RESEARCH ON LEARNING

The Pet Plant Project: Treating Plant Blindness by Making Plants Personal

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Abstract

"Plant blindness" is defined as the failure to appreciate the fundamental importance of plants. To address this phenomenon, we created the Pet Plant Project (P^3) where students grow an unknown plant from seed, monitor development, and relate lecture concepts to their plant on a daily basis. A qualitative survey was administered and analyzed to evaluate student responses to the experience. Themes in the analysis, identified across 209 student-participants at Tennessee Tech University, included positive reinforcement of lecture material, a new-found appreciation for plants, responsibility and pride related to plant care, a continued desire to grow plants, and more. Statistical results included: 73% of students noticed plants more after the project; 76% planned to grow plants in the future; and 68% made a connection with their own plant that bolstered engagement in course materials.

Key Words: *botany; plant blindness; pet plant; undergraduate education.*

○ Introduction

It is well known that students generally find animals more interesting than plants (Baird et al., 1984; Wandersee, 1986). Plants are often neglected in textbooks (Darley, 1990; Hershey, 1993, 1996; Uno, 1994), with comparatively little emphasis in high school standards and curricula relative to zoological material. Over time, this has resulted in a widespread condition referred to as "plant blindness" (Wandersee & Schussler, 1999), where an individual fails to notice plants or recognize their importance to the world. The implications of plant blindness are far reaching: generations of teachers and students are botanically illiterate (Hershey, 1996; Gagliano, 2013), resulting in the devaluation of plants as they relate to environmental sustainability, public health, and the economy (Tomescu, 2009; Balding & Williams, 2016). Yet plants and other photosynthetic organisms form the foundation for life on earth, and failure to acknowledge their biological significance will result in dire consequences for the health of the planet and our species.

Given the potential implications of continued plant blindness, how do we best reverse its progression? In the past decade, plant blindness has come to the forefront of pedagogical discussions in scientific communities (Strgar, 2007; Balas & Momsen, 2014; Ebert-May & Holt, 2014; Gimma & Burgess, 2014). The symptoms of plant blindness may have a physiological component that stems from how the human brain perceives its surroundings (Wandersee & Schussler, 1999; Balas & Momsen, 2014). As a result, learning approaches that are most likely to be effective will (1) make plants relevant in students' daily lives, (2) engage multiple senses at once (e.g., visual, touch), and (3) build on previously learned information to create deeper connections (Uno, 1994, 2009; Balas & Momsen, 2014). Several articles describe methods to increase the interest of young children in plants (e.g., Lindemann-Matthies, 2002; Fančovičová & Prokop, 2011), yet hands-on classroom activities at the high school or college level are relatively limited. Wandersee et al. (2006) published a writing template designed to identify a person's unique "Botanical Sense of Place" by linking plants to particular places or activities they remember from childhood. Another approach has been to georeference plant species or create floras of university campuses to encourage student interaction with plants (e.g., Pettit et al., 2014; Struwe et al., 2014).

These activities aim to show young adults why they should care about plants and how plants affect their daily lives. Yet even if students are convinced that plants are fundamentally important, making botanical lessons interesting to them is another challenge. Plants are so fundamentally different from animals that it is difficult for students to relate to them in a meaningful way (Hershey, 1996; Balas & Momsen, 2014). Maintaining student interest while covering topics such as plant anatomy, morphology, physiology, and reproduction requires special effort. In searching for an effective means to relate abstract course material to students in a large-format introductory botany lecture/laboratory course, we created the Pet Plant Project (P^3) where students grow an unknown plant from seed to maturity over the course of a semester.

