AN ANALYSIS OF SUCCESS OF CITIZEN SCIENCE PROJECTS IN TUCSON

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HEATHER ROSE PETERS

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Approved by:

Dr. Jean McLain

Department of Environmental Science

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An Analysis of Success of Citizen Science Projects in Tucson

Abstract

Citizen science is an emerging method of research that encourages collaboration between professionally trained scientists and volunteers, wherein the volunteers' participation can range from data collection to project development. This paper examines current literature and two local citizen science projects to identify the benefits, challenges, and overall importance of environmental citizen science. The literature review revealed benefits for researchers and participants and the need for community involvement in scientific research for more complete findings. In order to gain a better understanding of local environmental citizen science projects in Tucson, Arizona, two interviews with project directors were conducted. The Barrio Research Project and Project Harvest both focus on sustainability and emphasize participant self-efficacy. I conclude that citizen science is an emerging field that is of vital importance to amplifying previously unheard voices and improving environmental research.

Introduction

Citizen science is an emerging method of research that opens new doors for research worldwide by incorporating members of the public who bring different types of expertise into scientific studies. Citizen science has grown in popularity rather recently, within the last 20 years, and is becoming increasingly prominent across multiple disciplines (Dickinson & Bonney, 2012). Citizen science is constantly adapting and changing to community needs and visions which allows researchers to incorporate a wide range of viewpoints, expertise, and societal changes into their studies. For example, recently the usage of the word "citizen" in the name of this field of research has been called into question. The current debate around whether to rename the field and what could replace the word "citizen" came about in light of the recent social and political climate in the United States and elsewhere and will be discussed briefly in the report. Although the discussion around the term "citizen" is ongoing, this report will still use the term "citizen science" to describe the projects studied for the sake of consistency. Due to the broad range of scale, implementations, and applications in this relatively new field, this report will focus on environmental science and sustainability citizen science projects. Specifically, I aim to evaluate how two local citizen science programs in Tucson, Arizona fit into the cross-disciplinary category of environmental citizen science.

To better understand the current trends within the field, the report will start with a literature review of relevant research on citizen science, including a brief overview of the model supporting citizen science, as well as an exploration of why research that involves the public is so important. In order to gain a better understanding of local citizen science initiatives, the literature review is followed by an in-depth examination of two projects from the Tucson area, including the results of interviews with the project directors covering their projects' funding, goals, and lessons learned. The questionnaire used in the interviews can be found in Appendix A. These interviews, combined with the literature review and information gained from examination of the respective websites of the two projects, illustrate some of the underlying motivations, best practices, challenges, and outcomes of citizen science projects that focus on environmental sustainability in Tucson, Arizona.

The two citizen science projects analyzed in this paper both incorporate topics of current concern in the desert Southwest. The first project, the Barrio Research Project, is run through a community farm called La Siembra, which aims to increase resident self-efficacy and environmental sustainability within the surrounding neighborhood. The project itself aims to conserve a native species of lizards through education and habitat preservation and restoration. The second project, Project Harvest, also aims to increase participant self-efficacy and sustainability through the testing and monitoring of soils irrigated by harvested rainwater for possible contaminants. Although the projects are in different stages of their development, the interviews conducted revealed similar overarching goals and methods that align with the goals of citizen science as a whole.

Citizen Science Literature Review

Citizen science at its most basic level is a collaborative effort between trained scientists and members of the public to address questions posed by their research. The scale of these projects has a broad range of participation, complexity, and application, even within the discipline of environmental science (Dickinson & Bonney, 2012). Some public participation is limited to data collection, while other projects involve the participants in other aspects of research, such as project development and sharing of findings. Early citizen science projects fell mainly into the former category, often aided by internet databases (Dickinson & Bonney, 2012). However, recently the citizen participants' influence has expanded to project development and data sharing stages. This method of research is beneficial, not only to the participants but also for the accuracy of the research itself. In the following pages, current literature will explain the benefits and importance of this emerging methodology.

