitant to share information about fruits for various social reasons and a poor understanding of the content. Annie brought up her roommate who is a

nutritionist when explaining her reluctance to discuss fruits, "My nutritionist roommate will make fun of me if I say fruits are grains, grains are fruits, so I probably won't tell her that, ever." (Annie, Personal communication, April 6, 2016). Jenna also has reservations about discussing fruits for social reasons, "…I also don't know how interested that my meal mates would be in this, that they might just laugh a little at me." (Jenna, Personal communication, April 6, 2016). Emily has both social reservations and misconceptions about the content. Emily said, "…I do eat meals with Jenna here so she already learned it so its ok I won't tell her." (Emily, Personal communication, April 6, 2016). Emily's misconceptions about food and fruit appear when she said,

> Uh, probably not [talk about fruits are dinner], I normally have pasta which doesn't have vegetables or fruit in it so…[Jenna and Claire interrupt together: yeah, but pasta is wheat] So we will be eating fruits, I probably won't be trying to identify it I probably won't remember. (Emily, Jenna, Claire, Personal communication, April 6, 2016)

Claire is the only student at this table who would share the information she learned about fruits, but did not have a complete understanding of the information.

> Um I probably will bring up a discussion about things I didn't know were true, or true to me, like a berry is not an actual berry, a strawberry is not an actual berry, a true berry. Was it though? What was like a black berry? Or like a strawberry, what's a strawberry? [a strawberry is a strawberry] I think It's like an accessory? (Claire, Personal communication, April 6, 2016)

Claire wanted to discuss fruits, but did not have a strong understanding of them yet, which could prevent her from sharing information outside of class. Her tablemates did not offer answers to her questions about fruit types, which may indicate that all of the students at this table did not have a full understanding of the fruits lesson.

The students at tables three and seven seemed excited to share what they had learned about fruit at dinner that evening. Table three's approach to sharing information about fruit was to be annoying, or get a reaction out of family and friends. Delany acted out an imaginary

conversation she would have with her sister, "…I know my sister is a huge fan of strawberries and she is like "it is a berry" (in a higher pitched voice), she is very particular about it, I'm going to be like no, it's not! Haha" (Delany, Personal communication, April 4, 2016). Faith said, "Probably just to be annoying, uh, you know that avocado you are eating is not a vegetable, especially you know, Mom, an okra is actually a fruit not a vegetable" (Faith, Personal communication, April 4, 2016). Beth added, "I probably would just, to see their reactions, I would want to see how they react when I say, when I reveal, I give them this information" (Beth, Personal communication, April 4, 2016).

At table seven all the students said they would share some of what they learned about fruits. Gwynn said, "It's pretty interesting so if we have fruit I will probably tell them [friends] the correct name for it or something like that" (Gwynn, Personal communication, April 6, 2016). Imogen looked forward to arguing with friends that a tomato is a fruit and added, "I think it would be a fun conversation with people who are not in the class; it would be fun to discuss what they think are fruits" (Imogen, Personal communication, April 6, 2016). Instead of tomatoes, Kendall said she would discuss berries, "…I think I will break the ice for my friends that berries, that, like strawberries and blueberries and a raspberry, are not actually berries, they are a different kind of fruit" (Kendall, Personal communication, April 6, 2016). Kendall does not mention that strawberries are accessory fruits, blueberries are false berries and raspberries are aggregates specifically. Holly was the most hesitant to share information about fruits, "Well it depends how close we are. If I'm close to them I will say something, but if I'm not then I'm not going to bring up fruit and their structure" (Holly, Personal communication, April 6, 2016).

The students were specific about what type of fruit related information they would apply outside of the classroom. The fruit lesson was structured with three levels of information:

differentiating between fruits and vegetables, fruit types, and fruit structures. Jenna did not plan on applying any of the information she learned in class to the food she would eat later that day.

> Usually when I eat food, I like to focus on the taste of it and I don't usually think about the calories or nutrition about it, so I feel like I also won't really think about the different part of it. I will probably just think about if I like it or not. (Jenna, Personal communication, April 6, 2016)

Delany, Kendall, and Faith said they would focus on applying the information they learned about fruit types. Delany stated,

> For me I don't think I will be able to remember the exact levels of it, 'this is endocarp, this is mesocarp, this is expcarp,' but I will be able to think this is the cucumber is this sort of fruit, the pear is a pama (mispronouncing pome). (Delany, Personal communication, April 6, 2016)

Kendall did not list all the layers found in fruits, but indicated that she will not remember them. "I might try to recall the botanical terms, but I think the most important thing that I remember is that an apple is a pome and that a raspberry is not a berry" (Kendall, Personal communication, April 6, 2016). Faith vaguely mentions one fruit structure when describing the grapes she planned on eating later, "…I will remember that while I'm eating my grapes, that a grape is a true berry unlike a strawberry, and it has seeds and an exocarp but that's probably the extent of it" (Faith, Personal communication, April 6, 2016). Both Claire and Imogen said that they would try and remember the terms that they had learned in class without giving specifics.

Students were more likely to apply what they had learned about plant structures outside of the classroom if the information was new and exciting (e.g. axillary bud, inflorescences, and true berries). However, perceived social disinterest in botany prevented students from wanting to share information about plant structures with peers and family. Some students were eager to share to be annoying or to shock people with new information. Misconceptions and forgetting

the content also prevented students from applying or sharing this information beyond the classroom.

Emergent Themes

After analyzing responses to the four research questions, it became apparent that there were student responses to the small group discussion questions that were of interest, but did not directly answer the proposed research questions. This section explored responses related to the nature of science and plant blindness because several student responses addressed those two themes.