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The P^3 is an example of project-based learning, where students utilize acquired knowledge to tackle realistic problems (Barron & Darling-Hammond, 2008; Strobel & van Barneveld, 2009). The P^3 provides the opportunity to observe and interact with plants on multiple levels, from big-picture phenomena like germination and flowering to the biochemical pathways that drive these processes. Students in the sciences often have difficulty relating these hierarchical levels of information to one another. In chemistry education it has been widely accepted that students struggle to simultaneously understand the macroscopic, the submicroscopic or particle, and the symbolic views of matter (Nakhleh, 1992; Sirhan, 2007). Similarly, botany students must understand the anatomical and physiological makeup of plants, while integrating how these details relate to growth and development. Often these topics are perceived as esoteric by students, creating a disconnect between the lecture material and the real world (Bransford et al., 1999; Kellogg et al., 2010). With the P^3, students experience the growth of their plants on roughly the same timeline as complementary topics are covered in lecture, making students much more likely to make explicit connections between these macroscopic and microscopic views of plants.

After several semesters of P^3 implementation, the project has positively impacted student interactions with plants, successfully addressed plant blindness, and increased student interest and comprehension of the topics covered in the associated lecture. Here we present a description of the project and results of the data analysis, including a qualitative inventory that assessed student perceptions and growth throughout the project. Using the qualitative theoretical perspective of interpretivism (Crotty, 2003; Creswell, 2007; Bogdan & Biklen, 2007), our research purpose was to understand student perceptions of their own plant blindness, the construction of botanical experiences beginning with childhood, and how those perceptions may be challenged through a semester-long course project (P^3). The research questions that framed our study were: (1) In what ways does the P^3 serve as an effective tool to engage students in abstract botany concepts across a semester? (2) In what ways does the P^3 challenge plant blindness in young adults? and (3) How does the P^3 increase regular interaction with plants, both long- and short-term?

Implementation of the Pet Plant Project

The P^3 was initiated during the first laboratory meeting of the course to provide ample time for growth and development of the plants over the semester. Each student cares for a plant through a complete life cycle, hopefully from seed to seed. In the process, students observe germination, stem elongation, root development, flowering, pollination, and fruit/seed development. The order of lecture topics roughly correlates with the life cycle of the seed: plant anatomy and morphology are covered first, followed by growth and development, and ending with a survey of land plant diversity, where flowers and fruits are discussed in detail around the same time students are observing these structures in their own plants.

To begin the P^3, students first completed the writing template on the Botanical Sense of Place (Wandersee et al., 2006) to consider the importance of plants in their lives. Students then toured the teaching greenhouse and reflected on their personal levels of plant blindness. At the end of the first laboratory, each student was randomly assigned a single seed in a coded packet. Plant species were chosen based on ease of cultivation, likelihood for flowering and fruiting within 14–15 weeks, and successes observed in previous semesters (Table 1). Students were not provided with the identity of their seed but were given the list of seeds provided to the class. Withholding seed identification increased student curiosity and encouraged careful observation; identifications were later confirmed with their teaching assistant. Students were provided with soil, pots, and fertilizer in class, and teaching assistants provided general advice on planting, watering, and light requirements. Students planted their seeds and took their plants home. Students were encouraged to purchase an inexpensive desk lamp and a 60–80 watt equivalent cool white fluorescent bulb to provide sufficient light for their seedlings. Students could bring in their plants for repotting or for help diagnosing a problem at any point during the semester.

Students were required to make biweekly observations of their plants using a journal template (see Additional Resources), including a photograph of their plant, any developmental changes, a description of the overall health of their plant, and issues of concern. Students were also required to relate their observations to course material covered in lecture or laboratory that week. For example, if tropisms were covered in lecture, students might document their plant's phototropism toward their grow light. Students also participated in an online forum where they posted images, reported progress, and asked questions of their peers. Slack (www.slack.com) proved to be the best solution for this with easy photo sharing, commenting, and a user-friendly phone application and desktop interface. If a pet plant died at any point during the semester, students were required to get another seed (of the same species) and start again. If a student's plant died twice, he or she was given an established "backup" seedling that was started earlier in the semester. Thus, each student could still have the experience of growing a plant and obtaining flowers and fruit along with the rest of the class. Based on multiple semesters of observations, main causes of accidental death included: (1) pets (usually cats) eating the plant; (2) fungal infection due to low light, cold temperatures, and over-watering; (3) falls resulting in broken stems; and (4) sunburn from placing indoor-raised plants outside into direct sunlight too quickly.

