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From the Ground Up: An Arts-Based Analysis of Online Engagement Impacts on Youths' Conceptualizations of Hydroponics and Related Careers

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ABSTRACT: Online engagement programs can introduce youth to sustainable STEM solutions and careers through connections with agricultural and natural resources (ANR) experts. Prior research indicated youth are concerned about the planet's future. Sustainability experts can engage with youth to alleviate some of those concerns to show how they can positively impact soil and water quality challenges in urban areas. We applied arts-based data collection methods to examine how imagery from a live online electronic field trip (EFT) about hydroponics influenced urban high school students' visual conceptualizations of food-growing techniques and related career role models. We coded drawings and compared them directly to images featured in the EFT. We present the results in themes and a visual collage that indicates youth a) identified specific hydroponics techniques and technology, b) conceptualized women career role models as hydroponics experts, and c) described hydroponics as a sustainable agriculture solution for urban food insecurity. Findings through their drawings and reflections revealed EFT imagery influenced students' perceptions and responses, with the resulting collage highlighting important connections and themes. Future research could replicate the study across ANR topics, locations, and careers as well as implement real-time evaluation methods such as perception analyzer dials and opinion polling.

INTRODUCTION

Many agricultural and natural resources (ANR) scientists and Extension specialists at land grant universities examine sustainable agricultural practices and aim to find effective ways to share their findings with diverse audiences to mobilize continued conservation and food system improvements (Braiser et al., 2006; Cinzia et al., 2015; NASEM, 2019; Prokopy and Power, 2015). Sustainable agriculture includes approaches to address climate change, alleviate poverty, reduce pollution, restore soil health and water quality, and preserve biodiversity in environmental ecosystems (Kassam et al., 2010; Lal, 2008; Sharma et al., 2019). At the same time, generations of people are moving away from rural areas, fewer people are working in the agricultural industry, and traditional agricultural practices are evolving (Krishnan et al., 2016; Pawlowski, 2018; Tomlinson, 2015). This shift to urbanization logically raises questions of food production, with an increasing demand to feed a growing population with fewer rural producers (Satterthwaite et al., 2010). However, food production remains most viable in rural settings; Urban communities face challenges such as limited space to grow crops, food deserts, poor soil quality, and increased demand for water conservation (Kassam et al., 2010).

Scientists, Extension, and industry are working together to investigate controlled agricultural environments, smart technologies, and growing techniques that could benefit urban settings (NASEM, 2019). Hence, an opportunity exists for agricultural and natural resource communicators to collaborate with these subject matter experts to develop engagement efforts such as electronic field trips (EFTs) to bring Extension programming (non-formal) into classrooms (formal) to engage audiences in urban and sustainable agricultural topics to increase science literacy, content area knowledge, and everyday application (Frick, 1990; Frick et al., 1991; Irani and Doerfert, 2013; Kovar and Ball, 2013; Kurtzo et al., 2016; Stofer, 2015a).

Agronomists have experimented with vertical farming and hydroponics as two potential innovative sustainable agricultural techniques that could be used for growing food in densely populated urban areas. Vertical farming consists of growing plants on top of one another in layered structures from floor to ceiling inside controlled indoor facilities with light-emitting diode (LED) lighting and watering technologies (Thijs et al., 2022). Hydroponics techniques can be used in vertical farming structures within confined spaces such as freight containers. Vertical farming could reduce water and pesticide use yet continues to face cost and energy consumption challenges in efforts to reduce its environmental impacts (Lubna et al., 2022). Hydroponics growing techniques date back to the mid-18th century and serve to produce food in a growing tank without soil via a mixture of controllable water and nutrition solution (Jones Jr., 1982; Rufí-Salís, 2020; Velazquez-Gonzalez et al., 2022).

Some start-up companies have emerged to collaborate with communities, scientists, farmers, and utility companies to examine and implement vertical farming and hydroponics in controlled settings such as freight farms (Czerniak, 2013; Lubna et al., 2002). One such urban agriculture company sells and ships large freight containers equipped with vertical growing troughs, red and blue LEDs, and environmental controls with the goal to encourage crop production in small areas. However, initial interviews with farmers indicated the methods still need improvement as they require steep upfront investment, should possibly focus on organic crops, and the technology can strain energy systems (Czerniak, 2013). The University of Florida / Institute of Food and Agricultural Sciences (UF/IFAS) Northwest Research and Education Center-Suwannee Valley partnered with a freight farm company and electric power cooperative and institute to continue to research how a 40-foot controlled growing container placed and monitored on the research center's property impacts the power grid and community economy (Little, 2022).

As research, such as the freight farm study, unfolds in real-time, ANR communicators could work with subject matter experts to introduce audiences to science contexts and experiments through engagement programs (NRC, 2009). Youth in science learning settings are an ideal priority audience for sustainable agriculture and environmental communication engagement. Research has shown youth are concerned for the planet's future; National science education standards include expectations for youth to increase content knowledge about sustainability and nature of science concepts, and assessments have shown exposure to science careers and diverse role models could positively impact PK-12 students' career trajectories (NGSS Lead States, 2013; NRC, 2009; Poor, 2021; Zummo et al., 2020). Not only is agriculture widely pervasive, meaning local connections abound (Rumble et al., 2016; Stofer, 2015b; Stofer & Rios, 2018), but the connection to every individual on the planet is undeniable, providing an ideal opportunity for advancing understanding of research-based science developments and career opportunities (Barrick et al., 2018).

