PROGRAM EVALUATION:

The University of Washington Botany Greenhouse K-12 Education Outreach Program

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SUMMARY

This summative evaluation of the University of Washington Botany Greenhouse K-12 Education Outreach Program analyzed the contents of 468 thank-you notes written by program participants using the National Science Foundation's Framework for Evaluating Impacts of Informal Science Education Projects**.** Strong evidence was found for impacts in three STEM learning categories: Awareness, Knowledge or Understanding, Engagement or Interest, and Skills.

INSTITUTIONAL OVERVIEW

The University of Washington Botany Greenhouse houses one of the most comprehensive university botanical teaching collections in the United States. With over 3,000 different species in 190 plant families, the collection represents over 1% of the earth's known botanical diversity and is one of UW's most unique and beautiful assets.

Currently, four temperature and humidity controlled rooms represent warm tropical, cool tropical, and arid desert biomes within which the UW Botany Greenhouse collections tell the story of biology: the beauty, the diversity, and the ability to evolve to solve a problem. Diverse collections range from the giant foul-smelling seven-foot-tall Corpse Flower, *Amorphophallus titanum*, to showy orchids from the rainforest canopy, to the ancient, cone-bearing, two-leaved, desert-dweller *Welwitschia mirabilis,* that can live up to 2,000 years. These collections inform and inspire not just scientists but also students of art, landscape architecture, linguistics, anthropology, and engineering at the University of Washington.

The UW Botany Greenhouse is open to the public during regular business hours, Monday through Friday from 9am to 4pm. Visitors generally explore the collections independently with staff people available to answer questions or they take self-guided audio tours. Interpretation in the form of signage or planned exhibits is currently limited though planning has begun for the interpretation of the collections in conjunction with planning for the construction a new UW Botany Greenhouse facility. The new facility will be part of the UW's new Life Science Complex. Life Sciences Complex construction will begin in summer 2016 and is slated for completion in 2018.

PROGRAM DESCRIPTION

The K-12 Education Outreach Program at the University of Washington Botany Greenhouse grew organically. Former Greenhouse Manager, Doug Ewing and greenhouse staff had been providing tours of the greenhouse teaching collections to groups of students for many years. Thanks to a donation to support this program by a UW Biology Professor Emeritus, a docent training program that employed UW students as tour guides for visiting K-12 classes was initiated.

The docent-lead tour was designed to encourage students to think like a plant biologist. Basic plant needs such as light, water, air, nutrition, protection, and reproduction are discussed throughout the tour. The tour content then focuses on identifying adaptations and ecological relationships plants have evolved to meet these needs. A tour subtheme is the interaction between people and plants, including many tropical food crops. Students are also dramatically introduced to “the most deadly plant in the world,” and asked to guess its identity: tobacco.

The tour lasts approximately one hour. Multiple docents are provided to break up larger groups, aiming for about 10 students or less per tour group.

The K-12 Education Outreach Program was put on hold in 2015 as a result of limited staff time resources due in part to increased planning demands for the new Life Sciences Complex facility. The future of the program is not clearly defined so an evaluation of past impacts may help to drive decision-making regarding the design and scale of future K-12 programs in the new greenhouse facility.