During the last laboratory of the semester, students brought their plants into class. A contest among lab sections for various awards including "best dressed plant" and "most likely to succeed" initiated friendly competition and created excitement at the end of the semester (Figure 1). Students turned in their journals and a one-page essay on their plant species (taxonomy, domestication, uses) for grading. Students were also graded on their participation in the online Slack discussion.

Connections to Academic Standards

The current accepted standards for K-12 Science Education are the Next Generation Science Standards (NGSS), which align with the best practices provided in the *K-12 Framework for Science Education* (National Research Council, 2012). The P^3 encourages students to grapple with interconnected concepts in a deep and meaningful way, and provides opportunities to engage with the underlying ideas of science, both of which are themes emphasized in the *K-12 Framework*. Connections of the P^3 project to the three dimensions outlined in the *K-12 Framework* (scientific practices, crosscutting concepts, and disciplinary core ideas) are outlined in Table 2.

Table 1. List of plant species used for P^3, with notes on cultivation.

Common Name	Scientific Name	Flowering and Fruiting During 14–15 Week Semester	Cultivation Notes
Basil	*Ocimum basilicum*	No	
Morning glory	*Ipomea tricolor*	Yes, at end	Provide stakes
Zucchini	*Curcurbita pepo* var. *cylindrica*	Prolific; if students do hand pollinations plants will produce fruit	
Cucumber	*Cucumis sativus*	Prolific; if students do hand pollinations plants will produce fruit	
Marigold	*Tagetes patula*	Flowers	Very easy to grow
Cilantro	*Coriandrum sativum*	No	Two embryos emerge from each fruit, commonly mistaken as single seeds
Cherry tomato	*Solanum lycopersicum* var. *cerasiforme*	Yes, at end	
Common pea	*Pisum sativum*	Yes, if students perform hand pollination they will produce fruit	Provide stakes
Not recommended:			
Nasturtium	*Tropaeolum majus*	Flowers	Unreliable, needs high light levels
Fava bean	*Vicia faba*	Yes	Highly susceptible to fungal infection, potentially poisonous if eaten
Lavender	*Lavandula angustifolia*	No	Very slow growing
Corn	*Zea mays*	No	Too large for easy cultivation
Chives	*Allium schoenoprasum*	No	Vegetative growth only

