

Characteristics Of Non-Formal K-12 Pathway Programs Aiming To Enhance Diversity In Environmental Science

Lexi Caldwell
Durham, NC.

Dr. Nicolette L. Cagle
Duke University

Ilan Bubb
Saipan, CNMI

Madi Evans
Durham, NC.

Savannah Horton
Texas General Land Office

Jia Jiang
Ping An Technology

Abstract

To prepare individuals from underrepresented backgrounds to pursue academic and professional careers in environmental science, pathway programs aim to prepare participants for the 'next step' toward careers in environmental fields. We conducted interviews with non-formal environmental education programs aimed at K-12 student participants to: 1) understand the current objectives of non-formal environmental science-focused K-12 diversity pathway programs; 2) document techniques used to recruit and engage participants; and 3) identify approaches used by environmental science-focused K-12 diversity pathway programs to evaluate the effectiveness of recruitment and programming. This study reveals that while programs may target particular underrepresented demographic groups, program objectives are not always aligned with increasing diversity in the field or retaining those participants in environmental science careers. Additionally, findings demonstrate a lack of statistically validated participant recruitment strategies, teaching methods, and program evaluation techniques. We discuss the implications of these findings for K-12 environmental science pathway program stakeholders. We also offer areas for future research in environmental education programming and methods for evaluating program effectiveness.

Introduction

Environmental science innovation is critical to the advancement of sustainable development, particularly in addressing global environmental problems such as climate change, natural resource depletion, plastic use and disposal, and habitat loss (Fukasaku, 2005; OECD, 2001). Concomitantly, there is a growing number of jobs in the environmental science fields, including conservation biology, environmental engineering, ecotoxicology, water resource management, and environmental policy. The benefits of a diverse workforce have been well documented, as demographically diverse groups are likely to be more innovative than homogenous groups (van der Vegt, 2003). However, while employment in environmental fields grows, women and Latinx, Black, and Indigenous people remain underrepresented in these professions (Taylor, 2018c).

A number of challenges disproportionately prevent members of specific identity groups from persisting in STEM fields, including marginalization, cultural disconnection, and socioeconomic barriers (Allen-Ramdiel & Campbell 2014). While first-year undergraduate women and first-year students Black and Latinx students are as likely to enroll in STEM programs as men and White students, they are also more likely to switch to non-STEM majors (Anderson & Kim, 2006; Chubin, May & Babco, 2005; U.S. Department of Education, 2000). While many factors may influence retention, studies have indicated that inequality in pre-college academic preparation, such as through exclusion of minority youth from advanced classes, may play an important role (Riegle-Crumb et al., 2019).

Moreover, the historical relationship that many African American people have with the environment may influence their attraction to and retention in environmental science fields. Finney (2014) suggests that an African American's engagement in environmental science is often influenced by collective memory. For example, field work may elicit a sense of adventure to a White community, but it might remind an African American of the outdoor labor of enslaved Black people in the United States. Furthermore, depictions of outdoors and the environment often exclude Black people. Thus, pathway programs must recognize the inter-generational traumas of slavery, colonization, and subsequent land privatization and degradation, and historical disenfranchisement in environmental spaces. The increasing demand for qualified individuals in environmental science provides opportunity for environmental professions to become more representative of the population at large, provided systems are established to address existing barriers, and to address the inter-generational traumas of slavery, colonization, and related land privatization and degradation.

Prior research suggests that Black students may be interested in different areas of the environmental workforce than White students. Black students engaged in STEM fields are slightly less interested in outdoor and wildlife careers than White students, including working with the USFWS, environmental non-profits, nature centers, zoos, aquariums, and botanical gardens (Taylor, 2018b); however, Black students are interested in working with

environmental justice organizations (Taylor, 2018b). In another study, Black students ranked as very connected to nature 25% less often than their White peers, and were less often "very curious" about nature (Taylor, 2018a). Black students were also less likely than White students to identify as conservationists, but more likely to identify as scientists and environmental justice practitioners (Taylor, 2018b). These data should be considered when developing programs to engage students from underrepresented backgrounds in STEM fields, specifically in the environmental sciences.