Benefits

A unique aspect of citizen science is the wide diversity in participants: diversity in age, socioeconomic status, and cultural background of data collectors is not unusual. For example, participants in citizen science are not always adults, and some research projects specifically recruit youth and young adults to gather data. A few examples of environmental citizen science projects that are intended for children are The Oak Bodyguard Citizen Science Project (Castagneyrol, 2020), a Horseshoe Crab Citizen Science Program (Hiller & Kitsantas, 2014), and biodiversity monitoring projects in Ireland (Donnely et al, 2014) and several other countries (Schuttler et al, 2018). However, the question has been raised on whether the data gathered by young citizen scientists is accurate. How does it measure up to data gathered by trained, professional scientists? A study from 2020 found that while children may have some errors in their data collection, it is no more inaccurate than untrained, professional scientists. In both cases, quality checks on the raw data can be performed in order to ensure usability (Castagneyrol, 2020).

Involving children in citizen science projects has numerous benefits. A study of middle school students showed that the students who participated in a summer citizen science program monitoring Monarch butterflies helped the students develop better science fair projects. The science fair projects showed that children who had engaged in citizen science had improved scientific reasoning, analysis, and ability to draw conclusions. In addition, the students enjoyed the opportunity to experience the time and some of the procedures that go into being a scientist (Koomen et al., 2018). Another study illustrated that environmental citizen science projects can benefit child participants' development and encourage continued involvement in environmental science and justice as adults. The natural world that children typically encounter and interact with when participating in environmental citizen science projects has been shown to support mental and emotional well-being into adulthood. Also, the programs instill values of environmental stewardship, democracy, and participation in science (Makuch & Aczei, 2020). Multiple studies showed that youth participation in citizen science increased the children's sense of self-efficacy and future motivation to pursue a career in a Science, Technology, Engineering, and Mathematics (STEM) discipline (Makuch & Aczei, 2020; Hiller & Kitsantas, 2014) and increased their overall interest in science and conservation (Donnely et al., 2013; Schuttler et al., 2018).

Adult participants see similar benefits from participating in citizen science. Some effects can even be seen community-wide. Studies show that citizen science can benefit participants' self-efficacy, literacy, and capital, whether it be social, political, technological, or otherwise (Bremer et al, 2019). A Dutch study of an air-quality citizen science project where participants collected data and input it into an app found that volunteers better understood the topics of the project after participating, even though they did not have a comprehensive understanding of the science (Land-Zandstra et al., 2016). Another study on benefits for participants examined a Rwandan Malaria control citizen science project. Researchers found that participants also gained a better understanding of project topics. The study indicated increases in self-efficacy in volunteers, information sharing within the community, and interest in participating in future citizen science projects (Domina et al., 2020). Analysis of a community-initiated Tsunami awareness and preparedness project in New Zealand also supports these findings. Scientists discovered that citizen science projects can help build community resiliency through building self-efficacy on the individual and community level, and increasing community involvement, social capital, leadership, trust, and sense of community, among other benefits (Doyle et al., 2020).

One method of ensuring citizen science and the benefits associated with it are available to a wide range of demographics, particularly underserved communities, is utilizing existing social infrastructure such as *promotoras. Promotoras* are community health workers who are well known and trusted by members of their community; the information that they share with the community participants of the study will in turn be deemed trustworthy. A study done on Project Harvest found that including *promotoras* was especially important in establishing connections between project researchers and the participating communities. This is because the *promotoras* had a previously established social network and the expertise to allow them to serve as educators and support for the families participating in Project Harvest (Davis et al., 2020). *Promotoras* were able to act as go-betweens for participating citizen scientists and the professional scientists.

