

Bridging agricultural gaps through experience: Evaluating conservation attitudes among youth
and hydroponics learning outcomes among interns

by

Charles Wayne Carpenter III

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Approved by:

Major Professor
Jeremy Cowan

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Abstract

Many urban and minority youth have little exposure to sustainable crop production and therefore have a minor understanding of the importance and various practices used in conserving natural resources. To combat this knowledge discrepancy, the Student and Staff Success Office (SSSO) at Kansas State University has hosted Junior MANRRS groups since 2021 to expose youth to different facets of agriculture and provide hands-on/experiential learning opportunities. During the summer of 2024, the KSU Switzer-Nicodemus educational camp was hosted in partnership with Willow Lake Student Farm, engaging 25 minority youth (ages 7–17). Activities introduced participants to soil and water conservation practices to improve awareness, understanding, and attitudes toward natural resource conservation within crop production. Participants completed pre- and post-assessments, including Likert-scale and open-ended questions, as well as a nine-question multiple choice worksheet to evaluate learning outcomes. Results indicated that campers demonstrated improved agricultural knowledge and increased awareness of sustainability following lectures and hands-on experiences, with urban youth showing the greatest gains. This thesis also investigates the impact of hydroponics instruction on undergraduate students participating in a Research and Extension Experiences for Undergraduates (REEU)-sponsored internship program. With growing global food demands and limited arable land, hydroponic systems represent an innovative solution to sustainable crop production. However, barriers such as technical complexity and limited educational exposure hinder adoption. This study explores how structured learning—including a lecture and hands-on hydroponic workshop—affects students' agricultural knowledge, perceptions, and confidence. Pre-, post-, and follow-up surveys showed statistically significant gains, particularly among students who received hands-on instruction. The findings support experiential learning as a

critical tool in building understanding and confidence in both youth and undergraduate populations, while highlighting the importance of integrating experiential approaches into agricultural education to address knowledge gaps and prepare future leaders in sustainable agriculture.

Table of Contents

List of Figures	viii
List of Tables	x
Chapter 1 - Introduction.....	1
The Role of Experiential Learning in Agricultural Education.....	1
School-Based Agricultural Education (SBAE) and Extracurricular Opportunities.....	2
Barriers for Minority Youth and Need for Inclusive Opportunities	5
Creating Pathways Through Education and Outreach	6
REFERENCES	8
Chapter 2 - Perspectives of Minority Youth about Agricultural Conservation Practices Through	
Experiential Learning	18
ABSTRACT.....	18
INTRODUCTION	19
Experiential Learning.....	19
School Based Agricultural Education - SBAE	20
Extracurricular Ag Experiential Learning	21
Minority Youth and Experiential Learning	23
Perspectives of Minority Youth	24
What's offered.....	26
Organizations	27
THEORETICAL FRAMEWORK.....	28
MATERIALS AND METHODS.....	31
Camp Overview	31
Participants.....	31
Demographics	32
Camp Curriculum.....	32
First Module: What is Sustainability?.....	33
Camp Hands-On Experience.....	35
Second Module: Conservation Practices in Agriculture	35

Third Module: Review and Directed Research.....	36
Days 4 and 5: Reflection and Project Work.....	36
Camp Project.....	37
Instruments Administered and Data Collection.....	37
Statistical Analysis.....	38
RESULTS	39
Learning Outcome Worksheet - Pre-camp Knowledge	39
Learning Outcome Worksheet - Post-camp Knowledge (Change).....	40
SSSO Survey Questions – Pre-test.....	41
SSSO Survey Questions – Pre-camp to post-camp change	42
DISCUSSION.....	44
Knowledge of Agricultural Sustainability and Natural Resource Conservation	45
Attitudes and Perceptions about Natural Resource Conservation and Sustainability.....	50
Confidence in Practicing Sustainability and Willingness to Explore	57
CONCLUSION.....	59
REFERENCES	62
TABLES AND FIGURES	74
Chapter 3 - Assessing Learning Outcomes of Hydroponics Instruction Among Undergraduate Students Participating in A REEU-Sponsored Internship	91
ABSTRACT.....	91
INTRODUCTION	92
What is hydroponics?.....	92
Barriers to Adoption of Hydroponics	93
Necessity of future horticulturists / Experiential learning	94
Experiential Learning and Undergraduate Engagement	95
THEORETICAL FRAMEWORK.....	96
MATERIALS AND METHODS.....	99
Placing the Research in Context	100
Initial Hydroponics Presentation.....	100
Hands-on Experience.	101
Study Participants.	102

Data Collection and Instruments.....	102
Survey Instrument.....	102
Follow-up Survey.....	103
Statistical Analysis.....	104
RESULTS	104
Presentation Results	105
Pre-presentation Responses	105
Post-presentation Responses.....	107
Workshop results	110
Pre-workshop Responses	110
Post-workshop Responses.....	111
Follow-Up Survey Results.....	114
DISCUSSION.....	116
CONCLUSIONS	125
REFERENCES	126
Appendix A - Nicodemus Camp Learning Outcome Worksheet and SSSO Survey Instrument	148
Appendix B - PSEG Green Teams Hydroponics Survey Instrument	153

List of Figures

Figure 1. Kolb’s Theory of Experiential Learning (Kolb, 1984).....	81
Figure 2. The Model of Assumed Relationships Among Education, Knowledge, Attitude, and Resultant Behavior (Wiley, 1996)	82
Figure 3. Overall combined scores (percent correct) on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus a and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1.	83
Figure 4. Scores (percent correct) by gender on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1	84
Figure 5. Scores (percent correct) by location on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Ni Nicodemus and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1.....	85
Figure 6. Scores (percent correct) by grade level on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1.....	86
Figure 7. Overall camp responses from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.	87
Figure 8. Camp responses by gender from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr.	

MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.	88
Figure 9. Camp responses by location from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.	89
Figure 10. Camp responses by grade-level from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.	90
Figure 11. Kolb’s Theory of Experiential Learning (Kolb, 1984).....	141
Figure 12. The Model of Assumed Relationships Among Education, Knowledge, Attitude, and Resultant Behavior (Wiley, 1996)	142
Figure 13. Overall hydroponic presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	143
Figure 14. Comparing hydroponic presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	144
Figure 15. Hydroponic workshop responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	145
Figure 16. Comparison of intern responses following both interventions on the MSU Hydroponics Survey, administered to PSEG Green Teams after the hydroponics presentation during summer 2024 in Montclair, NJ and Manhattan, KS.	146
Figure 17. Comparing follow-up survey responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	147

List of Tables

Table 1. Self-reported demographics of 24 youth participating in the KSU-Switzer/Jr. MANRRS Educational Camp in Nicodemus and Manhattan, KS during one week in the summer of 2024 (n=24).....	74
Table 2. Overall post-camp scores (percent correct) on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.....	76
Table 3. Overall pre-camp responses from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.....	78
Table 4. Overall post-camp responses from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.....	79
Table 5. Overall pre-presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	133
Table 6. Overall post-presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	135
Table 7. Pre and post workshop responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	137
Table 8. Overall follow-up survey responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.	139

Chapter 1 - Introduction

Agriculture has been the foundation of human society for over 10,000 years (Zeder, 2008).

Through the years, production methods have evolved, and the amount we need to produce as a society has increased proportionally to population growth (Gilland, 2002). With a population expected to reach nearly 10 billion by 2050 (Gilland, 2002), agricultural producers must keep pace with growing demand, while encroachment from non-agricultural development decreases the availability of arable land (Cifuentes Torres et al., 2020; Sabandi et al., 2021). This requires farmers to find new and innovative ways to supply the 70% increase in total calories projected to support this increased population (Despommier, 2009; Pardey, 2010; FAO, 2020). Further, urbanization, which competes with agriculture for resources—especially land and labor—reduces the available labor pool vital to food production (Zhao et al., 2023). Therefore, exploring alternative and sustainable food production methods is imperative.

The Role of Experiential Learning in Agricultural Education

In light of an aging farmer population, shrinking rural communities, and a changing climate, it is imperative that we increase awareness and education among a broader range of youth on the opportunities and demand for leadership in agriculture and natural resource conservation. While educating youth about agriculture and natural resource conservation is critical, limitations and barriers exist. Not all communities have school-based agriculture education (SBAE) programs or teachers explicitly trained in agriculture. In addition to providing quality education and meaningful experiences in established agricultural curricula, we must expand these opportunities to new audiences. Extracurricular educational experiences provided by non-profit and extension educators may help bridge the gap. In addition, participation in extracurricular activities has been

linked to reduced dropout rates (Davalos et al., 1999). Further, numerous youth development organizations provide positive opportunities for youth to cultivate and develop life, career, and personal skills (Phelps et al., 2012). More well-known organizations offering agricultural and/or outdoor skills programs are FFA, 4-H, and Boy Scouts/Scouting of America.

Experiential learning enables learners to create a solidified foundation through a first-person lens and allows for a more in-depth understanding and meaningful experience (Schmitt-McQuitty et al., 2010). Various educators and researchers believe that "without an experience, there can neither be true learning nor real understanding of a concept or situation" (Schmitt-McQuitty et al., 2010; Boud & Cohen, 2000; Kolb, 1984; Dewey, 1938). According to Kolb's Experiential Learning Theory (Kolb, 1984), four pillars of experiential learning aid the process of knowledge formation: concrete experiences, reflective observation, abstract conceptualization, and active experimentation. Effective learning occurs when individuals move through all four stages. Kolb emphasizes that learning is most effective when direct experience is integrated with reflection, conceptualization, and experimentation—principles that align closely with SBAE and youth leadership programs similar to FFA and 4-H, where hands-on learning is paired with reflection and skill-building.

School-Based Agricultural Education (SBAE) and Extracurricular Opportunities

With the passage of the Smith-Hughes Act of 1917, Congress provided federal funding to promote vocational education, often termed career-technical education (CTE), in agriculture, trades and industry, and homemaking. These programs are largely built around providing contextualized, hands-on experiences to bring students up to an apprentice level of trade competency (U.S. Department of Labor, n.d.). Those CTE programs focused on agriculture and

agriculture technology serve a vital role in early exposure to agriculture-related careers, aid the learning needs of students, and help provide the future workforce for the agricultural industry and allied sectors (Eck et al., 2019). Further, these school-based vocational education programs increase positive connections between students and teachers and promote parental involvement (Phipps et al., 2008).

FFA is currently the largest agriculturally focused youth development organization offered through public high schools—as an adjunct to a school's SBAE program (National FFA Organization, 2010). Research supports the success of FFA due to engagement in school and community activities and leadership building, which promotes increased value in their careers regardless of occupation (Brannon et al., 1989; Townsend & Carter, 1983; Wingenbach et al., 1997; Balschweid et al., 2000). However, the demographics of the members are quite narrow and tend to serve a small group or demographic, specifically rural to small-town Caucasian students across the United States (Rayfield et al., 2008). With that said, the relatively narrow demographics could potentially cause individuals outside of the organization to either feel excluded or cast a negative light on FFA (Phelps et al., 2012).

4-H, another agriculturally focused youth development program, is offered in every county, parish, and district in the United States through Cooperative Extension services administered by 106 land-grant universities (Parra et al., 2022). With a motto of "learn by doing," 4-H provides hands-on learning experiences that deepen agricultural understanding and connect youth with the environment (Meichtry & Smith, 2007; West Virginia University Extension, n.d.). Despite its

widespread availability, significant challenges around diversity and accessibility persist (Sumner et al., 2018).

Scouting America (formerly Boys Scouts of America), has similarly aimed to inspire youth to develop life skills and responsible character. Over its 100+ year history, it has served over 100 million youth (Townley, 2007; Hilliard et al., 2014). However, minority and low-socioeconomic-status youth participation remains underrepresented (Pedersen et al., 2005).

Hydroponics and Barriers to Adoption

Hydroponics is a soilless production method that can be deployed indoors and scaled. It is an interesting candidate to help alleviate the strain placed on conventional agriculture to supply adequate nutrition for a growing population. Hydroponic systems allow producers to control production factors, such as nutrient levels and timing, pH, electrical conductivity (EC), temperature, and others, to ensure optimal plant growth (Sousa et al., 2023). This control allows hydroponic systems to improve water management, space efficiency, and reduce chemical applications (Ampim et al., 2022). Hydroponic production requires 95% less irrigation water than conventional agriculture production (Karasahin M., 2014). In addition, hydroponic systems can be stacked vertically to increase the production area with minimal overall increases in square footage (Sousa et al., 2023). Thus, hydroponic production has the demonstrated potential to improve space efficiency for food production (Ampim et al., 2022) with a significantly lower environmental footprint, compared to conventional agriculture (Romeo, D., 2018).

Despite its benefits, hydroponic systems are more complex than conventional fruit and vegetable production systems and carry a steeper learning curve (Pomoni et al., 2023). Additionally, the initial capital outlay, ongoing maintenance and labor costs are substantial challenges (Velazquez-Gonzalez, R.S. et al., 2022; Kannan, M., 2022). These systems also present risks for waterborne-disease spread, requiring specialized knowledge for operation (Solis-Toapanta, 2020). These factors create substantial barriers to the widespread adoption of hydroponics.

One of the most critical barriers to youth engagement with hydroponics is the lack of exposure to these systems in formal and informal educational settings. Because hydroponics is still seen as an emerging technology in agriculture, many SBAE programs—particularly in underfunded or urban schools—do not include it in their curriculum. Without early exposure through experiential learning opportunities, students are unlikely to develop the confidence, knowledge, or interest needed to consider hydroponics as a viable area of study or career path. Youth in urban and underserved communities are especially affected, as these locations often face greater educational and financial constraints that prevent access to newer agricultural technologies.

Barriers for Minority Youth and Need for Inclusive Opportunities

Over 17 million minority youth students in the United States attend Title I schools (Kids Count Data Center, 2021). Few of these schools offer SBAE programs, so students tend not to pursue a college degree or a career in STEM or STEAM fields (Jean-Philippe et al., 2017). Additionally, minority youth face barriers such as underrepresentation in extracurricular youth development programs, lack of mentors, and limited exposure to agricultural pathways (Spencer et al., 2014). Educators may not reflect the demographics of the communities they teach in (Miller et al.,

2024), contributing to environments where students feel disconnected. Without culturally competent teaching or inclusive content, minority students may experience implicit bias and negative assumptions from educators (Whipple et al., 2021; Hamilton et al., 2015; Miller, 2019). Due to limited exposure and historical exploitation within agriculture, minority youth often associate the field with low value, prestige, and wages (Brown., 2022; Vincent et al., 2012). This perception is reinforced by a lack of representation in agricultural majors and careers, leading to feelings of exclusion or disinterest (Hand et al., 2023). Additionally, families with lower educational attainment are less likely to have awareness of agricultural opportunities, decreasing the likelihood of youth pursuing these paths (Ward, 2006; Esters & McCulloh, 2008). These same barriers extend to emerging areas like hydroponics. When minority youth lack access to foundational agricultural education or extracurricular programs that feature hydroponics, their opportunity to engage with this growing field is limited. Without targeted experiential learning programs that introduce hydroponics through culturally relevant, hands-on experiences, these students are less likely to view themselves as potential contributors to or beneficiaries of future food systems innovations.

Creating Pathways Through Education and Outreach

Despite these challenges, several programs and organizations are working to mitigate these disparities. Schools such as the Chicago High School for Agricultural Sciences and Walter B. Saul High School provide predominantly minority student populations with access to comprehensive agricultural curricula and hands-on experiences in fields like animal science, food science, and horticulture (CHAS, n.d.). University programs have implemented intentional outreach efforts to expose underrepresented communities to college majors and careers in

agriculture, positively shifting perspectives and creating pipelines to education and employment (Foster et al., 2012; Wiley & Hobbs, 2021).

Programs like MANRRS (Minorities in Agriculture, Natural Resources, and Related Sciences) offer structured, tiered mentorship and development from high school through professional levels, fostering leadership and a sense of belonging (Talbert et al., 1999; Dorsey et al., 2004). At the collegiate level, Research and Extension Experiences for Undergraduates (REEU) and other undergraduate internships provide valuable exposure to agricultural research and community outreach, building confidence and skills in areas like hydroponics (Fontanier et al., 2019; Lopatto, 2004; Russell et al., 2007).

Although only a few studies assess the direct impact of hands-on hydroponics education in REEU settings (Fontanier et al., 2019), experiential learning broadly supports student self-efficacy, career interest, and deeper understanding of agricultural sciences (Craver and Williams, 2014; Tang et al., 2008; Papadopoulou et al., 2025). As the agricultural workforce continues to shrink and the demands on food systems increase, cultivating future leaders through inclusive, hands-on education is critical for meeting the challenges of tomorrow.

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Chapter 2 - Perspectives of Minority Youth about Agricultural Conservation Practices Through Experiential Learning

ABSTRACT

Many urban and minority youth have little exposure to sustainable crop production and therefore have a minor understanding of the importance and various practices used in conserving natural resources. To combat this knowledge discrepancy, Student and Staff Success Office (SSSO) at Kansas State has hosted Junior MANRRS groups since 2021 to expose them to different facets in agriculture and provide students with hands-on/experiential learning opportunities. During the summer of 2024, Kansas State's Junior MANRRS organization (KSU Switzer-Nicodemus educational camp) was hosted by the SSSO in partnership with the Willow Lake Student farm. This study seeks to evaluate the impact of different hands-on activities for student learning outcomes and perspectives regarding sustainability, natural resource conservation and agricultural knowledge. In total, 25 minority youth participated (age 7 - 17) during the summer camp. The activities were designed to introduce minority and urban youth participants to various soil and water conservation practices to improve their awareness, understanding, and attitudes toward natural resource conservation practices within crop production. Participants completed pre- and post-event assessments to evaluate changes in their perspectives and learning outcomes throughout the program. The instrument administered through the SSSO included seven questions (pre-) and (post-) questions presented in a Likert-scale and one open ended question. In addition, a learning outcome worksheet administered included nine multiple choice questions that evaluated the effectiveness of the camp curriculum. Results indicated that campers demonstrated improved agricultural knowledge and increased awareness of conservation and

sustainability practices following lectures and hands-on learning experiences. Urban youth showed the greatest gains, narrowing pre-existing knowledge and confidence gaps with their rural peers. However, while knowledge and confidence improved, participants' intentions to further explore conservation topics remained unchanged.

INTRODUCTION

In light of an aging farmer population, shrinking rural communities, and a changing climate, it is imperative that we increased awareness and education among a broader range of youth on the opportunities and demand for leadership in agriculture and natural resource conservation. While educating youth about agriculture and natural resource conservation is critical, limitations and barriers exist. Not all communities have school-based agriculture education (SBAE) programs or teachers explicitly trained in agriculture. In addition to providing quality education and meaningful experiences in established agricultural curricula, we must expand these opportunities to new audiences. Extracurricular educational experiences provided by non-profit and extension educators may help bridge the gap. In addition, participation in extracurricular activities has been linked to reduced dropout rates (Davalos et al., 1999). Further, numerous youth development organizations provide positive opportunities for youth to cultivate and develop life, career, and personal skills (Phelps et al., 2012). More well-known organizations offering agricultural and/or outdoor skills programs are FFA, 4H, and Boy Scouts/Scouting of America.

Experiential Learning

Experiential learning enables learners to create a solidified foundation through a first-person lens and allows for a more in-depth understanding and meaningful experience (Schmitt-McQuitty et al., 2010). Various educators and researchers believe that "without an experience, there can

neither be true learning nor real understanding of a concept or situation" (Schmitt-McQuitty et al., 2010; Boud & Cohen, 2000; Kolb, 1984; Dewey, 1938).

According to Kolb's Experiential Learning Theory (Kolb, 1984), four pillars of experiential learning aid the process of knowledge formation: concrete experiences, reflective observation, abstract conceptualization, and active experimentation. Effective learning occurs when individuals move through all four stages. Kolb emphasizes that learning is most effective when direct experience is integrated with reflection, conceptualization, and experimentation—principles that align closely with SBAE and youth leadership programs similar to FFA and 4-H, where hands-on learning is paired with reflection and skill-building.

School Based Agricultural Education - SBAE

With the passage of the Smith-Hughes Act of 1917, Congress provided federal funding to promote vocational education, often termed career-technical education (CTE), in agriculture, trades and industry, and homemaking. These programs are largely built around providing contextualized, hands-on experiences to bring students up to an apprentice level of trade competency (U.S. Department of Labor, n.d.). Those CTE programs focused on agriculture and agriculture technology serve a vital role in early exposure to agriculture-related careers, aid the learning needs of students, and help provide the future workforce for the agricultural industry and allied sectors (Eck et al., 2019). Further, these school-based vocational education programs increase positive connections between students and teachers and promote parental involvement (Phipps et al., 2008). SBAE and other CTE programs provide early experiences, positively impacting graduation rates of at-risk and special needs secondary students (Gray, 2004; Okou,

2004). While there are few research reports on SBAE programs specifically, CTE programs have decreased dropout rates by 81 % among secondary students (Bridgeland et al., 2006). Exposure to agricultural experiences and career paths at the secondary educational level (grades 6-12) is imperative in positively influencing perceptions and attitudes among youth (Jean-Philippe. et al., 2017). However, access to these programs depends on available funding. One of the biggest challenges in SBAE is a longstanding shortage of qualified educators (Castro et al., 2010; FFA, 2017). The relevance of vocational programs to their communities plays a role in funding vocational programs—there is a much lower demand for agricultural technicians in urban communities. Thus, fewer SBAE programs exist in urban schools (Talbert & Larke, 1995).

Additionally, there is a lack of diversity among SBAE educators, creating a condition wherein agricultural educators may not reflect the demographics of the communities in which they teach (Miller et al., 2024). With limited access to the hands-on experiences offered by SBAE programs, underrepresented youth often lack any basis for understanding or developing informed beliefs or attitudes about agriculture, creating a disconnect from agriculture-focused majors and careers (National Research Council, 2009). Finding other avenues to expose urban youth to agriculture is necessary to mitigate the impact of limited exposure.

Extracurricular Ag Experiential Learning

FFA is currently the largest agriculturally focused youth development organization offered through public high schools—as an adjunct to a school's SBAE program (National FFA Organization, 2010). Research supports the success of FFA is due to aspects of engagement in school and community activities and leadership building, which promotes increased value in

their careers regardless of occupation (Brannon et al., 1989; Townsend & Carter, 1983; Wingenbach et al., 1997; Balschweid et al., 2000). Although FFA has an expansive number of members part of the organization, the demographics of the members are quite narrow and tend to serve a small group or demographic specifically rural to small-town Caucasian students across the United States (Rayfield, Compton, Doerfert, Frazee, & Akers, 2008). With that said, the relatively narrow demographics could potentially cause individuals outside of the organization to either feel excluded or cast a negative light on FFA (Phelps et al., 2012).

4-H is another agriculturally focused youth development program available in every county, parish, and district in the United States. 4-H is offered through the Cooperative Extension services administered by 106 land-grant universities in the US (Parra et al., 2022). According to West Virginia University Extension (n.d.), the slogan, or motto, of the 4-H youth development program is "learn by doing". By providing hands-on learning experiences, 4H helps youth deepen their understanding of agriculture and develop a closer connection to nature (Meichtry & Smith, 2007). Also, these early, hands-on, extracurricular experiences allow students to build foundational life skills while promoting a connection to their environment (Berman, 2013). However, despite its widespread availability, there remains a significant lack of diversity and accessibility within the program (Sumner et al., 2018). For instance, some counties in New York have reported 4-H community club enrollments that are overwhelmingly Caucasian (Sumner et al., 2018). However, 4-H has set an ambitious goal of growth, aiming to create a minority participation that mirrors the population demographics, caters to diverse needs, and addresses the social conditions of the area they serve (National 4-H Council, 2017, p. 2).

Scouting America (SA), formerly called Boys Scouts of America, also serves over 2 million youth nationally; over its 100+ year history, it has served over 100 million youth (Townley, 2007). The organization aims to inspire youth to develop life skills to thrive as individuals and develop into adults with responsible character (Hilliard et al., 2014). (Hilliard et al. 2014; Wang et al. 2015). Findings show that scouting programs have positively impacted and promoted character development among youth. Although Scouting of America provides many benefits, minority, and low-socioeconomic-status youth participation is often underrepresented (Pedersen et al., 2005).