Many organizations have established environmental pathway programs to prepare participants from underrepresented groups for the 'next step' toward a career in environmental fields. In one report, of 1039 environmental organizations studied, 17% offered diversity pathway programs targeting a variety of age groups (Taylor, 2018c). Other environmental pathway programs are developed through partnerships between school districts and universities. Such programs may provide learning experiences for elementary through high school students to develop interest prior to these students determining their career path. Some of the strengths and gaps of environmental organization pathway programming have been identified; for example, while there exist programs to target participants of all racial, socioeconomic, and gender identities, and while 23.4% of programs have a leadership or career development component, post-program support is generally lacking across these programs (Taylor, 2018c).

To understand how K-12 environmental pathway organizations currently work to recruit and retain a greater number of individuals from underrepresented backgrounds in these fields, we explored the following questions in this study: 1) What are the primary objectives of K-12 diversity pathway programs in environmental fields, 2) What techniques are used to prepare students for the next stage in the pathway, and 3) What data-driven, statistically supported evidence exists to support the use of current techniques to recruit participants, teach disciplinary content, and prepare students for the next stage in the environmental science pathway. Here, we present findings from interviews with K-12 environmental science pathway programs from across the United States, taking a qualitative approach. This manuscript concludes with rec-

ommendations for practitioners seeking to modify their techniques for recruiting and retaining individuals from underrepresented backgrounds in STEM through K-12 pathway programs.

Methods

The research was conducted in three phases: participant recruitment, interviews, and qualitative analysis. Participant recruitment and interviews took place simultaneously. Once the data analysis began, recruitment efforts ceased.

Participant Recruitment

We used online search engines and snowball sampling (i.e., referrals from organizations) to identify programs willing to be interviewed for this project. Keywords in searches included “diversity”, “environmental education”, and “K-12”. Once potential programs were identified, we sent out a recruitment email (Appendix A). Organizations supporting environmental pathway programs for K-12 students, with local, national, and international reach, were considered for participation. We define K-12 environmental pathway programs as those programs that explicitly worked with or sought to work with under-served (e.g. Black, Latinx, Indigenous, female, low-income) K-12 students in outdoor settings or with the intent of teaching environmental content or skills. Of the 55 pathway program representatives contacted by email and phone, 17 (30%) representatives were successfully interviewed.

Interviews

All interviewees were considered leaders within their organization (CEO, executive director, director, program manager, outreach coordinator, or diversity & inclusion manager), ranged from their early 20s to late 50s, and included 10 women and 7 men. Semi-structured interviews, lasting between 30 and 45 minutes, were conducted over the phone. During the interviews, participants were asked to comment about the state of diversity in environmental science fields, the populations their program targets, participant recruitment, strengths and weaknesses of current programs, and how they aimed to prepare participants for the next stage of the environmental pathway (i.e. college or career).

After obtaining consent to record the interview, the following questions were asked:

- What are your general thoughts on (human) diversity in environmental fields?
- What types of diversity e.g., underrepresented minorities, women, LGBTQ, socioeconomic) are you most concerned about in environmental fields? What types of diversity does your pathway program target and why?