Importance

With numerous potential benefits shown across multiple studies, the popularity of citizen science is increasing along with its importance and impact. Several reasons brought up in the interviews and supported by peer-reviewed literature support the importance of citizen science. A key point to highlight is that scientific research and the community both benefit from citizen experts' involvement. According to a study done by anthropologist Dr. Melissa Checker of Hyde Park in Augusta, Georgia on local environmental justice movements and their interactions with the Environmental Protection Agency (EPA), risk assessment procedures have been suffering since the 1990s from a lack of community input. After suffering for decades from living in an area surrounded by industrial sites and railroad tracks, the residents of Hyde Park convinced the EPA to do a study of the surrounding water and soil for contaminants in the early 1990s. Although the EPA's field study found no areas with contaminants over the level of being at risk to human health, residents were not convinced by this data. They cited decades of higher incidents of chronic illness, cancer rates, and birth defects, as well as experiences with floods exposing them to polluted water (Checker, 2007).

After public outcry and years of environmental justice action by the Hyde Park community, the residents of Hyde Park were eventually relocated over a period of seven years. In 2016 the community was entirely relocated and the area was razed and turned into a flood control pond by the City of Augusta (Hansen, 2017). As Checker explains, risk assessment studies may not consider inconsistencies between the lab and real-world conditions. Relying only on laboratory data without considering the culture and demographics of the people at risk may lead to incomplete findings (Checker, 2007). By including the community, as community-led citizen science projects do, risk assessments and other research can avoid potential scientific bias from laboratory results that may not consider the effects of multiple chemicals, the time over which people have been exposed, and the toxic awareness that comes from living in an area.

Not only does citizen science allow for more comprehensive and inclusive findings, but examples exist where citizen science may have prevented scientific studies from doing harm, demonstrated by an EPA-led cleanup of a PCB (polychlorinated biphenyls) contaminated Superfund site on the Akwesasne reservation in New York and Canada. After determining the fish in St. Lawrence River to be contaminated with PCBs, a group of chemicals that can cause birth defects, cancer, and other serious diseases, in 1978 the Mohawk Council of Akwesasne issued a fish advisory prohibiting pregnant and nursing people, women of childbearing age, and children under 15 from eating fish from the surrounding water. Other demographics were told to limit their consumption. In 1984 the EPA declared the area a Superfund site. This advisory, along with data from decades of environmental studies had a devastating effect on the surrounding Akwesasne Mohawk community (Hoover, 2013).

In addition to impacting their economic livelihood by preventing fishing, the advisory also hurt the health of people who had previously relied on local fish as a main food source and had profound cultural impacts, including the loss of language and traditional relationships fostered by the fishing, preparation, and eating of fish. The study concludes that the focus on risk avoidance rather than risk reduction and the absence of cultural considerations were the root causes of these harms. Once studies found that the surrounding community was suffering due to the fish advisory, clean-up efforts began with dredging the contaminated river sediments and removing the factories that caused the pollution. The study asserts that the fish advisory was treated as a long-term solution rather than a short-term, temporary one until the river could be cleaned and fish safely consumed again. If the Akwesasne Mohawk culture of fish consumption had been considered in the risk assessment process, the information about who could eat fish and how much fish they could have, as well as the risks, may have been better understood by the community. Instead of cutting out fish entirely, some groups could have continued to consume local fish (Hoover, 2013). Failing to consider cultural implications led to devastating cultural and economic losses, which a citizen science or community-based research approach may have prevented. However, citizen science and other community-based participatory research could help avoid this in the future.

Citizen science can aid in the effort to adapt to calls for greater inclusion of the public in scientific research, especially government-funded research. However, the word “citizen” can be exclusionary to those that are not citizens in the legal definition of the word. This is a problem because, ideally, citizen science includes, and is open to, all people within a community and all relevant forms of expertise. Excluding the demographic of immigrants, documented and otherwise, who do not have citizen status also excludes a wealth of knowledge and critical perspectives on current and future research (Lowry & Stepenuck, 2021; Eitzel et al., 2017). Some members argue that it should be renamed “participatory science,” while others have suggested the word "community." Some programs have already changed their name, like the Natural History Museums of Los Angeles Community (formerly citizen) Science Program (Why community science?, n.d.). However, Dr. Sacoby Wilson, the director of the Center for Community Engagement, Environmental Justice, and Health (CEEJH) at the Maryland Institute for Applied Environmental Health has criticized this. He contends that community science is already practiced in the environmental justice movement. Consequently, appropriating the name of an already established form of research would be wrong and may lead to confusion. The discussion over how to adapt the name "citizen science" to something that reflects the goals of the practice while respecting other movements and fields is ongoing.