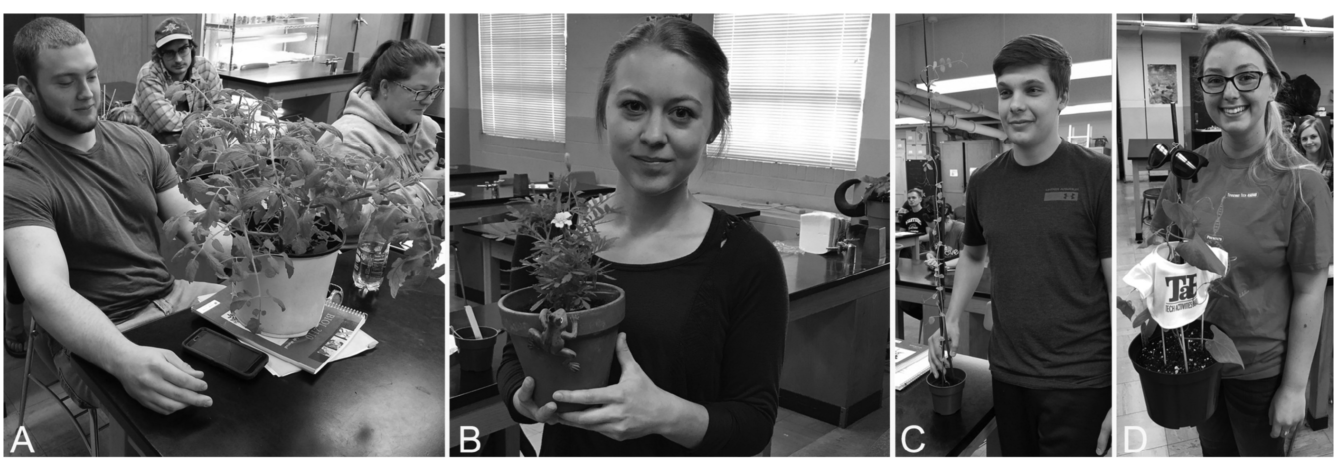

Figure 1. Examples of plants grown from seed during the Pet Plant Project. **(A)** Student with cherry tomato. **(B)** Student with marigold. **(C)** Student with pea plant. **(D)** Student with morning glory, awarded "best dressed" in lab section.

Table 2. Connections of the P³ to the "three dimensions" as described in *A Framework for K-12 Science Education* (National Research Council, 2012).

Dimension 1: Scientific and Engineering Practices	Dimension 2: Crosscutting Concepts	Dimension 3: Disciplinary Core Ideas–Life Sciences
1. Asking Questions and Defining Problems 4. Analyzing and Interpreting Data 8. Obtaining, Evaluating, and Communicating Information	2. Cause and Effect 4. Systems and System Models 6. Structure and Function 7. Stability and Change	Core Idea LS1: From Molecules to Organisms: Structures and Processes LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS1.C: Organization for Matter and Energy Flow in Organisms LS1.D: Information Processing Core Idea LS4: Biological Evolution: Unity and Diversity LS4.D: Biodiversity and Humans

○ P³ Research Methods

Institutional Review Board approval was granted by Tennessee Tech's IRB (approval no. 1740). Although the P³ has been implemented and improved over five semesters in total, data collection spanned two semesters, Fall 2016 and Spring 2017, in the general botany course offered each semester at Tennessee Tech. Data collection included observations of class lectures and labs and responses from a qualitative end-of-semester survey. The survey included ten open-ended questions meant to gauge students' prior experience growing plants and their views about botany as a result of completing the P³ (Table 3). Data were collected from a total of 209 student-participants. Each culminating Survey Question (SQ) helped inform one of the three Research Questions (RQ), as identified in Table 3. Survey responses were collected through a Google Form and exported into an Excel spreadsheet for analysis. Inductive analysis was performed (Maxwell, 1996; LeCompte, 2000) on the survey responses, utilizing categorization strategies to organize and report the data. Each of the three researchers reviewed and coded the survey responses in the Excel spreadsheet; from these codes common themes were derived. Next, researchers discussed the most prevalent themes that helped answer the research questions. The professor's observations during class and labs helped refine and confirm themes found in the survey data.

○ Results

A variety of themes were identified in student responses to help answer the study's research questions, which are explored below. Results for each SQ and sample responses are provided in Table 3.

Research Question #1: In what ways does the P³ serve as an effective tool to engage students in abstract botany concepts across a semester?

A common theme in student responses was greater comprehension and increased use of academic language surrounding botany concepts; students wrote about the intricacies of photosynthesis, respiration, plant anatomy, and environmental factors that affected their plants. A majority of the student participants (121 students, 58%) reported increased comprehension of the true complexity behind the statement "plants need sun, water, and air" as a result of growing their own plants. Another theme was the hands-on reinforcement grounded in P³. Sixty-eight percent of participants (141 students) stated that watching and caring for their plant outside of class bolstered their engagement with and interest in the lecture material, a powerful theme among participants. Others said they paid more attention in class in order to learn how to care for their plants better and to understand how and why their plants were growing; students specifically wrote about nutrients, the importance of water and sunlight, artificial versus natural light, biochemical reactions, and cellular processes. The theme of personal engagement in course concepts was evident when many students said P³ made the material much more interesting because they could relate to botany concepts on a personal level. When students were asked about an increase in ability to understand the significance of cellular processes to plant survival (SQ3), 197 (94%) answered positively, five students (2%) answered negatively, and seven students (3%) remained neutral. Additionally, when asked about how observing their plant at home influenced interest in the course subject matter (SQ4), 169 students (80%) responded positively, nine (4%) responded negatively, and 31 students (14%) were neutral in their response.