Physical field trips are not often possible for teachers and students due to several logistical limitations (Anderson and Zhang, 2003; Cassady et al., 2008; Loizzo et al., 2019; Stofer, 2022). However, instructional and communication technologies (ICTs) are more abundant than ever before and can help alleviate some of the infrastructure and cost barriers to traditional in-person communication and education formats (Loizzo et al., 2019; Beattie et al., 2020; Krebs et al., 2021; Ratheeswari, 2018). One such ICT example is an electronic field trip (EFT), through which students remotely engage in live interactions with scientists and experts on location through web-cast video stream and chat (Loizzo et al., 2019; Poor, 2021). The EFT model provides an opportunity to link students from across the world to hydroponics experts, giving students access to knowledge on the topic and the opportunity to engage in real time with specialists. Studying student perceptions of science topics after participating in EFTs can give science communicators a greater understanding of how engagement programs can impact K-12 education and provide a potential model for future ANR and STEM outreach initiatives (McLeod-Morin et al., 2020).

CONCEPTUAL FRAMEWORK

Social Cognitive Theory (SCT; Bandura, 1977) and Social Cognitive Career Theory (SCCT; Lent et al., 1994) guided the study. SCT describes a triadic reciprocal relationship among environmental, personal, and behavioral factors. Bandura (1977) found that learning through observation and socialization in an environment influence a person's cognitive knowledge, increase a person's self-efficacy (confidence) to perform a behavior, and potentially lead to behavior change. When in-person engagement is not possible for social learning, vicarious observation and conversation through visual media-mediated experiences can also increase learning and positively impact actions (Bandura, 2009; Yilmaz et al., 2019). Application of an SCT lens to the current study would allow the examination of how dialogue with experts and observation of hydroponics behaviors through an EFT impact viewers' sustainable agriculture knowledge and behavior intentions.

SCCT builds on SCT to examine how personal, environmental, and behavioral components shape an individual's career pathway. SCCT adds components of personal inputs (gender, race, background, etc.), learning experience impacts, environmental influences, and career choice goals, expected outcomes, and attainment (Lent et al., 1994). Roberts and Grant (2021) found SCCT as a useful framework for STEM career research in that it emphasizes how self-efficacy internal and external factors can influence a student's choice of college majors and potential career interests. While the following study did not directly ask research participants to indicate their interest level in hydroponics careers, it did examine how EFT visuals, dialogue, and demonstration influenced students' hydroponics learning and perceptions of career role models. Hence, the EFT was considered as a learning experience within the SCCT framework with the potential to impact participants' career exposure, conceptualizations, and interests.

Purpose & Research Questions. Science communicators, educators, and Extension professionals could use innovative assessment approaches beyond surveys to study how outreach and engagement programs affect target audiences. For instance, arts-based research methods (Aenlle et al., 2022; Leavy, 2020) provide an opportunity to discover how program participants visualize ANR information and experts. The purpose of this study was to explore how a live, interactive EFT about 1) hydroponic growing methods in agriculture and 2) related career role models influenced youths' learning as demonstrated through their self-created drawings of the content. The following research questions (RQs) sought to illustrate how vicarious observation through the interactive EFT and its provided imagery influenced student perceptions of ANR content. They further provide an innovative model for future ANR and STEM outreach and assessment by highlighting important results from this outreach initiative, showcasing student comprehension, interpretation, and application of STEM content. These RQs guided the study:

RQ1: How did youths' visual representations of hydroponic growing techniques reflect content from a hydroponics-focused EFT?

RQ2: How did youths' visual representations of hydroponic career role models reflect content from a hydroponics-focused EFT?

RQ3: In their written reflections, what ways did youth describe applying hydroponics to their own lives?

METHODS

Study Design and Context. The study followed a qualitative, case study design (Yin, 2014) and employed arts-based data collection techniques through participant-made art as the primary data source (Leavy, 2020). The case parameters included a population of an urban Florida high school students as participants with an EFT acting as the intervention. Program impacts were measured using arts-based post-drawings and qualitative written responses. After participating in a live steamed hydroponics and greenhouse-growing 45-minute EFT in north Florida, student participants completed guided worksheets to create drawings to illustrate their perceptions of hydroponic growing techniques. Students also provided written descriptions of their drawings and responded to an open-ended prompt asking them to apply the EFT content to their own lives. The EFT took place at the UF/IFAS North Florida Research and Education Center–Suwannee Valley in Live Oak, FL in November 2022. Graduate students (including the two lead authors Dyment and Atkins) in a course in the Department of Agricultural Education and Communication (taught by author Loizzo) created and implemented the *From the Ground Up* EFT.