Nature of Science

The students commented on several aspects of the nature of science when responding to the group reflection questions. McCommas, Clough, and Almazora (1998) broadly define the nature of science,

> The nature of science is a fertile hybrid arena which blends aspects of various social studies of science including the history, sociology, and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors (p. 4).

Lederman (2007) outlines six aspects of the nature of science to help define the construct: Scientist's use both observations and inferences, theories and laws are fundamentally different, Scientists' make empirical observations about the natural world, scientists'' are situated in a cultural context, and science is tentative yet durable. observations of the natural world, scientific knowledge is subjective and theory laden, and They made comments related to the history of science, how scientist work and learn with art, and what is science (Lederman, 2007). The comments were from all three tables during group discussion time during after lessons two and three.

Faith and Delany brought up the history of science when they discussed Charles Darwin's drawings that he used to capture representations of plants and animals during his voyage on the Beagle. Their conversation went as follows:

> Faith: Um ok so how drawing and science are similar, I think they probably are similar in a way so aspects especially naturalistic side labeling and diagraming and describing I mean wasn't it Charles Darwin (Delany: Yes!) like a really good naturist and (Delany: exactly!) was like a really good drawer and you know because they couldn't take pictures back then he would draw theses (Delany: Yes!) very detailed
>
> Delany: That's kinda what I thought immediately when we were asked this question about how Charles Darwin kinda took record of all of these animals and I defiantly think that's what science and drawing have in common because you are able to see these animals you are able to see the things that stand out to you if you notice a Galapagos turtle that has a long neck you're going to draw an outrageously long neck in order to associate that hey this is a tortes that has a long neck (Faith and Delany, Personal communication, April 4, 2016)

Faith's historical perspective on art and science influenced her opinion on how scientists use art within their discipline. When asked if she thought scientists use art she responded, "…I guess just like probably back in the day before they had photographs documenting new fruit or a new plant that they saw." (Faith, Personal communication, April 6, 2016)

Other students responded to the question, "Do you think scientists draw and paint with watercolors to learn about plants?" Four students, Claire, Jenna, Kendall, and Faith, believed that scientists would only use art while they are learning about science or just starting out as working scientists. Many students were concerned with the art medium the scientist would use, several cited that watercolor was not the best choice for scientists. Kendall commented, "I would say they draw probably, to help learn about plants, but not paint because it is really meticulous" (Kendall, Personal communication, April 6, 2016). Imogen was the strongest opponent against scientists using watercolors, "I don't really see scientists being artistic enough to perfect their watercolor skills, I see that they probably do it computerized. I'm thinking about a text book like

all of the illustrations are from the computer." Her statement may indicate that she thinks scientists lack artistic skills, and that technical drawings are more accurate when produced by a computer.

The students touched on science as a human endeavor and that there are multiple methods used in science while discussing the similarities between art and science. Jenna said, "One way they are similar is that anyone can draw just like anyone can be a scientist, and also there are different approaches to drawing just like people approach science in different ways." (Jenna, personal communication, April 4, 2016). Emily piggybacked on what Jenna said by adding, "…but also though, that each person's experience in drawing in science can yield potential different results or the same results depending on the materials used" (Emily, Personal communication, April 4, 2016). Both students recognize that science is a human enterprise.

Although it is widely recognized that science is a creative endeavor, three students at table seven indicated that art is creative and science is fact based. Holly stated, "…science is very fact based, and drawing can be artistic and you can do whatever you feel like, I suppose." (Holly, Personal communication, April 4, 2016). After struggling to find any similarity, Kendall said, "…um but they're different because drawing is like very creative and science is very fact based" (Kendall, Personal communication, April 4, 2016). Gwynn added the idea of interpretation is only for art by stating, "I think drawing can be similar to science when you like need a visual representation, but drawing can also be up to interpretation whereas science is more fact biased" (Gwynn, Personal communication, April 4, 2016).

Plant blindness

Plant blindness is the "…tendency for human beings to neither notice nor value plants in the environment" (Balding & Williams, 2016, p.1192). Students at all three tables made

comments about how they did not notice plants on campus or in the environment. The comments at table one indicated the greatest degree of plant blindness. Annie said, "I didn't really notice flowers on campus, I know there are a lot. I don't consider them something I like to stare at." (Annie, Personal communication, April 4, 2016). Claire and Emily indicated that they did not look at leaves differently after the lesson, Claire said, "No I haven't, I have just noticed more leaves, but I have not looked at their structure.", and Emily agreed, "…I have not looked at leaves any differently…" (Claire, Emily, Personal communication, March 30, 2016). Jenna indicated that she did not notice leaves or flowers any differently after the lessons on plant structures. She said, "Um I honestly haven't noticed leaves differently at all since last class." and

> I mean I feel like, I feel like I never closely look at flowers outside of the classroom so I never closely see a flower closely enough to see the parts of a flower that we learned about, so I feel like I won't look at them any differently unless I see them up close then I will be able to see the parts we learned about. (Jenna, Personal communication, April 4, 2016)

At table three, there was a similar sentiment, Delany said, "…I don't spend my days looking at leaves I'm not a nature person." (Delany, Personal communication, March 30, 2016). Unlike Delany, Beth and Faith indicated a change in their plant blindness. Beth explained,

> I mean I always saw flowers but I never payed attention to how they, before, I never really paid attention to how complex they were, like their structure, and how they're made, I feel like I have a better understanding of the composition of a flower and all of the functions of its parts. (Beth, Personal communication, April 4, 2016)

Faith also felt that the information she learned in class would change how she views flowers.