Research Question #2: In what ways does the P³ challenge plant blindness in young adults?

When asked what factors, as a result of this project, now influence their general appreciation of a plant, recurrent themes included a newly realized appreciation of the number of aspects that go into keeping a plant healthy, their uses by humans as food and medicine, how important plants are to maintaining the health of the environment and providing oxygen for life, and their aesthetic value. Student-participants also wrote about the complexity of plant life and plant resiliency. Most students wrote about being more in tune with details of their surroundings. Other important themes were responsibility, ownership, and personal connections to their pet plant. Students wrote about how "interesting" and "fascinating" it was to watch the plant growth process; they also wrote about their pride in being responsible for that growth. Multiple students commented on human dependency on plants, along with concepts of plant beauty and resiliency, survival, diverse environments, complexity, and sensitivity.

Table 3. Culminating survey questions used to gauge student responses to the P^3 (N = 209). Relevant research questions (RQ1-3) are described in the introduction. Sample student responses are also included for each question.

Survey Question	Relevant Research Question	Positive	Negative	Neutral	Sample Student Responses
SQ1. Prior to this assignment, had you ever grown a plant before from seed, or otherwise cared for a plant over a long period of time? If yes, please briefly explain.	RQ2	101	98	10	"Yes, my family really liked gardening so I grew up around it." "No, I have never grown a plant prior to this project."
SQ2. Do you consider yourself to have a green thumb (meaning that you are "good with plants")? How has that changed as a result of this project?	RQ3	75	116	18	"I would consider myself to have the furthest thing from a green thumb. I have never once grown anything because I was afraid it would just die. This project has changed that completely, it has given me hope that I can actually grow my own plants."
SQ3. How has your ability to understand the significance of cellular processes to plant survival increased? In other words, what does "plants need sun, water, and air" now mean to you?	RQ1	197	5	7	"Now that I have taken this class I understand the process involved in plant metabolism and cellular respiration, which allows me to understand not only why sun, water, and air is important but also how the plants actually use them."
SQ4. How did observing your plant at home affect/influence your interest in the subject matter covered in class?	RQ1	169	9	31	"I wanted to learn more about my plant so I could better take care of it. Listening to the lectures were interesting when it applied to growing your own plant."
SQ5. When you are walking on campus or at home, do you feel that you notice plants more than you did prior to this project? Why?	RQ2	157	46	6	"Yes! I look to see if they are complete, incomplete, perfect, imperfect, what kind of pollinators attract it, what stage in its life cycle is it in, all sorts of things I learned in class."
SQ6. Are you planning to continue to grow your plant after this semester ends? Do you feel attached to your plant? Explain.	RQ3	139	62	8	"I don't only plan on growing my plant, I have started an herb garden back home, and have three other flower pots. . . . I feel quite attached to my plant, and have even given it a name, as can be seen on Slack. I feel that being responsible for it, and being through each step has given me a deep respect for my plant, and I can't just throw that away."
SQ7. Think back to the first week's visit to the greenhouse. How would you feel if we took you back there? What would be different?	RQ2, RQ3	175	0	34	"I would feel happier as I now have a better understanding of all the different types of plants and what they are useful for and just having an appreciation for the plants in terms of their survival over millennia. I would find myself studying each individual plant more and not just focusing on the 'pretty plants,' as I now realize that all plants, whether they be pretty or plain, are essential to either me, as a human being, or some other sort of creature."