PROGRAM THEORY OF CHANGE

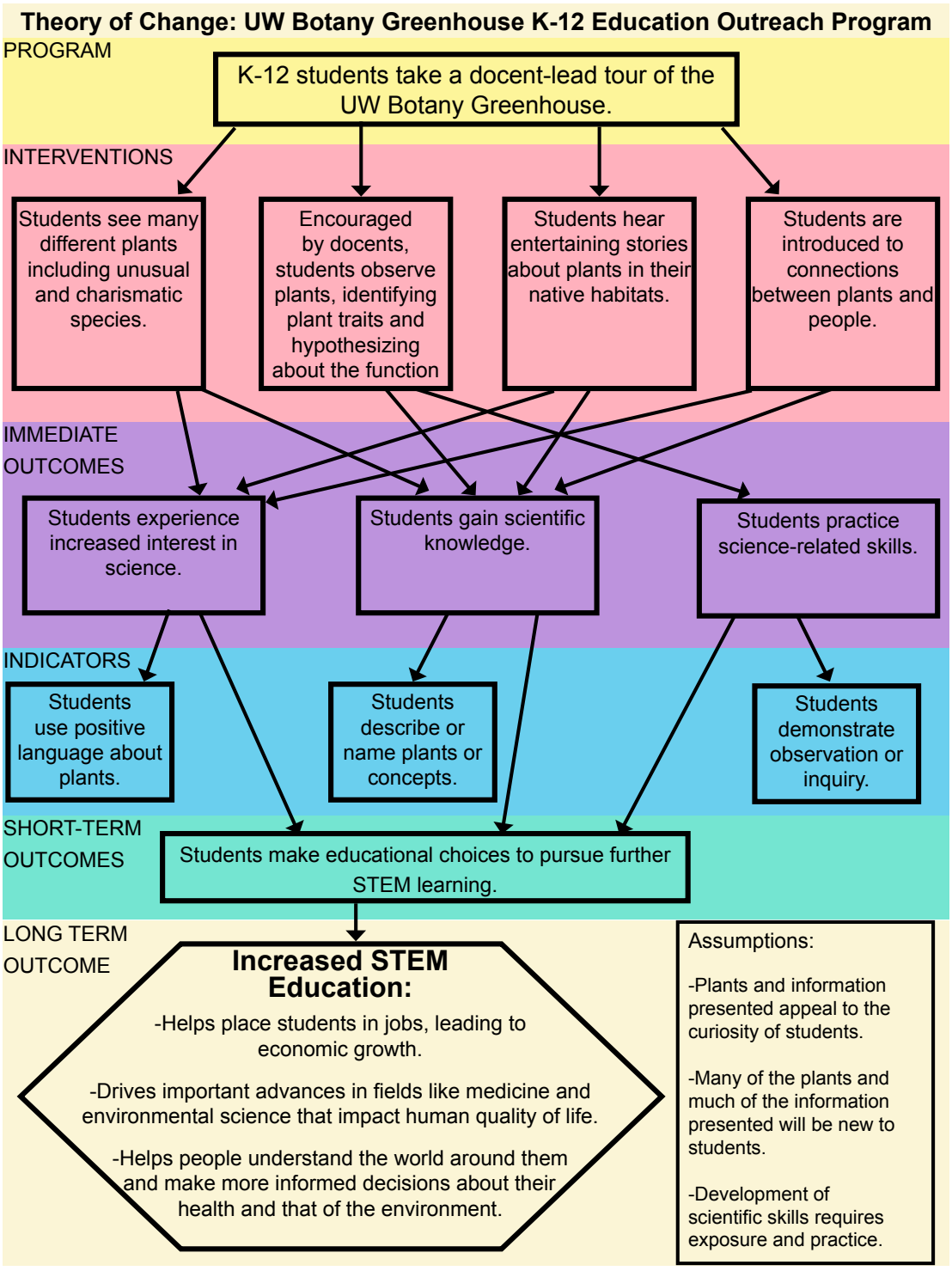
Defining a theory of change for the University of Washington Botany Greenhouse K-12 Education Program illustrates how the program will affect societal change including specific possible impacts of the program, the pathways to these endpoints, and the indicators of program success. According to Dr. Andrea A. Anderson in her publication, *Community Builder's Approach to Theory of Change: A Practical Guide to Theory Development*:

> "At its most basic, a theory of change explains how a group of early and intermediate accomplishments sets the stage for producing long-range results. A more complete theory of change articulates the assumptions about the process through which change will occur, and specifies the ways in which all the required early and intermediate outcomes related to achieving the desired long-term change will be brought about and documented as they occur" (Anderson, n.d.).

Rather than including all the possible changes that could result from the program, the theory of change developed for the UW Botany Greenhouse K-12 Education Program concentrated specifically on the immediate outcome of increased STEM education for students. This decision was made based on the assumption that the STEM education outcome was the motivating reason for running the program in the first place and other positive outcomes would be considered fringe benefits.

In his 2010 address introducing the launch of "Change the Equation," a program to improve STEM education, President Barack Obama argued, "We know how important this is for our health. It's important for our security. It's important for our environment. And we know how important it is for our economy" (Sabochik, 2010). With purported benefits of STEM education so wide-ranging and broad, the theory of change from this small-scale program could not reasonably address them all. Instead the theory of change focused on the intermediate measurable outcomes directly resulting from the program. To measure any further ripple effects would not have been possible given the limitations of the data available and size of the program and budget.