Citizen science is an emerging field that shows great promise. The current literature demonstrates the potential of citizen science projects to increase data collection, public engagement and understanding of environmental topics, and bridge the divide between science and the public. The following interviews are examples from Tucson, Arizona, and southern Arizona that offer insight into the current efforts to bring the environmental benefits of citizen science to Tucson and beyond.

Flowers & Bullets: La Siembra

Image 1. Photo of goats grazing at La Siembra, retrieved from Flowers & Bullets website (n.d.)

The Flowers & Bullets Collective is a grassroots environmental justice and sustainability organization that started in early 2012. The founders, Tito Romero and Jacob Robles, who are Latinx and Indigenous men, have lived in the central Tucson neighborhood called Barrio Centro their whole life. Through Flowers & Bullets, they wanted to combat the effects of systemic economic and environmental racism using art and, later through the addition of Dora Martinez, using gardening (History, n.d.). One of the projects that the group has started recently, called La Siembra or the Midtown Farm pictured above in Image 1, focuses on citizen science and community involvement in local urban agriculture efforts. La Siembra means “the season of sowing” in Spanish. The name was chosen because the goal of La Siembra “is to transform a closed public elementary school campus into a neighborhood resource [in Julia Keen] that can help feed, educate, employ and empower local residents toward a more resilient, sustainable and hopeful future" (La Siembra, n.d.). In order to accomplish their goal, the Midtown farm has crops, chickens, goats, and community events and workshops. One aspect that makes La Siembra a true citizen science project is its partnerships with the University of Arizona and the School Garden Program. These partnerships allow La Siembra to apply for grants to fund the farm and to support individual research projects such as the Barrio Research Project currently headed by Mallary Rae Parker (they/them), who was interviewed for this project.

Image 2. Regal Horned Lizard, pictured at La Siembra taken by M. Parker (July 28, 2020).

The Barrio Research Project (BRP) is an effort to record data about local flora and fauna on the farm and in the surrounding neighborhood and conserve endangered species like the Regal Horned Lizard, *Phrynosoma solare*, pictured above in Image 2. These lizards are native to the desert areas of Arizona, New Mexico, and Sonora, Mexico (Rorabaugh, 2019). Due to habitat loss, these lizards have become less common in urban areas, although they are not classified as endangered (M. Parker, personal interview, March 8, 2021). The lizards are beneficial to humans in that they eat harvester ants, the large dark ants commonly found in backyards in Tucson, which are aggressive when defending their nest and can sting (Schalau, 2019). This makes the lizards good natural pest control. The project started in June of 2019. According to Mx. Parker, there are two phases of the project. The first phase is what they call the "talking phase" and involves determining the project purpose and goals, talking to community members and other academics, and planning (M. Parker, personal interview, March 8, 2021).

Dr. Philip Rosen, a research scientist in the School of Natural Resources and the Environment at the University of Arizona, originally brought the idea of conserving the Regal Horned Lizard to Mx. Parker's attention. When they questioned the community members about the lizards, Mx. Parker found that many people had similar memories of the lizards from their childhood. People who grew up in the neighborhood and surrounding areas remembered seeing and playing with the lizards, namely putting them on their backs and rubbing their stomachs to put them to sleep. However, Mx. Parker cautions against handling the lizards unless it is necessary to move them. After recalling this collective memory, people often mentioned that they had not seen as many lizards recently. With the connection between the community and the Regal Horned Lizard established, the project entered the second phase or the "Data Phase" at the end of last year, 2020 (M. Parker, personal interview, March 8, 2021).