> Um I defiantly think I will be more appreciative of the complex structures (laughing) that the flowers are, yes so I defiantly think I will go and look at them differently and be like-oh is that an inflorescence or is that a simple flower? (Faith, Personal communication, April 4, 2016)

Only one student at table seven indicated any change or indication of plant blindness. Holly said, "I think that I will look at flowers differently because I will know what, like, what the inside of

them will look like" (Holly, Personal communication, April 4, 2016). The student remarks indicated that learning about plant structures may help some students notice plants in their environment more, however, some students did not notice plants in their environment regardless of learning new information about plants.

Anti-intellectualism. When asked the question, "Let's pretend in the future the school gives your class a "vegetable" tray of carrots, snap peas, broccoli and cherry tomatoes as a snack for a party. What information do you think you will be able to tell your students about their snack?" (Appendix B, RQ2#13). The question was intended to see what the students perceived they would remember from the lesson in the future, however it revealed more about what the students felt they should and should not teach their future students. Faith was teased by Delany when she explained how she would teach the students while Beth was spared, even though she proposed a more in depth discussion. The response to the question proceeded as follows:

> Faith: I mean you could just go into general carrots are a vegetable, snap peas are actually a fruit broccoli, I mean you could make a lesson out of it kinda but
> Delany: Here is Miss Faith teaching us again, making everything into a lesson (teasing)
> Faith: They would probably be really annoyed and be like just give me my carrots sticks and chicken nuggets you know (giggling).
> Delany: Anything to add Beth?
> Beth: I would probably break it down for them before they eat it
> Faith: Like how? How do you break it down?
> Beth: Just depending of the structure like kinda break it into different parts and explain different parts, and like explain how position can define the parts, like try to find the order.

This exchange was particularly interesting because Delany teased Faith when she said she would try to teach the students the difference between fruits and vegetables, and then Faith indicated that her students would not be interested in learning and would just want to eat. There was pressure from classmates to limit instruction, followed by the assumption that elementary students would be more interested in eating than learning new information. When Beth indicated

that she would teach the students about the fruits on the tray in greater detail she was not teased possibly due to her general reluctance to answer questions.

In response to the same question, Claire, at table seven, indicated that socializing and having fun at a class party were more important than a brief mention of science related information. Claire explained, "Um, I probably won't tell them which ones are which ones, um, just because they are probably there to have fun and socialize so I don't want to take away from their um socializing yep." (Claire, Personal communication, April6, 2016). Pre-service teachers may not informally include botanical information in their future classroom because they might prioritize socialization over science teaching.

Overall, social acceptance seemed to be a bigger hindrance to students sharing information and making close observations about the earth than learning and remembering botanical structures. Annie indicated that she would not contradict her nutritionist roommate with botanical terminology, "I think my nutritionist roommate will make fun of me if I say that the grains are fruits so I don't think I will be saying that very often, or trying to identify them during dinner." (Annie, Personal communication, April 6, 2016). Jenna also mentioned that discussing what she had learned in class could result in her being laughed at. Jenna said, "…I also don't know how interested that my meal mates would be in this [fruit structures], that they might just laugh a little at me." (Jenna, Personal communication, April 6, 2016). Both quotes indicated that the students were afraid of being made fun of for sharing what they had learned. The functional definition of learning is, a change in behavior from an experience, so if there is social pressure for students to not change their behavior after a classroom experiences students may not express what they learned through words or actions.

Conclusion

This chapter provided detailed descriptions of the three lessons, and the students participation during the activity in which they created botanical representations. The student's conversations during the small group reflection time provided insight into all four research questions, and generated discussions that did not address the research question but could not be ignored, so it was reported in the emergent theme section. The results, limitations, and future research are discussed in detail in the following chapter.

Chapter 5: Discussion

This chapter begins with a discussion of the results from each of the four research questions, provides practical notes on teaching practice, addresses the limitations of the study, and makes suggestions for future research. Several important findings emerged from the study including: the impact of students' background on her participation in creating representations, students' perceptions of learning, her varying emotional responses to the three different lessons, and the students' willingness to discuss and perceive botanical structures beyond the classroom.

Student Background

The results demonstrated that the students' backgrounds were highly varied regarding art training and self-perception of their artistic ability. The students who participated in the study were similarly lacking in botanical knowledge and experience. Only a few students commented on their past experience creating botanical representations while the others did not mention creating botanical representations at all.

The students' self-disclosed level of artistry had the biggest impact on the students' participation and perception of learning during the lesson because it was the skill area with the most diversity. Students who had art training seemed to perceive that they learned more and enjoyed drawing and water coloring more than the students who believed they were not artistic. Gardner (1973) found that peers had the largest negative impact on a child's self-perception of artistry, however, in this study the people who had the biggest negative impact on the students' perceived level of artistry were not their peers, who were supportive or indifferent, but their siblings' comments or actions during childhood and adolescence. The students may have been more supportive because they are nearing the end of adolescence or had entered adulthood, and Gardner's study was on children.

As indicated by school standards and other studies, all students seem to struggle with the botanical structures because they lacked a background in botany (Drew, 2011, Kramer, Zorn-Arnold, & Havens, 2013, NGSS, Lead State, 2013). Although this finding is not surprising in light if NGSS standards, it is important to note because it impacts botany careers in the United States (Bureau of Labor Statistics, 2014-2015, see appendix A). Only the students at table one commented on creating botanical representations in the past, so it is difficult to comprehend how that particular past experience impacted the lesson. However, their comments may indicate that some elementary and junior high schools are using art interventions to teach botany and that it was a memorable lesson to some students. It should be noted that the students remember the lesson, but still had limited knowledge of botany.