The EFTs examined followed the *Steaming Science* model that blends systemic instructional design and video production for content development and engagement (Loizzo et al., 2019). The hydroponics EFT was webcast live to high school students in class from the research center, with two UF/IFAS Extension specialists (Wanda and Hannah) serving as the hydroponics experts and another (Jay) who provided a real-time demonstration of a bucket hydroponics system that students could implement at school and/or home. The learning objectives were:

After the EFT students should be able to...

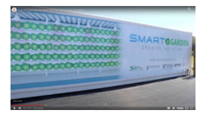
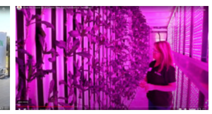
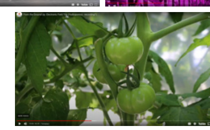
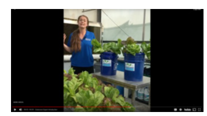
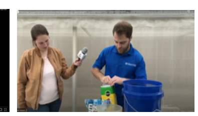
1. Define the term hydroponics.
2. Discuss the benefits of sustainable agricultural practices for our future.
3. Demonstrate how a hydroponics system and its various components (including technology).
4. Describe sustainable agricultural careers and job duties related to hydroponics.
5. Explain how hydroponics could be used in their daily lives.

Specific content, objectives, and further breakdown of the EFT in provided in Table 1.

Tracking analytics from the software used to stream the EFTs showed locations in Florida, Michigan, New York, North Carolina, Alabama, California, and Virginia tuned into the programs. The UF Institutional Review Board for Human Subjects approved the study. The research was part of the larger Streaming Science project funded by the United States Department of Agriculture–National Institute of Food and Agriculture.

Participants. Data were collected from a high school located in an urban area of Brevard County, Florida. While multiple schools from across the U.S. and Canada participated in the

Table 1. *Curricular Table with EFT Elements.*

Segment	Themes	Learning Objectives	Featured Expertise	Duration	Visuals
One	What is Hydroponics and Where Are We? *Introduction to hydroponics, the experts, and the research center.*	1	Row Crop Extension Agent (Jay) Extension Education specialist (Kelly)	10 minutes content 5 minutes question & answer (Q&A)	Experts and communication team Video roll in of the research center facilities and grounds  
Two	Crops and Different Systems. *Sustainable freight farm tour, technology, and greenhouse example.*	2,3	Row Crop Extension Agent (Jay) Extension Agricultural Assistant (Wanda) Extension Education specialist (Kelly)	10 minutes content 5 minutes (Q&A)	Video roll-in tour of freight farm smart garden, ultraviolet light, plants, technology, and tomatoes in a greenhouse   
Three	Future of Agriculture. *Bucket hydroponics demonstration, sustainability, and careers.*	4,5	Row Crop Extension Agent (Jay) Extension Agent of Commercial Horticulture (Hannah) Extension Education specialist (Kelly)	10 minutes content 5 minutes (Q&A)	Video roll-in explanation of sustainable hydroponics and live demonstration of bucket system  

EFT, this was the only school selected for this case study due to their willingness to participate and disclose student data. The total population of the school at the time was 565 students. Ethnicity of the school was predominantly white and Hispanic, although ethnicities of participating students were not specified. Teachers were recruited through *The Streaming Science Project*'s social media, an email listserv, and the project's website. Participants (n = 10) were in grades 10-12 and enrolled in a small, advanced placement science class. Of the 10 participants, five were female, two were male, and three did not disclose their gender. Five students were in 11th grade, four in 12th grade, and one in 10th grade.

Data Collection and Analysis. The methods used for the study can be described as arts-based, visual, and participatory (Leavy, 2020). Participants created visual art about a particular topic and answered written prompts pertaining to their artwork and perceptions; this is also commonly referred to as the "draw and write" technique (Angell and Angell, 2013; Leavy, 2020; McWhirter, 2014). After participating in the EFT, teachers provided students with a brief worksheet designed by the research team. Like the Draw A Scientist Test (DAST; Chambers, 1983), the worksheet instructions guided participants to draw a hydroponics grower working to develop a healthy hydroponics system, describe their drawing, and list three ways they could use hydroponics in their lives. All questions on the worksheet were designed to reflect the learning objectives, and students spent 15-20 minutes completing it.

We used arts-based research data analysis methods to interpret EFT imagery and participant-made art to examine participants' perceptions, attitudes, and knowledge (Aenlle et al., 2022). Through the drawings, we were able to observe participants' individualised articulations of their emotions, positionality, imagination, and understanding (Leavy, 2020). All data (EFT recording, drawings, drawing descriptions, and prompt responses) were coded by hand through a deductive and inductive coding process. We revisited the EFT recording, allowing us to review the provided imagery shown to participants. Using predetermined deductive codes, we noted the timestamps of each instance a code appeared in the EFT, recording these in an Excel spreadsheet. A separate spreadsheet marked codes in student drawings and prompt responses. This practice streamlined comparison of student imagery to related EFT images. To analyze the participant-made data, we exported PDF pages of student drawings and responses and marked codes on the sheets beside the corresponding image or phrase. These were then recorded in the spreadsheet, designating the matching student (identified numerically). Code frequency across student responses was the primary factor in determining not only the themes, but theme significance.