One tool BRP uses to collect data is the phone app iNaturalist. The app was created by the California Academy of Sciences and the National Geographic Society. It can be used as a learning tool as well as a data collecting tool for citizen science projects (Seltzer, 2021). The project leader can create a project, in this case the BRP, and then other users of the app can submit their observations to the project. These observations are geotagged to help with accurate reporting. In this way, the project leader, Mx. Parker, is able to collect data about the various flora and fauna sightings, not just the Regal Horned Lizard, from around the community. While Mx. Parker acknowledged that the app is not perfect because not everyone who participates in the project has a phone, it is still an effective tool. They are currently developing a hard-copy worksheet version of the iNaturalist data submission tool that community members can pick up from the Midtown Farm. The hard-copy data sheets are then entered into the app manually. On March 20, 2021, the project hosted a BioBlitz. A BioBlitz is when community members and researchers get together and spend a few hours collecting data. These and other community events hosted at and around the farm pictured below in Image 3 are frequented by children and adults from the surrounding area.

Image 3. A Community Gathering at La Siembra, retrieved from the Flowers & Bullets website (2019)

According to Mx. Parker, a large number of participants are families with children and homeschooling programs. The children want to learn more about science and the environment they live in. As discussed earlier, the literature and Mx. Parker's personal experience shows that the hands-on experience makes science more accessible to children from demographics that might not feel welcome in the field otherwise. Their involvement has the added benefit of learning about nature as something that exists in their own backyard, not just in parks and other places traditionally considered natural. Considering how the current COVID-19 pandemic has moved many activities, including school, into the home, the experience provided by citizen science projects like the BRP has the potential to ease the transition into at-home learning.

However, with the COVID-19 pandemic, there have also been several changes and setbacks for the BRP. Mx. Parker identified three main effects of the pandemic on the project: fewer participants, delays and extensions, and the stress of processing personal sickness and global pandemic. Due to the large percentage of homeschool participants, the pandemic caused a decrease in participation both in the BRP and at La Siembra in general. Although both projects are outdoors, maintaining health and safety, mask protocols, and social distancing practices all affected the ability of the Midtown Farm to operate as it had previously. The COVID-19 pandemic and subsequent change in what activities were safe also meant that the BRP's timeline had to be extended and research was largely delayed. Lastly, the stress of personal illnesses, intermittent exposures and subsequent quarantines, and the stress of living through a pandemic all affected operations at La Siembra as well.

Image 4. Native shrubs and water conserving landscaping on the border of La Siembra farm, retrieved from the Flowers & Bullets website (n.d.)

La Siembra combines core principles of community-led and community-supported citizen science. The project was initiated through collaboration between professional scientists from the University of Arizona and community members' experiences with the native lizards. The residents of the Julia Keen and Barrio Centro neighborhoods can gather data through the iNaturalist app that helps track the Regal Horned Lizard, while they learn about scientific methods and other local flora and fauna. Residents and volunteers at La Siembra also help through reestablishing native plants and sustainable planting practices that help conserve the Regal Horned Lizard's habitat as seen in Image 4. Community members, especially children and young adults, are given the opportunity to experience scientific research first-hand and to connect with the surrounding environment.

Project Harvest

Image 5. A typical rainwater harvesting system Source: Sonora Environmental Research Institute, Inc.

While the Barrio Research Project at La Siembra is still in the early stages of development, Project Harvest is concluding. Project Harvest is a community-led citizen science project based at the University of Arizona and funded by the National Science Foundation. The project started in 2016 with the objectives to harvest rainwater for the irrigation of home and community gardens and then to monitor the water, soil, and plant quality. An example of a typical rainwater harvesting set-up in shown in Image 5. Because the communities participating in Project Harvest are often located either in areas impacted by mining or in urban areas (Tucson), it is possible that harvested rainwater can contain contaminants that could hinder the quality of irrigated garden produce. The project trains participants in the scientific method and how to measure contaminants in soil and water. The data collected by citizen researchers and environmental scientists from the project is combined to create a comprehensive dataset. The goal is to use this co-created dataset is to "inform guidelines and recommendations for safe, harvested rainwater use on gardens" and to provide Arizona communities with the information needed to safely harvest and use their own rainwater (About, 2021).