Student Perceptions of Learning

Overall, students seemed more concerned about how easy or fun it was to create a representation than how much they learned, particularly during lessons one and three. These values may be due to the "customer service" trend in higher education, in which students are customers who are there to be entertained and given inflated grades, instead of challenged to learn and think critically (Nichols, 2017). It will be interesting to see how pre-service teachers who have progressed through college as customers will view their students when they have a classroom of their own in the future.

During small group reflection, the students indicated that the lessons were either for visual or kinesthetic/hands-on learners. The conflation and confusion about learning styles could be due to the lack of evidence that learning styles exist (Riener & Willingham, 2010).

> …when we poll our undergraduate classes on the belief in a number of myths of popular psychology, the one that "people have their own learning styles" is typically endorsed by more than 90 percent of our students. This belief has the potential to shape and constrain the experience that students have in the college classroom. For example, if a student

> believes she is a visual learner and therefore disengages and daydreams when a lecturer turns off the PowerPoint and tells a story, this will pre-vent her from learning the concept through a compelling narrative. (Riener & Willingham, 2010, p.35)

The students may have described the activity as visual or kinesthetic because they were engaged or enjoyed the activity and wanted it to align with their perceived learning style.

Adult coloring books are a recent popular trend and they purportedly have a calming and meditative effect on the person coloring (Barrett, 2015). However, they are not marketed as a learning tool, so the students may have been influenced by current adult coloring book marketing. During the coloring book activity time, students had the most off-topic conversations. These ranged from other classes to superhero movies, which may indicate that the students were not focused on learning the leaf structures while coloring in their sheets. Also, many of the students did not correctly color in each structure on the leaf structure work sheet a different color to highlight the various structures (See Appendix F). Several used a single color for a leaf with three to five different structures labeled (e.g. Holly, Kendall, Imogen). The students only commented on seeing differences between leaf types at the end of the lesson, as opposed to similarities and the form and function of leaves, which could have indicated a closer level of observation (Naghsineh et al., 2008). Also, there was a lower chance that the student would fail at coloring in the coloring sheet, so there seemed to be less effort to learn because their success was almost guaranteed.

From my observations, I believe the students seemed to learn the most from drawing flowers, even if they did not overwhelmingly select this lesson when asked which lesson taught them the most. The group discussions during the activity time were related to the flower structures, and only occasionally strayed off topic. The students may have not selected the flower drawing lesson because it was the middle lesson, and people are more apt to remember the first

and last items in a series (Azizian & Polich, 2007). The students successfully relied on each other to construct and complete the representations. They recalled differences, similarities, and the relationship between form and function, which may indicate a deeper understanding of the flower structures. A functional definition of learning is a change in behavior after an experience, so when the students reported noticing new features of flowers it indicates a shift in their behavior, which could be viewed as learning (Barron et al., 2015; De Houwer, Barnes-Holmes, & Moors, 2013).

During the small group discussion after lesson, three students reported, (a) being more focused while water coloring, (b) it was easy, (c) that the act of water coloring was not helpful to learning. The students reported being more focused, but their dialogue during the activity indicated that they were focused on painting and not learning plant structures. The majority of students only discussed the plant structures during the last ten minutes of activity time, and struggled to label the wet paper. The reason students said this activity was easy was because they only had time to complete two representations of fruits. Some students found that drawing the fruits before water coloring them was more helpful to understanding fruit structures than water coloring their drawings. The biggest detriments to learning plant structures through water coloring were, time constraints which limited the number of representations the students could create and the student's discussing the act of water coloring rather and how entertaining it is rather than plant structures. Water coloring could be used more appropriately as a tool to get students excited about practicing plant structures they already know instead of a tool to learn about them for the first time.

Student Emotive Response

Learning, memory, attention, and decision making are all impacted by emotional thought,

so it is important to consider students' emotions in the classroom (Immordino-Yang & Damasio, 2007). The students found coloring the diagrams to be calming, relaxing and enjoyable. Some students felt that way because it reminded them of childhood. However, the activity instructions left them feeling confused and hesitant to start. Unlike traditional coloring books, which encourage creative expression, the botany coloring book has small letters labeling the structures and two pages of text describing how to color in the worksheet. None of the participants read more than the first few lines of text. Many of the students ignored the labels and colored the representations the same way you would a traditional non-academic coloring book, which they found enjoyable (Appendix F). This confusion could have been avoided if the example coloring page images used in the PowerPoint were correctly colored using a variety of non-realistic colors to highlight the different structures.

The students' emotional response to drawing was clearly divided by their self-perception of their artistic abilities. The two students with art training felt that drawing was well suited to the botanical information and spoke positively about the lesson. The students who describe themselves as non-artistic (e.g. Annie, Beth, Delany, Imogen, and Kendall) experienced fear and increased anxiety (e.g. Imogen & Kendall) when drawing flowers.

Unlike the fear and anxiety some students experienced during the drawing lesson, most of students were excited to watercolor representations of fruits. A few self-described non-artistic students had conflicting feelings about water coloring, and one student was "terrified". Similar to the drawing lesson, self-described non-artists were more likely to experience negative emotions than students who have art training or enjoyed coloring and doodling. To help students overcome their anxiety about drawing the instructor could emphasize that creating representations is a tool to help them learn and not artistic endeavor.