Minority Youth and Experiential Learning

Over 17 million minority youth students in the United States attend Title 1 schools (Kids Count Data Center, 2021)—defined as schools with a large proportion of youth from low-income families (U.S. Department of Education, n.d.). Few of these schools offer SBAE programs, so students tend not to pursue a college degree or a career in STEM or STEAM fields (Jean-Philippe et al., 2017). In addition, youth growing up in low-income households and who have other social barriers are underrepresented in extracurricular youth development programs and understudied in their development (Spencer et al., 2014). Providing extracurricular and experiential learning experiences for minority youth can help build positive character and connect them to adult role models, helping them thrive in their transition to adulthood (Vandell et al., 2015; Milton et al., 2023).

While there are many positive correlations between youth mentors and positive youth development, minority youth still face barriers in SBAE or participation in extracurricular

activities, such as it not being offered in all schools and a lack of sufficient agricultural curriculum (Pense & Leising, 2004; Talbert & Edwin, 2008). Furthermore, with a vast majority of minority youth living in suburban and urban environments, educational programs need development and improvement in these locations (U.S. Census Bureau, 2020; National Council of Agriculture, 2009). SBAE, CTE, or outdoor extracurricular programs allow students to gain valuable educational experience and positive mentors that can benefit them in their future (Halpern, 2005).

Another key barrier lies in a lack of diversity of teachers and mentors in agricultural education spaces. This misalignment can lead to environments where minority students feel disconnected from the material and the educators themselves (Bird et al., 2013). Without culturally competent teaching or implementing inclusive program material, educators may unintentionally create environments where minority youth feel unwelcome (Whipple et al., 2021). Findings have shown that non-minority educators are unaware of the barriers to minority youth, which, as a result, causes obstacles to understanding educational and community needs (Whipple et al., 2021). As a result, in many cases, implicit bias can occur between minority youth and educators, which can manifest in characteristics such as harsher disciplinary measures, less positive feedback, and negative assumptions about the capabilities of minority students (Hamilton et al., 2015; Miller, 2019).

Perspectives of Minority Youth

All of these systemic barriers can contribute to how minority youth perceive agricultural education and careers. Also, due to a lack of exposure and historical exploitation within

agriculture, minority youth tend to associate agriculture with low value, prestige, and wages (Brown., 2022; Vincent et al., 2012). In addition to ethnic and socioeconomic factors, younger generations do not have the same interest in agriculture as previous generations (Girdziute L., 2022). This perception is reinforced by youth missing the potential interdisciplinarity of agriculture, instead seeing only the physically demanding nature of farming and ranching (Hand et al., 2023). The lack of minority representation in college majors in the agricultural sciences may compound these "negative images" of agriculture. Minority youth may perceive agricultural careers as unwelcoming, leading to feelings of exclusion or disinterest (Hand et al., 2023). Furthermore, minority and socioeconomically disadvantaged youth are more likely to have families with lower levels of education, which negatively affects the perception of higher educational attainment for youth (Ward, 2006). With a lack of higher educational experiences amongst the families of minority youth, there is a lower likelihood of those youth being exposed to a range of opportunities available in agricultural education and careers. (Esters and McCulloh, 2008). University programs have made efforts intentionally to expose underrepresented communities to college majors and careers in agriculture and have documented the success of these outreach efforts. These efforts have positively shifted the perspectives of minority youth and created a pipeline to education and careers to combat a decreasing agricultural workforce (Foster et al., 2012; Wiley & Hobbs, 2021). In response to these challenges, agricultural education has gradually modernized and has broadened its reach into suburban and urban areas (Hand et al., 2023). SBAE programs have diversified their curriculum, shifting from farm-based to more non-farm-based curricula (Talbert et al., 2022). This transition captures students with interests outside of production agriculture careers, including food science, plant science, biotechnology, environmental science, and natural resources management (National Council for

Agricultural Education, 2015; Talbert et al., 2022). This allows minority youth the opportunity to glimpse into the agricultural sciences through SBAE-specific classes.

What's offered

To address the access gap, Chicago High School for Agricultural Sciences (CHAS), located in Chicago, IL, and Walter B. Saul High School, located in Philadelphia, PA, are both 4-year high schools that focus curricula specifically on agricultural sciences. Both schools serve a predominantly minority student body and offer hands-on experiences in agriculture-related disciplines, such as animal science, horticulture, food science, agricultural business, and mechanics (CHAS, n.d.) CHAS and Walter B. Saul High School's missions are to prepare students for enrollment into higher education and careers in agriculture. It should be noted that both are special admissions schools and are available only to students who meet their admissions criteria, which weights prior academic achievement and participation on community service, volunteerism, and extracurricular activities (CHAS, n.d.).

Beyond secondary education, universities have implemented intentional outreach efforts to understand the perspectives of minority youth to provide better educational experiences for those students. There is literature supporting the effectiveness of collegiate outreach programs to recruit and guide minority youth to programs that they might not otherwise have known exist or understood well enough to make an informed decision about. A week-long SBAE program provided minority youth participants in Kentucky with more positive attitudes about careers in food and agricultural sciences (Wiley et al., 1997). Kitchen et al. (2018) demonstrated that access to STEM-based educational programs positively influenced minority youths' interest in STEM-

related careers. Furthermore, minority youth participating in college readiness programs have had positive shifts in their understanding of and attitudes toward career opportunities in agricultural sciences (Foster et al., 2012; Wiley & Hobbs, 2021). These initiatives create clearer pipelines for students from underrepresented backgrounds to enter the agricultural workforce.

Organizations

In addition to the enhancement of SBAE curricula for minority youth, there are organizations that are mitigating these barriers. The National Society for Minorities in Agriculture, Natural Resources, and Related Sciences (MANRRS), founded in 1988, has provided a space for students to interact and network to share experiences (Talbert et al., 1999). MANRRS is designed to attract minority youth and college students to agriculture and related fields and to improve negative perceptions about the industry (Dorsey et al., 2004; Jones, 1994; Larke et al., 1987). One of the goals of MANRRS is to increase interaction and connections between students and professionals, allowing students to enhance their leadership and organizational skills.

A distinctive feature of MANRRS is its tiered membership structure, including Junior MANRRS (Grades 7-12), Collegiate MANRRS, Professional, and Corporate Partners. This tiered model helps build a continuous pipeline from middle and high school through postsecondary education and into professional careers. Organizations like MANRRS complement SBAE and outreach programs by fostering a sense of belonging, community, and leadership development among underrepresented students.

THEORETICAL FRAMEWORK

This study seeks to evaluate the impact of hands-on activities on minority youth campers' understanding and perspectives about agriculture, sustainability, and natural resource conservation. The theoretical framework for this study is based on Kolb's (1984) theory of experiential learning (Appendix B) and Swanson's (1972) Model of Assumed Relationships Among Education, Knowledge, Attitude, and Behavior as applied by Wiley (1996) to minority youth and their exposure to agriculture-related topics (Appendix C).

Kolb (1984) assumes that knowledge is more readily acquired through personal (embodied), contextualized (embedded) experiences than traditional classroom instruction. Kolb's theory holds that meaningful learning occurs in a cycle beginning and ending with concrete experience. Concrete experiences, when an individual participates in an educational activity, require the learner to fully immerse themselves in the concept in a way that engages their minds and bodies to learn and/or acquire the skill. Following the learning experience, the learner may reflect on what they observed during the activity, contemplating the concept[s] that [was/were] taught both as a lens to understand the activity and through the lens provided by the activity itself. This reflection may lead uncover conflicts [or agreements] with the participant's pre-existing understanding about the world, or attitudes or perceptions about the concept, and they may attempt to parse those relationships [between the old and the new] in a process Kolb dubbed "abstract conceptualization." This might result in the learner gaming out how they might have approached the activity differently, to test whether the new information is more [or less] valid than the old. Or, they might conceive a way to improve upon the concept or skill based upon some related knowledge or skill they already held. Or, they may simply visualize incorporating

the new concept into their daily lives. From there, the learner may choose to seek additional information or to actively experiment with the concept, giving rise to a new concrete experience. Thus, restarting the learning cycle.

However, not all educational settings provide opportunities to engage in this full experiential learning cycle and sometimes following learners' progress is not possible; and, thus, the outcomes of the cycle cannot be evaluated. For these reasons, this study also incorporates the Model of Assumed Relationships Among Education, Knowledge, Attitude, and Resultant Behavior (Wiley, 1996). This model proposes that through educational intervention, knowledge transfer occurs, which can shift attitudes sufficient to motivate behavioral changes. Wiley's theory is a modification of Swanson (1972) which originally used the theory to modify health behavior. Swanson highlights that exposure to some information can create "cognitive dissonance," where new information conflicts with a learner's existing understanding, values, or attitudes about the concept. And, it may require experimentation in order to overcome that dissonance and change the attitude. But is that not the whole point of education—to dispel the kinds of misinformation, and the attitudes created by bad or no information, that give rise to the dissonance caused by new knowledge, and to replace it with new and better information and ways to view and approach the world? And, armed with that new information and the worldview it engenders, shift and/or align behaviors accordingly. Wiley (1996), has adapted the theory to highlight the impact of agricultural educational interventions and how they influence individuals to acquire knowledge, shape attitudes, and promote behavioral change in youth.

Building on these frameworks, this study allows the researchers to evaluate Wiley (1996) model combined with Kolb's (1984) Experiential Learning Theory. Researchers will assess the learning outcomes from the informational presentations and the attitudinal shifts after participants are exposed to new information about sustainable agriculture and natural resource conservation practices. Additionally, we will examine the impact of hands-on experiences on participants' intentions on further inquiry of the subject and motivation in replicating the experience in their own lives; combining both methods will allow the researcher to understand whether informational presentation and hands-on agricultural activities can positively influence participants' perceptions and behaviors regarding agriculture and natural resource conservation.

The objectives of the study were to:

1. Assess whether hands-on experiences contributed to campers' understanding of conservation practices.
2. Assess the perspectives of the campers on the importance of sustainability and conservation practices.
3. Assess the campers' willingness to further explore and apply sustainability into their own lives.
4. Determine the effectiveness of lesson plan in increasing agricultural knowledge and improving campers' perspectives regarding natural resource conservation practices.

MATERIALS AND METHODS

Camp Overview

The Kansas State University (KSU)-Switzer/Jr. MANRRS Educational Camp is an annual summer youth camp hosted by the KSU College of Agriculture's Student and Staff Success Office (SSSO) at KSU in partnership with the Kansas Black Farmers Association. SSSO has co-hosted the KSU-Switzer/Jr. MANRRS Educational Camp since 2017. The camp spans two locations: half is held at KSU's campus in Manhattan, KS, while the other half is in Nicodemus, KS. This camp aims to expose minority youth to academic and career opportunities in agriculture through hands-on experiences and other agriculture-related activities. During their time at KSU, campers stay in residence halls, having "day-in-the-life" experiences of what it is like to be a college student. Campers are introduced to agriculture majors, such as grain science, animal science, horticulture, and agronomy; and they participate in interactive activities led by KSU faculty and staff. While at KSU, the camp activities included additional agriculture-related activities in animal science and wheat/milling science, which were outside the scope of this project. Campers were also exposed to career opportunities in the agricultural field and college information and resources at KSU. Once campers arrived in Nicodemus, Kansas, they learned about the history of Nicodemus, KS through a visit to the Nicodemus National Historic Site. Furthermore, other activities included horseback riding lessons, a tour of a Cargill grain elevator, and a USDA Water Field Day. All events occurred throughout the five-day camp.

Participants

The population of interest was minority youth campers, age ten to seventeen, from primarily urban areas. These campers were from cities in Texas, Kansas, and Missouri, such as Arlington,

Topeka, Kansas City, Nicodemus, and St. Louis. The KSU-Switzer Nicodemus Camp staff promoted the camp through outreach efforts at local churches, community centers, and community-led organizations throughout Kansas, Missouri, and Texas. Interested youth were required to complete a camp application and submit a \$25 registration fee to secure a spot. Camp enrollment was conducted on a first-come, first-served basis; however, to ensure the camp can reach a broader audience, preference was given to first-time campers over returning participants. If space remained after new applicants were confirmed, returning campers were admitted in the order in which their applications were received. For this study, researchers examined and analyzed data collected during the 2024 camp. Group assignments were made by SSSO prior to the beginning of the camp, with the goal of ensuring each group included a balanced mix of ages, genders, and urban/rural backgrounds to promote diverse interaction and inclusive learning experiences.

Demographics

Campers included 12 males (50%) and 12 females (50%); 88% identified as Black/African American, 12% identified as Biracial; 75% were from urban areas, 21% were from rural areas (we were unable to identify the location of one camper [5%]); 80% were at the secondary education grade level (6th – 12th grade), 16 % were at the primary education grade level K – 5th-grade level, and 4% of campers had completed high school, but not yet entered college.

Camp Curriculum

To achieve our research objectives, we analyzed survey and worksheet responses collected from campers during a five-day youth agriculture camp. Our primary focus was to expose the campers

to various specializations while emphasizing the importance of sustainability and natural resource conservation in agriculture.

The research team injected three daily modules —30 minutes to an hour of instruction utilizing PowerPoint—into the camp's curriculum and 30 additional minutes was allotted on Days 4 and 5 for campers to ask questions about and independently research their conservation practices to further develop their posters. The lecture presentations were delivered by one of the researchers, who also supervised their camp projects. The guided lectures presentation were implemented to serve as the education stage in the Wiley (1996) theoretical framework. Additionally, the lessons were coupled with a camp project that allowed campers to work in groups of five to focus on an assigned conservation practice, which they presented at the camp's conclusion. The assigned conservation practices were on soil or water conservation techniques used in agriculture, and included drip irrigation, crop rotation, cover crops, no-till, and composting. The poster project activity was implemented to reinforce the knowledge that campers had previously learned throughout the lectures, which served as the reflection stage of the Kolb's Experiential Learning Theory (1984).

First Module: What is Sustainability?

The first instructional module introduced campers to sustainability and its role in agriculture and exposed them to several conservation practices. This module was delivered on Day 1 in a classroom on the KSU campus. This module was the foundation for the overall curriculum including the poster project they would work on throughout the camp. Campers first completed two evaluations: a nine-question, paper-based knowledge quiz (Appendix A1) to establish

individual baselines for measuring learning outcomes and a seven-question survey (Appendix A2) to establish baselines for measuring changes in their perceptions and attitudes about sustainability and natural resource conservation. Campers then worked with others at the table they were seated at to complete a Kahoot.it quiz (game). The quiz game covered the same questions from the learning outcomes worksheet but allowed them to "break the ice" by working together to answer them. This activity was not tracked for later evaluation. The formal presentation then provided an overview of the three pillars of sustainability (economic, environmental, and social), how each pillar of sustainability relates to food production, our environment, the future of agriculture, and our place in the world. Campers were taught what natural resources are, how agriculture relies on and affects those resources, and various conservation practices used in agriculture to conserve and protect them. Specifically, no-till farming, crop rotation, cover cropping, composting, and drip irrigation were emphasized during the first lesson and highlighted throughout the remainder of the camp.

At the end of the module, campers were given group assignments that were distributed to create groups with a balanced mix of age and gender. Campers worked in these assigned groups through the remainder of camp, and each group was randomly assigned an individual conservation practice that would be the topic of their camp [poster] project. Once split into groups, the project objectives were explained, and campers were given approximately 30 minutes to begin work on their posters. Tri-fold poster boards, markers, colored pencils, glue, and tape were provided to campers to create their posters. At this point, campers were only able to include a title, a brief definition of the conservation practice, and their names on the poster.

Camp Hands-On Experience

On Day 2, campers toured KSU's Willow Lake Student Farm (WLSF), located approximately six miles off-campus in Manhattan, KS. Campers were shown examples of small- to mid-scale farming there; some seeing this form of agricultural production for the first time. During the tour, they were exposed to some of their assigned agricultural conservation practices, including crop rotation, composting, and drip irrigation. While the farm was not implementing no-till or cover-cropping at the time of the tour, the WLSF farm manager explained why those were not being practiced. This experience gave campers a contextualized example of how these practices might be used to improve the sustainability of agriculture. The tour culminated in campers planting two, 100 ft long rows of sweet potato slips, allowing them to engage directly in vegetable farming. This experience provided a practical, interactive learning environment to connect classroom instruction with real-world practices and served as the concrete experience stage in the Kolb's Experiential Learning Theory (1984).

Second Module: Conservation Practices in Agriculture

The second instructional module, delivered by one of the researchers at KSU on Day 2 of the camp, began with a 30-minute presentation designed to teach campers about the importance, benefits, and disadvantages of the five agricultural conservation practices assigned to the groups. The lesson provided an overview of how each practice is implemented, in what context(s) the practice might be most beneficial, how it benefits farmers, and how it can improve the environment. Additionally, the presentation highlighted when it would not be appropriate to implement a practice and/or its potential drawbacks.

Following the presentation, campers were allotted 30 minutes to work on their camp project with their groups. Campers applied the information from the presentation about their assigned conservation practice to their posters, translating the information about their practice to a visual medium.

Third Module: Review and Directed Research

On Day 3, the third module began with a review of the first two modules. The session facilitator asked questions to refresh their memories about sustainability and the conservation practices they had learned previously. The campers were placed back in their groups, and each group was given four prompts/questions to direct further research for their poster. These questions were designed to deepen campers' understanding of how their conservation practice applies to sustainability's social, economic, and environmental pillars. Two questions focused on the environmental aspect, and the other two focused on the social and economic aspects of their assigned conservation practice. Questions for each group were specific to their assigned conservation practice. In total, this module was 60 minutes long.

Days 4 and 5: Reflection and Project Work

On Days 4 and 5, campers were allotted at least an hour on Days 4 and 5 for unstructured time to work on their group's poster, which would be presented on Day 6 at the end-of-camp ceremony. Campers were in a classroom environment, but no formal lesson was delivered. Instead, campers were encouraged to ask questions to clarify [or reinforce] their understanding of the practices, as necessary and gave the opportunity for campers to reflect on the knowledge previously learned; which served as the reflective observation stage in the Kolb's Experiential Learning Theory

(1984). In addition, campers focused more on the creative aspect of their projects—e.g., drawing, decorating, etc. Once their posters were completed, campers developed and practiced their presentations in preparation for the end-of-camp ceremony.

Camp Project

The campers' experiences culminated in project presentations on the final day of the camp. There was five groups (Assignment explained in participants section) of five campers and assigned a conservation practice to research and prepare a poster to present. Posters were to consist of each group's findings about their assigned conservation practice. They were to include definitions, ecological importance, and benefits and disadvantages of the assigned conservation practices for farmers, the land, and the community. Across the camp, participants were allotted a total of four hours to work on their posters in increments of approximately 30 minutes to one hour.

After camp, presentations were given at the Nicodemus National Historic Site. Campers' families and members of the Nicodemus community attended these presentations, which lasted approximately 10-15 minutes per group. Campers displayed their posters, explaining the illustrations of the conservation practices they worked on throughout camp and information they had accumulated through lectures.

Instruments Administered and Data Collection

The Camp Survey (Appendix A2) was an adapted version of the Multicultural Academic Program Success Program (Wiley & Hobbs, 2021) and was administered by a member of KSU SSSO. The survey was administered during the introductions at the beginning of the camp and

before the poster presentation on the final day of the camp. Twenty-four (n=24) out of 25 total campers completed pre-post camp surveys (Appendix A2) and the learning-outcome worksheet (Appendix A1) at the KSU Switzer-Nicodemus Educational Camp. The survey was designed to collect campers' perceptions of the importance of sustainability, the implementation of conservation practices used by farmers, and what responsibility they and their peers have to conserve resources. Questions asked for responses using a Likert scale from 1 to 5, with one indicating "Strongly Disagree" and five indicating "Strongly Agree."

Similarly, 24 campers completed Learning Outcome Worksheets (Appendix A1) to evaluate the knowledge gained throughout the six-day camp. The initial worksheet was given at the beginning of the camp to evaluate campers' awareness and knowledge of sustainability and natural resource conservation practices before camp. A post-intervention worksheet was administered after the camp to determine how much campers learned about those topics during the camp. The Learning Outcome Worksheets had a total of 7 questions about the information that was taught as part of the camp curriculum. The SSSO Survey and the Learning Outcome Worksheet were administered during the same blocks of time.

Statistical Analysis

Survey data were collected using paper instruments and then inputted into Excel before being analyzed using Stata/SE 17.0, with significance set at $p \leq 0.10$. As responses were ordinal and the data failed tests for normality (assessed via Shapiro-Wilk), non-parametric methods were used throughout the analysis. A McNemar's test assessed significant shifts in paired categorical responses, such as yes/no or correct/incorrect, between pre- and post-tests. The Wilcoxon signed-

rank test was used to assess within-group changes from pre- to post-test across survey items. To analyze differences between demographic groups (e.g., gender, grade level, rural/urban), the Mann-Whitney U test was used for comparisons between two different groups and the Kruskal-Wallis test for comparisons across three or more categories.

Effect sizes were used to estimate the magnitude of observed changes and differences amongst groups. For Wilcoxon and Mann-Whitney comparisons, effect sizes were estimated using Cohen's d:

$$\left| \frac{Z}{\sqrt{n}} \right| \quad \text{Eq. 1}$$

where Z = Z-score and n = number of participants. Effect sizes in the social sciences are rated “small”: $d = 0.2$; “medium”: $d = 0.5$; “large”: $d = 0.8$; and, “very large”: $d = 1.2$ (Cohen, 1988).

In addition to comparing overall scores on pre- and post-intervention responses, comparisons were made by demographic groups (i.e. gender, grade level, rural-urban background) to determine whether differences exist. These differences were explored using the Wilcoxon signed-rank tests, and significant results were reported alongside their corresponding effect sizes.

RESULTS

Learning Outcome Worksheet - Pre-camp Knowledge

Overall, campers scored 57.4%, on average, on the Learning Outcome Worksheet, prior to any instruction. Campers scored over 50% on all questions except questions 3, 7, and 9. Female campers' ($n=12$) average pre-test score was 67.6%, while males ($n=12$) scored 47.2% on average.

Campers' performance on questions 1, 2, 6 and 9 differed significantly by gender ($P < 0.05$). Average pre-test scores for elementary-school-aged campers (grades K - 5; $n=4$) was 66.7%, 55.4% for campers in middle school (grades 6 – 8, $n=9$), and high-school-aged campers (grades 9 - 12; $n=11$) was 55.4%. On question 2, elementary and middle school campers received scores significantly higher ($P < 0.01$) than campers in high school. Furthermore, urban campers ($n=18$) scored an average of 57.2% on the pre-test, while rural campers ($n=5$) scored 66.7%. Rural campers scored significantly higher ($P < 0.05$) on questions 7 and 9 when compared to urban campers (Table 2).

Learning Outcome Worksheet - Post-camp Knowledge (Change)

Campers' ($n=24$) overall average scores on the Learning Outcome Worksheet post-test were 76.8%, a significant improvement ($P < .01$) of 19.4% from the pre-test. While the combined overall scores on all questions increased, the improvement on questions 4-7 and 9 was significant ($P < 0.05$). Female campers scored 88.0%, and male campers scored 65.9%, on average, and both demonstrated significant improvement in scores from pre to post-test ($P < .10$). Female campers' scores were significantly higher ($P < .05$) on questions 1 and 9 on the post-test than male campers. Additionally, female campers displayed significant improvement on question 7. There were no significant differences between grade levels on individual post-test questions. Urban campers scored 77%, and rural campers scored 89%, on average, on the post-test. There were minimal difference in scores between campers that were from urban and rural locations. (Table 3).

SSSO Survey Questions – Pre-test

The first prompt on the SSSO Survey, “Sustainability is important to my future,” assessed campers' attitudes toward the importance of sustainability in their future. On average, campers viewed the statement positively, though only slightly (3.65). There were no significant differences in campers' perspectives on the first prompt when compared by gender, grade level, and geographic location. The second prompt, “It is important for farmers to implement conservation practices to protect natural resources,” focused on campers' perspectives on the importance of farmers implementing conservation practices to protect natural resources. The overall average response amongst campers was (3.66), indicating some agreement. No significant differences were detected when comparing responses by gender or geographic location of campers. However, high school campers agreed with the statement (4.18) more than middle school campers, who held a more neutral perspective (3.11, $P < 0.05$), with an effect size of 0.49 (medium-large).