Our initial codebook included deductive codes such as *Smart Garden*, *bucket hydroponics*, and *farmer* pertaining to research questions chosen ahead of analysis, and identified inductive codes such as *wick system*, *accessibility*, and *Wanda* were identified and added to the codebook. To increase validity and reliability, data and researcher triangulation were employed through examining multiple data sources (EFT recording and drawings). Authors followed a constant comparison analysis process to independently code the data and then compare codes and coding decisions (Fram, 2013; Hewitt-Taylor, 2001). Codes with consensus were immediately accepted. Authors held discussions about diverging codes, explaining rationales for their individual decisions. This practice allowed different perspectives to emerge and be considered. All final codes were agreed upon and informed the formation of themes and, ultimately, the collage. Given the personal connections of certain researchers to the data, we employed crystallization (Lindlof and Taylor, 2011). Crystallization celebrates and joins multiple points of view and sets of knowledge formed by the researchers' experience with a group or culture, enhancing and enriching findings (Lindlof and Taylor, 2011).

The collage design process for data presentation ultimately aided in the analysis. One of the noted strengths of arts-based research is its ability to reach new insights in data, often finding new interconnections and presenting data in novel, accessible ways (Leavy, 2020). Collage design involved decisions of how to best present the data, including where to situate images and which themes should be emphasized. This process required thought into how the themes and codes meshed together, where they overlapped and diverged, and where images naturally fit. This innately prompted deeper and more mindful consideration of the data, its meaning, and what message the collage should invoke. Additionally, piecing the collage together illuminated connections not previously considered and revealed an overall connectivity among all themes that was formerly overshadowed by the individuality of various themes and concepts.

Researcher Positionality. The first and second authors (Dyment and Atkins) were enrolled in a graduate course that implemented the EFT examined in the study. Dyment assisted with video recording and editing of the freight farm hydroponics segment and served as an on-camera host for the EFT. She aligns with the constructivist paradigm, believing that people construct and assign their own meanings to reality, which can vary across individuals. Atkins assisted in developing a Teachers' Guide for the EFT, connecting the EFT content to state education standards. She subscribes to the pragmatic research paradigm and believes that reality is objective but is known imperfectly and from different perspectives. We all live in the same reality, but we do not all view it the same. The third author (Loizzo) founded and facilitates *The Streaming Science Project*, designed and taught the graduate course that implemented the EFT examined in the study, and served as Co-Principal Investigator (PI) on the USDA grant that funded the EFT and coinciding research. Loizzo also developed and taught a graduate-level arts-based research class that the first two authors enrolled in, analyzed the students' drawing data, and drafted the results for this study as part of their final course project. She subscribes to the constructivist research paradigm and believes human beings create and interpret their own reality which is not one-size-fits-all. The fourth author Stofer, also a Co-PI, is a Research Associate Professor in STEM Education who has worked for over 15 years in public engagement production and research. Stofer uses a pragmatic, postmodernist research framework. Last author DeCubellis was the PI on the grant. Both Stofer and Decubellis served as guest speakers in the EFT course, facilitated the overall grant project, and assisted with teacher/student recruitment, assessment design, and validating of the manuscript to limit the first three authors' biases due to their closeness with the EFT development and data. All authors had prior connections to agriculture and natural resources contexts from either their personal or professional backgrounds as well as an interest in science engagement and increasing youths' understanding of agricultural practices and careers.

Limitations. With a small sample size, our study cannot be considered a representative sample for all high school students in the United States. As a case study, this study provides a foundation for future, larger studies to replicate and produce more comprehensive results. Our participants attended one school, which further limited the results. There is a chance for bias in the results, as the researchers were heavily involved in the production and distribution of the examined EFT. However, transparency of data, constant comparison, and crystallization efforts served to mitigate biases in the results.

RESULTS

Given the visual component of the data, both in student drawings and EFT imagery, a visual representation of the study's findings was warranted. Further, the comparative nature of the EFT images and subsequent student drawings called for a visual medium to display the results to facilitate and highlight associations. Under the umbrella of visual arts participatory methods and participant-made art, a collage displaying results served as both a method of inquiry and representation (Gerstenblatt, 2013; Leavy, 2020). The collage brought the thematic findings to life as it interrelated students' drawings with common, prominent imagery presented in the EFT, and allows readers of this study to visually draw comparisons and trace relationships between the two image types. Each research question and coinciding themes are first presented in the following subsections. Then, the overall collage holistically depicting the results and their relationships is presented.

RQ 1: How did youths' visual representations of hydroponic growing techniques reflect content from a hydroponics-focused EFT?

Emergent themes in response to each RQ are listed along with parent and child codes used for labeling participants' related drawing features and written descriptions.