The Theory of Change for the UW Botany Greenhouse K-12 Education Outreach Program is mapped as follows:



METHODOLOGY

Measurement of indicators outlined in the UW Botany Greenhouse K-12 Education Outreach Program Theory of Change map was completed retrospectively. Over the years the UW Botany Greenhouse has received over 400 thank-you notes from students who have participated in the K-12 Education Outreach Program. Not only are these documents expressions of gratitude, they contain personal reflections, illustrations, and information about learning from a wide range of students. In an effort to capture and quantify some of these details, a document content analysis was performed on each of the Thank-You notes. This analysis grouped student thank-you writers into four groups based on grade level: grades K-3, grades 4-6, middle school, and high school. Each thank-you note was then evaluated based on an already established framework for measuring the impacts of informal science education programs: the National Science Foundation's Framework for Evaluating Impacts of Informal Science Education Projects.

National Science Foundation's Framework for Evaluating Impacts of Informal Science Education Projects

The National Science Foundation's Framework for Evaluating Impacts of Informal Science Education Projects, also known as the Informal Education and Outreach Framework was published in 2008 by the Informal Science Education (ISE) program at the National Science Foundation (NSF). The framework was developed by the Informal Education and Outreach Working Group, lead by the NSF and nested within the national Academic Competitiveness Council (ACC). The ACC was created in response to the Deficit Reduction Act of 2005 which initiated a cross-agency review of all federally funded STEM (Science, Technology, Engineering and Math) education programs.

The Informal Education and Outreach Framework defines five broad categories of potential project impact on two audience categories: public audiences and professional audiences. For the purposes of this project, the following impacts on public audiences were utilized:

Informal Education & Outreach Framework

Impact Category	Public Audiences
Awareness, knowledge or understanding (of)	Measurable demonstration of assessment of, change in, or exercise of awareness, knowledge, understanding of a particular scientific topic, concept, phenomena, theory, or careers central to the project
Engagement or interest (in)	Measurable demonstration of assessment of, change in, or exercise of engagement/interest in a particular scientific topic, concept, phenomena, theory, or careers central to the project
Attitude (towards)	Measurable demonstration of assessment of, change in, or exercise of attitude toward a particular scientific topic, concept, phenomena, theory, or careers central to the project or one's capabilities relative to these areas. Although similar to awareness/interest/engagement, attitudes refer to changes in relatively stable, more intractable constructs such as empathy for animals and their habitats, appreciation for the role of scientists in society or attitudes toward stem cell research
Behavior (related to)	Measurable demonstration of assessment of, change in, or exercise of behavior related to a STEM topic. These types of impacts are particularly relevant to projects that are environmental in nature or have some kind of a health science focus since action is a desired outcome.
Skills (based on)	Measurable demonstration of the development and/or reinforcement of skills, either entirely new ones or the reinforcement, even practice, of developing skills. These tend to be procedural aspects of knowing, as opposed to the more declarative aspects of knowledge impacts. Although they can sometimes manifest as engagement, typically observed skills include a level of depth and skill such as engaging in scientific inquiry skills (observing, classifying, exploring, questioning, predicting, or experimenting), as well as developing/practicing very specific skills related to the use of scientific instruments and devices (e.g. using microscopes or telescopes successfully).

(Friedman et al., 2008, p.21)

In addition, an "Other" category can be added to this framework to allow for impacts unique to a project that would not be otherwise measured but may impact STEM capability such as creativity for example (Friedman et al., 2008, p.11). The Informal Education and Outreach Framework also acknowledges that this framework may not capture fully all the outcomes of a project and that it is unlikely that all of the impact categories will apply to any single project (Friedman et al., 2008, p.12).

Project / Framework Fit

Accepting these limitations, this framework is a good fit for the evaluation project based on several factors. First, the framework's measurements overlap very well with the indicators specified in the UW Botany Greenhouse's theory of change for the K-12 Education Outreach Program.

Secondly, the evaluation project is occurring after the STEM program education being measured has already concluded. In accordance, the Informal Education and Outreach Framework is intended for summative evaluation. Though the Thank-you notes analyzed for the project were a rich source of information, the data is already limited and unstandardized. In this case, an evaluation framework that is broad-based such as the Informal Education and Outreach Framework is needed to identify trends in very varied responses for many different individuals.