The third prompt was “It is important to me to know that my food is produced sustainably.” Overall, campers tended to agree (3.75). There were no significant differences in perspective between genders. However, elementary and high school campers agreed with the statement (4.00 and 4.18, respectively), while the attitudes of middle school campers were more neutral (3.11; $P > 0.05$); this difference had an effect size of 0.51 (medium-large). In addition, urban campers indicated a more neutral perspective (3.55) than their rural counterparts (4.40; $P < 0.05$), who agreed somewhat strongly, with an effect size of 0.48 (small-medium). The fourth prompt, “Everyone has a responsibility to conserve natural resources,” weighed campers' perspectives on the shared responsibility for conserving natural resources. The overall response from campers

was slightly positive (3.66), and no significant differences in perspective were detected between genders or among those from different geographic locations. However, while high school campers agreed that everyone bore some responsibility to conserve natural resources (4.09), elementary school campers held a more neutral, if not slightly disagreeable, perspective (2.75) on natural resource conservation as a shared responsibility ($P < 0.10$), with an effect size of 0.51 (medium-large).

The fifth survey prompt was “I can implement conservation practices in my own life.” The overall average response to this question indicated some agreement (3.62). Gender and grade level did not significantly affect responses. Conversely, urban campers had little confidence in their ability to implement conservation practices (3.50), though campers from rural areas were more confident in their abilities (4.40; $P < 0.05$); this difference in confidence had an effect size of 0.44 (medium). The sixth prompt was “I intend to look for more information about conservation practices or sustainability.” The average overall response from campers was (3.29), indicating a relatively neutral response. There was no significant difference in responses amongst campers' genders, grade levels, or geographic locations.

SSSO Survey Questions – Pre-camp to post-camp change

After camp, participants agreed (4.08) that sustainability is important to their futures (Prompt 1). Their post-camp perspectives on this prompt did not differ by gender, grade-level, or geographic location. However, elementary school campers' average response of (4.00), was significantly ($P < 0.10$) higher than their pre-camp response of (3.75), with an effect size 0.83 (large).

By the end of camp, campers agreed (4.21) that it is important for farmers to conserve natural resources (Prompt 2), which reflects significantly stronger agreement than their pre-camp score (3.66; $P < 0.05$), with an effect size of 0.43 (medium). Male campers tended to agree (3.92) less than their female counterparts (4.50; $P < 0.10$), with an effect size of 0.35 (small). There were no significant differences in responses to Prompt 2 based on campers' grade level or geographic location. However, urban campers' perspectives on the importance of farmers conserving natural resources shifted toward more agreement after the camp (+0.73) compared to rural campers (+0.20; $P < 0.10$), with an effect size of 0.53 (medium). Additionally, elementary and middle school campers experienced significant gains in agreement with the sentiment, +1.25 and +0.89, respectively, with effect sizes of 0.84 (large) and 0.65 (medium-large), respectively. Campers agreed that it "is important for [them] to know that their food is produced sustainably" (4.04). There were no significant differences in campers' responses by gender or grade level. However, rural campers expressed significantly strong agreement (4.40) than urban campers' (3.89, $P < 0.10$); though, the effect size was small (0.35).

Overall, campers averaged agreed (4.08) that everyone shares in the responsibility to conserve natural resources (Prompt 4), an increase of 0.45 over their pre-camp rating ($P < 0.05$), with an effect size of 0.45 (small-medium). There were no significant differences between campers' responses when compared by gender after the camp. However, male campers expressed a significantly greater change in their perspectives (+0.75) compared to female campers (+0.09; $P < 0.01$), with an effect size of 0.76 (medium-large). Despite expressing no increase in agreement with everyone's shared responsibility, rural campers' responses (4.40) were still significantly more in agreement ($P < 0.05$) than urban campers, whose agreement increased significantly

(+0.56; $P < 0.05$, $d = 0.51$ [small-medium]) to 4.00. In addition, high school campers' average response of 4.27, indicating strong agreement, differed significantly from elementary campers' more neutral response (3.50; $P < 0.05$), with an effect size of 0.43 (small).

The campers' overall average response to Prompt 5 was 3.83, indicating weak intent to look for more information about conservation practices or sustainability. There were no significant differences in responses or overall change for campers at the grade level, gender, or geographic location. By the end of camp, participants did not believe they could implement conservation practices in their own lives (3.29; Prompt 6), and there were no significant differences in responses by gender, grade level, or geographic location. Finally, campers agreed that the activities at Nicodemus helped improve their understanding of conservation practices (4.21; Prompt 7), and this was consistent across genders, grade levels, and geographies. graphic groups (i.e. gender, grade level, rural-urban background) to determine whether differences exist. These differences were explored using the Wilcoxon signed-rank tests, and significant results were reported alongside their corresponding effect sizes.

DISCUSSION

The primary goal of this study was to examine the effectiveness of experiential learning activities at the KSU Switzer Jr. MANRRS educational camp in increasing youth participants' the awareness and knowledge of agriculture and natural-resource conservation practices in hopes to improve their attitudes and, ultimately behaviors, in those areas.

Knowledge of Agricultural Sustainability and Natural Resource Conservation

Campers' scores increased on the Learning Outcome Worksheet demonstrating an improved agricultural knowledge due to the hands-on activities and overall camp experience. The most considerable improvements were in questions about their understanding of what natural resources are, the three pillars of sustainability, the definition of no-till farming, and when to use drip irrigation. Likewise, a study conducted with 177 primary and secondary students assessed the impact of school-based environmental education on participants' understanding, interests, attitudes, and behaviors about the natural world (Ballantyne et al., 2001). Youth responses indicated that hands-on experiences raised their awareness and understanding of environmental issues, such as climate change, pollution, and the effects of litter on wildlife. Exposure to hands-on activities promoting sustainability and conservation helped participants recognize their impact on their local environment. This also promoted intergenerational dialogue, as youth reinforced their understanding by sharing newly acquired knowledge with both family and community members (Ballantyne et al., 2001). In another study, a pre-post comparison was conducted with 1,412 fourth-grade students during 2014–2016 who participated in the AgVenture workshop in Maryland, VA (Ridgeway et al., 2018). Through informational sessions and hands-on activities, the workshop provided a foundation in five key topic areas: soil/crop production, watersheds, poultry, cattle, and grains/nutrition. Participants demonstrated improved knowledge of agriculture-related STEM concepts, with average scores increasing by as much as 31.67%. The students attributed their learning to the educators' enjoyable presentation and hands-on experience. A study published in 2004 assessed the self-reported knowledge, attitude, and behavior of youth aged 10-18 who participated in a conservation program held at a Florida Zoo, focused on animal husbandry (Kruse et al., 2004). Kruse found that individuals who participated

in the camp demonstrated improved understanding of environmental conservation, local and global wildlife, zoo conservation efforts, and animal treatment and adaptations. The improvement in understanding was attributed to the interactive presentations and campers participating in hands-on experiences. A study conducted in 2009 compared the learning outcomes of 128 predominately minority eighth grade students in Las Vegas, NM, half of whom participated in science courses (during sixth through eighth grade) integrated with an agricultural extension and education center, while the other half had more traditional classroom science classes. The treatment group scored higher on a standardized, general-science test, demonstrating a better understanding of concepts such as scientific investigations, physical science, earth science, and science and people, compared to students whose curriculum did not integrate with the extension center. While campers in our study did not benefit from three years of agricultural education, it is reasonable to assume that their overall understanding of science-based concepts has benefited from having hands-on experiences in the agricultural context. Similar to the current study findings, youth participants who engage in hands-on activities exhibit an improved understanding of conservation and environmental sustainability concepts.

Male campers scored lower than female campers on the Learning Outcome Worksheet both before and after camp. Differences were observed on questions defining conservation practices, the three pillars of sustainability, identifying what natural resources are, and knowing when to use drip irrigation. The U.S. Department of Education (2007) published data showing that female students achieved comparable or better learning outcomes and academic advancement in the sciences compared to male students, which agrees with our results. Setiawan et al. (2023) compared 114 male and female students, age 14–16, in Indonesia on their environmental

knowledge, sustainability awareness, and understanding of sustainability practices after participating in a biology course that incorporated education for sustainable development (ESD). Setiawan found that female students demonstrated significantly higher environmental knowledge, including on global warming, various ecosystems, water pollution, and sustainability behaviors such as recycling and water consumption. Setiawan attributes female performance to the idea that women have a closer connection to nature. Whether this conclusion is accurate in the United States is unclear, but Setiawan's results align closely with our findings of female campers scoring better on the Learning Outcome Worksheet when compared to male campers. A study published in 2020 assessed the learning outcomes after 120 eighth-grade students attended a series of lessons regarding weather and climate science (Dormody et al., 2020). Results from the comprehension assessment found that female participants had higher science comprehension scores and a larger gain from pre- to post-intervention when compared to males. Although the findings were attributed to the effectiveness of laboratory experiences for females' understanding of physical science concepts (Lee & Burkham, 1996), similar trends were found in the current study, despite the lack of laboratory components. Further exploration must be conducted to understand the gender gap between female and male youth; additionally, finding effective strategies to mitigate the differences in knowledge obtainment from both genders is imperative to youth education practitioners. Dormody et al. (2020) suggest educators should consider incorporating lessons that are inquiry-based, problem-solving, and team-based to enhance students' understanding and retention of science content (Johnson et al., 2012; Cheng et al., 2018).

Urban campers had a lower score than rural campers on the Learning Outcome Worksheet regarding questions about the three pillars of sustainability and when to use drip irrigation. A study conducted at two separate Midwestern high schools found that rural students outperformed urban students on "Knowledge of Agriculture" tests (Frick et al., 1995). The study results were credited to urban students lacking interaction with agricultural operations and awareness of careers compared to their rural counterparts. Frick recommended more flexible educational programming to introduce urban students to agriculture, food, and natural resources and the opportunities in those fields. Moreover, an article published in 2006 compared the agricultural literacy of 12th graders who reside in urban/suburban and rural areas (Pense et al., 2006). Rural students scored 17 points higher on the agricultural literacy assessment than urban/suburban students, outscoring urban students on all five categories of the assessment: Understanding of Agriculture, History and geography, Science environment, Business and economics, and Food, Nutrition & Health. Pense acknowledges that the urban students in the study were not agriculturally literate, and efforts must be made to integrate agricultural concepts in multiple subjects, especially where agriculture is not formally taught in school. Pense's results align with the current study's results; both demonstrate that urban youth have little background and/or context from which to draw when responding to questions about agricultural concepts, whether in school or extracurricular activities, exacerbating the gap between urban and rural students.

However, by the end of the camp, urban participants outscored rural campers on the question about the three pillars of sustainability. They also closed the gap with rural campers regarding when to use drip irrigation. These improvements highlight the impact of the camp on urban campers' agricultural knowledge. A study published in 2012 assessed three years (2009, 2010,

2011) of Roots and Wings, a six-month gardening program for urban youth in Rockford, IL, to determine its impact on the dietary behaviors, agricultural knowledge, and leadership skills of youth participants, age 6–10 (Pierce et al., 2012). Urban youth expressed greater perceived knowledge of gardening and the environment and heightened care towards the environment after attending the program. The author attributed the hands-on gardening activities, sustainable agriculture lessons, and garden planning lectures to the improved perception of the environment and agriculture. While Pierce evaluated the outcomes of a six-month-long intervention—compared to six days in the current study—and did not objectively evaluate participants’ knowledge and/or attitudes prior to the intervention, both studies demonstrate the positive impact that exposure to agricultural concepts via hands-on experiences has on urban youth and the knowledge they can gain through such an intervention. Similarly, a study conducted in 2009 at a large urban school district in the Northeast surveyed 600 students to assess their knowledge, beliefs, and attitudes toward the environment. Urban students demonstrated an improved understanding of concepts after participating in the urban ecology course curriculum (Hashimoto-Martell et al., 2011). Although our study was not semester-long, it aligns with Hashimoto-Martell’s findings and further supports that limited agricultural curricula affect urban youths’ understanding of sustainability concepts. By the end of the camp, urban campers scored higher than rural campers on some items and showed no significant difference on others, illustrating the effectiveness of the curriculum in narrowing existing knowledge gaps.

Campers at every grade level demonstrated improved knowledge about agricultural conservation practices and sustainability on the Learning Outcomes Worksheet by the end of camp—indicating that the learning modules and camp activities were effective for all age groups

participating in the camp. Similarly, a study conducted in 2013 assessed awareness and behavioral changes after elementary and middle school youth participated in an Extension Sustainability Camp held by Utah State (Brain et al., 2013). While participating in the sustainability camp, youth had the chance to take part in activities centered around sustainability, such as: composting, farm visits, designed wind turbines, and visiting wastewater treatment, implementing guided journaling to reinforce each day's learning (Brain et al., 2013). Further, a study published in 2017 evaluated the educational impact of a field trip to delta preserves near the Gulf of Mexico on high school students aged 15-18. Students exhibited an increase in understanding about the local flora, fauna, and landscapes of the delta region after bird watching, performing water quality tests, and taking guided nature walks on various trails. Both studies attribute students' increased understanding of sustainability and natural resource conservation to the outdoor experiences and hands-on learning components (Jose et al., 2017 & Brain et al., 2013). Together, both of these reports reinforce the idea that hands-on activities made substantial contributions to campers' learning outcomes in the present study.

Attitudes and Perceptions about Natural Resource Conservation and Sustainability

By the end of the week-long camp, participants expressed more agreement with the importance of farmers to implement conservation practices, and that everyone shares in the responsibility to conserve natural resources. A survey of 67 diverse urban high school students found similar outcomes after participating in a month-long internship at The Nature's Conservancy (TNC) Leadership in Environmental Action for the Future (LEAF) program (Gupta et al., 2021). Individuals gained fieldwork experience and were mentored by environmental science experts while living at a TNC-affiliated nature preserves. After attending the LEAF program, individuals

had increased pro-environmental behaviors in recycling, volunteering, and advocating for environmental change; these findings were credited to hands-on activities and projects that interns participated in throughout the LEAF program (Gupta et al., 2021). While the Gupta study reported an uptick in pro-environmental behavior, it is reasonable to assume that such behaviors were accompanied by, if not predicated on, shifting attitudes. Further, a study conducted in 2021 in California surveyed the impact of engaged, hands-on experiences centered around environmental education on youth campers, age 12-15 years, attending Catalina Island Camp (Nelles, G. L et al., 2023). The camp taught youth participants about the negative effects of poor environmental stewardship and the importance of mitigating, even reversing, these adverse effects (Nelles, G. L et al., 2023). After the experience, campers indicated that their increased awareness of environmental issues (e.g. pollution and climate change) helped them develop a consciousness of the natural world around them, empowering them to become change-makers—as stewards of the environment (Nelles, G. L et al., 2023). The study's results were attributed to the exposure to the outdoors and more effective environmental education curricula provided by the summer camp (Nelles, G. L et al., 2023). Combining immersive outdoor/environmental experiences with high quality educational offerings increases youth's exposure to the natural world and environmentally focused careers, which may not be accessible to all youth. Our results add support to this idea and extend those findings to include minority youth as beneficiaries of hands-on learning experiences having built more awareness and commitment to conserving natural resources.

Our results further suggest that gender may play a role in the impact of hands-on learning experiences, especially regarding a shared sense of responsibility to conserve natural resources.

In this case, female campers indicated greater agreement with the idea that everyone has a role in natural resource conservation. Although there is limited research available on outcomes of agriculture-based education among minority youth, gender disparities have been noted in STEM-related education and career interest. A study in Chicago sampled over 150 URM youth in middle and high school who had participated in the Science Minors and Achievers (SMA) program at the Museum of Science and Industry (Price et al., 2018). Female alumni of the SMA program reported greater interest in pursuing STEM careers than their male counterparts. (Price et al., 2018). The higher interest in STEM majors was attributed to staff encouragement and support of interns (Price et al., 2018). Although the current study does not assess the interest in STEM careers, Price et al., (2018) aligns with the current study findings by highlighting the difference in attitudes by gender towards science related topics. Additionally, a study conducted in 2007 in Minnesota surveyed 1,299 middle and high school students and assessed the differences in gender regarding students' interests and attitudes toward science-related topics (Desy et al., 2007). Females in the study showed contrasting responses to the current study, with female students having a more negative attitude toward studying science-related topics than male students (Desy et al., 2007). However, those same female students were more interested in science-related careers than their male counterparts (Desy et al., 2007). The authors posited that young female students may associate "science" majors with a specific subset of the field (i.e. chemistry and physics) instead of holding a broader view of science that includes agriculture, among other life sciences (Desy et al., 2007).

Before the intervention, urban campers expressed less agreement than rural campers on key concepts, including the importance of knowing their food is produced sustainably, shared

responsibility for conserving natural resources, and confidence in applying conservation practices in their own lives (Table X). These differences may be due to limited overall exposure to agriculture, a dearth of agricultural curriculum in urban schools, as well as reduced access to outdoor learning experiences (Henry et al., 2014; Jean-Philippe et al., 2017). Jean-Philippe et al., (2017) surveyed 122 urban high school students after participating in a High School Agricultural Education Initiative (HSAI) program. The urban high school students expressed a lack of confidence to discuss issues related to global food-security and perceived themselves to have limited understanding of climate change and sustainable energy going into the program (Jean-Philippe et al., 2017). But, even after the program, those negative perceptions persisted (Jean-Philippe et al., 2017). While the educational program challenged students' views on food security and sustainability issues, the intervention was too short to generate significant change (Jean-Philippe et al., 2017). The authors recommended that educators provide URM audiences, and urban students in general, regular exposure to academic and professional opportunities to increase understanding and interest in agriculture and natural resource fields. A study published in 2005 compared differences in environmental concern, attitudes, and behaviors between individuals who lived in rural and urban Spain (Berenguer et al., 2005). In that study, rural individuals expressed a greater sense of "moral" obligation to care for the environment and greater concern for issues related to conservation practices than urban dwellers. Responses were credited to the [immediate] relevance and gravity of environmental issues when they exist closer to where people reside (Berenguer et al., 2005). The proximity of agricultural concerns to rural participants would support stronger pre-intervention concern about natural resource conservation, while urban dwellers would likely demonstrate more immediate concerns about pollution, over-population, and other issues that specifically affect the urban environment

(Berenguer et al., 2005). This seems to align well with the observations in the current study, where rural campers held stronger pro-environmental attitudes than their urban peers at the beginning of the camp.

However, by the end of the camp, urban youth had closed the gap, finding more agreement on the importance of their food being produced sustainably and on their own ability to employ conservation practices in their own lives. This was likely due to urban campers having more to learn about agricultural conservation practices in the first place. Similarly, hands-on activities in an agricultural and environmental challenge program at the University of Louisiana at Lafayette stimulated critical thinking about agricultural and environmental issues (Poudel et al., 2005). Participants reported increased motivation and confidence in their ability to understand environmental problems and in having the technical skills necessary to find and enact solutions to those problems, as a result of the hands-on nature of the program (Poudel et al., 2005). The researchers advocate for these types of hands-on environmental and agricultural opportunities, due to their potential to raise interest, understanding, and critical thinking among youth in this subject matter (Poudel et al., 2005).

Despite having made greater strides in improving their understanding and attitudes about everyone's shared responsibility to conserve natural resources, urban campers remained less convinced than rural campers. With urban youth having limited exposure to outdoor spaces, where natural resources can be seen and experienced, they may not have any basis for feeling responsible for the stewardship of the environment compared to rural students, who may have more access to the natural world. This idea has been referred to as "the extinction of experience"

(Soga et al., 2016), which suggests that through a lack of interaction with nature, individuals are less likely to see the benefits and value of the natural world that might otherwise prompt them to be stewards of the environment (Soga et al., 2016; Wells et al., 2006). 576 students at a large midwestern university were surveyed to assess the relationship between early childhood outdoor experiences and environmental attitudes (Ewert et al., 2005). Increased participation in outdoor activities early in life, as well as early exposure to pro-environmental content, contribute to one's adult beliefs about the environment (Ewert et al., 2005). However, while [later] outdoor experiences can improve pro-environmental beliefs, individuals may still be hampered by the pre-existing beliefs and attitudes they bring to environmental educational interventions. This could help explain the lower post-camp scores among urban campers, relative to rural campers, despite their having reported greater changes in their pre- to post-camp attitudes. In other words, the urban campers had a taller hill to climb. And while the urban youth in the current study made reported more profound attitudinal shifts, regarding shared responsibility for conservation, extended exposure and/or additional education on agriculture and natural resource conservation is advisable. Additionally, there may be difficulty in evaluating the success of environmental education, particularly for underrepresented or socioeconomically disadvantaged audiences who may lack exposure to environmental science curricula (Blumstein et al., 2007). Further, the difficulty in establishing proper control groups creates additional obstacles in evaluating true attitude shifts (Blumstein et al., 2007).

Campers' responses varied by grade level in response to statements that assessed their attitudes about the importance of farmers implementing conservation practices to protect natural resources and the importance of knowing that food is produced sustainably. High school campers

demonstrated more agreement with the statement than middle school campers prior to camp. Likewise, a study conducted in 2007 found that middle school students had less favorable views or attitudes toward science-related subjects and topics than high school students (Desy et al., 2007). Post-intervention results showed that the camp's hands-on experiences closed the gap between middle and high school campers, implying those experiential activities effectively leveled perceptions across age groups (Desy et al., 2007).

Elementary campers provided notably different responses from high school campers before and after the camp, particularly regarding the shared responsibility to conserve natural resources. Existing literature presents mixed findings on this topic. For instance, Faber et al. (2013) surveyed nearly 10,000 primary and secondary students in North Carolina to evaluate youth attitudes toward STEM subjects, careers, and 21st-century skills. Faber reported minimal variation in attitudes across grade levels following completion of a STEM initiative, contrasting with the current study's results. However, Larson et al. (2009) surveyed 190 minority youth in Georgia who are 6- to 13-year-olds and compared individuals who participated in a one-week environmental-education summer camp program. They compared them to youth who did not participate in the summer camp. Results from the study demonstrated that the environmental education camp benefited older children's "eco-affinity" or personal connection with nature more than younger campers (Larson et al., 2009). The author points out that after the age of 10, children's eco affinity begins to decline, in part, due to decreased emphasis on outdoor, science-related activities in the curriculum of older students (Larson et al., 2009; Coyle, 2005). Concluding that older campers had more to gain from the camp than younger campers who had already started with a high eco-affinity (Larson et al., 2009). Larson's study is similar to the

current study in that older campers' attitudes changed to have more of a positive view of nature. However, in the current study, elementary (younger) campers remained less agreeable toward their responsibility for conserving natural resources.

Confidence in Practicing Sustainability and Willingness to Explore

Prompts five and six on the SSSO Survey assessed campers' confidence to apply sustainability in their lives and willingness to explore and learn more about conservation practices. By the end of the camp, participants' confidence in implementing conservation practices independently improved. Similarly, hands-on experiences incorporated into a summer camp for youth aged 10-14 years old focused on earth sciences gave campers a deeper understanding of large-scale environmental issues and what actions could help mitigate those problems after attending the camp (Cheeseman et al., 2019). Further, that camp armed youth with actionable steps to learn different strategies to mitigate environmental issues, helping spark pro-environmental attitudes and behavior. A study conducted in 2013 assessed undergraduate students' confidence in operating a recirculating culture system after participating in a six-week module as part of a Greenhouse Operations Management course (Craver and Williams, 2014). After students attended the lessons, constructed the hydroponics systems, managed the EC and pH, and planted in them, they demonstrated more confidence in managing the recirculating systems. The improved confidence was attributed to the hands-on experiences provided by the module. Although Craver and Williams' study is from an undergraduate class, it aligns with the outcome of the current study—that once campers could learn about natural resource conservation, see them in person, and gain hands-on experience, they became more confident in their ability to implement them independently.

Urban campers had significantly lower confidence in implementing conservation practices before the intervention than rural campers. However, by the end of the intervention, urban campers' confidence improved such that there was no significant difference from rural campers' confidence. A case study published in 2015 examined the impact of a year-long farm internship program in Baltimore on urban high school students (Broaddus et al., 2015). Following the program, participants exhibited improved confidence in farm skills and independently identified and completed farm tasks (Broaddus et al., 2015). These outcomes were attributed to the classroom sessions that discussed plant science, ecology, and environmental issues and the experiential learning opportunities [on-farm] that empowered interns to maintain their own garden plots (Broaddus et al., 2015). Although Broaddus's study spanned an entire year, it reinforces the idea that outdoor learning opportunities can foster confidence in urban youth to replicate the skills and knowledge that might otherwise be out-of-place, given their context.