Beyond the Classroom

After the three lessons, students indicated that they were more likely to share new and surprising information with friends and family than science content that they already knew. For example, students indicated they would share the location of the axillary bud at the base of leaves, reproductive structures in flowers, or the botanical definition of a berry. A study conducted with Malaysian undergraduates, found that students may prefer to share information electronically instead of face to face (Chin Wei, Siong Choy, Geok Chew, & Yee Yen ,2012). In the present study, all of the information sharing questions proposed hypothetical face to face interactions, which may have impacted student responses. Students may have been more likely to share a link to a web page or short video on Facebook, twitter, or other social media platforms about plants rather than discuss them in person.

However, students were more concerned about social acceptance than sharing information about plants. Some students did not want to bore friends and family, seem weird, be laughed at, or discuss information that could contradict a different field (e.g. nutrition). One student also made fun of another for proposing an impromptu lesson on fruits and vegetables at a hypothetical class party. Anti-intellectual is defined as, "A person who scorns intellectuals and their views and methods", and it appears that the students were demonstrating anti-intellectual behavior or censoring themselves because they feared it (Oxford Dictionary Online). Hook (2004) found that undergraduate students that scored high on an anti-intellectual scale were likely to have difficulty with academic adjustment, institutional attachment, and degree completion. The study also found anti-intellectualism scores did not impact social adjustment or emotional distress. This study indicates that anti-intellectual behavior is present in college classroom and that it is an important indicator of student success. The study however, does not

address students' fear of anti-intellectual backlash if they were to discuss ideas from a college course with friends or family. Teacher educators should be aware of the students' anti-intellectual ideology and attempt to create at a classroom culture that values information and experts.

Limitations

There were several limitations to this study, including the number and selection of participants, length of data collection (three lessons), the relationship between the teacher/researcher and the students, and the format of the small group discussions. The three tables were purposefully selected for this study; however, a random selection of tables would have yielded different opinions and conversations about the three lessons. All of the participants were female pre-service elementary teachers in their first or second year at a private university. The results are not generalizable to college students learning about plants because of the limited diversity and non-random selection of participants.

The study only took place during three lessons. The results may have been different if the students had multiple class periods to engage with each of the three types of representations or longer class periods to spend more time participating in the botanical representation activity. Also, the order of the lessons may have influenced student's responses. The first lesson was novel, the second may have been forgotten, and the third was the most recent when they were recalling which lesson taught them the most.

Another limitation of this study is that I was the instructor of record and the researcher. The participants may have censored their responses to not offend me or responded more positively to create a more favorable relationship. Conversely, because the lessons took place

towards the end of the semester some students may have formed negative opinions about the course and instructor that could have colored their experience during the lessons.

The small group reflections, which were held at the end of the class period, may have limited what the students said in response to the scripted questions. Because they were taking turns interviewing their tablemates there may have been social pressure to agree with one another, or cut their response short so they would not be the last group to leave the classroom. Also, the students did not ask each other probing questions the way an interviewer or researcher would.

It is also worth noting that the students had different levels of interest in leaves, flowers, and fruits, which may have impacted their participation in the lessons and changed their perception of the representation they were creating. The students seemed most interested in fruit, followed by flowers, and least interested in leaves.

Future Research

To expand upon this study there are several unexplored areas that might provide a more complete picture of using art interventions in college botany lessons with pre-service teachers. Researchers should explore varying lengths of time for art interventions, different art interventions, and comparing different groups of students utilizing art interventions to learn about plant structures. Because there are very few studies on college students using art to learn about botany there are many opportunities for novel research.

In the present study, there were only three lessons that incorporated art and botany, which may have not given the students enough time to practice coloring in worksheets, drawing, water coloring, and identifying plant structures. Extending the art interventions to other pre-service teacher science topics or creating a longer unit on plants could provide that students with more

practice and possibly change their self-perception as an artist and/or their perceptions of learning science content. Requiring a science coloring book, sketchbook, or watercolor paper note book that the students use throughout the course may be one way to extend art interventions in a pre-service teacher science course. Another way to create redundancy would be to have the students color in a pre-labeled worksheet for homework to prepare for the lesson, and then have the students draw, label, and then watercolor the same plant structures during class time. This would provide the students with more repetition with both art interventions and botanical structures.

In addition to varying the length of time, there are a myriad of different possible art interventions. The students in this study suggested using un-labeled pre-drawn plant diagrams that they would color in and label themselves. The students also suggested drawing, labeling, and coloring in their work with colored pencils instead of watercolors. Additionally, other types of paint, pastels, or modeling clay could be used to create scientific representations. Changing the art intervention could also change the level of instructional support that the students' receive.

The selected art intervention may change students' perceptions of learning science content; however, the type of students may also have an impact. A comparative study between pre-service teachers, non-science majors, and biology majors may shed light on which group of students benefits the most from using art to learn about botanical structures. The pre-service teachers in this study discussed using art to teach plant structures with children, and several students had recent experience with art because they work with children. Students who are not majoring in education may have different perceptions of the usefulness of art interventions, and different past experiences with art because they may not have recent contact with children creating art.

Unrelated to botany and art interventions, the emerging culture or fear of of anti-intellectualism at American colleges and universities should be studied in more detail. This research happened to inspire some conversations where some students put one another down for describing how they would seize a teachable moment at a school party, and others indicated they would not share botanical information for fear of being made fun of. Although this was not the intention of this study, the students' conversations highlight the need for more research in this area.

Conclusion

Although there is not a clear best art intervention when creating botanical representations with freshman and sophomore pre-service teachers, I would recommend drawing botanical structures. Drawing is advantageous because students were focused during activity time, made and recalled detailed observations, required the least expensive supplies, and could practice drawing and make close observations of plants outside of the classroom. Moreover, I would recommend having an art teacher provide instruction or a how-to drawing guide to help the students who are not confident in their artistic abilities. The students were supportive of their classmates' representations, so the instructor should focus on improving the students' artistic self-perception and self-confidence during science lessons that incorporate art to address the anxiety non-artists felt during the drawing lesson. If time permits, I would recommend allowing the students to color their representations with colored pencils similar to the coloring book diagrams to reinforce the structures they had drawn.