- Now I'd like to think more explicitly about the work that you're doing in terms of environmental pathway programs. By this I mean a program that seeks to increase the representation of a particular group in environmental fields. I'd also like to focus on the work being done at the K-12 end of that pathway, that is from kindergarten to senior year in high school. First, please briefly describe any work that you're doing that you would consider part of a K-12 diversity pathway program in environmental fields.
- What are the primary objectives of your pathway program? Do those objectives differ from typical K-12 pathway program objectives? If so, how?
- What techniques does your program use to recruit participants? Which of these is most successful? What types of relationships does your program have with community partners or other institutions? How did those relationships begin? How are those relationships maintained?
- What techniques does your program use to teach disciplinary content? Which of these are most successful?
- What techniques does your program use to prepare students for the next stage in the pathway (e.g., if a high school program, preparing for college)? Which of these are most successful?
- What other strategies is your program using for success? What are the strengths of your current program?
- What are the weaknesses of your current program?
- How does your program evaluate success? Do you have resources that you use that have provided statistically validated techniques for recruitment, teaching disciplinary content, or preparing students for the next state in the pathway?
- What advice would you give an elite university entering the realm of K-12 pathway programming?
- What other programs do you know of that do similar work?

The above questions were asked in each interview, but additional and variable follow-up questions were used to elicit further explanation. All interviews were transcribed by the interviewer.

Coding

Interview transcripts were analyzed by two researchers, who coded for different themes or nodes established by the structured interview questions. Nodes addressed major themes among the interviews. Examples of nodes include:

- Thoughts on diversity in the environmental field
- Program objectives
- Ways the program prepares students for the next stage in their environmental education pathway
- Strategies for recruiting students to participate in the

pathway program

- Methods of evaluating program effectiveness

To ensure both researchers were coding in the same manner, three preliminary interviews were coded in NVivo 11, a qualitative research software program, by both coders. All of the transcripts were read once before coding to identify key themes and motifs. Although primarily a qualitative study, frequency was recorded for each node and subnode for all interview transcripts.

Results & Discussion

Diversity in Environmental Education

When asked to explain their understanding of the state of human diversity in environmental fields, 56% of participants explicitly noted that diversity was lacking in environmental fields. Statements reveal that program representatives understand that environmental fields are not representative of the demographics of the United States. Specifically, 35% of respondents reported that the field is dominated by White people.

There are many more teachers and admin that are involved in environmental education that are White [2018, Interview 1]

[Diversity in environmental education] is definitely not representative of the population divide [2018, Interview 7]

We need to increase diversity across the board [2018, Interview 4]

I still think the overall diversity of the environmental education field does not represent society at large [2018, Interview 6]

It is much more White and upper middle class [2018, Interview 6]

While a majority of respondents discussed the lack of diversity currently in environmental fields, 56% also reported that they believed that there has been improvement regarding diversity.

I have noticed a vast improvement when I first started. Just scientists in general, there were fewer women and over time that's really changed [2018, Interview 1]

My initial thoughts on the state of diversity in environmental field is that it's slowly becoming more diverse because organizations and groups are becoming more conscious about it [2018, Interview 13]

I would say that things are on a positive step forward [2018, Interview 9]

These data reflect a concern for lack of representation in environmental education, and environmental science more broadly. Prior research suggests that students' aca-

demographic self-belief and academic outcomes are enhanced when they are demographically similar to their educator (Egalite & Kisida, 2018). If students' environmental educators do not share identities with students from marginalized backgrounds, K-12 pathway programs may provide additional opportunities to support students in cultivating positive experiences in environmental sciences. Lack of visible representation may be an additional barrier to students from underrepresented backgrounds integrating a scientific identity, one predictor of pursuit and retention of science careers (Hurtado et al., 2009). K-12 pathway program educators to share identities with participants, or to include a mentorship component to support students viewing themselves as environmental scientists. Several respondents indicated that they view environmental education as becoming more diverse, suggesting that K-12 pathway programs may be one part of a larger movement already in progress.

Program Objectives and Diversity

When asked to identify the objectives of their program and the role of diversity, equity, and inclusion in those objectives, 50% of study participants responded that encouraging students to pursue STEM fields, including environmental science, was a main objective.

The main priority here is to expose them to this field and want to stay in this field [2018, Interview 13]

The plan is to get students interested in science. I guess it is just science, and while we do focus on environmental science, our goal is to get students to realize their potential in STEM and have a desire to reach new levels in high school and college and potentially a career [2018, Interview 2]

Maybe this is one of the first things I said about our program and what we do to help connect students with opportunities in the environmental field and its really that network effect [2018, Interview 3]

The second most common objective (36% of respondents) was to expose students to the outdoors and connect them directly to the environment.