In our interview, Project Harvest director Dr. Mónica Ramírez-Andreotta (she/her) emphasized the importance of community-led research, including the need to listen to the community before starting a project, especially local leaders like *promatoras*. As described in the literature review, *promotoras* are an essential part of Project Harvest. They provide a social network through their relationships with community members. Trainings, like the one pictured in Image 6, on how to test harvested rainwater and soils for contaminants can be disseminated through the *promatoras* to the rest of the Project Harvest participants. Through their pre-established connections, *promotoras* are able to provide trusted information to all members of the community, including Spanish-speaking participants that may have faced challenges in participating without the *promotoras*. Keeping to this tenet of citizen science, Dr. Ramírez-Andreotta started the project in 2015 with a community needs assessment (M. Ramírez-Andreotta, personal interview, April 6, 2021).

Image 6. A training session where *promotoras* (seated) are learning the methodology for rainwater testing from University of Arizona researchers (standing) that they will in turn teach to community participants.

The assessment found that many members of the neighborhoods participating in Project Harvest had questions about the quality of rainwater they were gathering and whether it was safe to use on food-producing gardens. After determining what the community wanted to know, Dr. Ramírez-Andreotta wrote a grant application, that included the participation of University of Arizona researchers, local experts on rainwater harvesting, *promotoras*, and dozens of community members which she received in 2016 and so was able to start the next phase of the project: training project participants in water and soil collection and analysis, collecting data from thousands of water, soil, and plant samples (pictured below in Image 7), and working with participants. Now the project is in the final phase of analyzing and disseminating the data gathered with the help of the citizen scientists, while simultaneously measuring the benefits experienced by participants. The goal is to create a database of contaminants in soils and water for the three different areas included in the project, with participant access first and later public access to anyone who could benefit from the data (M. Ramírez-Andreotta, personal interview, April 6, 2021).