Campers' responses to question six after camp indicated that they were relatively neutral in their intent to seek out additional information about conservation practices—and did not change from their pre-camp scores. A study conducted from 2012-2013 assessed the impact of the environmental education program at Lake Superior Stewardship Initiative (LSSI) on 418 youth from 4-8th grade regarding their environmental attitudes, awareness, and behavioral intentions (Bergman, 2015). While “eco-appreciation” and awareness improved for most students, males, and older students did not increase their “eco-learning”/behavioral intentions (Bergman, 2015). Bergman (2015) noted that the correlation between environmental behaviors and environmental awareness is often weak. So, although an individual might gain more understanding of an environmental subject, it does not necessarily mean that interest or behavioral changes follow

(Bergman, 2015). Conversely, a study published in 1999 evaluated the impact of a one-week Summer Science Camp focused on hands-on environmental education (Mittelstaedt R. et al., 1999). Mittelstaedt found that the camp participants expressed interest in learning more about nature and the natural environment after participation in the camp (Mittelstaedt, R. et al., 1999). The author attributed the increased interest after the camp to the camp programming's outdoor experiences, such as exploring the woods and wildlife near the camp (Mittelstaedt, R. et al., 1999). Findings from Mittelstaedt contradict the responses from the current study that displayed that although campers improved in understanding natural resource conservation, it didn't necessarily correlate with their intentions to look more in-depth regarding natural resource conservation. As others have noted, it is through consistent immersive experiences of place-based stewardship education (PBSE) that the students can develop a caring, ethical relationship with the planet and each other (Gallay et al., 2020).

CONCLUSION

This study sought to evaluate the impact of the KSU Switzer Jr. MANRRS educational camp on youth participants' agricultural knowledge, awareness of conservation practices, and confidence in applying sustainability concepts. Findings demonstrated that hands-on experiential learning experiences contributed to significant gains in agricultural knowledge and awareness of conservation practices, especially among urban minority youth, who had limited previous exposure to agricultural and natural resource conservation education. Agricultural knowledge improved amongst all groups, however two cases stood out. Both urban and male campers started with a lower baseline scores in agricultural knowledge than their rural and female counterparts, respectively. While urban campers gained enough understanding and confidence in

implementing conservation practices to close the gap with rural campers by the end of camp, male campers lagged behind females both before and after the intervention. Despite the shifts in knowledge gained and attitudes toward natural resource conservation, campers interest in further exploring conservation practices on their own remained largely unchanged after camp—emphasizing a key issue in environmental education: increased awareness and knowledge do not necessarily foment behavior change. Existing literature supports the idea that fostering lasting pro-environmental attitudes may require repeated, immersive experiences rooted in community, rather than just a single intervention.

Future research should explore the long-term impacts of agricultural or environmental educational interventions and find methods to shift students' interest and engagement in conservation beyond the camp setting. Future projects would benefit from having more balanced demographics among participants, providing more nuanced understanding of how demographic factors can affect learning outcomes. While this study examined gender, grade level, and geographic location, the relatively low numbers of participants in some demographics prevented us from analyzing the interactions among those factors. Exploring these intersections could provide more robust data from which to understand the impact of hands-on, experiential learning in agriculture and natural resource conservation interventions in the future. Additionally, the survey and Learning Outcomes Worksheet focused on surface-level knowledge and self-perceptions; however, those instruments could not capture deeper conceptual understanding or actual behavior changes. Despite these limitations, this study provides valuable evidence that hands-on agricultural education can enhance knowledge and conservation awareness, particularly among youth with limited prior exposure to agriculture. Our results suggest that short-term,

hands-on programs like the KSU Switzer Jr. MANRRS camp can be an effective starting point for increasing agricultural literacy and conservation awareness among underrepresented youth.

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TABLES AND FIGURES

Table 1. Self-reported demographics of 24 youth participating in the KSU-Switzer/Jr. MANRRS Educational Camp in Nicodemus and Manhattan, KS during one week in the summer of 2024 (n=24).

Variable	Frequency	Percent
Geographical Location		
Rural	18	75%
Urban	5	21%
Unknown	1	4%
Gender		
Male	12	50%
Female	12	50%
Grade level		
Primary	4	16%
Secondary	19	80%
Completed High School	1	4%
Race		
African American	21	88%
Multiracial	3	12%

Table 2. Overall pre-camp scores (percent correct) on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus.

	Questions									
	1	2	3	4	5	6	7	8	9	AVG
Pre-Camp Results										
Overall	79.5	67.0	45.8	62.5	50.0	70.8	33.0	66.0	41.6	57.4
By Gender										
Female (n=12)	100.0	83.0	58.0	67.0	58.0	92.0	25.0	67.0	58.0	67.6
Male (n=12)	58.0	50.0	33.0	58.0	42.0	50.0	42.0	67.0	25.0	47.2
<i>P</i> -value	***	*	NS	NS	NS	**	NS	NS	*	**
By School Level										
Elementary (n=4)	100.0	100.0	75.0	75.0	25.0	75.0	25.0	50.0	75.0	66.7
Middle (n=9)	78.0	89.0	33.0	55.0	44.0	78.0	22.0	67.0	33.0	55.4
High (n=11)	72.0	36.0	45.0	64.0	64.0	64.0	45.0	73.0	36.0	55.4
<i>P</i> -value	NS	**	NS	NS	NS	NS	NS	NS	NS	NS
By Location										
Rural (n=5)	80.0	60.0	40.0	80.0	60.0	60.0	80.0	60.0	80.0	66.7
Urban (n=18)	83.0	72.0	50.0	61.0	50.0	72.0	22.0	72.0	33.0	57.2
<i>P</i> -value	NS	NS	NS	NS	NS	NS	**	NS	*	NS

Table 2. Overall post-camp scores (percent correct) on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.

Post-Camp Results		Questions									
		1	2	3	4	5	6	7	8	9	AVG
Diff. from Pre-test											
	Pre-Test	79.5	67.0	45.8	62.5	50.0	70.8	33.0	66.0	41.6	57.4
	Post-Test	83.0	79.0	50.0	79.0	75.0	91.0	70.0	79.0	83.0	76.56
	P-value	NS	NS	NS	**	NS	NS	NS	NS	NS	**
By Gender											
	Female (n=12)	100.0	92.0	50.0	92.0	83.0	100.0	83.0	92.0	100.0	88.00
	Male (n=12)	67.0	67.0	50.0	67.0	67.0	83.0	58.0	67.0	67.0	65.89
	P-value	**	NS	NS	NS	NS	NS	NS	NS	**	
By School Level											
	Elementary (n=4)	100.0	75.0	50.0	75.0	75.0	100.0	75.0	100.0	100.0	83.33
	Middle (n=9)	78.0	78.0	56.0	78.0	78.0	89.0	67.0	67.0	78.0	74.33

By Location	High (n=11)	82.0	82.0	45.0	82.0	73.0	91.0	73.0	82.0	82.0	71.78
	<i>P</i> -value	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	
	Rural (n=5)	100.0	80.0	60.0	100.0	100.0	100.0	60.0	100.0	100.0	88.89
	Urban (n=18)	83.0	83.0	50.0	77.0	72.0	89.0	78.0	78.0	83.0	77.00
	<i>P</i> -value	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>

Table 3. Overall pre-camp responses from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.

Pre-Test Results	Questions					
	1	2	3	4	5	6
Overall	4.17	3.66	3.75	3.66	3.62	3.29
By Gender						
Female (n=12)	4.41	3.83	3.92	3.83	3.75	3.25
Male (n=12)	3.92	3.5	3.6	3.5	3.5	3.3
Z	1.436	0.601	0.492	0.784	0.306	-0.253
r	0.29	0.12	0.10	0.16	0.06	-0.05
P-value	NS	NS	NS	NS	NS	NS
By School Level						
Elementary (n=4)	4.75	3.50 ab	4.0 ab	2.75 b	3.75	3.25 ab
Middle (n=9)	4	3.11 b	3.11 b	3.6 ab	3.44	2.9 b
High (n=11)	4.09	4.18 a	4.18 a	4.09 a	3.72	3.64 a
Z		-2.182	-2.299	-1.982	NS	-1.714
r		-0.49	-0.51	-0.51	NS	-0.38
Chi 2x	1.407	4.396	4.998	3.831	0.207	2.352
P-value	NS	**	**	**	NS	*
By Location						
Rural (n=5)	4.4	4.2	4.6	4.4	4.4	3.6

Table 4. Overall post-camp responses from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.

		Questions						
Post-Test Results		1	2	3	4	5	6	7
Diff. from Pre-test								
	Pre-test	4.17	3.66	3.75	3.66	3.62	3.29	
	Post-test	4.08	4.21	4.04	4.08	3.83	3.29	4.21
	Z	0.464	-2.096	-1.051	-2.209	-0.544	0.168	
	r	0.09	-0.43	-0.21	-0.45	-0.11	0.03	
	P-value	NS	**	NS	**	NS	NS	
By Gender								
	Female (n=12)	4.08	4.5	4.17	3.92	4	3.17	4.42
	Male (n=12)	4.08	3.92	3.92	4.25	3.6	3.42	4
	Z	0	1.717	0.971	-0.987	0.852	-0.601	1.001
	r	0.00	0.35	0.20	-0.20	0.17	-0.12	0.20
	P-value	NS	*	NS	NS	NS	NS	NS
By School Level								
	Elementary (n=4)	4	4.75	4.25	3.5 b	4	3	4.25
	Middle (n=9)	3.89	4	3.78	4.11 ab	3.78	3.11	4.2
	High (n=11)	4.27	4.18	4.18	4.27 a	3.81	3.54	4.18

<i>r</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	-0.43	<i>NS</i>	<i>NS</i>	<i>NS</i>
Chi 2x	1.376	2.005	1.984	2.598	0.15	1.293	0.074
<i>P</i> -value	<i>NS</i>	<i>NS</i>	<i>NS</i>	*	<i>NS</i>	<i>NS</i>	<i>NS</i>
By Location							
Rural (n=5)	4.4	4.4	4.4	4.4	4.0	3.8	4.4
Urban (n=18)	4.06	4.17	3.89	4.00	3.83	3.11	4.11
<i>Z</i>	-1.07	-0.32	-1.68	-0.952	-0.31	-1.40	-0.36
<i>r</i>	-0.22	-0.07	-0.35	-0.20	-0.07	-0.29	-0.08
<i>P</i> -value	<i>NS</i>	<i>NS</i>	*	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>

Figure 1. Kolb's Theory of Experiential Learning (Kolb, 1984)

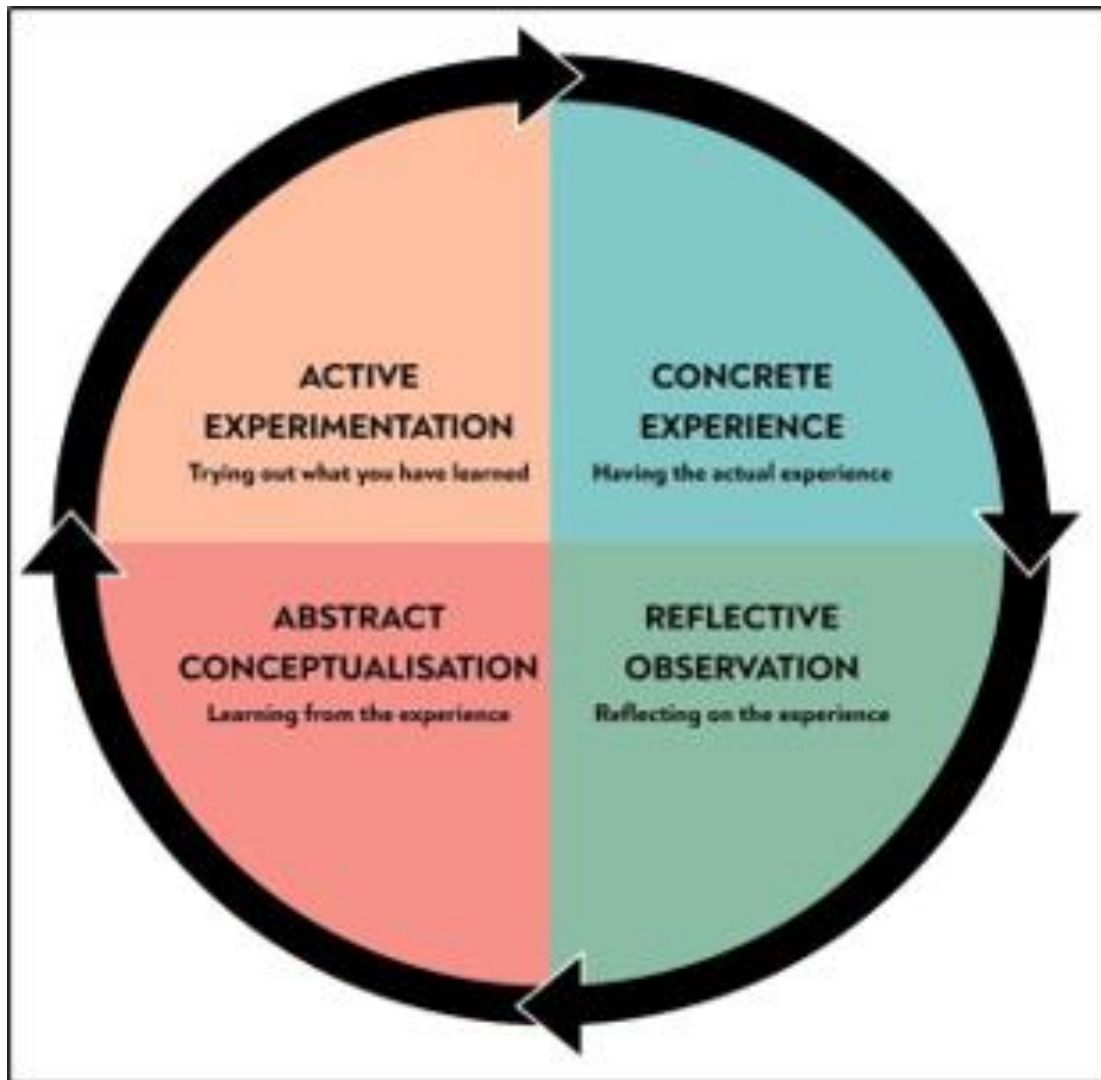


Figure 2.The Model of Assumed Relationships Among Education, Knowledge, Attitude, and Resultant Behavior (Wiley, 1996)

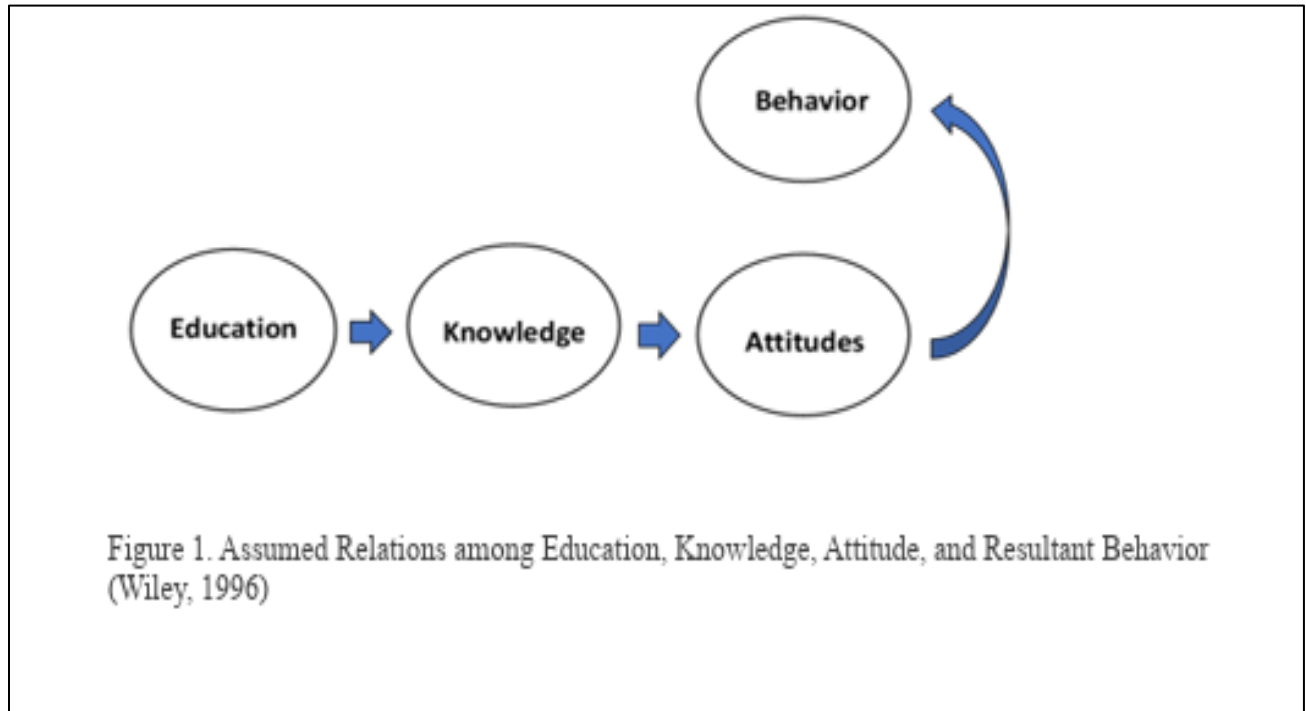


Figure 3. Overall combined scores (percent correct) on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus a and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1.

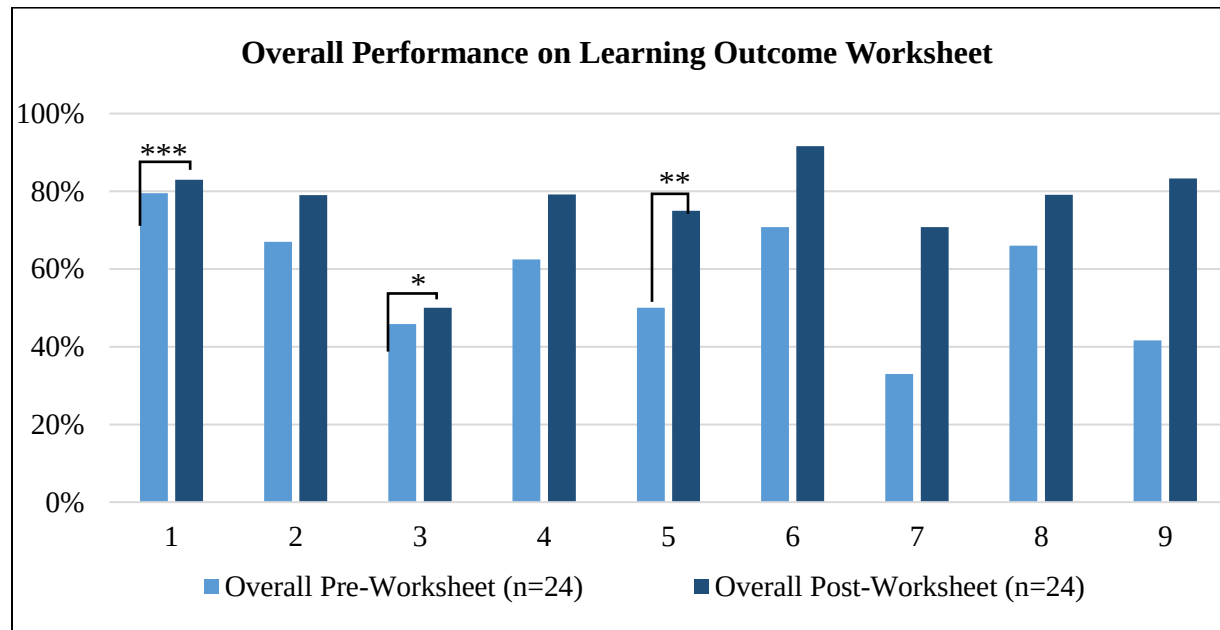


Figure 4. Scores (percent correct) by gender on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1

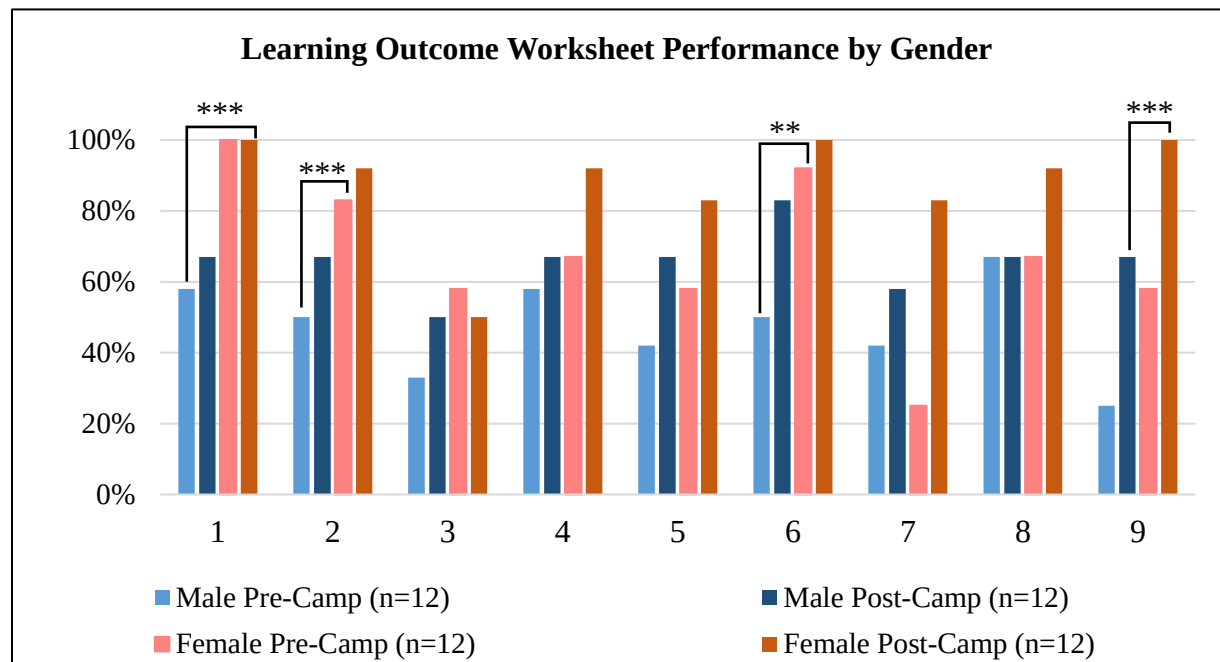


Figure 5. Scores (percent correct) by location on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Ni Nicodemus and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1.

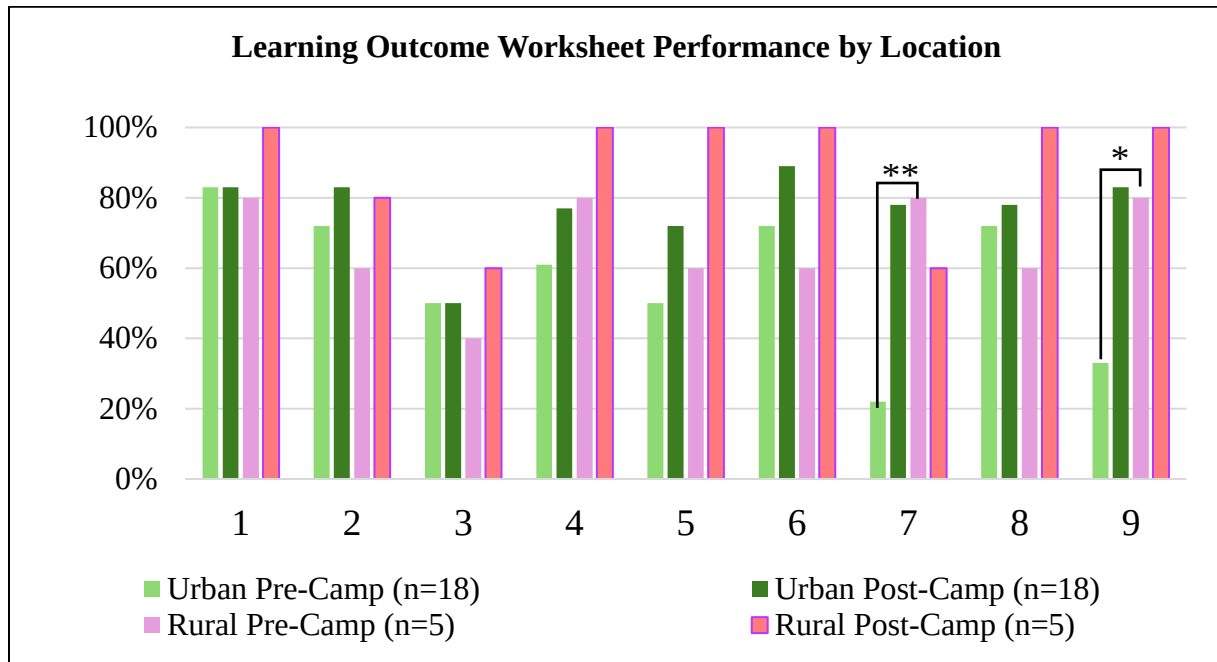


Figure 6. Scores (percent correct) by grade level on a learning outcome worksheet taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of Learning Outcome Worksheet questions in Appendix Table A1.