1. ***Students identified specific systems used for growing hydroponics.***
    a. Smart Garden
        i. Lighting
        ii. Electronic Monitoring
    b. Wick System
    c. Bucket Hydroponics
2. ***Students associated hydroponics with sustainable farming and food production.***
    a. Water
    b. Recycle/Reuse
    c. Produce (food/fruits/vegetables)

The student drawing in Figure 1 included codes *facilities*, *produce*, and *lighting*. The student drew a smart garden with "red + blue / purple lights" growing kale, which was represented in the EFT. Numerous students drew some form of *facility*, whether it was the panels of produce, the shipping container of the Smart Garden, or the rows of tomato plants. Many drawings also contained *produce*, interlinking the two codes in their imagery. The *wick system* was included as a child code of *facilities*, as it demonstrated structural understanding of a hydroponics smart garden. An example of youths' visual conceptualization of *sustainability* depicted in a simplified form was a student drawing of Wanda with a recycling symbol on her shirt. Additionally, student written responses yielded richer insight for their understanding of *sustainability*. One student specifically noted that their depiction of a hydroponics system included recycled water, which is a sustainability conservation practice.

RQ 2: How did youths' visual representations of hydroponic career role models reflect content from a hydroponics-focused EFT?

Themes and supporting codes included:

3. ***Some students identified Wanda, a woman UF/IFAS specialist, as a hydroponics grower.***
    a. Women
    b. Wanda
    c. University of Florida Specialist
4. ***Most students did not make obvious identifications of hydroponics growers.***
    a. Grower
    e. Farmer

The code *women* emerged as a prominent characteristic of people depicted in students' drawings, as seen in Figure 2, and three students' written descriptions denoted a female grower (like Wanda and Hannah, Extension agents featured in the program). UF/IFAS Extension agent Hannah gave a pre-recorded demonstration of how viewers could create their own bucket hydroponics system at home. UF/IFAS specialist Wanda specifically appeared in two of the pre-recorded EFT videos that were played during different segments. She guided viewers through a high-tech freight

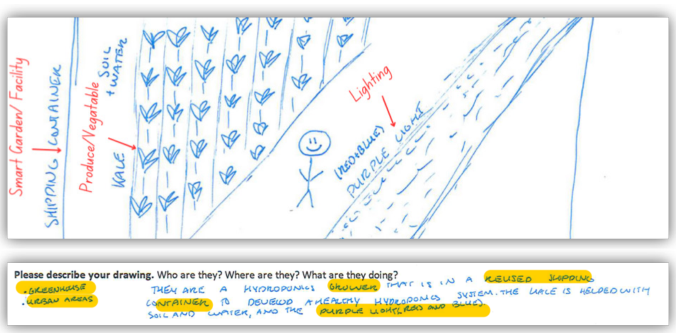


Figure 1. Example of one researcher's coded student drawing (above; codes are in red: *facility*, *produce/vegetable*, *lighting*) and written response (below; highlights demonstrate codes: *urban farming*, *grower*, *reuse*) that demonstrated understanding of hydroponics and sustainability concepts.

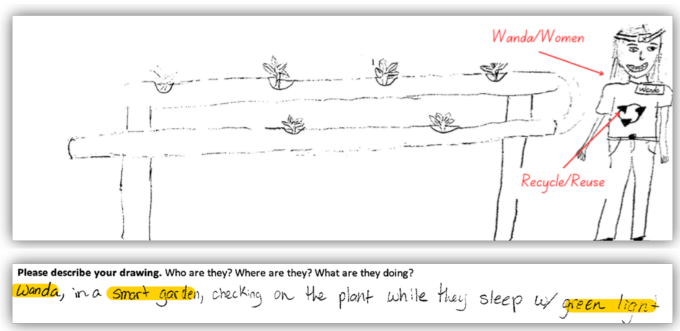


Figure 2. A student drawing and description showing the codes *Wanda* and *women*. The student drew Wanda checking on the hydroponics system with a green light, an action and technology specifically mentioned in the EFT.

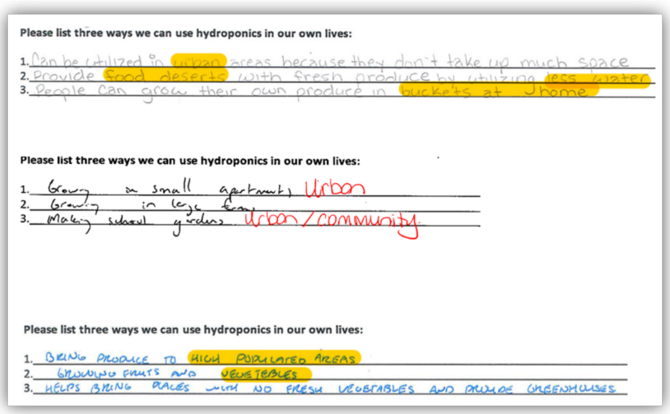
farm and greenhouse using hydroponics techniques and technologies. One student specifically included a nametag with *Wanda* on it. Another student wrote about a worker they created in their drawing as a *UF/IFAS Specialist*, indicating they also acknowledged the expert in the EFT content. One of the more interesting inductive codes was *farmer/grower*. Numerous students drew a neutral figure, noting it as either a farmer or a grower, with no organizational or gender affiliation. None of the students' drawings included specific clothing, nametags, or direct labels that indicated any of the depicted figures were meant to be Jay (the male Extension expert who hosted the EFT and gave the live bucket hydroponics demonstration).