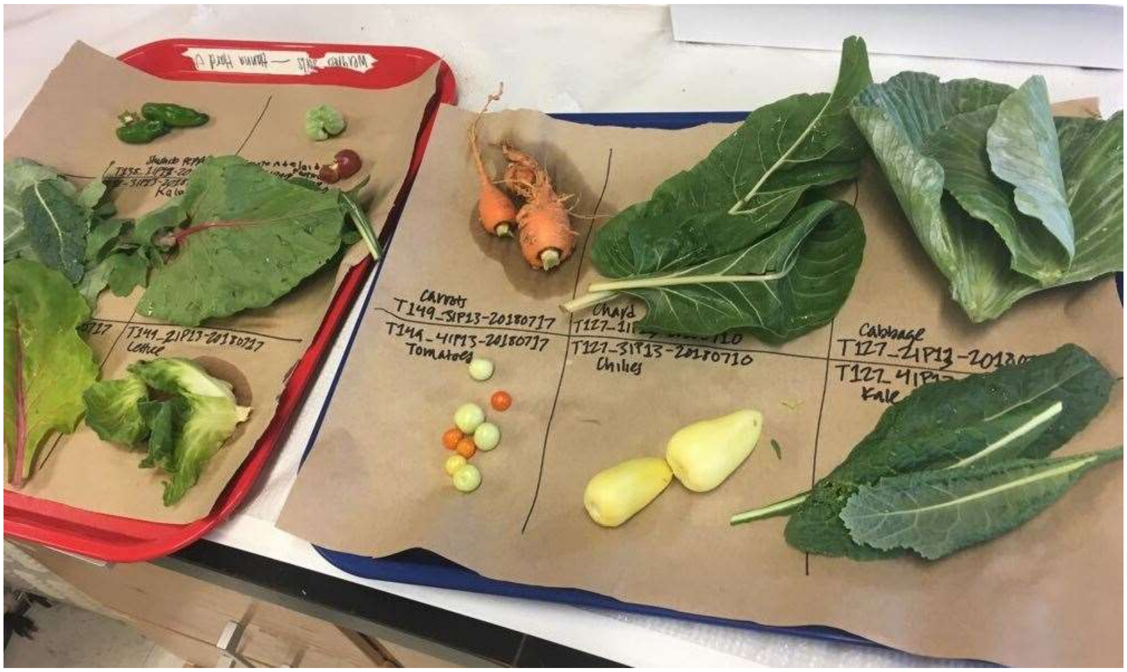

Image 7. Harvested vegetables being analyzed for contaminant content.

Dr. Ramírez-Andreotta has recorded several benefits for participants in Project Harvest, some of which are also discussed in citizen science literature. She emphasized the importance of using mixed methods for measuring participant effects and benefits such as written pre- and post-surveys with open-ended questions, focus groups, follow-up interviews, regular communication with participants, participant observations, and encouragement of journal entries to name a few. As a result of Project Harvest activities, community cohesiveness and action have both seen increases. One example she provided was a participant who recognized that a local mining operation was exceeding fugitive dust limits, so the participant reported the incident to state regulators, who ensured the dust was brought under control. This example illustrates the increased self-efficacy and empowerment to make change that Dr. Ramírez-Andreotta has noted in this and previous citizen science projects. Another benefit Project Harvest participants experienced was increased numerical and scientific literacy. Project Harvest not only trains nonprofessional scientists on how to measure contaminants in soils and water but also teaches them how to interpret data. An interesting finding initially pointed out by a *promotora* was that the ability to interpret data about contaminants in their soils and water carried over into interpreting COVID-19 data. This unintended but welcome benefit allowed a noteworthy percentage of participants to better understand trends of the pandemic and the graphs depicted in the media because of their experience with Project Harvest (M. Ramírez-Andreotta, personal interview, April 6, 2021).

Image 8. A data sharing night, when community members come to the UA to learn the results of chemical and biological analyses of their harvested rainwater.

Although participants were better equipped to process the data about COVID-19, the pandemic still negatively impacted the project. Similarly to the BRP, safety protocols such as social distancing and avoiding large gatherings hindered the way Project Harvest operates.

Sampling, home visits to discuss findings, community meetings like the one pictured in Image 8, and other processes central to the operation of the project became risky, especially for vulnerable members of the community. Unfortunately, there were complications with moving the data collection and all communications online. Internet access in rural and underserved communities is low, which made data sharing and virtual meetings difficult. Those that could attend virtual meetings had to adjust to a new communications format (such as Zoom) which did not always allow for easy communication. The loss of prominent community leader Elementary school teacher Kimberly Chavez Lopez Byrd and her brother, among others, to COVID-19 deeply affected Project Harvest participants and University of Arizona researchers. The losses fortified Dr. Ramírez-Andreotta's determination to postpone community gatherings. In-person gatherings are still on hold for the time being, but Dr. Ramírez-Andreotta and other members of the Project Harvest team are working to finish the database with their results, compile the experiences of participants with the project, and determine what the community wants to do next (M. Ramírez-Andreotta, personal interview, April 6, 2021).

Dr. Ramírez-Andreotta's past experience with citizen science includes projects in Boston, Massachusetts, and the Garden Roots project in Arizona, all of which shapes her approach to current and future projects. From her experience in these past projects as well as her work with Project Harvest, she emphasizes the importance of "meeting people where they are, and listening" (M. Ramírez-Andreotta, personal interview, April 6, 2021). Through co-learning and mutual respect, Dr. Ramírez-Andreotta and other researchers gained access to intergenerational knowledge about gardening from participants who had been growing food crops for years. The data gathered by participants also showed a pattern of higher contaminants present in harvested rainwater during monsoon seasons. Dr. Ramírez-Andreotta theorized that this is likely because of the buildup of contaminants on roofs and in the gutters from dust and particulate matter settling during the long periods without rain. Although she is an experienced director of citizen science projects, Dr. Ramírez-Andreotta learned a great deal from Project Harvest. The conclusion will elaborate on lessons learned, along with key similarities and differences between this project, BRP, and projects discussed in the literature review.