Water coloring in the science classroom can be used to get students excited about participating in an activity. If the students are confident in the science material, water coloring can make them excited to practice what they have already learned. Because of the time it takes to

create a watercolor, I would recommend using this form of representation to excite students and deepen or expand their already solid understanding of botanical structures.

Appendix A

Projected Growth in Botany Related fields during a Ten-year period in the United States (2012-2022)

Occupation	Entry level Education	Projected Growth	Employment Change (jobs)
Environmental science and protection technicians	Associate's	19%	6,200
Environmental Sciences and Specialists	Bachelor's	15%	13,200
Biological Technicians	Bachelor's	10%	8,000
Agricultural and Food Scientists	Bachelor's	9%	3,600
Natural Sciences Managers	Bachelor's + 5 years experience	6%	2,900
Forest and Conservation Workers	High School	4%	500
Conservation Scientists and Foresters	Bachelor's	3%	900
Agricultural and food science technicians	Associate's	3%	800
Agricultural Worker	No diploma or High School	-3%	-25,000
Forest and conservation technicians	Associates	-4%	-1,200
Floral Designer	High School	-8%	-5,000
Logging Workers	High School	-9%	-3,800

Data obtained from: Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2014-15 Edition, Conservation Scientists and Foresters, on the Internet at http://www.bls.gov/ooh/life-physical-and-social-science/conservation-scientists.htm (visited July 20, 2015).

Appendix B

Lesson 1- Structured Interview questions

RQ1#1- Please tell the story of the last time you colored in a coloring sheet before this class.

RQ1#2- Do you consider yourself artistic? Please elaborate with a story.

RQ1#3- Before this lesson how much did you know about plants?

RQ2#1- Do you feel coloring the coloring book pages helped you understand the structure of leaves? Why or why not?

RQ2#2- Did this lesson change the way you think about leaf structure?

RQ2#3- During this time next year do you think you would be able to correctly label a leaf-structure coloring sheet? If yes, how which structures would you remember?

RQ2#4- Let's pretend one of your future students brought you leaves they collected at recess. How would you create a brief informal learning experience with that student? Would you remember leaf structures to teach the student?

RQ3#1- How did you feel when you were coloring in the coloring book pages?

RQ3#2- How do you think your classmates at the other tables felt about coloring the coloring book pages?

RQ4#1- Can you tell me how has completing this lesson has changed the way you look at the plants on campus?

RQ4#2- When you leave the classroom do you think you will stop to examine leaves or pointed out their features to a friend? What would you tell them?

Lesson 2 Structured Interview Questions

RQ1#4- Do you like to, or did you ever like to draw? Please tell a story to explain you answer.

RQ1#5- What kind of feedback have you received on coloring in coloring books, drawing, or painting from family, friends, and/or teachers? Please describe what people have told you.

RQ1#6- Can you explain ways that drawing and science are similar and different?

RQ2#5- Do you feel drawing the flowers helped you understand their structure? Talk about your experience in class today to support your answer.

RQ2#6- Thinking back to our lesson can you tell me which structures you found the most interesting? Tell me about as many as you can.

RQ2#7- Let's pretend its Valentine's Day and someone special gives you flowers as a gift. How many flower structures do you think you would be able to point out to them several months from now?

RQ2#8- Compared to your previous experiences learning about flowers, do you think you will remember the information from this lesson longer because you were actively drawing their structures? Please explain your answer.

RQ3#3- How did you feel when you found out we were drawing flowers instead of coloring worksheets?

RQ3#4- Were you concerned about how your tablemate's drawings looked? How did you feel when your tablemates looked at your drawings?

RQ4#3- After drawing flowers today, do you think you will look at flowers outside of the classroom differently? Please elaborate.

RQ4#4- Think back to the lesson on leaf structures. Did you notice leaves and their structures while you were outside since our last class? Did you show friends and family the leaf structures you learned in class?

Lesson 3 Structured Interview Questions

RQ1#7- Can you tell me about the last time you water colored? Be sure to include how old you were and why you were water coloring in your story.

RQ1#8- Do you think scientists draw and paint with watercolors to learn about plants?

RQ2#9- Do you think drawing and water coloring fruit structures helped you notice structures you did not see before?

RQ2#10- The past three lessons we colored in work sheets, drew simple diagrams, and drew realistic pictures and water colored them. Out of the three lessons which one do you feel taught you the most about plant structures? Please support you answer with examples.

RQ2#11- What could I, Melissa Patterson, do as an instructor to help you learn more about plant structures?

RQ2#12- We have a test coming up in a few weeks. Do you think you this activity will help you correctly label fruit structures on the test?

RQ2#13- Let's pretend in the future the school gives your class a "vegetable" tray of carrots, snap peas, broccoli and cherry tomatoes as a snack for a party. What information do you think you will be able to tell your students about their snack?

RQ3#5-How did you feel when you found out we were drawing realistic pictures and water coloring them?

RQ3#6- Was it important to you that your watercolor looked good?