RQ 3: In their written responses, what ways did youth describe applying hydroponics to their own lives?
Themes and supporting codes included:

5. ***Students associated hydroponics with sustainability and urban farming.***
    a. Urban Farming
        i. School Gardens
        ii. Small Apartments
    b. Food Deserts
    c. Sustainability
6. ***Students understood hydroponics to be an accessible form of producing food.***
    a. Accessibility
        i. "Grow Own Food"
        ii. "Buckets at Home"

The ubiquitous code was *urban farming* (Figure 3). For instance, Student 3 stated, "[Hydroponics] can be utilized in urban areas because they don't take up much space." Others, including Student 10, took a more abstract approach. Instead of explicitly mentioning urban farming, they described using hydroponics in typically urban settings familiar to them and wrote, "Growing in a small apartment," and "Making school gardens." Students also understood hydroponics as a means of growing in areas with minimal water or poor soil quality, connecting back to ideas of urban locations. Additionally, *sustainability* appeared in a different form than in RQ1/theme 2, when looking at youth's relationships with hydroponics. Student 2 stated, "Provide food deserts with fresh produce by utilizing less water," indicating a sense of sustainability to connect urban growing methods to food insecurity reduction and conservation practices to improve natural resources such as water quantity, access, and availability in communities.

The notion of *accessibility* appeared in some student responses. Student 1 stated, "We can grow our own food [using hydroponics]." Not only did statements such as this indicate hydroponics as an accessible form of growing, but it also showed the participant maintaining the use of "we" language from the writing prompt in their response and that they viewed hydroponics application from a first-person perspective. They believed that they could implement their own food growing systems and practices. Contrarily, Student 3 used third-person language and did not include themselves in the collective "we" of hydroponics users. Instead, the student wrote, "People can grow their own produce in buckets at home." The statement tied together the codes of *accessibility*, *urban farming*, and *bucket hydroponics*.


Please list three ways we can use hydroponics in our own lives:
1. Can be utilized in urban areas because they don't take up much space
2. Provide food deserts with fresh produce by utilizing less water
3. People can grow their own produce in buckets at home

Please list three ways we can use hydroponics in our own lives:
1. Growing in small apartments Urban
2. Growing in large farms
3. Making school gardens urban/community

Please list three ways we can use hydroponics in our own lives:
1. BRING PRODUCE TO HIGH POPULATED AREAS
2. GROWING FRUITS AND VEGETEBLES
3. HELPS BRING PLACES WITH NO FRESH VEGETABLES AND PROVIDE GREENHOUSES

Figure 3. Examples of three students' written responses that were coded for *urban farming* and "*buckets at home*."

Collage Representation of Themes. When considering complex and interconnected concepts in arts-based research, collage serves as a form of visually conceptualizing, categorizing, and contextualizing ideas and themes (Davis and Butler-Kisber, 1999; Butler-Kisber and Poldma, 2010; Capous-Desyllas and Bromfield, 2018). Data analysis yielded numerous interrelated themes among student drawings, presenting an opportunity to weave the concepts together in a visually compelling form. The following collage (Figure 4) represents the themes discovered in student drawings.

The holistic collage design encompasses not only the nature of the EFT, but also the subject matter of hydroponic growth. The vines of the tomato plant connecting to student drawings and EFT images signify the sustainable food growing theme of the EFT and the interconnectivity of all imagery; certain drawings contain multiple themes, and even the themes are interrelated. They all belong to the same, central concept. Student drawings overlap with multiple EFT images to showcase the duality of their content, creating a complex, interwoven collage of ideas.

The collage was sectioned based on *who* versus *what*. Inanimate objects, equipment, and plants were grouped to one side (e, d, f), while human elements were kept to the opposite side (a, b). While both are still linked, they represent distinct components of the hydroponic process. Both sides contain each element (human and inanimate), but placement