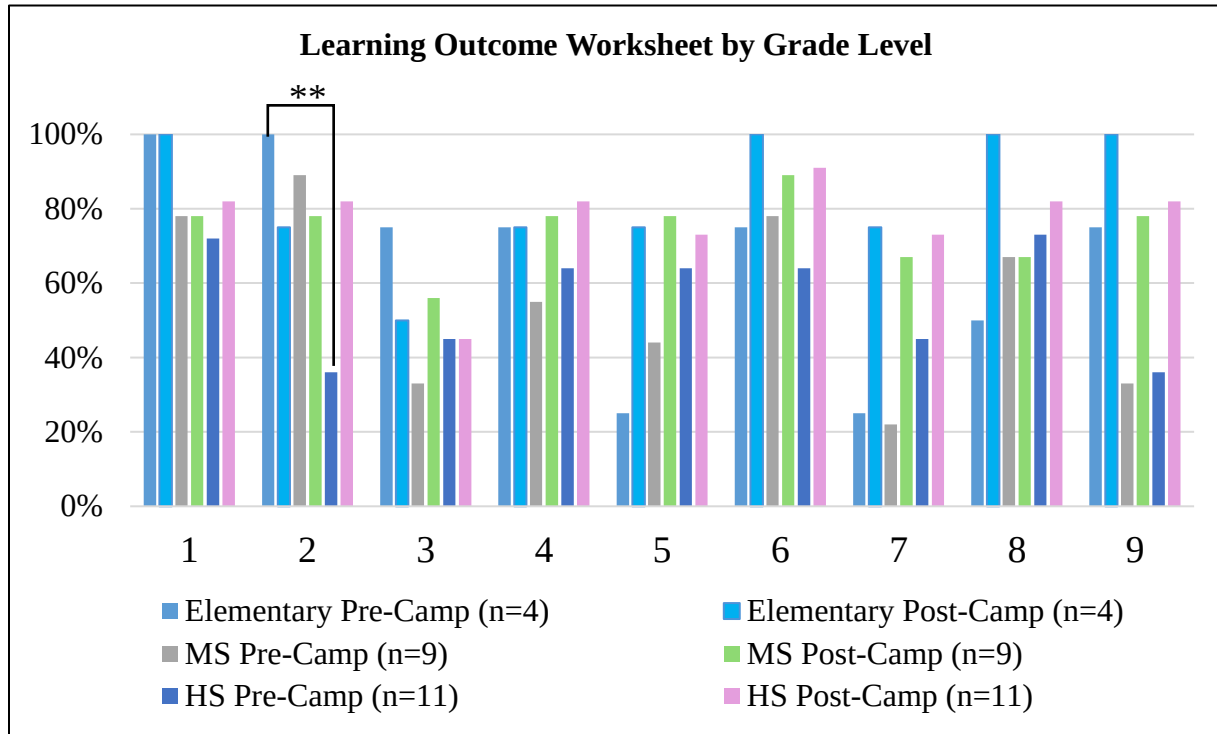


Figure 7. Overall camp responses from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.

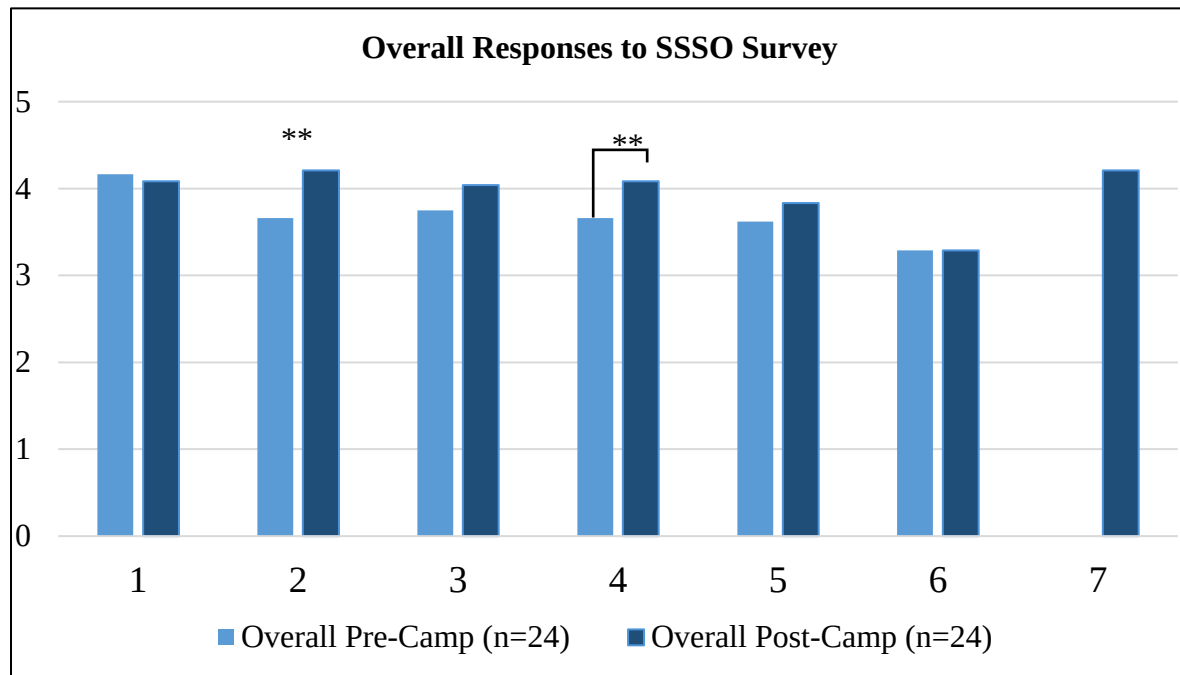


Figure 8. Camp responses by gender from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.

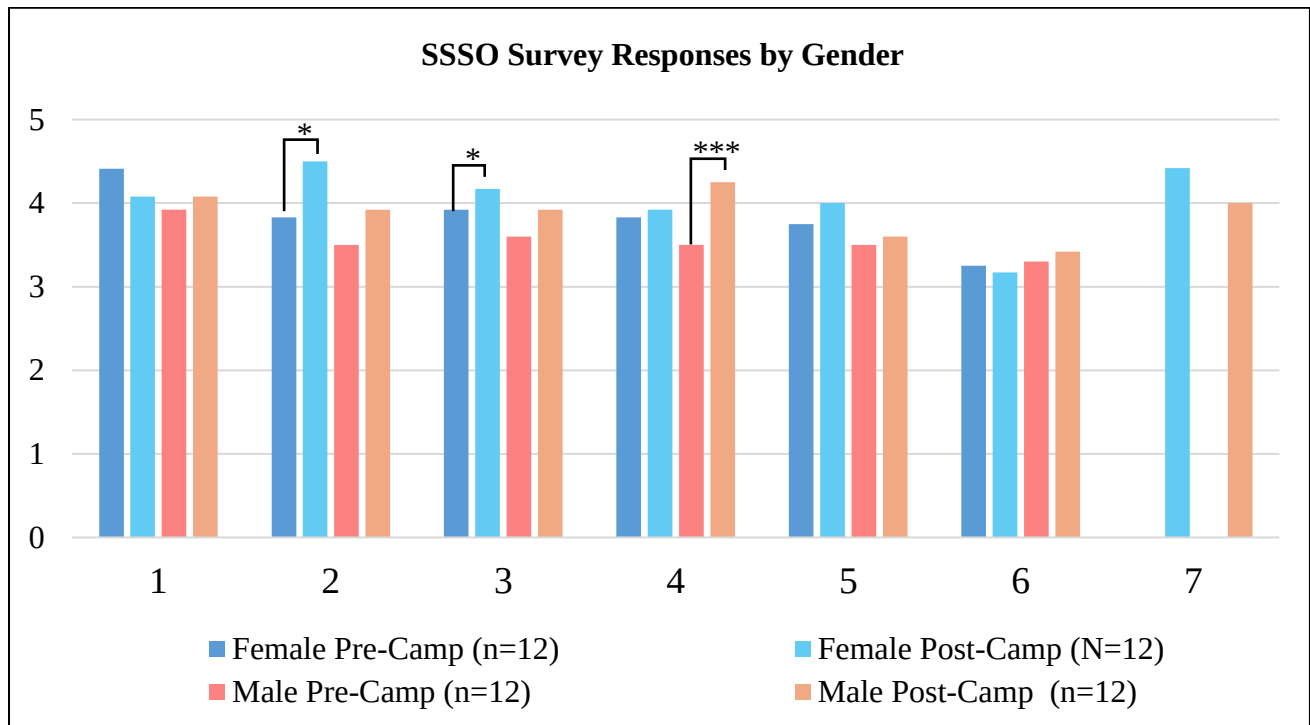


Figure 9. Camp responses by location from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) the KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.

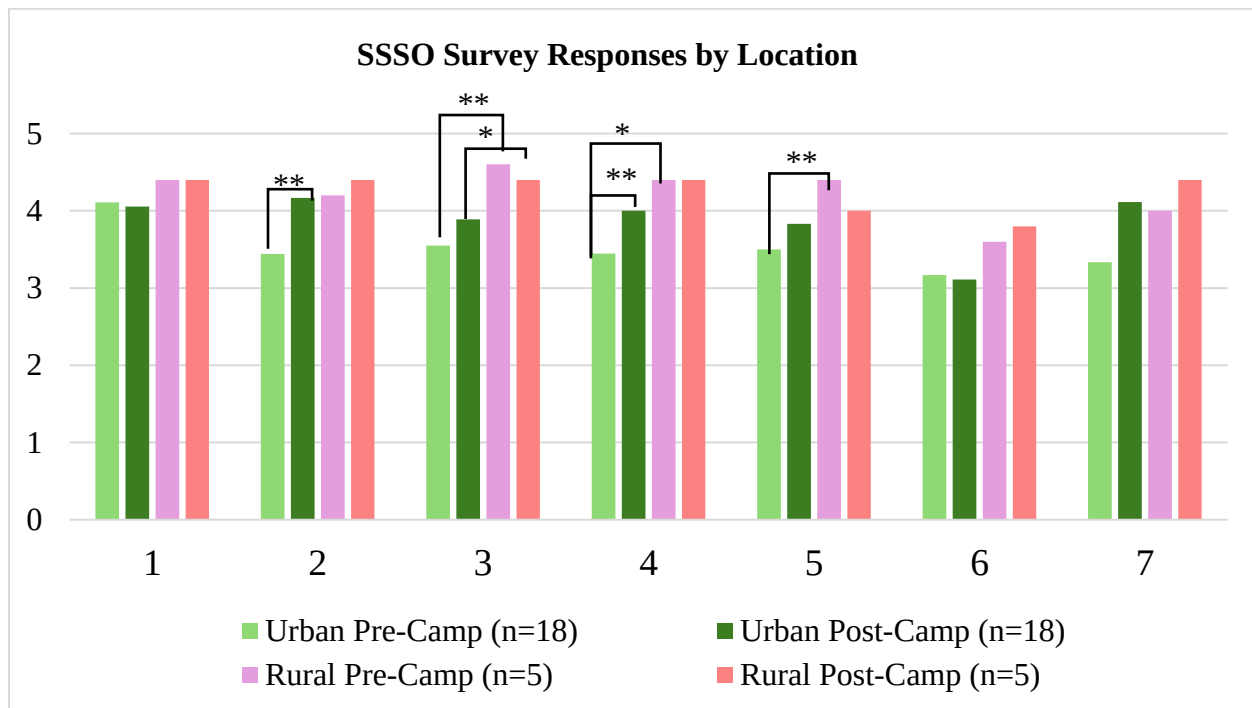
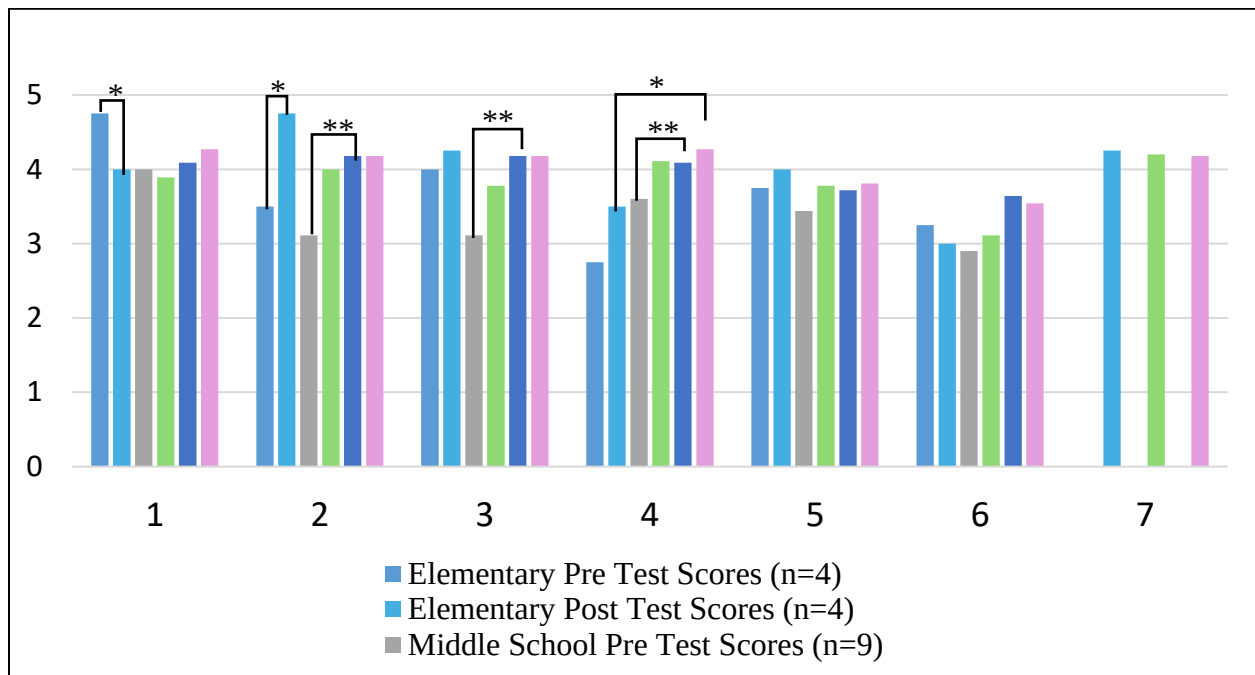


Figure 10. Camp responses by grade-level from the SSSO Survey taken by elementary through high school aged campers both before (pre-camp) and after (post-camp) KSU-Switzer/Jr. MANRRS Educational Camp during the summer of 2024 in Nicodemus and Manhattan, KS. Text of SSSO Survey prompts in Appendix Table A2.



Chapter 3 - Assessing Learning Outcomes of Hydroponics

Instruction Among Undergraduate Students Participating in A

REEU-Sponsored Internship

ABSTRACT

This study investigates the impact of different types of hydroponics instruction on undergraduate students participating in a Research and Extension Experiences for Undergraduates (REEU)-sponsored internship program. With growing global food demands and limited arable land, hydroponic systems represent an innovative solution to sustainable crop production. Despite their potential, barriers such as technical complexity and limited educational exposure hinder widespread adoption. This study explores how structured learning—including a lecture presentation and a hands-on hydroponic workshop—affects students' agricultural knowledge, perceptions, and confidence regarding hydroponics. Data were collected using pre- and post-surveys and a follow-up assessment, comparing results between participants who attended only the lecture and those who participated in both the lecture and hands-on workshop. Results indicated statistically significant gains in knowledge and confidence, particularly among students who received hands-on instruction. The study supports experiential learning as a critical tool in improving students' understanding of hydroponic systems and highlights the importance of integrating such approaches into undergraduate agricultural education to build a more competent future workforce in controlled environment agriculture.

INTRODUCTION

Agriculture has been the foundation of human society for over 10,000 years (Zeder, 2008).

Through the years, production methods have evolved, and the amount of food we need to produce as a society has increased proportionally to population growth (Gilland, 2002). With a population expected to reach nearly 10 billion by 2050 (Gilland, 2002), agricultural producers must keep pace with growing demand, while encroachment from non-agricultural development decreases the availability of arable land (Cifuentes Torres et al., 2020; Sabandi et al., 2021). This requires farmers to find new and innovative ways to supply the 70% increase in total calories projected to be needed in support of this increased population (Despommier, 2009; Pardey, 2010; FAO, 2020). Further, urbanization, which competes with agriculture for resources—especially land and labor—reduces the available labor pool vital to food production (Zhao et al., 2023). Therefore, exploring alternative and sustainable food production methods is imperative.

What is hydroponics?

Hydroponics is a soilless production method that can be deployed indoors and scaled. The field offers promise to help alleviate the strain placed on conventional agriculture to supply adequate nutrition for a growing population. Hydroponic production requires adequate substrates to anchor plant roots (Velazquez-Gonzalez, R.S. et al., 2022), which are then submerged, periodically flooded, or kept moist with a nutrient solution using one or more of a variety of techniques (Maharana, L. et al., 2011). Hydroponic systems allow producers to control production factors, such as nutrient rates, pH, electrical conductivity (EC), temperature, and other environmental factors, to ensure optimal plant growth (Sousa et al., 2023). This control allows hydroponic systems to optimize water management, space efficiency, and reduce chemical applications

(Ampim et al., 2022). The world's agricultural sector accounts for approximately 70% of all freshwater use (FAO, 2021). Fortunately, hydroponic production requires 95% less irrigation water than conventional agriculture production (Karasahin, 2014). In addition, hydroponic systems can be stacked vertically to increase the production area with minimal overall increases in square footage (Sousa et al., 2023). Thus, hydroponic production has the demonstrated potential to improve space efficiency for food production (Ampim et al., 2022) with a significantly lower environmental footprint compared to conventional agriculture (Romeo, D., 2018). Due to impending population growth and a shrinking arable land base, hydroponics could relieve a strained agricultural sector that struggles to produce an adequate and nutritious food supply.

Barriers to Adoption of Hydroponics

Despite its benefits, hydroponic systems are more complex than conventional fruit and vegetable production systems and carry a steeper learning curve (Pomoni et al., 2023). Additionally, the initial capital outlay, ongoing maintenance and labor costs are substantial challenges for hydroponic production (Velazquez-Gonzalez, R.S. et al., 2022; Kannan, M., 2022). Given that hydroponic systems recirculate water (generating substantial water savings), there is significantly greater risk for waterborne-disease spread requiring specialized knowledge to successfully operate a system (Solis-Toapanta, 2020). Together, these limitations create a substantial obstacle to the widespread adoption of hydroponics at scale (Bunyuth, 2024). These barriers and the relative rarity of these systems limit exposure for the average individual to become acquainted with hydroponics. This lack of exposure to hydroponics will reduce the number of potential adoptees relative to more common or visible practices.

Through educational experiences, individuals gain knowledge about a subject, which leads to attitudinal change and ultimately behavioral changes regarding the topic (Swanson 1972; Wiley et al. 1996). School-based agriculture education (SBAE) and the hands-on learning provided in such a setting, can expose youth (usually in secondary grade levels) to agricultural production and the opportunities available to them. Relevant scholarships support the positive impact of experiential learning opportunities specifically in agricultural sciences (Craver and Williams, 2014; Papadopoulou et al., 2025). In 2023, the National Agricultural Education Supply & Demand Study surveyed teachers, school and state education administrators in 45 U.S. states to identify 9,212 SBAE programs (Smith et al., 2023). Yet, agriculture and horticultural programs are often absent or underfunded in urban schools, and when offered, they may not emphasize innovative technologies like hydroponics (Spielmaker et al., 2006).

Necessity of future horticulturists / Experiential learning

While elementary-level youth and adults have more intentional gardening exposure, the teenage audience seems underserved (Purcell et al., 2010). Limited programming for teenagers has a crucial negative impact on developing interest in pursuing a major or career in horticulture. Experiential learning in this period of life can contribute to students' self-efficacy and confidence in executing a skill, which is positively correlated with career interest and choice (Tang et al., 2008). Thus, by incorporating hands-on learning opportunities focused on the technology and skills required to grow nutritious foods hydroponically, we may create workforce pipelines better able to meet the needs of a growing population.

The shrinking pool of agricultural workers is a growing concern, with an average of 39% of horticultural jobs remaining unfilled annually (Groeker et al., 2015). Horticulture, as a major, has also has seen a decline in enrollment since 2004 (Arnold et al., 2014), leaving the horticulture industry wanting graduates to fill positions that require trained professionals (Dickey et al., 2014). Horticulture is the science and art of growing fruits, vegetables, flowers, and ornamental plants. With less than a third of four-year institutions still having "horticulture" as a department title or offering the subject, a lack of awareness and interest in the horticultural field may limit or create negative perceptions of the discipline (Higgins, 2014; Smith, 2014; Dole, 2015). These negative perceptions could be that agricultural careers are often seen as low-paying and demeaning work, which can further contribute to the declining interest (Vincent et al., 2012).

Experiential Learning and Undergraduate Engagement

In response to the lack of exposure to agricultural educational programming, Undergraduate Research Experiences (URE) and Research and Extension Experiences for Undergraduates (REEU) are programs that provide undergraduates with internships that explore agricultural research, which may incorporate innovative technologies. Unlike URE, which focuses primarily on research, REEU programs integrate community outreach (Extension) to bring research-based information to the general public. The hands-on experiences REEU interns have, give them valuable exposure to agriculture, help them develop skills relevant to the industry, giving them a foundational understanding of the scientific process while exploring careers in agriculture research and Extension (Fontanier et al., 2019). Participating in a REEU or URE internship prepares participants for graduate school or technical careers in agriculture (Lopatto, 2004; Russell et al., 2007).

While existing research highlights the benefits of hands-on experiences and the impact that it has in horticultural topics (Craver et al., 2014; Fontanier et al., 2019; Lavis et al., 2010), only one article has been identified reporting on REEU programs' potential to introduce (and recruit) students to a horticulture program, but did not assess the effectiveness of hands-on learning in hydroponics (Fontanier et al., 2019). This presents a gap limiting our understanding of the potential for REEU programs to shape participants' perspectives, interests, attitudes, and confidence in skill acquisition in hydroponic production to drive future workforce development in the industry.

THEORETICAL FRAMEWORK

This study examines the differences in outcomes for REEU interns who attend only a hydroponics lecture compared to those who participate in both a hydroponics lecture and a related hands-on activity. The theoretical framework for this study is based on Kolb's (1984) theory of experiential learning (Appendix B), and Wiley (1996) model of Assumed Relationships Among Education, Knowledge, Attitude, and Resultant Behavior (Appendix C).

According to Kolb (1984), learning occurs more effectively through social and personal experiences than through formal education alone. For meaningful learning to take place, Kolb's theory emphasizes the importance of experiencing each step of the learning cycle: concrete encounters, reflective observation, abstract conceptualization, active experimentation, and concrete encounters. Concrete experiences occur when learner actively participate in an educational activity, that engages their whole selves to both learn about and gain skill in a topic. The second stage is the reflective observation occurs when participants reflect on the hands-on experience—they think about, process, and analyze the encounter from a retrospective view.

During the abstract conceptualization stage, learners form their own theories about the topic to make sense of the experience, applying existing knowledge to contextualize the experience and conceptualize themselves incorporating the concept, activity, or related tasks into their lives. At this stage, a learner may choose to seek additional information or experiences—to actively experiment with the concept, even applying what was previously learned to new situations or testing new ideas, giving rise to new experiences, and thus, restarts the cycle.