Thirdly, the program being measured is administered by student docents and has variations based on the ages and interests of the program participants. Though there is a general tour agenda, the exact content for each past tour cannot be captured. Applying a detailed, age-specific framework such as the Next Generation Science Standards would not suit all program participants and could not accurately measure which impacts resulted from the program. A broad framework, again, better applies to a flexible program with a wide range of participant ages.

Finally, the program evaluated may seek to apply for grant funding from public, private and governmental foundations in the future. Using a framework that collects project-level impacts in a systematic way and is in common use will help potential funders understand the impacts of this program in relation to other well-known NSF funded programs. The Informal Education and Outreach Framework was created by individuals experienced in informal science education and its evaluation, leaders in hundreds of projects. Use of the NSF's framework in this evaluation project may demonstrate to funders an understanding of the best practices and standards in the informal STEM education field.

As previously stated the use of the Informal Education and Outreach Framework will not measure all the possible outcomes of the program. Anecdotally for example, many of the graduate student docents have reported that giving tours has influenced their approach to science pedagogy and made them better and more confident teachers. Docents also have noted positive changes in their ability to communicate with the public about their research. While it would be interesting to try to measure more of these impacts, they are not within the scope of this evaluation and information about these impacts could not be obtained from the given data source.

Specific Evaluation Criteria

To standardize the approach to document content analysis, specific potential indicators within the thank-you notes were defined. Reviewing a sample of about 50 notes informed the development of indicators by providing examples of the types of content that would be present within the documents. Though the program's theory of change does not include behavioral or attitudinal change indicators as defined by the Informal Education and Outreach Framework due to aforementioned limitations of the program, in accordance with the framework, any possible evidence of this outcome was included in the evaluation. Evidence of changes in attitude and behavior were not however expected to be substantial and the design of this evaluation should not be considered appropriate for measurement of these categories. Indicators were recorded as either present or absent. The specific evaluation criteria used for the program evaluation is as follows:

Thank-you Note Content Analysis Criteria

STEM Impact Category	Potential indicators (Within Thank You Notes)	Evidence that impact was attained
Awareness, knowledge or understanding of STEM concepts, processes or careers	Botany/Taxonomy: Student references a specific plant by name. Ecology: Student describes an ecological concept. Plant Physiology: Student describes unique plant structures and/or functions.	After touring the greenhouse students will exhibit an increase in plant scientific knowledge.
Engagement or interest in STEM concepts, processes, or careers	Student uses positive language about plants such as: -"I liked…" -"…was awesome/cool/interesting" -"My favorite was…" Student asks further questions.	After touring the greenhouse students will be excited about plants.
Attitude towards STEM-related topics or capabilities	Student explicitly expresses an interest in studying plants or having a career in botany or horticulture.	After touring the greenhouse students will feel more inclined to pursue STEM education or careers.
Behavior resulting from experience	Student expresses an intention to avoid smoking tobacco.	After touring the greenhouse, students exhibit behavior that contributes to positive well-being.
Skills based on experience	Observation Skills: Student demonstrates observation of specific plant characteristics through illustration. Scientific Inquiry: Student proposes a question or hypothesis that demonstrates elementary scientific reasoning	After touring the greenhouse students have practiced scientific observation and/or reasoning skills.

Document Analysis Samples

The following examples of an analyzed Thank-you note will further illustrate the study methodology:

Example A
Grade Level: K-3

STEM Impacts Categories:

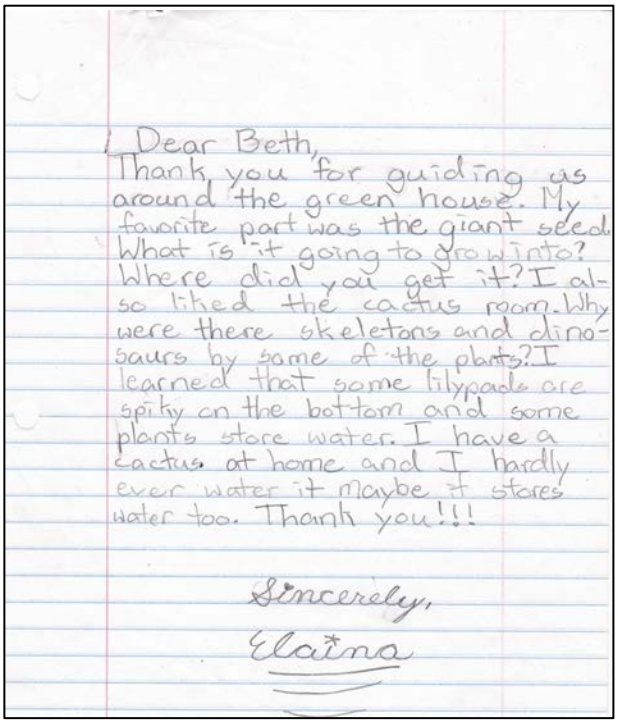
Awareness/Knowledge/ Understanding: PRESENT
- Ecology/Physiology: plant adaptation of camouflage, plant carnivory.