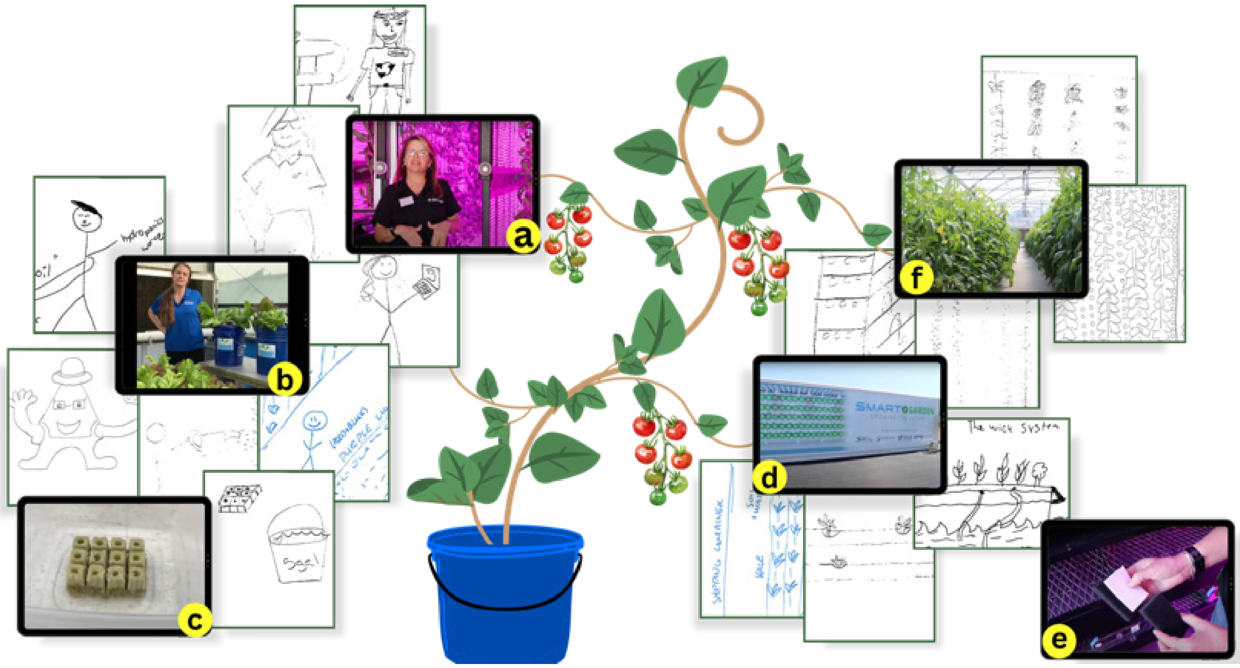


Figure 4. Collage of screen captures of EFT imagery alongside student drawings including similar content and concepts. EFT images include: (a) Wanda in the Smart Garden, (b) Hannah and hydroponic produce, (c) Growing cubes, (d) Smart Garden shipping container, (e) wick system, (f) Hydroponic produce in a greenhouse.

decisions were made based on the predominant element displayed and connections to surrounding themes.

To zoom in on portions of the collage and further showcase how it is a representation of the study's findings, Figure 5 highlights the themes *Students identified specific systems used for growing hydroponics*, and *Some students identified Wanda, a woman UF/IFAS specialist, as a hydroponics grower*, from RQ1 and RQ2 respectively. There are several similarities between the student drawing and the highlighted EFT image. The person the student drew resembles Wanda and is wearing a shirt that says "UF", like Wanda's actual shirt in the EFT imagery. The person in the student drawing is standing next to rows of hydroponic produce like Wanda in the image.

The student drawing in Figure 6 highlights the theme *Students associated hydroponics with sustainable farming and food production* from RQ1. The image from the EFT depicts hydroponic produce growing in a greenhouse, and the student drew produce growing in a similar fashion.

The student drawing in Figure 7 shows the theme *Students associated hydroponics with sustainable farming and food production* and *Some students identified Wanda, a woman UF/IFAS specialist, as a hydroponics grower* from RQ1 and RQ2 respectively. The image from the EFT depicts Wanda in front of the Smart Garden shipping container with an image of rows of hydroponic produce. The student drew Wanda (indicated by her nametag) wearing a shirt with the recycle/reuse symbol and standing next to rows of hydroponic produce.

DISCUSSION AND CONCLUSIONS

The study aimed to apply visual arts-based research methods to explore how a livestreamed, interactive EFT influenced youths' conceptualizations of hydroponics, related careers, and their understanding of sustainable agriculture. Overall, participants' drawings indicated the content and messages of an EFT can impact explicit and implicit understanding of ANR content and careers. Results showed youth included explicit imagery from the EFT in their post-draw-

Figure 5. A student drawing (left) compared to a screen capture of the EFT segment of Wanda in the Smart Garden (right).

Figure 6. Hydroponic produce image from the EFT (left), and a student drawing depicting a hydroponics grower and produce (right).

Figure 7. Wanda standing next to an image of rows of produce, and a student drawing depicting Wanda next to hydroponic produce.

ings, such as Smart Garden technologies and growing practices like bucket hydroponics, freight farm containers, and greenhouse techniques. The detailed post-drawings of explicit EFT content showed it is possible for youth to vicariously observe and comprehend ANR and STEM demonstrations through computer-mediated EFT communication and dialogue with experts, as posited by SLT (Bandura, 1977).