Wiley (1996) proposes that education transfers knowledge which has the capacity to shift attitudes about a concept, and that shift can motivate behavior change. However, Wiley adapted Swanson (1972) which specifically focuses on behavior change after a health intervention. Swanson points out that some knowledge produces “cognitive dissonance”, where the knowledge conflicts with existing attitudes. In these cases, an individual may still act in opposition to their existing attitude, and through the action have greater capacity or motivation to change their attitudes (Swanson, 1972). Further, Swanson posits that a “credibility gap” may exist where an attitude intervenes to inhibit action despite new knowledge being gained. Altogether, Swanson either casts doubt on the reliability of linear models, whether cyclical or not, that rest on the assumptions that attitudes beget action or requires a different conceptualization of the process to extract or distill the attitude-action dependency into a less problematic framework.

Fortunately, Kolb’s theory does not demand that attitudes shift for future action to be taken on new knowledge. Instead, only that the initial experience begets reflection and abstraction of the knowledge gained through the experience to motivate experimentation, i.e. future action. However, Kolb’s theory is focused on experiential learning, which is not always possible or

practical. Yet, even theoretical learning (without an embodied experience) can initiate reflection, abstraction, and experimentation. In this case, it may be worth considering Wiley's model as an "on-ramp" to Kolb's experiential-learning cycle (Appendix B). Put another way, drawing a tentative connection from behavior to education, in Wiley's model, brings it into closer alignment with the cyclical nature of Kolb's theory. Additionally, the flexibility in Kolb's framework allows for the doubt that attitudes insert between knowledge and action without stymying that action, effectively solving Swanson (1972) initial dilemma regarding cognitive dissonance. In the present research, we will impose both a theoretical learning component (a presentation) and, for a subset of participants, an experiential learning component (a hands-on, hydroponic-system construction workshop). With the knowledge provided by these components, we expect that participants will have improved attitudes about hydroponic production. Given limited time, we will not directly measure behavior change, but instead look at increased interest in producing vegetables, generally, and utilizing hydroponics, specifically, as a surrogate for future action. This two-component investigation should allow us to evaluate Wiley's model both on its own—vis-a-vis attitudinal and behavioral changes among presentation-only participants—and to evaluate it as an on-ramp to Kolb's theory—for the subset of participants that will receive the hands-on workshop. We hope to observe attitudinal shifts through both activities, but to further elucidate the role of hands-on learning in shifting attitudes by focusing some of our survey questions on the participants' confidence in using a hydroponics system. Because skill-confidence, an attitude towards one's own ability to perform an action, presupposes an element of practice and requires some reflection and abstraction of the concept [and experience], we should be able to measure changing attitudes about participants' skill confidence at the same time we measure shifting attitudes about hydroponics generally. By focusing on skill

confidence, we believe that we can reinforce the general idea that attitude [shifts] beget behavior change (or interest/intent), consistent with Wiley, while emphasizing the role of reflection and abstraction as integral to those shifts, effectively bringing Wiley in further alignment with Kolb.

This study's objectives are to:

1. Assess the impact of an informational presentation on hydroponic production on REEU interns regarding their knowledge and perspectives about hydroponics and confidence in operating a hydroponics system;
2. Assess the impact of a hands-on hydroponics workshop on hydroponic-system construction and use on REEU interns regarding their knowledge and perspectives about hydroponics and confidence in operating a hydroponics system;
3. Compare the efficacy of both educational methods on shifting skills-confidence and overall perceptions and attitudes about hydroponics.

MATERIALS AND METHODS

We developed a 60-minute, lecture-style presentation on the basics of hydroponics that was delivered to 48 interns during the PSEG Institute for Sustainability Studies (ISS) Green Teams internship program (Green Teams) at Montclair State University (MSU). We further developed a hands-on module that was delivered to a subset of the original participants—10 interns who were selected to take a tour of Kansas agriculture—during which the interns constructed and planted two hydroponics towers. Participants of both presentations complete assessments to measure changes in knowledge and perceptions about hydroponics, comfort-level with the technologies and their use and management. Quantitative assessments were subjected to statistical analyses,

and qualitative assessments were coded and analyzed using Wilcoxon signed-rank test, Mann-Whitney U test, Kruskal-Wallis test method.

Placing the Research in Context

Green Teams Program. The participants involved in the study were 50 upper-level undergraduate interns from the Green Teams program at Montclair State University. The program is an annual, 10-week, interdisciplinary program that draws students from universities nationwide and assigns them to teams of five (“Green Teams”), each working with local host organizations on sustainability-related projects. The program recruits host organizations, including for-profit and not-for-profit companies and municipalities, which define sustainability challenges that become the projects the green team assigned to the host will address during their internship. In addition to project work, Green Teams interns engage in weekly training sessions to broaden interns’ understanding of core sustainability topics, group counseling and team-building exercises, and other activities—like field trips, hands-on experiences, and professional development—organized by ISS to make for a memorable and meaningful internship experience. At the end of the program, each green team presents their project in both a written report and a TED-talk-style presentation to host organizations, stakeholders, peers, and [interns’] families and friends.

Initial Hydroponics Presentation

At the beginning of the 10-week program, 45 of the 50 Green Teams interns attended an "Introduction to Hydroponics" lecture as part of their sustainability training. The presentation was delivered on the afternoon of June 4th in room 120 of the Center for Environmental and Life Sciences at Montclair State University by a member of the research team. The focus of the

summary lecture about hydroponics was to educate Green Team interns regarding the significance of hydroponics in vegetable production, the various systems and crops suitable for hydroponic production, the environmental benefits of controlled-environment agriculture (CEA), and the potential role that soilless production can play in our food system in the future. After the initial lecture, interns completed the first survey instrument and participated in a Kahoot game to assess the knowledge gained from the presentation lecture and discussion. (Time 1)

Hands-on Experience.

Two groups of five interns, the Green Teams assigned to agriculture related projects, participated in a hands-on workshop on hydroponic system construction. This workshop began with a brief review of the concepts introduced during the initial hydroponics lecture, then transitioned to an introduction to the components of a recirculating solution culture system, including growing media, nutrient solutions, and pH and electrical conductivity (EC) probes. Interns then worked with their teams to construct a vertical grow tower (Tower Garden FLEX, Juice Plus+ Company, LLC., Collierville, TN, USA). The teams assembled the towers and planted swiss chard (*Beta vulgaris* L. var. *cicla*), kale (*Brassica oleracea* L. gp. *acephala*), and bibb and leaf lettuce (*Lactuca sativa* L.) varieties. After construction, interns measured the electrical conductivity (EC) and pH of the nutrient solution before starting the pump to circulate water through systems. However, continued maintenance of the systems was not a component of the workshop. This activity allowed interns to gain hands-on experience constructing and planting in a hydroponics system. Students completed the same survey instrument [again] after this hands-on activity (Time 2).

Study Participants.

Forty-eight interns (n= 48) attended the introductory lecture, called “Introduction to Hydroponics”, during one of the weekly trainings as part of the Green Teams program at Montclair State University. 58% of participants were from non-environmental science/agriculture backgrounds.; of the remaining 42%, only one intern was majoring in horticulture. Ten of the 48 interns (two Green Teams) were assigned projects directly related to agriculture—one team developed an augmented-reality training for autistic workers in a hydroponic, vertical farm, the other team developed soil-monitoring tools for a farm experiencing flooding and associated soil issues. Those two teams were flown to Kansas for a 10-day tour of Kansas agriculture, to show them a broader range of agricultural enterprises in the U.S. The tours included agricultural operations that showcased sustainable technology and innovations. The site tours also included university [agricultural-] research sites and non-profit conservation organizations to enhance interns' practical understanding of sustainability practices and explore how they may relate to their internship projects. While in Kansas, these interns participated in the hands-on workshop on hydroponic tower construction and use at Kansas State University.

Data Collection and Instruments

Survey Instrument

An 11-question survey (Appendix D) was administered immediately following the summary lecture (Time 1) (4 Jun. 2024) and hands-on workshop activity (Time 2) (20 Jun. 2024) to assess the interns' understanding, perspectives, and confidence following each intervention. This survey aimed to capture shifts in comprehension, interest, perspectives, and confidence concerning

hydroponic systems and their application, especially in the context of sustainability. The first section of this survey consisted of five questions focused on assessing the interns' understanding and attitudes about the role of hydroponics in vegetable production (Table 1). The second section of the instrument contained three questions regarding the interns' interest in vegetable production (Table 2). The third section of the instrument included three questions assessing interns' confidence in setting up and using a hydroponic system (Table 3).

Pre-and post-intervention responses were requested within the same instrument and answers were requested at the same time, mitigating the potential for false confidence being expressed before the presentation (Drennan et al., 2008). Survey questions elicited responses using a Likert-scale numbered 1 to 5, with (1) indicating "Strongly Disagree", (2) indicating "Disagree", (3) indicating "Neutral", (4) indicating "Agree", and (5) indicating "Strongly Agree".

Follow-up Survey

A follow-up survey (Time 3) was administered four months after the initial presentation and included the same questions as the previous surveys. The intent of this survey was to evaluate, any change in participants' perceived knowledge, perspectives regarding hydroponic production, and confidence in setting up and maintaining a hydroponic system. This survey was administered through Qualtrics and an invitation was sent via email to all interns who attended. Researchers sent six invitations to Green Teams interns and received 17 responses.

Statistical Analysis

Survey data was collected from paper survey instruments, Qualtrics, exported to Microsoft Excel, and analyzed using Stata/SE 17.0, with significance set at $p \leq 0.10$. Due to non-normal data distributions (as assessed by the Shapiro-Wilk test), non-parametric methods were employed. The Wilcoxon signed-rank test was used to evaluate within-subject changes between pre- and post-responses, while the Mann-Whitney U test and Kruskal-Wallis test were used to assess differences across two or more independent groups, respectively. Cronbach's alpha was calculated to assess the internal consistency of the survey instruments.

To complement statistical significance testing, effect sizes were calculated. For Wilcoxon signed-rank and Mann-Whitney U tests, the effect size r was computed using the formula (Eq. 1) where Z is the z-score is divided by the square root of N which is the number of observations. These effect size measures provided an indication of the significance of the findings.

“Cohen's d ”:

$$\left| \frac{Z}{\sqrt{n}} \right| \quad \text{Eq. 1}$$

To rate effect sizes in the social sciences (small, $d = 0.2$; medium, $d = 0.5$; large, $d = 0.8$; and very large, $d = 1.2$) (Cohen, 1988).

RESULTS

The first two prompts of the MSU survey assessed interns' perceived understanding of hydroponics and its importance within vegetable production Prompts 3 to 5 assessed interns' attitudes regarding hydroponic production. In addition, prompts 6 to 8 assessed interns' interest

in vegetable production and prompts 9 to 11 evaluated interns' confidence in maintaining a hydroponic system.

Presentation Results

Pre-presentation Responses

The first prompt of the MSU Hydroponics survey asked interns: "I have a basic understanding of what hydroponics is". Overall, interns (n=45) reported a slightly negative response of (2.60). Interns who attended the hands-on workshop and presentation (n=10) were provided neutral responses, (3.20), compared with which differed significantly ($P < .10$) from the slightly negative responses from interns who attended the presentation only (2.43, n=35). Here, the effect size was 0.26 (small). In addition, there were no significant differences amongst workshop-bound interns (n=10) who were assigned the hydroponic project (n=5) compared to interns who were not (n=5).

Prompt two asked interns, "I understand the importance of hydroponics production within the field of vegetable crop production". The overall response of interns was (2.62) and there were no significant differences between the groups. Prompt three interns were asked to rate their agreement with the following: "It is important to know that my food is coming from an environmentally sustainable source". Overall, interns agreed with the statement (4.04); there were no significant differences between groups. Prompt four asked interns if they agreed that Hydroponics is a sustainable method for vegetable production. The overall response was (3.44), there were no significant differences between the groups.

Prompt five interns rated the following statement: "I believe understanding how to use and maintain a hydroponic system could benefit me". Interns averaged a response of (3.18), indicating a neutral response. There were no significant differences between the presentation and workshop attendees. However, workshop participants who did not have a hydroponic project had a response of (4.40), indicating a strongly positive response, significantly different from workshop interns with a hydroponic project, who had a response of (3.00), indicating a neutral response. The effect size of this difference was 0.82 (large).

Prompt six asked interns the following statement: "I would like to have my own hydroponics system". The interns' overall response to the prompt was (3.13), and there was no significant difference between groups. In prompt seven, interns asked, "I would be interested in growing vegetables for myself and my family." The average response was (3.76), there were no significant differences among the groups. Prompt eight asked interns the following statement: "I would be interested in a career in vegetable production." Overall, interns averaged (2.49), there were no significant differences between the groups.

Prompt nine asked interns, "I feel confident that I could grow hydroponic vegetables for myself". Overall, the interns' response was a (2.40), indicating a negative response to the prompt. Interns who attended both the workshop and presentation had an average response of (3.10) compared to interns who only attended the presentation, (2.20), which was significantly higher ($P < .10$), and the effect size was 0.26 (small). Prompt ten interns were asked "I feel confident that I could set up a hydroponics kit". Overall, interns averaged a response of (2.31). There were no significant differences between groups. Prompt eleven interns were asked, "I feel confident that I can

monitor the EC and pH in a hydroponics production system." Overall, interns averaged a response of (2.15), and there were no significant differences among the groups

Post-presentation Responses

The first prompt asked interns: "I have a basic understanding of what hydroponics is". Overall, interns averaged a (4.56) on the post-test in response to prompt one, which was significantly higher than the pre-test ($P < .01$) and has an effect size of 0.60 (medium-large). There was no significant difference between the groups. Prompt two asked interns: "I understand the importance of hydroponics production within the field of vegetable crop production". Overall, the average was (4.62) in response to prompt two, significantly higher ($P < .01$) than the pre-test. Findings show an effect size of 0.60 (medium-large), and the groups had no significant differences.

Prompt three interns were asked to rate their agreement with the following: "It is important to know that my food is coming from an environmentally sustainable source". Overall, interns had an average response of (4.89) to prompt three, which was significantly higher ($P < .01$) than the pre-test, with an effect size of 0.41 (small-medium). There were no significant differences between the groups. Prompt four asked interns if they agreed with the following: "Hydroponics is a sustainable method for vegetable production". Overall, interns averaged a (4.62), which was significantly higher ($P < .01$) than the pre-test, with an effect size of 0.47 (small-medium). There were no significant differences between the groups.

Prompt five interns rated the following statement: "I believe understanding how to use and maintain a hydroponic system could benefit me". Overall, interns averaged a response of (4.22) to prompt five, indicating a positive response which was significantly different ($P < .01$) from the pre-test, with an effect size of 0.61 (large). Furthermore, workshop and presentation attendees had a significantly more positive response of (4.40; $P < .10$), with an effect size of 0.25 (small), when compared to presentation-only attendees, who had a response of (4.17). There were no significant differences between workshop interns with or without a hydroponics project.

Prompt six asked interns regarding the following statement: "I would like to have my own hydroponics system". Overall, interns averaged a response of (3.87) in response to prompt six. Findings show a significant difference when compared to the pre-test ($P < .01$), with an effect size of 0.47 (small-medium). There were no significant differences between the groups. In prompt seven, interns asked, "I would be interested in growing vegetables for myself and my family". Interns overall averaged a response of (4.08), which indicates a positive response. Findings show a significant difference ($P < .01$) from the pre-test with an effect size of 0.47 (small-medium). In addition, interns who attended only the presentation scored significantly lower ($P < .10$) with a response of (4.00) than participants who attended both the presentation and workshop, with an average of (4.40). The effect size was 0.29 (small), and there was no significant difference among workshop interns with or without a hydroponics project.

Prompt eight asked interns the following statement: "I would be interested in a career in vegetable production". Interns overall averaged a response of (3.27), which was significantly different ($P < .01$), with an effect size of 0.47 (medium-large) when compared to the pre-test. There were no significant differences among the groups. Prompt nine asked interns, "I feel

confident that I could grow hydroponic vegetables for myself". Overall, interns averaged a (3.49), which was significantly different ($P < .01$) from the pre-test with an effect size of 0.60 (large). Also, interns who attended the presentation and workshop had a significantly ($P < .01$) more positive perspective, with a response of (4.3) when compared to interns who attended only the presentation, which had a response of (3.26); the effect size is 0.49 (medium-large). There was no significant difference between workshop interns with or without a hydroponics project.

Prompt ten interns were asked "I feel confident that I could set up a hydroponics kit". Overall, interns averaged a (3.44) in response to prompt ten. When compared to the pre-test, interns had a significantly different ($P < .01$) response with an effect size of 0.65 (large). Moreover, workshop and presentation attendees had a significantly different ($P < .01$) response of (3.90) compared to presentation-only attendees, which had a response of (3.31). The effect size of the difference is 0.63 (large). There was no significant difference between workshop interns with or without a hydroponics project. Prompt eleven interns were asked, "I feel confident that I can monitor the EC and pH in a hydroponics production system". In response to prompt eleven, interns averaged a response of (3.20). Compared to the pre-test, the interns' average score was significantly different ($P < .01$), with an effect size of 0.63 (large). In addition, workshop and presentation attendees had a response of (3.40), which was significantly different ($P < .01$) when compared to presentation-only attendees' response of (3.14), with an effect size of 0.49 (medium-large). There was no significant difference between workshop interns with or without a hydroponics project.

Workshop results

Pre-workshop Responses

The first prompt of the MSU Hydroponics survey asked interns: "I have a basic understanding of what hydroponics is". Interns who attended the hydroponics workshop (n=10) averaged (3.55) on the pre-test in response to prompt one. Workshop interns' responses were significantly lower ($P < .05$) when compared to their presentation post-test responses, with an effect size of 0.68 (medium-large). Prompt two asked interns: "I understand the importance of hydroponics production within the field of vegetable crop production". Workshop attendees had an average response of (3.35), which was significantly lower ($P < .05$) when compared to their presentation post-test responses, with an effect size of 0.81 (large). Prompt three interns were asked to rate their agreement with the following: "It is important to know that my food is coming from an environmentally sustainable source". Workshop interns averaged a response of (4.20), displaying a positive perspective.

Furthermore, prompt four asked interns if they agreed with the following: "Hydroponics is a sustainable method for vegetable production". Workshop interns had an average response of (3.80), which was significantly lower ($P < .05$) when compared to their presentation post-test responses, with an effect size of 0.82 (large). Additionally, prompt five interns rated the following statement: "I believe understanding how to use and maintain a hydroponic system could benefit me". Workshop interns averaged a response of (3.50) on prompt five. Prompt six asked interns the following statement: "I would like to have my own hydroponics system." Workshop interns averaged a response of (3.44), indicating a neutral response.

In prompt seven, interns asked, "I would be interested in growing vegetables for myself and my family". Workshop interns' response was (3.90), which was significantly lower ($P < .05$) when compared to the presentation post-test, with an effect size of 0.64 (medium-large). Prompt eight asked interns the following statement: "I would be interested in a career in vegetable production". Workshop interns averaged a score of (3.30), which was significantly lower ($P < .05$) when compared to their presentation post-test responses, with an effect size of 0.56 (medium-large).

Prompt nine asked interns, "I feel confident that I could grow hydroponic vegetables for myself". Workshop interns averaged a neutral response with a score of (3.10), which was significantly lower ($P < .10$) when compared to their presentation post-test responses, with an effect size of 0.71 (medium-large). Prompt ten interns were asked "I feel confident that I could set up a hydroponics kit". Workshop interns averaged a response of (2.20), indicating a negative perspective. Responses were significantly lower ($P < .05$) when compared to their presentation post-test responses, with an effect size of 0.73 (medium-large). Furthermore, prompt eleven asked interns the following: "I feel confident that I can monitor the EC and pH in a hydroponics production system". Interns averaged a response of (2.90) on prompt eleven.

Post-workshop Responses

The first prompt of the MSU Hydroponics survey asked interns: "I have a basic understanding of what hydroponics is". Workshop interns averaged a response of (4.75) on prompt one, which was significantly different ($P < .05$) compared to the pre-test. The effect size of this difference was 0.60 (large). There were no significant differences among the groups. Prompt two asked interns:

"I understand the importance of hydroponics production within the field of vegetable crop production". Interns averaged a score of (4.75), indicating a strongly positive response, which was significantly higher ($P < .05$) than the pre-test, with an effect size of 0.60 (large). There were no significant differences among the various groups.

Prompt three interns were asked to rate their agreement with the following: "It is important to know that my food is coming from an environmentally sustainable source". Workshop interns averaged a response of (4.70) on the third prompt, indicating a strongly positive response, which was significantly higher ($P < .10$) than the pre-test, with an effect size of 0.41 (medium). There were no differences between the groups. Prompt four asked interns if they agreed with the following: "Hydroponics is a sustainable method for vegetable production". Workshop interns averaged a significantly higher response ($P < .05$), averaging (4.40). This difference had an effect size of 0.47 (medium), and no significant difference existed between the groups. Additionally, workshop interns' responses were significantly lower ($P < .05$) when compared to their presentation post-test response of (4.90), with an effect size of 0.71 (medium-large).

Prompt five interns rated the following statement: "I believe understanding how to use and maintain a hydroponic system could benefit me". Workshop interns had a strongly positive response with a score of (4.50), significantly higher ($P < .01$) than the pre-test. The difference had an effect size of 0.61 (large). In addition, workshop attendees' responses differed significantly ($P < .10$) when compared to presentation attendees ($n=35$) post-test responses of (4.17), with an effect size of 0.25 (small). Prompt six asked interns the following statement: "I would like to have my own hydroponics system". Interns averaged a response of (4.33) on

prompt six, which differed significantly ($P < .05$) from the pre-test, with an effect size of 0.47 (medium-large). There were no differences among the groups.

In prompt seven, interns asked the following: "I would be interested in growing vegetables for myself and my family". Workshop Interns displayed a strongly positive perspective with an average response of (4.50), which differed significantly ($P < .05$) from the pre-test. The effect size of this difference was 0.47 (medium-large). Also, workshop attendees' perspectives differed significantly ($P < .10$) when compared to presentation-only attendees' responses of (4.00), with the effect size being 0.47 (medium-large). Prompt eight asked interns the following statement: "I would be interested in a career in vegetable production". Workshop interns averaged a response of (3.70), significantly different ($P < .05$) compared to the pre-test. The effect size of the difference was 0.47 (medium-large).

Prompt nine asked interns, "I feel confident that I could grow hydroponic vegetables for myself". Workshop interns had a strongly positive perspective on prompt nine, with an average score of (4.50). This differed significantly ($P < .05$) from the pre-test, with an effect size of 0.60 (medium-large). Moreover, workshop attendees had a significantly different ($P < .01$) response when compared to presentation-only attendees' responses of (3.26), with an effect size of 0.60 (medium-large). Prompt ten interns were asked "I feel confident that I could set up a hydroponics kit". Workshop interns averaged a response of (4.90), which differed significantly ($P < .01$) when compared to the pre-test, with an effect size of 0.65 (medium-large). Also, workshop interns' responses were significantly higher ($P < .05$) when compared to their presentation post-test response of (3.90), with an effect size of 0.70 (medium-large). In addition,

workshop attendees had significantly different ($P < .01$) perspectives when compared to presentation-only attendees' response of (3.31), with an effect size of 0.63 (medium-large).

Prompt eleven interns' were asked, "I feel confident that I can monitor the EC and pH in a hydroponics production system". Workshop interns had a strongly positive perspective with an average score of (4.40), which differed significantly ($P < .01$) when compared to the pre-test, with an effect size of 0.63 (large). Also, workshop interns' responses were significantly higher ($P < .05$) when compared to their presentation post-test response of (3.90), with an effect size of 0.76 (medium-large). In addition, workshop attendees had a significantly different ($P < .01$) response when compared to presentation-only attendees' response of (3.14), with an effect size of 0.49 (medium).

Follow-Up Survey Results

The first prompt of the MSU Hydroponics survey asked interns: "I have a basic understanding of what hydroponics is". Follow-up survey respondents ($n=17$) averaged a score of (4.78). There were no significant differences between the groups. In addition, prompt two asked interns: "I understand the importance of hydroponics production within the field of vegetable crop production". Interns averaged a response of (4.69), and no significant differences existed between groups. Prompt three interns were asked to rate their agreement with the following: "It is important to know that my food is coming from an environmentally sustainable source". Interns averaged a response of (4.61); no significant differences existed between the groups. Furthermore, prompt four asked interns if they agreed that Hydroponics is a sustainable method for vegetable production. Interns averaged a response of (3.75). There were no significant

differences between the groups. Prompt five interns rated the following: "I believe understanding how to use and maintain a hydroponic system could benefit me." The interns had a positive response with a score of (4.36). There were no significant differences among the groups.