Conclusion: Similarities, Differences, and Lessons Learned

Interviews with leaders from both citizen science projects stressed the importance of self-efficacy, community involvement, and environmental stewardship. However, the interviewees had two different perspectives as one project is just beginning and the other is coming to a close. Dr. Ramírez-Andreotta explained a few of the main lessons she learned from Project Harvest and running a citizen science project through a pandemic. She emphasized the importance of visual aids, especially instructional videos on how to collect and analyze samples. Dr. Ramírez-Andreotta said that most of the participants preferred visual aids and videos over the instructional manuals and that if she had to do the project over, she would invest in visually-based tools first. Another important takeaway is the importance of the *promotoras.* Dr. Ramírez-Andreotta emphasized that these community health workers were the keystone of the project. The literature shows the importance of including and communicating with the community, and *promotoras* provide a key pathway between the community and university researchers.

Both Dr. Ramírez-Andreotta and Mx. Parker learned that while the internet is a useful tool, an entire project cannot rely on it, especially when those projects involve underserved or rural communities. Many examples of citizen science projects use the internet and phone apps to collect data and fulfill outreach (Donnely et al, 2013; Seltzer, 2021; Dickinson et al., 2012;

Land-Zandstra, 2016; Schuttler et al, 2019). However, both directors emphasized the importance of in-person community meetings to share findings, hear concerns, and build community connections. This illustrates the general trend away from citizen science projects where participants only collect data, and towards citizen science where participants are involved from the start from project development to data collection and all the way through to sharing their findings. In fact, some of the *promotoras* in Project Harvest will share co-authorship in scientific publications arising from Project Harvest.

The more involved participants are in the projects, the more benefits scientific research and the participants themselves will see. Research projects will benefit from the expertise participants bring and the increased opportunity for data collection when recruiting a whole community (Checker, 2007; Donnely et al., 2013; Hansen, 2017; Schuttler, 2019), while participants experience benefits ranging from building scientific knowledge and career skills to increased self-efficacy and community resiliency (Bremer et al., 2019; Domina et al., 2020; Doyle et al., 2020, Davis et al, 2020). Along with the numerous benefits, the increasing prevalence of citizen science in environmental research and its growing capacity to amplify expertise and perspectives of previously unheard voices makes this emerging field of research vital to environmental science and the scientific community as a whole.

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Appendix

Appendix A- Interview Questionnaire

1. When did you first start working on this project? That is, when did the idea for this become something you put into motion?
    a. When did the project officially start?
    b. What inspired you to start the project?
2. What did the process of starting this project entail?
    c. Did you have to go through any city/state/federal government processes?
3. How did you get the funding you needed?
    d. What were some of the challenges in acquiring funding?
    e. Do you still struggle with those now that the project is established?
4. How do you engage the community?
    f. Alt: how did/do you get the word out about your project?
    g. Have you seen a change in participants' attitudes toward science and sustainability since they've become involved?
        i. Have you seen a change in the community at large?
    h. What do you do when members of the community stop participating? How do you encourage participation?
5. How many people work/volunteer for this project?
6. How has the COVID-19 pandemic affected your project?
    i. How do you continue to do this work with social distancing protocols?
7. What future do you want to see for your project?
    j. What improvements/changes would you like to see?

k. How do you envision your project growing?

8. If you could go back and give yourself advice from when you were starting this project, things to avoid, or things you wish you had done sooner, what would you say?

    l. Alternatively, what advice would you give someone starting a community science project?