Engagement/Interest: PRESENT
- "I really liked..." and "It's cool"

Skills: PRESENT
- Illustrations show observation of specific and unique plant forms.

Attitude: ABSENT

Behavior: ABSENT



Example B
Grade Level: 4-6

STEM Impacts Categories:

Awareness/Knowledge/ Understanding: PRESENT
- Ecology/Physiology: Plants store water, plant reproduction (giant seed)

Engagement/Interest: PRESENT
- "liked the cactus room"
- Asks questions

Skills: ABSENT

Attitude: ABSENT

Behavior: ABSENT

Example C
Grade Level: Middle School

STEM Impacts Categories:

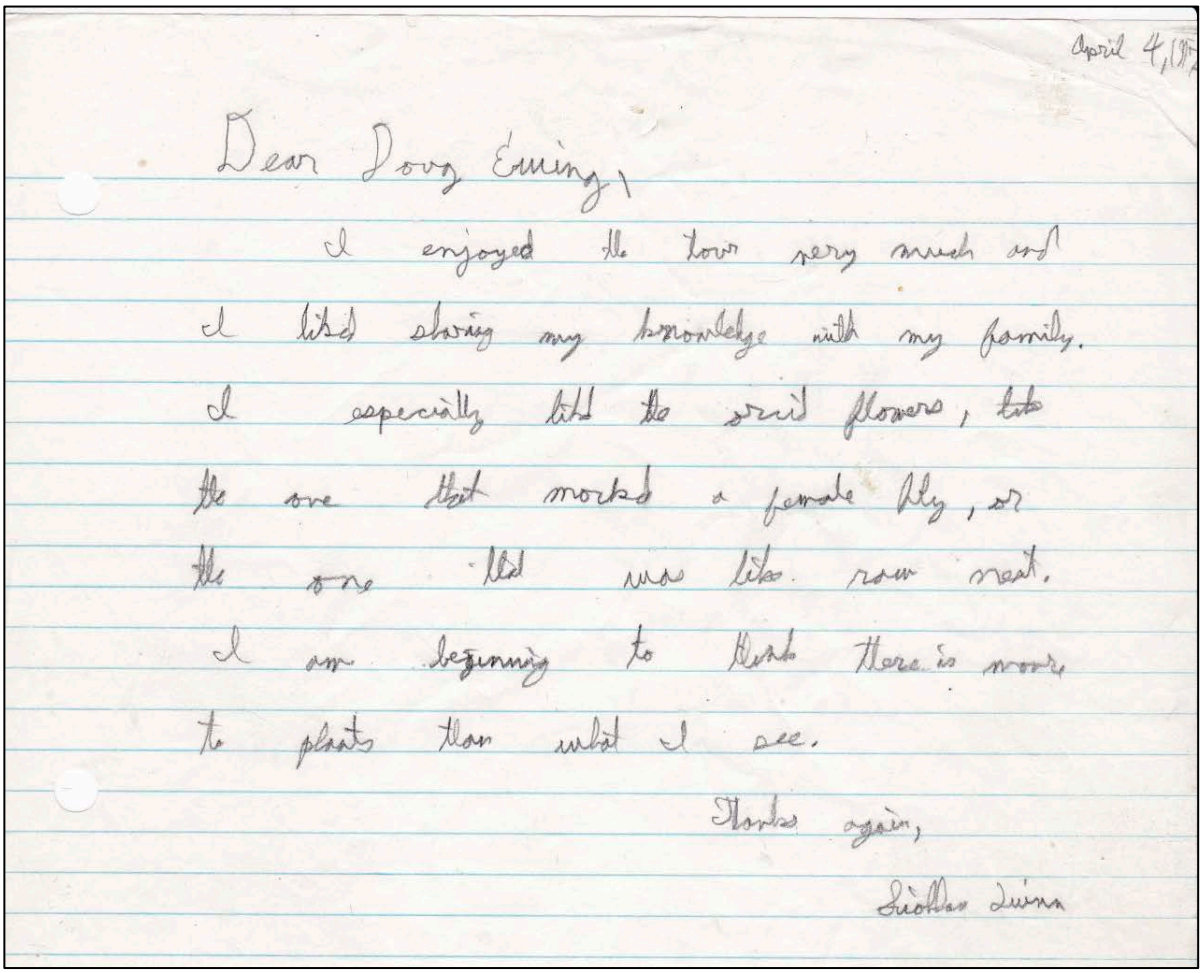
Awareness/Knowledge/ Understanding: PRESENT
- Ecology/Physiology: Orchid mocked female fly/like raw meat
- "I liked sharing my knowledge with my family."