Prompt six asked interns the following statement: "I would like to have my own hydroponics system". Interns averaged a score of (3.75). There were no significant differences between the groups. In prompt seven, interns asked, "I would be interested in growing vegetables for myself and my family." Interns averaged a score of (4.17). There were no significant differences between the groups. Prompt eight asked interns the following statement: "I would be interested in a career in vegetable production". Follow-up survey respondents averaged a response of (3.08). There were no significant differences between the groups.

Prompt nine asked interns, "I feel confident that I could grow hydroponic vegetables for myself". Interns averaged a score of (3.42), indicating a neutral response. However, workshop attendees (n=5) had a response of (4.10) that differed significantly ($P < .10$) when compared to presentation attendees' (n=12) response of (3.17), with an effect size of 0.42 (medium).

Prompt ten interns were asked "I feel confident that I could set up a hydroponics kit". Interns averaged a score of (3.61), indicating a slightly positive response. Workshop attendees' average response of (4.5) differed significantly ($P < .10$) when compared to presentation attendees' response of (3.25), with an effect size of 0.47 (medium). Prompt eleven interns were asked "I feel confident that I can monitor the EC and pH in a hydroponics production system". Interns displayed a response of (3.89); there was no significant difference between groups.

DISCUSSION

The primary objective of this study was to evaluate the impact of a hydroponics lecture and hands-on experience on interns in the PSEG Green Teams REEU program, particularly regarding their attitudes, understanding, and confidence in operating a hydroponics system.

Following the initial hydroponics presentation, attendees expressed a positive shift in their understanding, attitudes, interest, and confidence. The National Farm to School Network (NFSN) reported that their Gro More Good Hydroponics Pilot Project initiative, which integrates hydroponics into classroom curricula, had engaged over 1,954 students by March 2020 (Harris, 2020). According to “teachers, administration, teaching aides, [and] community members,” “there was a perceived 20% increase in student interest and a 15% increase in adult interest in gardening” among those impacted (Harris, 2020). Although the NSFN pilot program primarily targeted primary and secondary education, integrating hydroponics in the classroom, thereby demonstrating its role in food production, positively influenced participants' understanding, interest, and attitudes (Harris, 2020). A 2015 study introduced hydroponics and aquaponics curricula to fifth and sixth graders, after which students expressed a greater interest in gardening and creating hydroponic and aquaponic systems at home, and reported more pro-environmental attitudes, and concordant behavioral changes among participants (Schneller et al., 2015). While both of these studies focused on younger students, their curricula and exposure to hydroponic production methods resulted in significant attitudinal shifts among the students.

Further supporting these findings, Schraw et al. (1995) demonstrated that structural features of educational content—such as clarity, vividness, and ease of comprehension—significantly affect learner interest. Moreover, researchers have linked increased interest during educational

interventions to the use of visual aids and culturally relevant references, a phenomenon known as the "seductive details effect" (Rey, 2012). A study involving 201 undergraduate students evaluated situational interest following a presentation delivered in an "appealing" format (Senko et al., 2021). Responses indicated that the inclusion of seductive details led to greater interest in a physics topic compared to a less appealing presentation. This concept of the seductive detail effect is highly relevant to our current study, as the initial hydroponics presentation provided foundational knowledge using culturally relevant references, a diverse array of images of various systems, and comprehensive details on maintaining a hydroponics system. While our results support the effectiveness of this approach in enhancing knowledge and interest, they also raise concerns that the appealing nature of the presentation may have artificially inflated participants' self-reported outcomes. Rajagopal et al. (2011) conducted a study showing that exposure to high-imagery advertisements can lead to misconceptions about a product. After surveying 100 undergraduate students, the results indicated that participants exposed to high-imagery ads—without any personal experience of the product—exhibited attitudes of confidence similar to those who had actually tried the product. This suggests that visualizations of a concept can create false beliefs or attitudes, resulting in unwarranted confidence in something not personally experienced.

Differences began to emerge between students who attended the presentation (only) and those who would also be participating in the hands-on workshop as early as the post-presentation survey. While all interns exhibited similar increases in their perceived knowledge about hydroponics, the interns bound for the hands-on workshop expressed a greater interest in vegetable production than their presentation-only peers' weeks before the workshop was to be

delivered. In addition to simply knowing a hands-on lab was coming, half of those participants had committed to a summer-long instructional design project in hydroponics—two parallel anticipatory cues that, by raising both expectancy for success and perceived utility (Eccles & Wigfield, 2002) and in anticipation of forming concrete action plans (Gollwitzer, 1999), amplified their situational interest in hydroponics and home-food production.

Furthermore, anticipation of an event or experience is closely linked to the acquisition of related knowledge before the experience (Polegato et al., 2019). The results of the current study indicated that interns who participated in the workshop perceived themselves as having a significantly greater understanding of hydroponics compared to those who only attended the presentation. This suggests that knowledge acquisition may have occurred among students prior to the experience. A study involving 102 participants examined the relationship between sources of interest and participants' perceived interest in a topic. Findings indicated that prior knowledge is positively correlated with interest in a topic (Brantmeier et al., 2006). However, this finding contradicts earlier research that suggests individuals can have knowledge about a subject without any related interest (Baldwin et al., 1985). While Carrell et al. (1998) support Baldwin's findings, Schraw et al. (1994) argue that greater interest in a topic is associated with individuals' familiarity with the subject matter (Brantmeier et al., 2006). Additionally, various other factors have also been identified as influential in shaping perceived interest.

Among participants who attended both the presentation and workshop, there was a significant decrease in survey response scores across all domains (understanding, attitudes, interest, and confidence), when taking the pre-test survey after the hands-on workshop. While it is possible

that this decrease was real, only sixteen days passed between the interventions, and half of those students were actively engaged in a hydroponics-related project—suggesting that for those students understanding should have been increasing throughout. Post/pre-evaluation instruments are explicitly designed to improve the reliability of pre-to-post score comparisons by having more-informed, current selves rate their recently less-informed, past selves. In this study, the initial hydroponics lecture provided information on hydroponic production. Further, the interns' post-workshop scores were at or above their post-presentation scores suggesting that their post-presentation scores were likely inflated in absolute terms. These fluctuations appear to exemplify the Dunning-Kruger Effect (DKE), a cognitive bias in which individuals with relatively low levels of competence in a subject overestimate their own abilities, while those with higher competence tend to underestimate their capabilities (Dunning & Kruger, 1999; Smith, 2024). A study conducted in 2021 explored the DKE among 41 first-year college students enrolled in online classes (Dogan et al., 2023). In this study, students were asked to predict their scores after each exam and rate their confidence in those predictions. The findings showed that low-performing students predicted significantly higher scores for themselves compared to their higher-performing peers, despite exhibiting no difference in confidence between the two groups (Dogan et al., 2023). This suggests that low-performing students had the same level of confidence regarding their performance on the exam as high-performing students (Dogan et al., 2023). This observation relates to the current study, where it is plausible that once interns engaged in constructing, planting, and maintaining a hydroponics system, they realized how much they did not know prior to the hands-on workshop. Thus, their low pre-workshop self-evaluation demonstrates that they had overestimated their knowledge, attitudes, and interest while underestimating the effort/skill required to operate and manage a hydroponics system at

the end of the presentation. This may also reflect an inflated judgment of their learning (JOL). JOL refers to individuals' perceptions of how effectively they have learned a subject and their confidence in retaining that information (Senko et al., 2021).

Interns' attitudes shifted positively after the workshop regarding hydroponics being a sustainable production method, and they reported higher confidence in setting up and maintaining the pH and EC of a hydroponics system relative to their responses after the presentation. These results emphasize the impact of hands-on workshops, building on what the presentation provided for participants. Interns exhibited self-efficacy and confidence in performing the workshop tasks—key indicators of a successful intervention (Lavis, 2005). A study published in 2012 reported similar outcomes; there, undergraduate student exhibited more confidence in answering questions about water relations and improved attitudes towards the value of locally grown produce after participating in a hands-on experience at a greenhouse facility during a study abroad trip (Snyder et al., 2012). Responses were attributed to students' immersion into different cultures and the tour of the farm and greenhouse facility in Honduras (Snyder et al., 2012). Likewise, a study following 101 3rd and 5th grade students found that hands-on gardening experiences integrated into their curriculum positively affected students' attitudes towards consuming vegetables, even developing a preference for them as a healthy snack choice (Lineberger, 2000). Echoing the findings of the current study, that after participation in a hands-on experience attitudinal changes can occur.

After attending the hands-on workshop, interns reported improvements, relative to their presentation only peers, in their interest in growing vegetables for themselves and their families. Cummings et al. (2020) surveyed 36 undergraduate, non-science majors about their attitudes and

perceptions of hydroponics production after completing a project-based learning course. The students reported that learning about hydroponics could benefit their personal lives, a significant contrast to their responses before engaging in the class and its hands-on experiences (Cummings et al., 2020). While Cummings et al. (2020) did not directly compare this intervention to a traditional lecture-based format, their findings provided evidence that the hands-on nature of the course contributed to increased motivation and a deeper understanding of the material. A study involving 5th and 6th grade students who received hands-on instruction in hydroponics and aquaponics found that students exhibited pro-environmental attitudes and behavioral changes, leading to a greater interest in gardening and establishing hydroponic and aquaponic systems at home after the intervention (Schneller et al., 2015). In a survey of 327 high school students, researchers found that access to gardens and hands-on experience in the garden led students to being more open to try new vegetables and fruits, and to consume local foods (Greer et al., 2017). The literature clearly shows that hands-on, experiential learning about gardening and hydroponics improves participants' attitudes toward producing and consuming vegetables, which aligns with the findings of our study.

Workshop attendees expressed stronger agreement that knowing how to use and maintain a hydroponics system is beneficial, compared to their peers who attended only the presentation. With increased exposure to constructing and operating a hydroponics system, workshop participants recognized the potential advantages of hydroponics more than those who only attended the presentation, thereby demonstrating the effectiveness of both the presentation and workshop in conveying the benefits of hydroponics for themselves. Papadopoulou et al. (2025) conducted a study of 57 fourth and fifth graders that assessed their experiences during a hands-

on activity integrating hydroponics and 3D printing. The students reported recognizing the benefits of using hydroponics and showed interest in incorporating hydroponic gardening into their daily lives. The research team attributed this outcome to a scaffolding learning approach, in which instructors enabled students to work independently on the hydroponics project and solve problems within their groups as those problems arose (Papadopoulou et al., 2025). In another study, 40 undergraduate students participated in an urban food production initiative on campus, and reported increased recognition of the benefits of learning to operate a hydroponics system (Madden et al., 2017). The researchers posited that students achieved a level of “self-resiliency” through obtaining a basic understanding of plants and food cultivation; in other words, empowering the students to become self-sufficient through acquiring essential life skills (Madden et al., 2017). Those students perceived indoor hydroponic gardening as more challenging than outdoor gardening after the initiative (Madden et al., 2017). However, their demonstrated ability to use a hydroponic system, despite the perceived difficulty of maintaining the system, boosted their confidence in gardening in any setting, reinforcing their understanding of the benefits of operating and maintaining a hydroponics system (Madden et al., 2017).

The hands-on workshop provided participants with practical experience in building and operating a hydroponics system, significantly boosting their confidence in managing these systems independently, relative to those who attended only the presentation. Forty undergraduate students in a Greenhouse Operations Management course, which included hands-on hydroponics [group] projects, reported increased confidence in managing hydroponics systems (Craver and Williams, 2014). Those who actively participated in the construction, planting, and maintenance of a hydroponic system throughout the semester showed a notable improvement in their ability to

maintain such systems (Craver and Williams, 2014). Similarly, Lavis et al. (2010) found that undergraduate students in an irrigation course experienced a significant boost in confidence after collaboratively installing residential irrigation systems during class laboratories. When students compared their classroom experience to their hands-on activities, they acknowledged that installing the system greatly increased their understanding and confidence in the process (Lavis et al., 2010). Lavis et al. (2010) attribute these findings to collaborative activities enhancing students' self-efficacy. This aligns with Fenci et al. (2005), who reported that collaborative learning was effective in promoting self-efficacy. In the present study, the workshop interns worked in groups of five to complete the construction, planting, and maintenance of the hydroponic system. This collaborative approach allowed students to feel more confident while co-acquiring new skills through the experience (Baldwin et al., 1999). Moreover, findings reaffirm Kolb's (1984) Experiential Learning Theory; the increase in confidence from the workshop interns displays that after participating in the concrete (hands-on) experience, the interns reflected on the experience and conceptualized their ability to construct, maintain, and manage a hydroponics system independently. Therefore, the hands-on interns exhibited more confidence in conceptualizing themselves to replicate the activity and to begin active experimentation.

In response to a follow-up survey, administered four months after the workshop, the interns who participated in both the presentation and workshop reported feeling more confident in growing hydroponics for themselves and setting up a hydroponic kit, compared to those who only attended presentations. These results can be attributed to a concept known as procedural memory, which is a long-term memory that stores information about tasks or skills (Squire,

2004). Craver et al., (2014) findings displayed the retention in confidence from undergraduates' students after participating in hydroponics throughout their Greenhouse Operations Management class. Students were surveyed four separate times throughout the course, the first two times before participating in the module, the third time after completing the module and the final time at the end of the semester. Once completing the module student's confidence in operating a hydroponics system persisted two months after completing the hydroponics module (Craver et al., 2014). Results were attributed to the hands-on experience students had throughout the course and its impact in solidifying confidence in operating various components of a hydroponics system. Talawalbeh (2013) compared the retention of knowledge and confidence among 100 nursing students divided into two groups who attended different training sessions. The experimental group received training that included a PowerPoint presentation, a demonstration on a static manikin, and a hands-on simulation (utilizing virtual reality), while the control group attended only the PowerPoint presentation and demonstration. The experiment revealed that the experimental group exhibited higher retention of knowledge and confidence, as evidenced by a survey conducted three months after the intervention. Talawalbeh et al. (2013) attributed this difference to the experimental group's opportunity to apply the clinical skills they had just learned in a simulation scenario. Although the current study does not utilize a simulation approach for hands-on experience, the workshop interns' ability to reinforce newly learned skills and receive constructive feedback enhanced their confidence in growing hydroponics and using a system.

CONCLUSIONS

Our results suggest that the hydroponics presentation was effective in increasing interns' initial understanding, interest, and confidence. However, the hands-on workshop amplified those effects. Workshop interns reported improved attitudes toward the potential contribution of hydroponics in food production and in their lives, ultimately increasing their interest in growing vegetables for themselves and their families. Additionally, workshop attendees reported greater confidence in setting up a hydroponics kit, maintaining a system, and growing vegetables hydroponically. Our results join existing scholarship in highlighting the positive impact of experiential learning in promoting confidence, increasing engagement, and promoting skill retention compared to lecture-based learning alone.

Moreover, the study provides insight into additional benefits of hands-on learning by highlighting the sustained understanding about and interest in hydroponics, as well as enduring confidence in operating a system. The retention of confidence demonstrates that hands-on experience helps reinforce learning through real-world application. These results support the idea that STEM and agricultural educators should incorporate hands-on group activities into lesson plans and curricula to increase engagement and long-term impacts. By combining traditional lectures with immersive experiences, educational programs can empower individuals to be confident in using hydroponic to grow food for themselves and their communities.

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Table 5. Overall pre-presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

	<i>Questions</i>										
	1	2	3	4	5	6	7	8	9	10	11
Pre-presentation Results											
Overall (N=45)	2.60	2.62	4.04	3.44	3.18	3.13	3.76	2.49	2.40	2.31	2.15
By Activities Attended											
Presentation-only	2.43	2.51	4.17	3.43	3.03	3.09	3.74	2.34	2.20	2.14	2.09
Interns (n=35)											
Workshop Interns (n=10)	3.2	3.0	3.6	3.5	3.7	3.3	3.8	3.0	3.1	2.9	2.4
z	1.75	1.08	1.06	-0.44	-1.56	-0.47	-0.26	-1.42	-1.77	-1.48	-0.34
r	-0.26	-0.16	0.16	-0.07	-0.23	-0.07	-0.04	-0.21	-0.26	-0.22	-0.05
P-value	*	NS	NS	NS	NS	NS	NS	NS	*	NS	NS

By Intern Project											
Hydroponics project (n=5)	2.80	2.80	3.80	3.20	3.00	3.00	4.00	3.20	2.60	2.40	2.40
No Hydroponics Project (n=5)	3.60	3.20	3.40	3.80	4.40	3.60	3.60	2.80	3.60	3.40	2.40
Z	0.87	0.54	-0.66	0.66	1.84	0.76	-0.12	-0.56	0.99	1.07	0.00
r	0.39	0.24	-0.29	0.29	0.82	0.34	-0.05	-0.25	0.44	0.48	0.00
P-value	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS

Table 6. Overall post-presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

Questions											
	1	2	3	4	5	6	7	8	9	10	11
Post-presentation Results											
Overall (n=45)	4.56	4.62	4.89	4.62	4.22	3.87	4.08	3.27	3.49	3.44	3.20
Z	-2.56	-2.55	-1.73	-1.99	-2.58	-1.98	-1.99	-2.00	-2.55	-2.78	-2.68
r	-0.60	-0.60	-0.41	-0.47	-0.61	-0.47	-0.47	-0.47	-0.60	-0.65	-0.63
P-value	***	***	***	***	***	***	***	***	***	***	***
By Activities Attended											
Presentation (n=35)	4.49	4.57	4.49	4.54	4.17	3.77	4.00	3.11	3.26	3.31	3.14
Workshop (n=10)	4.8	4.8	4.5	4.9	4.4	4.22	4.4	3.8	4.3	3.9	3.4
Z	-1.311	-0.819	-0.934	0.61	-1.686	-1.51	-	-1.084	-3.261	-4.221	-3.281
							1.923				
r	-0.20	-0.12	-0.14	0.09	-0.25	-0.23	-0.29	-0.16	-0.49	-0.63	-0.49

<i>P</i> -value		<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	*	<i>NS</i>	*	<i>NS</i>	***	***	***
By Intern Project												
Hydroponics Project		4.80	4.80	4.60	5.00	4.40	4.20	4.40	3.80	3.80	3.40	3.20
(n=5)												
No Hydroponics Project (n=5)		4.80	4.80	4.40	4.80	4.40	4.20	4.40	3.80	4.80	4.40	3.60
Z		-0.904	-0.904	-0.149	-0.808	0.387	0.146	-	1.076	1.315	1	1.423
								0.149				
r		-0.40	-0.40	-0.07	-0.36	0.17	0.07	-0.07	0.48	0.59	0.45	0.64
<i>P</i> -value		<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>	<i>NS</i>

Table 7. Pre and post workshop responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

		Questions										
		1	2	3	4	5	6	7	8	9	10	11
Workshop Pre-Survey												
Results												
	Overall (n=10)	3.55	3.35	4.20	3.80	3.50	3.44	3.90	3.30	3.10	2.20	2.90
Workshop Post-Survey												
Results												
	Overall (n=10)	4.75	4.75	4.70	4.40	4.5	4.33	4.50	3.70	4.50	4.90	4.40
	Z	-2.563	-2.554	-1.727	-1.986	-2.579	-1.982	-1.986	-2	-2.553	-2.777	-2.683
	r	-0.60	-0.60	-0.41	-0.47	-0.61	-0.47	-0.47	-0.47	-0.60	-0.65	-0.63
	P-value	**	**	*	**	***	**	**	**	**	***	***
Workshop vs. Presentation												
	Presentation (n=35)	4.49	4.57	4.49	4.54	4.17	3.77	4.00	3.11	3.26	3.31	3.14

Workshop (n=10)	4.75	4.75	4.70	4.40	4.5	4.33	4.50	3.70	4.50	4.90	4.40
Z	-1.31	-0.82	-0.93	0.61	-1.686	-1.51	-1.92	-1.084	-3.261	-4.221	-3.28
r	0.20	0.12	0.14	-0.09	0.25	0.23	0.29	0.16	0.49	0.63	0.49
P-value	NS	NS	NS	NS	*	NS	*	NS	***	***	***
By Intern Project											
Presentation-only (n=35)	4.49	4.57	4.49	4.54	4.17	3.77	4.00	3.11	3.26	3.31	3.14
Hydroponics Project (n=5)	4.90	4.90	4.80	4.60	4.60	4.40	4.60	3.40	4.20	4.80	4.00
No Hydroponics Project (n=5)	4.60	4.60	4.60	4.20	4.40	4.25	4.40	4.00	4.80	5.00	4.80
Chi 2x	1.91	1.02	0.64	0.82	2.39	0.82	3.21	1.80	10.65	16.41	11.19
P-value	NS	NS	NS	NS	NS	NS	NS	NS	***	***	***

Table 8. Overall follow-up survey responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

		Questions										
		1	2	3	4	5	6	7	8	9	10	11
Follow Survey Results												
Overall (n=17)		4.78	4.69	4.61	3.75	4.36	3.75	4.17	3.08	3.42	3.61	3.89
		4.62	4.82	4.68	4.65	4.32	3.44	4.12	3.15	3.44	3.65	3.47
By Activities Attended												
Presentation (n=12)		4.58	4.75	4.75	4.67	4.25	3.67	3.92	3.08	3.17	3.25	3.3
Workshop (n=5)		4.7	5	4.5	4.6	4.5	3.9	4.6	3.3	4.1	4.6	3.8
Z		-0.364	-1.195	0.792	0.254	-0.82	-0.381	-1.411	-0.383	-1.744	-1.924	-0.764
r		-0.09	-0.29	0.19	0.06	-0.20	-0.09	-0.34	-0.09	-0.42	-0.47	-0.19
P-value		NS	NS	NS	NS	NS	NS	NS	NS	*	*	NS
By Intern Project												

Presentation-only (n=12)	4.58	4.75	4.75	4.67	4.25	3.67	3.92	3.08	3.17	3.25	3.30
Hydroponics Project (n=3)	4.83	5.00	4.17	4.67	4.50	3.83	4.33	3.50	4.17	4.67	4.00
No Hydroponics Project (n=2)	4.50	5.00	5.00	4.50	4.50	4.00	5.00	3.00	4.00	4.50	3.50
Chi 2x	0.435	0.625	2.19	0.139	0.547	0.176	2.259	0.411	2.962	3.435	0.801
P-value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figure 11. Kolb's Theory of Experiential Learning (Kolb, 1984)

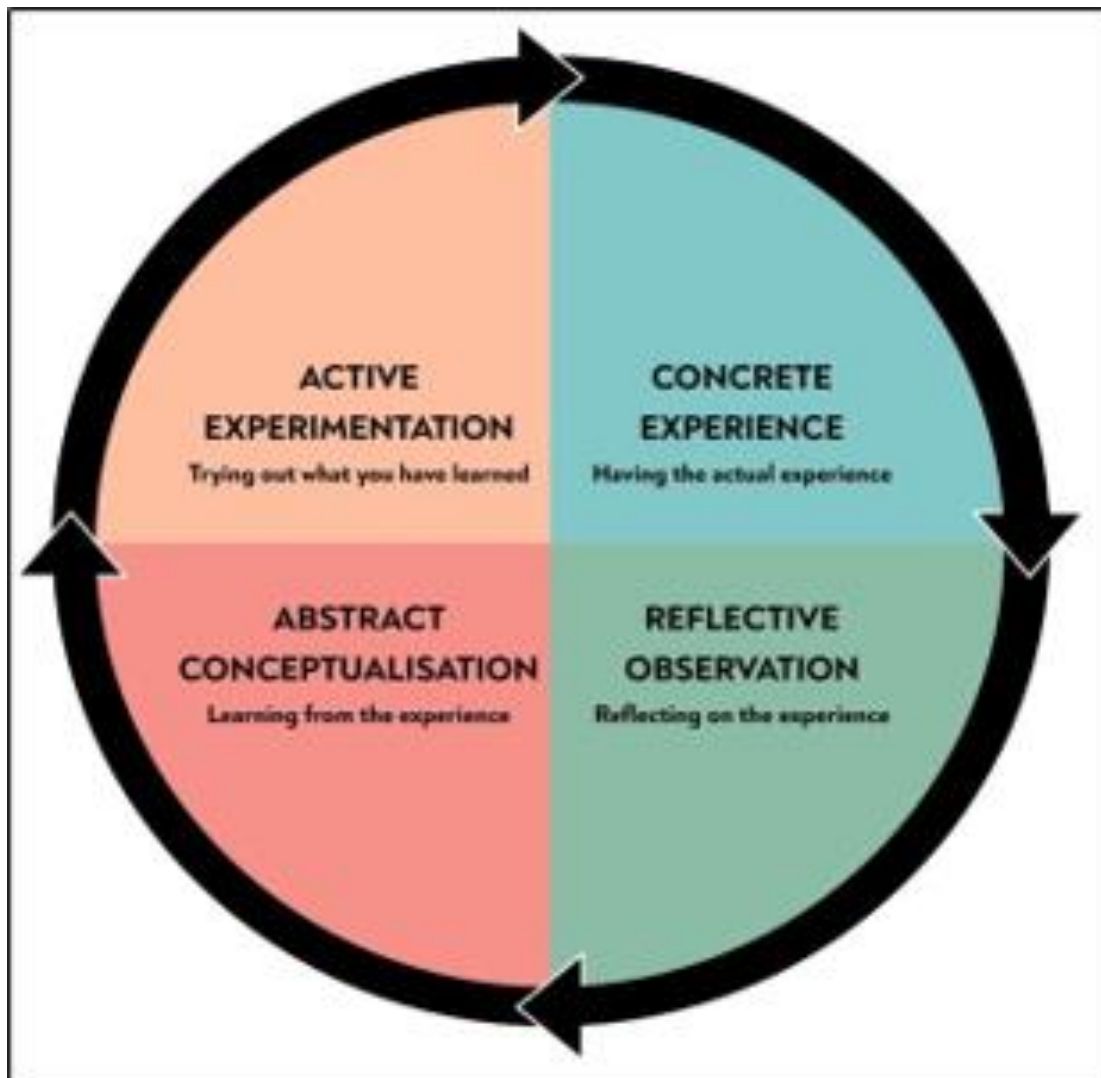


Figure 12. The Model of Assumed Relationships Among Education, Knowledge, Attitude, and Resultant Behavior (Wiley, 1996)