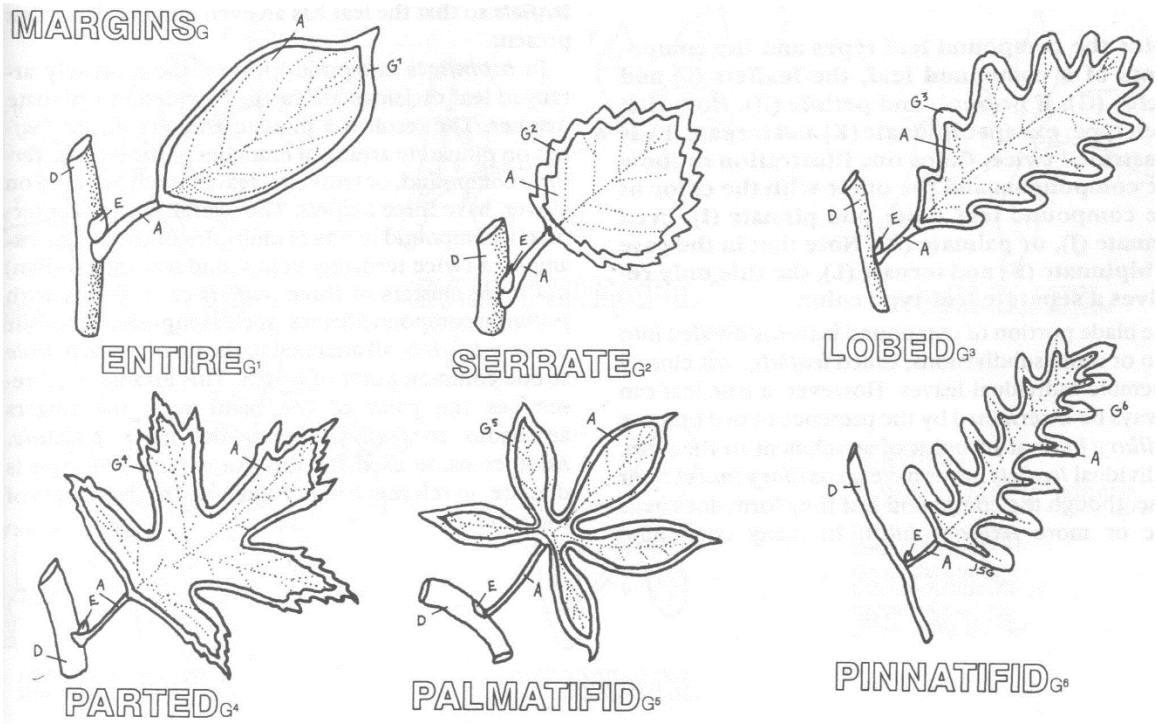
RQ3#7- Was it important that you water color was botanically accurate?

RQ4#5- When you eat dinner tonight do you think you will try to recall the botanical terms that describe the plants you are eating?

RQ4#6- We learned many new names for fruit, their structures, and that some things you eat were fruit that you did not expect. Do you think you will share this information at your next meal with friends?

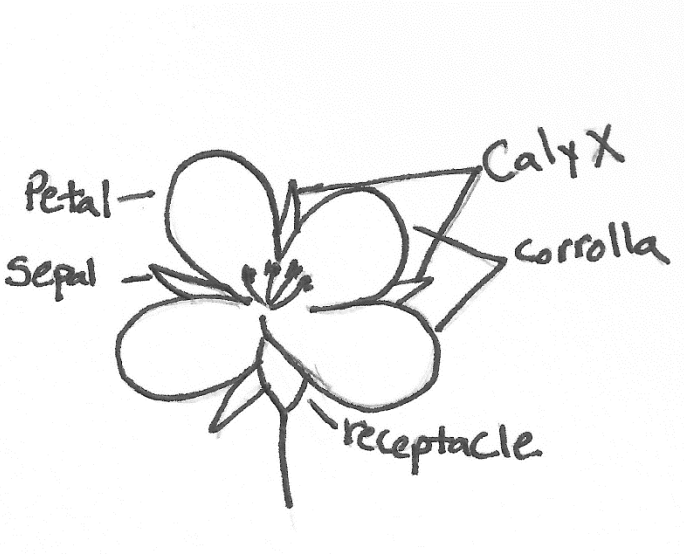
***RQ(1-4)# (1-13)= The research question (RQ) number corresponds to the reflection question that attempts to inspire a conversation about one of the four research question. The following, #(1-13), designates the specific question.

Appendix C



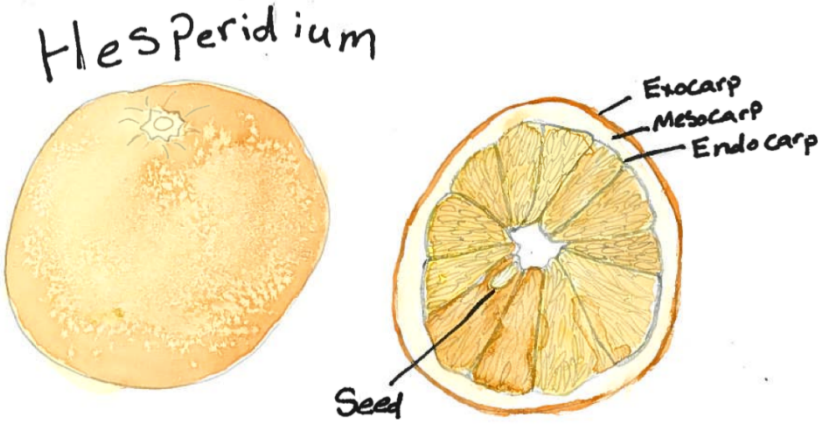
(Copied from Paul Young 1983)