Engagement/Interest: PRESENT
- "I especially liked…"
- "I am beginning to think there is more to plants than what I see."

Skills: ABSENT

Attitude: ABSENT

Behavior: ABSENT



April 4, 19

Dear Doug Ewing,

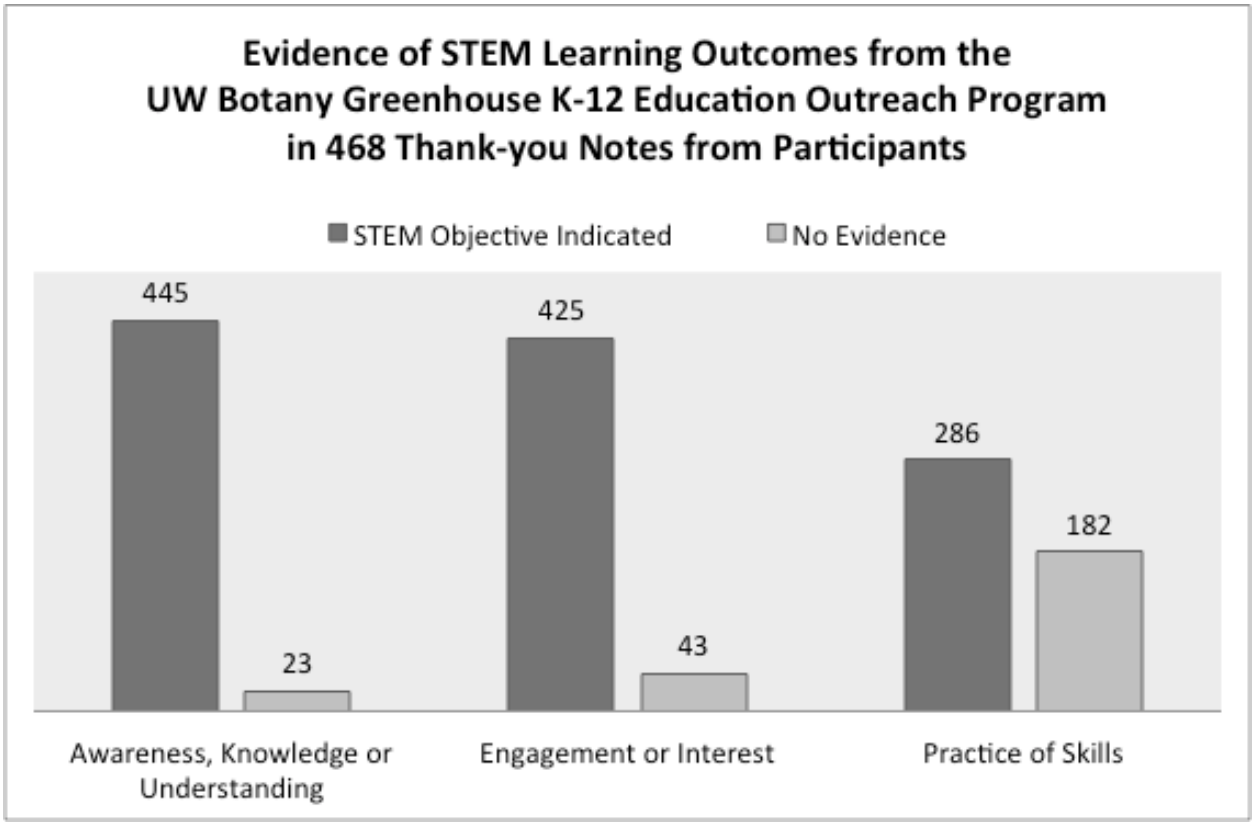
I enjoyed the tour very much and I liked sharing my knowledge with my family. I especially liked the coral flowers, the one that mocked a female fly, or the one that was like raw meat. I am beginning to think there is more to plants than what I see.