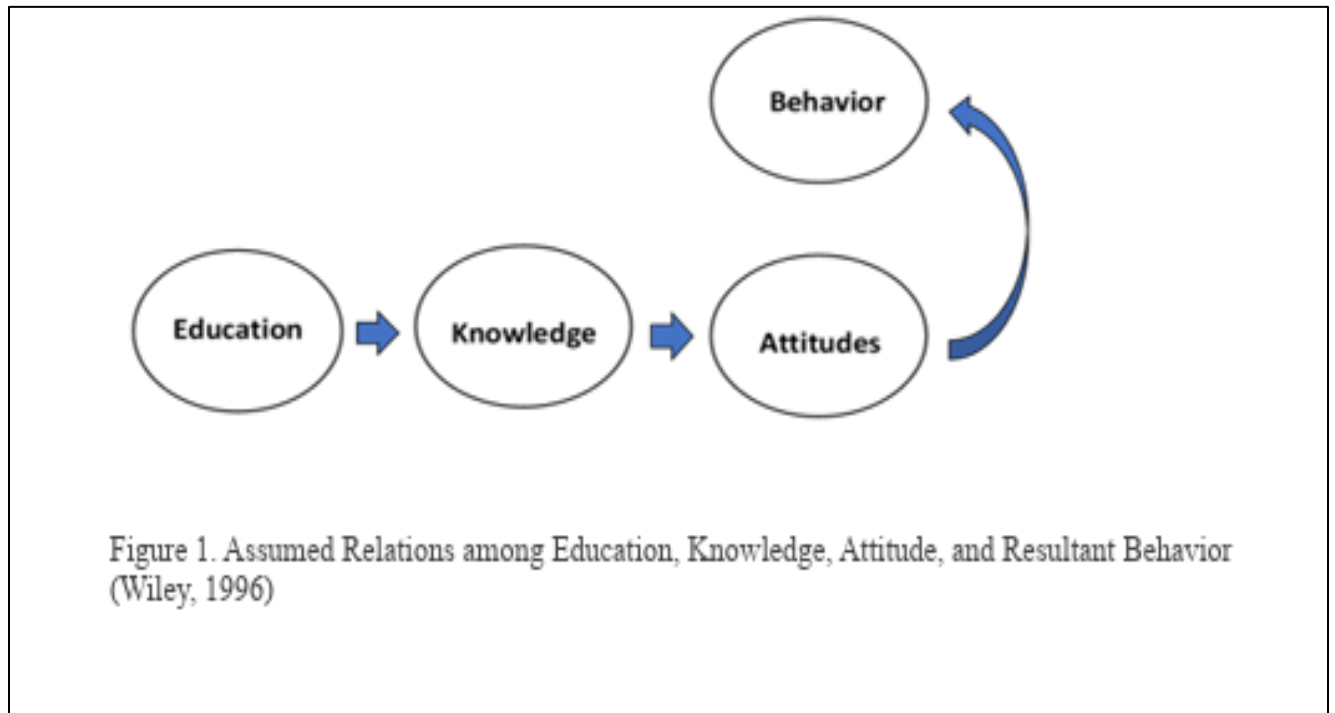


Figure 13. Overall hydroponic presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

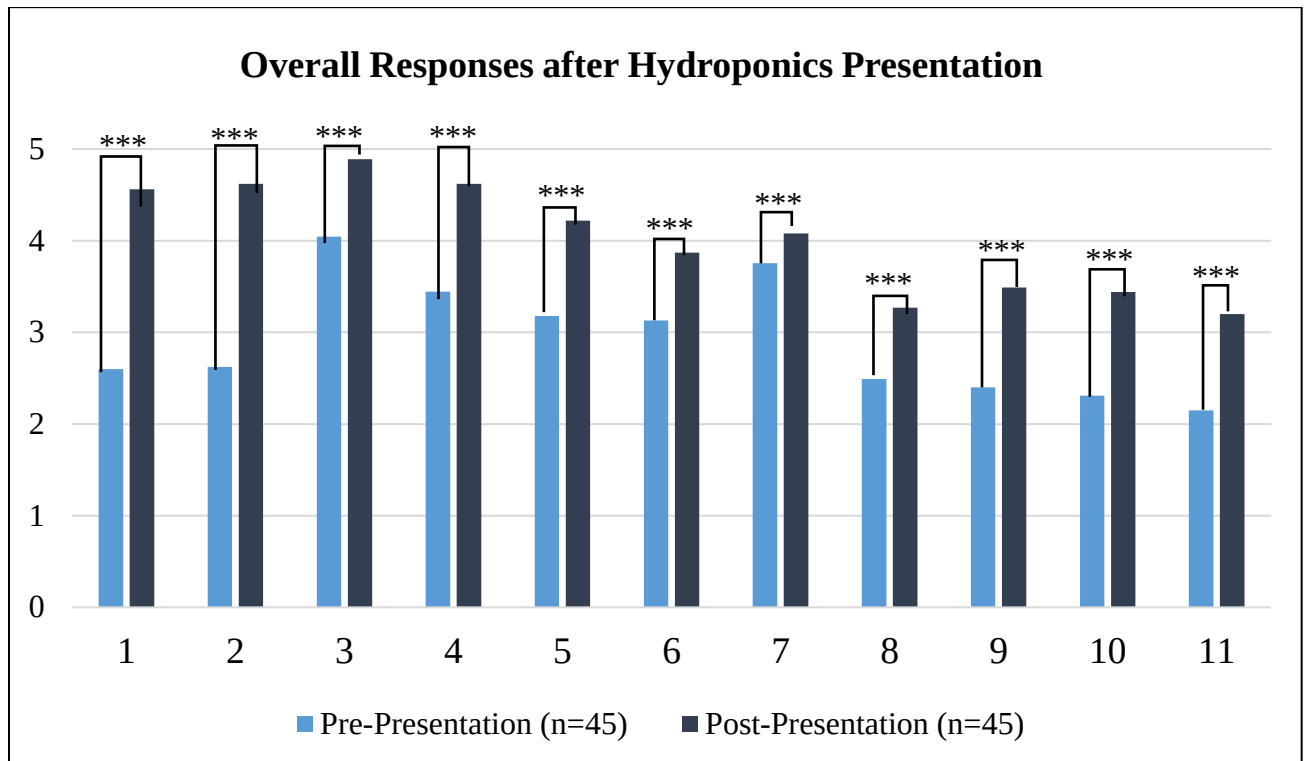


Figure 14. Comparing hydroponic presentation responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

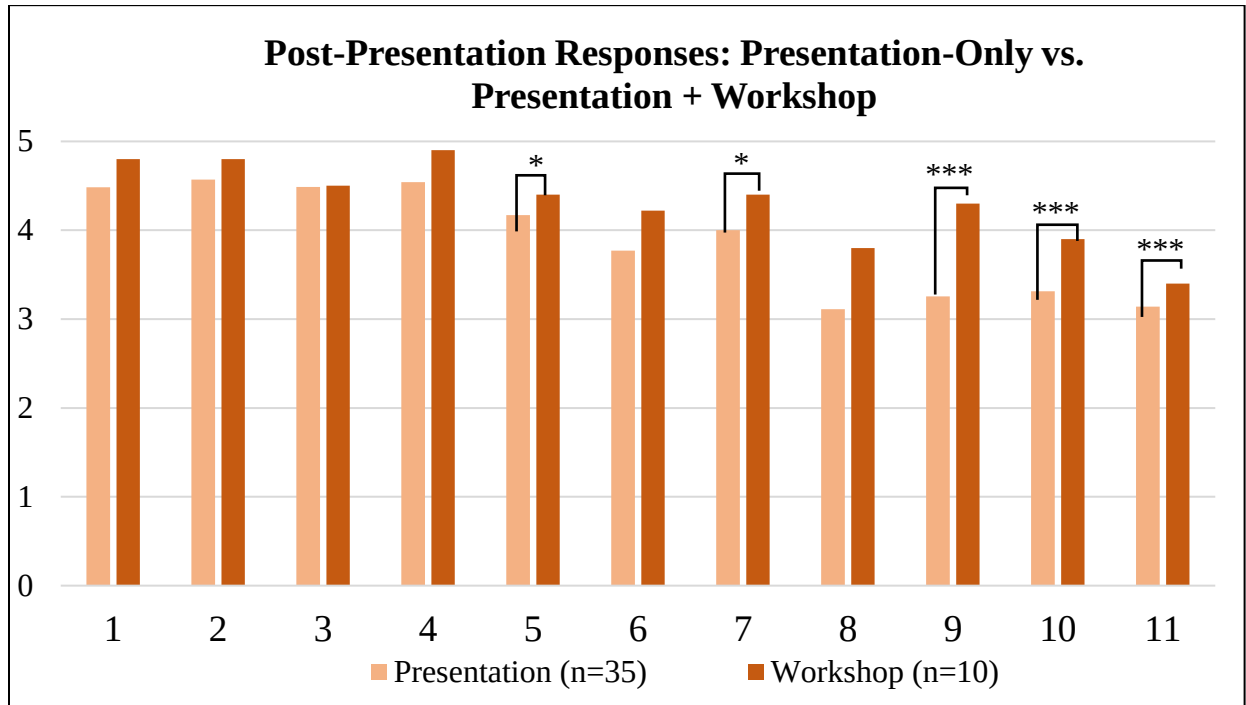


Figure 15. Hydroponic workshop responses on the MSU Hydroponics Survey taken PSEG

Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.

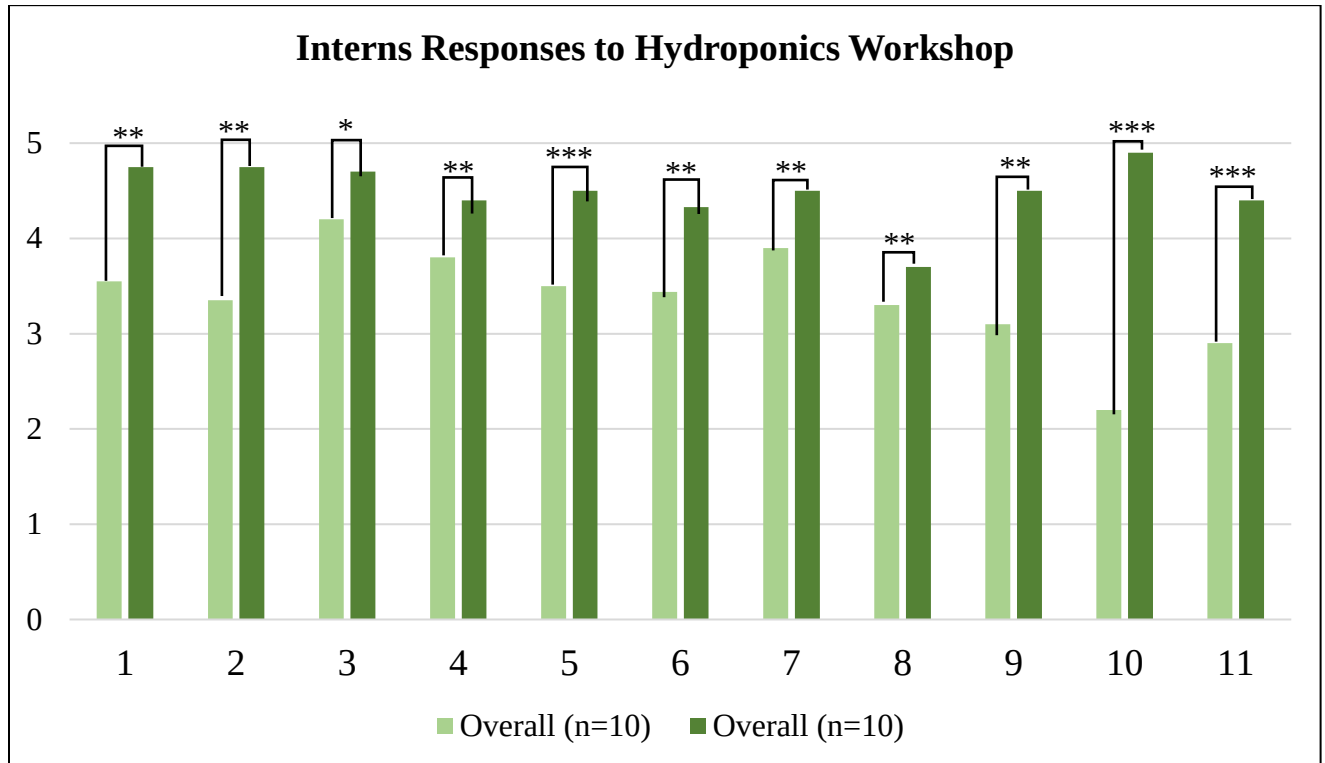


Figure 16. Comparison of intern responses following both interventions on the MSU Hydroponics Survey, administered to PSEG Green Teams after the hydroponics presentation during summer 2024 in Montclair, NJ and Manhattan, KS.

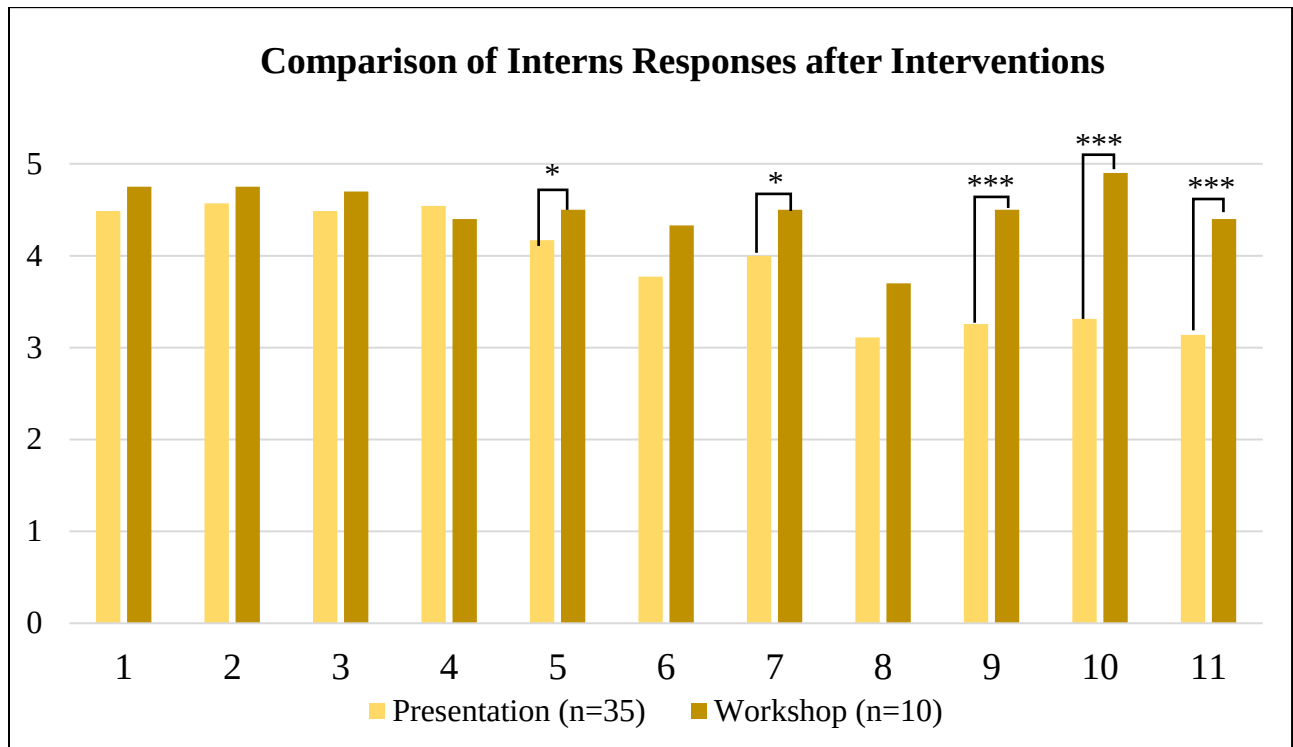
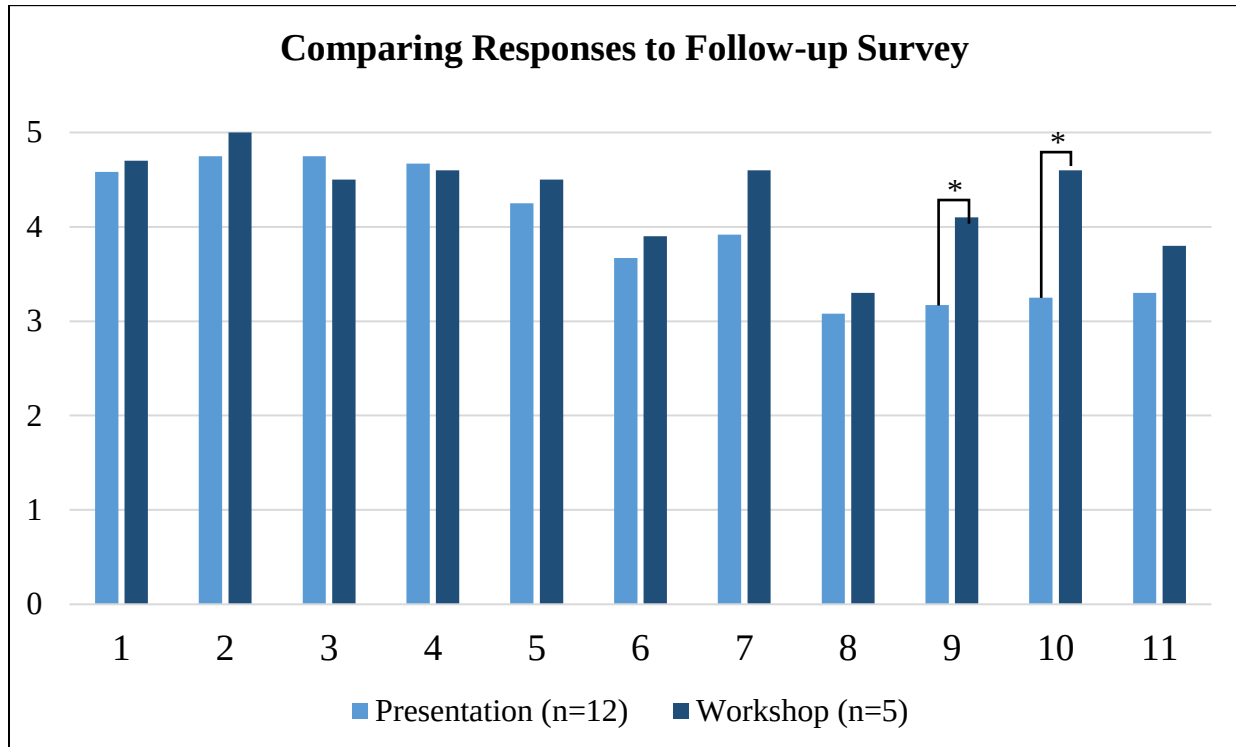


Figure 17. Comparing follow-up survey responses on the MSU Hydroponics Survey taken PSEG Green Teams after the hydroponics presentation during the summer of 2024 in Montclair, NJ and Manhattan, KS.



Appendix A - Nicodemus Camp Learning Outcome Worksheet and SSSO Survey Instrument

Table A1. Campers responses to multiple choice questions on the Learning Outcome Worksheet at Switzer/Jr. MANRRS Educational Camp. The pre- and post-test means, desired responses, and percentage changed are indicated in the table for each question.

Question:	Pre- Test Mean	Post- Test Mean	Desired Response	% Change
1) Old leaves and food scraps and other kitchen or garden waste that break down overtime.	79.5%	83%	D. Compost	3%
2) An efficient method is to put water only where the plants need it.	67%	79%	G. Drip Irrigation	12%
3) Plants that farmers grow to protect their soil improve its health, reduce water loss and control pests.	45.8%	50%	B. Cover Crops	4%

4) Planting different crops season after season in a field to reduce disease and insect pests.	62.5%	79.16%	F. Crop Rotation	*17%
5) Planting a crop without disturbing the soil.	50%	75%	A. No-Till	**25%
6) What might be considered a natural resource?	70.8%	91.6%	B. Raw Materials that come from nature, such as soil, water, and plants.	**21%
7) What are the three pillars of sustainability?	33%	70.8%	A. Social, Economic & Environmental Soundness	***38%
8) Erica noticed that after she cuts vegetables and trims plants, there are leftover bits like peels and leaves. What could Erica do with these leftover bits instead of throwing them away?	66%	79.1%	D. Compost the waste	13%

9) Jalen grows flowers and vegetables in his backyard garden. He uses a water hose to water his plants but wants to find a more efficient way to water. Which of these methods is the most water efficient?	41.6% 83.3% C. Drip Irrigation	***42%
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Table A2. Camper's responses to Likert Scale questions from the SSSO Survey at Switzer/Jr. MANRRS Educational Camp. The pre- and post means, desired responses, and percentage changed are indicated in the table for each question.

Question:	Pre- Test Mean	Post- Test Mean	Desired Response	% Change
1. Sustainability is important to my future.	4.17	4.08	5	- 8.3%
2. It is important for farmers to implement conservation practices to protect natural resources.	3.66	4.21	5	54.8%
3. It is important to me to know that my food is produced sustainably.	3.75	4.04	5	29%
4. Everyone has a responsibility to conserve natural resources.	3.66	4.08	5	42.3%
5. I can implement conservation practices in my own life.	3.62	3.83	5	21.3%
6. I intend to look for more information about conservation practices or sustainability.	3.29	3.29	5	0.0%

7. The activities at Nicodemus helped improve my understanding of conservation practices.	4.21	5	
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Appendix B - PSEG Green Teams Hydroponics Survey Instrument

PSEG GREEN TEAMS PRE-POST TEST OF PRESENTATION

Questions/Statement	Before the workshop	After the workshop
For the following questions, circle or mark an X, on the line indicating your level of agreement with each statement (1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree):		
I have a basic understanding of what hydroponics is.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I understand the importance of hydroponics production within the field of vegetable crop production.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
Knowing that my food comes from an environmentally sustainable source is important to me.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
Hydroponics is a sustainable method for vegetable production.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I would like to have my own hydroponics system.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I would be interested in growing vegetables for myself and my family.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I feel confident that I could grow hydroponic vegetables for myself.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I believe understanding how to use and maintain a hydroponic system could benefit me.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I would be interested in a career in vegetable production.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I feel confident that I could set up a hydroponics kit.	1-----2-----3-----4-----5	1-----2-----3-----4-----5
I feel confident that I can monitor the EC and pH in a hydroponics production system.	1-----2-----3-----4-----5	1-----2-----3-----4-----5