(continued)

Table 3. Continued

Survey Question	Relevant Research Question	Positive	Negative	Neutral	Sample Student Responses
SQ8. Having completed your plant project, what would you now say are the most important factors that influence your appreciation of a plant?	RQ2	n/a	n/a	n/a	"That plants are very valuable, everything that we eat, we never think that someone took the time growing it and making sure that the plant is well kept. So now when I eat a tomato, I will be thinking about the fact that it was not easy growing this tomato and for it to be ripe and juicy took a lot of progress." "I of course appreciate them for making the oxygen I need and the beauty they supply our world with, but now seeing them grow and knowing what process they do and how much time and energy they take I appreciate them for their strength and determination to survive."
SQ9. Has your pet plant experience made you more likely to grow other plants in the future? Explain.	RQ2, RQ3	153	32	24	"Yes! I loved seeing it grow and having to care for something. I felt a little important because I contributed to the environment, and it was like a little pet." "Yes. Knowing that I can successfully grow a plant, I will likely grow another one."
SQ10. As a result of your experiences this semester with the P^3, are you still blind? Why or why not?	RQ2	186	11	12	"I have 20/20 now in the plant world. I appreciate how it takes such a delicate balance to keep each and every plant in nature alive. I notice more plants now as I'm walking around outside and think about how long it took them to grow and what special conditions it took for them to grow in."

When asked if they noticed plants more now after the project (SQ5), 157 students (73%) said YES. Another confirmation that P^3 worked to reverse plant blindness was that 47% of students (98) reported never growing or caring for a plant before the project (SQ1), but 73% of students (153) stated they plan to grow plants in the future (SQ9). Additionally, SQ7 asked students about revisiting the greenhouse; 175 students (84%) responded positively, 0 students responded negatively, and only 34 students (16%) submitted neutral answers. In the final question on the survey, students were asked if they still considered themselves blind. Eighty-nine percent of participants (186) said NO, 5% (11 participants) answered YES, and 6% (12 participants) submitted a neutral answer.

Research Question #3: How does P^3 increase regular interaction with plants, both long- and short-term?

Based on responses from the culminating survey, only 74 students (35%) reported previously working in a flower or vegetable garden, and 98 students (47%) had never grown a plant from seed or cared for a plant over a long period of time. Fifty-seven students (27%) reported they did NOT have a green thumb before P^3, but growing their pet plant increased their confidence. Not only did students want to keep their plant alive, but they also focused on keeping their plants "healthy" and "happy." Students wrote that they better understood the responsibility associated with care and maintenance of a plant, but an additional theme across participants was a desire to continue to grow plants in the future. Students described their newfound confidence in growing plants, as well as detailed care regimens. A theme across participants was to use the word "love" when referring to the plant; however, students also discussed the "stress" of keeping the plant alive. By the end of the project, students reported on their long-term connections with plants, such as buying additional plants at the local garden center, growing a new garden, and a sense of pride throughout the growth process. Not only did most participants say they would continue to grow the plant they started in P^3 (139 students, 67%), but also the theme of future plant growth was overwhelmingly supported, with 153 students (73%) saying they would grow plants again as a result of this project. The impact on students, both short- and long-term, was clearly evidenced in the survey results.

Implications of P^3 Findings

Life on earth could not survive without plants, yet their ecological role is often invisible in modern society (Sanders, 2015). The P^3 is a simple and effective tool for increasing student interest and appreciation of plants: it makes plants relevant in their daily lives, encourages careful observation, and facilitates comprehension of lecture material. This project works well in large lecture courses but could be adapted to smaller class settings and/or implemented as part of high school biology curricula. For many students, it was the first time they had ever grown a plant from seed. Most significantly, the P^3 greatly increased student interest in abstract lecture topics that are typically challenging for students. When there is a rapidly developing plant waiting at home each day, students witness the effects of cellular changes in real time, making the learning experience much more meaningful. Activities that directly address plant blindness and botanical illiteracy are essential at all levels of education, but even more so in high school and post-secondary education where students begin to form their own unique world view. Not only did P^3 participants share their newfound fascination with plants in their daily environment, but many students expressed a continued commitment to care for and maintain plants in the future. Addressing plant blindness will enable students to make better informed decisions about public policy as it relates to plants and the essential ecosystems they support.

Additional Resources

All teaching materials associated with this activity can be accessed at http://sites.tntech.edu/skrosnick/pet-plant-project-teaching-resources/.

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