Thanks again,

Siobhan Quinn

RESULTS

The evaluation of the UW Botany Greenhouse K-12 Education Outreach Program yielded the following results:



UW Botany Greenhouse K-12 Education Outreach Program STEM-Learning Impacts

Grade Level	Thank-you Notes Counted	Number of Thank-you Notes Indicating:		
		Awareness, Knowledge or Understanding	Engagement or Interest	Skills
K-3	300	291	275	190
4th-6th	91	86	75	73
MS	31	27	30	12
HS	46	41	45	11
All Grades	**468**	**445 (95%)**	**425 (90%)**	**286 (61%)**

In addition, 31 indications of changes in Attitude were counted, most of which where instances of students expressing a future interest in studying science and/or attending the University of Washington. Only 5 indications of possible changes in Behavior were counted, all of which can be attributed to statements about avoiding smoking tobacco.

DISCUSSION

Based on these results, STEM-Learning impacts resulting from the UW Botany Greenhouse K-12 Education Outreach Program were indicated in a large majority of the thank-you notes from student participants received by the greenhouse. Of 468 student writers, 95% indicated awareness, knowledge or understanding of STEM topics or concepts. Engagement and Interest in STEM topics was indicated in 90% of the thank-you notes. Demonstration of the practice of STEM skills was indicated by 61% of students.

These results are overwhelmingly positive with regard to the program's theory of change based objectives. They should however be considered alongside factors that may have skewed these results. For one, a thank-you note is not an impartial source of information. By its very nature, it tends to provide favorable accounts of an experience. Indications of interest in particular have the possibility to become exaggerated due to the communication form. Students also may have been influenced by the content of the thank-you notes of classmates, again possibly inflating actual impacts. Furthermore, while most students have written the notes in response to teacher prompts, those who did not gain anything from the program may have opted out of writing a thank-you note, thus their experiences have not been counted.

This evaluation also faced limitations. Because the thank-you notes were written very soon after participation in the program, the evaluation cannot measure what the longer-term effects may have been or whether the found impacts lasted. Certain impact categories were more difficult to measure based on grade. High school students for example were less likely to include illustrations, thus making it more difficult to measure their practice of scientific observation skills. Due to these variations in thank-you note styles between age groups, comparisons between the findings for different grade-level groupings are not reliable. Behavior and Attitude category changes in particular are not well measured with this evaluation design because it lacks both the long-term data, front-end data and answers to specific questions that would make measurement of these changes more feasible.

CONCLUSION

Though possible factors of influence and limitations should be considered, the evaluation does provide initial evidence that the program has been very successful in providing significant STEM education outcomes to participants. With regards to the National Science Foundation's Framework for Evaluating Impacts of Informal Science Education Projects, based on ease of use and applicability to the program theory of change, the framework proved to be a valuable tool that may be used again in future evaluation efforts. Future evaluation might also include the collection of more data during the tour and the collection of specific answers to questions related to STEM categories. This might take the form of direct observation of tours, or the solicitation of surveys or interviews with participants.

BIBLIOGRAPHY

Anderson, A. (n.d.). *The Community Builder's Approach to Theory of Change: A Practical Guide to Theory Development* (Vol. 4). New York.

Friedman, A. J., Campbell, P. B., Dierking, L. D., Flagg, B. N., Friedman, A. J., & Korn, R. (2008). *Framework for Evaluating Impacts of Informal Science Education Projects: Report from a National Science Foundation Workshop*.

Sabochik, K. (2010). Changing the Equation in STEM Education. Retrieved June 01, 2015, from https://www.whitehouse.gov/blog/2010/09/16/changing-equation-stem-education