Imagery of women agricultural sciences career role models (Wanda and Hannah) from the video roll-ins that played during the webcast also featured in students' drawings. However, there did not appear to be any drawings of the male Extension specialist (Jay) who spoke live throughout the program and gave a bucket hydroponics demonstration, receiving the most air time of all Extension agents. Like decades of other studies that used the DAST (Chambers, 1983) to measure STEM outreach program impacts on participants' perceptions of scientists, this study also found that when a female career role model is featured, youth's post-drawings show likenesses of the woman. Featuring Wanda and Hannah in the program appeared to have influenced students' impressions of who can be hydroponics/greenhouse growers. According to SCCT, personal factors such as background, gender, race, etc. have the potential to impact a person's career path (Lent et al., 1994). Hence, youth who identified with role models in the EFT could have an increased interest in hydroponics careers.

For the drawings that clearly featured a female hydroponics expert ($n = 3$), the student artists indicated their gender was also female. The female students may have more implicitly included Wanda and Hannah in their drawings as they may have related more to them. It is important to note that the remainder of the drawings ($n = 7$) included stick figures, a non-gendered character, or did not include a person at all. This may have been because the instructions did not direct students to focus on gender, or the drawings without gender symbols were possibly intended to be male, while the drawings meant to depict female characteristics used specific symbols and language to stress the gender.

The visual medium of the collage allowed us to view not only the core themes in student drawings, but also the interconnectedness of the various themes. While concepts such as gender and sustainable food production may not be obviously connected from a surface level, many themes and concepts overlapped in student drawings, and all derive from the same EFT. The collage puts these linkages and connections on display while grounding all images to a common, core concept in a way written or oral descriptions could not. The collage also showcases both the student and EFT imagery in a unique way, allowing us to explicitly see the inspirations for student ideas and artwork. These benefits were essential to address RQs 1 and 2, allowing us to acutely explore how EFT imagery influenced students. The mirroring of imagery in the collage is an unambiguous representation of this influence and it provided us the opportunity to explore not only what themes existed in the data, but how they intermingled and worked together.

As the population grows in urban areas and youth are concerned about climate change, student written results indicate that EFTs could encourage youth adoption and implementation of sustainable tactics for agricultural practices. Students identified opportunities to apply hydroponics in a variety of settings, such as home and school, and for several reasons, such as growing food for themselves, others, or environmental preservation. Youth described the mechanics of hydroponics to grow their own food sustainably in small, urban spaces where soil quality may be poor and water access limited. Yet, they also included elements of helping solve community problems such as food deserts and feeding heavily populated areas. Some also mentioned hydroponics as helpful for the environment. Students appeared to connect and apply learned concepts from the EFT for both personal and community-wide benefit.

Recommendations and Future Research. Over the last seven years, *The Streaming Science Project* has researched EFT impacts on youth and teachers through pre/post-surveys, post-retrospective assessments, post-interviews, and pre/post-drawing comparisons. The prior studies have shown EFTs can positively impact participants' learning, conceptualizations of environmental conservation practices, feelings toward wildlife, and pro-environmental behavior intentions. This was the first study to compare participants' post-drawings directly to an EFT's imagery through visual coding and utilization of arts-based collage methods to display and analyze connections in the overall findings. Future research could examine additional EFTs about other ANR topics and career role models via the same visual arts-based research methods to determine if results are similar or differ between subject matter, live locations, demonstrations, and featured experts. As *Streaming Science* continues to innovate and connect ANR scientists and youth through EFTs, the project will move beyond typical pre/post-assessment research designs and continue to examine impacts through arts-based methods and add real-time assessments. The arts-based methods from this study should be expanded across multiple EFTs, topics, and participant groups. Narrative inquiry could also be used for youth to write stories about their perceptions of the program topics, demonstrations, and careers. Additionally, future research should focus on real-time assessment methods such as application of perception analysis software and metrics to examine participants' synchronous interest and engagement with EFT content and experts, qualitative analysis of live program transcripts and text chat, and analysis of live poll results with attitude, content knowledge, and open-ended questions embedded within the program. Future research may also examine impacts of presenter personality in terms of engagement of audiences.

Future live web-streamed programs such as EFTs about ANR topics for youth should to directly connect career role models in real-world research settings with schools and 4-H clubs for non-formal and informal STEM learning. The EFTs should feature more women and people from marginalized backgrounds. The experts could share about their histories and paths to their careers. Demonstrations through EFTs can introduce students to solutions such as sustainable agricultural techniques that they can apply to the communities around them. Science communicators and educators should coach featured EFT experts to connect their demonstrations to the program learning objectives and to dialogue with youth in a conversational, jargon-free way. ANR engagement program developers and experts should creatively push boundaries of locations to showcase real-world and cutting-edge contexts that audiences would not be able to see in person. Demonstrations must be focused on target messages and learning objectives to ensure participants can recall specific tools, tasks, and approaches needed to explain the concept to others, make connections to personal, community, and global contexts, and potentially replicate the featured models and behaviors in their own lives.

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ABBREVIATIONS

ANR: Agricultural and Natural Resources; DAST: Draw a Scientist Test; EFT: Electronic Field Trip; LED: Light-emitting Diode; PI: Principal Investigator; RQs: Research Questions; SCT: Social Cognitive Theory; SCCT: Social Cognitive Career Theory; UF/IFAS: University of Florida/ Institute of Food and Agricultural Sciences

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