Appendix D



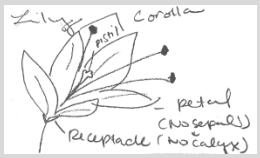
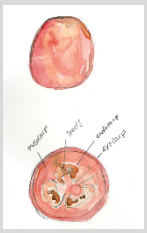
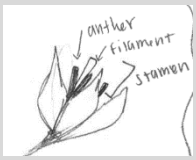
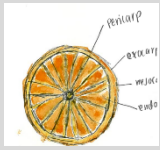
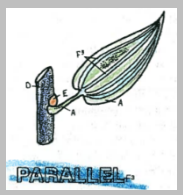
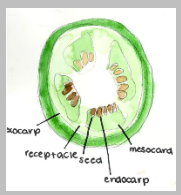
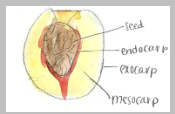
(Melissa Patterson, 2015)

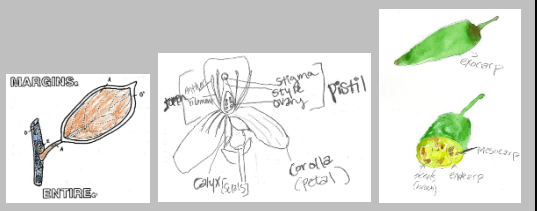
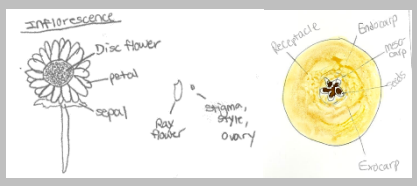
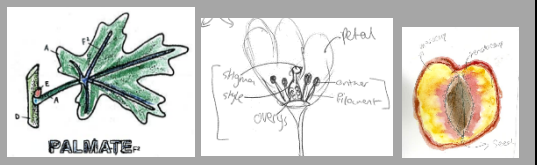
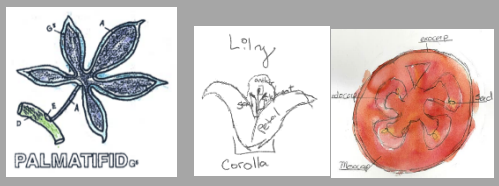
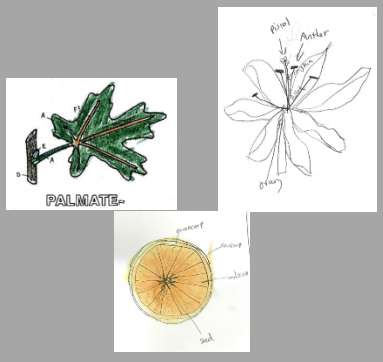
Appendix E

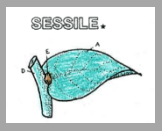
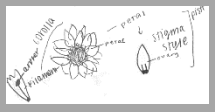
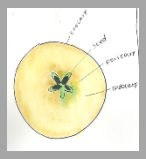
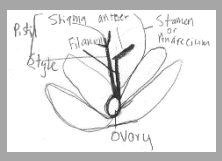


(Melissa Patterson 2015)

Appendix F

Participant	Quote	Representations
Faith (Table 3)	"…I had sever dyslexia for, when, well I still have it but it was a lot harder when I was younger so the outlet that I always did was art because it wasn't confusing letters and numbers um so I always enjoyed art…but yeah I'm more of a painter, its always been positive feedback from friends and family also from teachers and art teachers and I continue I wish I continued more in college…" (Personal communication, April 4, 2016)(Question RQ1#5)	  
Holly (Table 7)	"I am very artistic I took art all my life and middle school and high school and went to art competitions and such I have not continued this in college although I do hope to take some art classes in the future" (Personal communication, March 30, 2016) (Question RQ1#2)	  
Emily (Table 1)	"The type of feedback [on art] that I have gotten, has generally been average as long as I color in the lines everyone says it looks good." (Personal communication, April 2, 2016) (Question RQ1#5)	  
Jenna (Table 1)	Um, I like to color…in coloring pages. I don't necessarily like to draw. I doodle in my notes for school in my notebook, so	  

	it that counts I do enjoy drawing. (Personal communication, April 2, 2016)(Question RQ1#4)	
Claire (Table 1)	I think I'm a pretty good color-er um given that I'm a little like older than the age of five, (laughing) so I think I can color in the lines pretty well. (Personal communication, April 2, 2016) (Question RQ1#5)	
Gwynn (Table 7)	"I'm not good at drawing so I would prefer to color" (Personal communication, April 4, 2016) (Question RQ1#4)	
Annie (Table 1)	"Um so I'm not a very good drawer so it was hard… to color, I mean to draw (laughing)." (Personal communication, April 4, 2016) (Question RQ3#3)	
Delany (Table 3)	"I defiantly hate drawing I'm the least artistic person in the world… I don't like drawing I never have probably never will" (Personal communication, April 4, 2016)(Question RQ1#4)	
Beth (Table 3)	Personally I'm not a fan of, I'm not really a fan of drawing but I feel like it helps with memories like with this assignment I feel like I will remember the structures better. My biggest fear would be not drawing it accurately because I'm not really, drawings is not really my strong suit, so my biggest	

	fear is that I would not be drawing it accurately or depicting it as accurately as I should (Personal communication, April 4, 2016)(Question RQ1#4)	
Kendall (Table 7)	"I don't consider myself artistic I was a jock in high school and I was on the yearbook staff so I never really took art ever unless I was in elementary school." (Personal communication, March 30, 2016) (Question RQ1#2)	  
Imogen (Table 7)	"um not I am not artistic at all I have very bad handwriting and I'm not very creative" (Personal Communication, March 30, 2016) (Question RQ1#2)	  

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