Trying to get kids out and get them connected to those water bodies locally [2018, Interview 1]

Our big goal is to try and get these kids to our nature reserves [2018, Interview 7]

I work with students of all backgrounds in connecting them to our place where we live and our relationship to it [2018, Interview 8]

Of the study participants interviewed, 82% responded that their programs targeted specific populations. The demographic group most frequently targeted by the programs in this study were individuals from low-income backgrounds (56% of respondents).

We reach some lower socioeconomic areas that un-

fortunately in the South really translates to racial divide [2018, Interview 1]

Our goal is to work with kids that are economically disadvantaged and live in environmentally dangerous areas [2018, Interview 6]

Although the vast majority of programs had specific participant populations in mind that would lead to the overall increase of diversity in the field, only 41% of programs explicitly mentioned increasing diversity or building diversity in the field as a *primary objective* of their respective programs.

Nearly all of the programs interviewed had intentional demographic targets, suggesting that these programs may provide opportunities for individuals from underrepresented backgrounds to be exposed to environmental sciences. Still, few programs expressed the long term objective to increase diversity in environmental science careers. So while programs may intentionally *recruit* individuals with identities that are underrepresented in environmental science, the programs may not tailor their *programming* around the skills, interests, strengths, and needs of the participating group. To overlook the underrepresented group that is being targeted while designing the program is to ignore the rich knowledge that these students bring to these programs, and that can serve as valuable assets for their immersion in STEM (González et al., 2005). When programs and organizations are targeting specific groups of individuals, particularly those who have been marginalized in the field, it is important to understand the environment in which they learn best and to provide access to experiences that will be most meaningful (Kanu, 2006). If programs hold increasing diversity as a central objective, coordinators may better plan K-12 program curricula to benefit the student stakeholders.

Connecting students to outdoor experiences was the second-most frequently cited program objective. If students engage in outdoor learning in a location that is geographically near their hometown, they will be able to directly relate their learning to their personal background (Wlodkowski & Ginsberg, 1995). Relating content to life experience in this way is an essential component in culturally responsive pedagogy, teaching that uses "the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (Gay, 2010). By connecting their learning to their lives, a diverse group of pathway program participants may recognize the relevance and applicability of environmental science. Moreover, outdoor learning experience can facilitate pro-environmental attitudes and behavior in students, which may provide the framework for students pursuing careers in environmental science (Mannion et al., 2012).

Environmental Pathway Preparation Techniques

Almost all of the programs interviewed were open to K-12 students inclusive (81%) while the rest focused their efforts exclusively on high school-aged populations (19%). Respondents indicated different techniques to prepare students for the next level of involvement in their environmental academic and career pathway, but the most common preparation method was through mentorship programs (33%).

One of the things that they think is really important is to have the university students talk about their backgrounds and their academic majors. Because it is making college seem relatable and attainable for the students [2018, Interview 10]

We also brought a lot of Native American undergraduate students to serve as resident assistants and mentors [2018, Interview 4]

Another 29% of programs mentioned efforts to expand their participants' leadership skills to promote involvement within their local communities.

I hope some of the skills we taught them like, communication, time management, and research skills are transferable to other disciplines as well [2018, Interview 4]

We do leadership development to help students realize their potential and that they can be leaders [2018, Interview 2]

Mentoring encompasses a wide variety of activities, most of which benefit the mentee through socialization, learning, career advancement, psychological adjustment, or preparation for leadership (Johnson 2016). Common mentoring activities that have shown some success in the E-STEM literature include connecting to other education levels (e.g., high school to college, undergraduate to graduate school), putting student achievements in the spotlight, introducing students to professional and scientific societies, fostering peer-to-peer interaction, building community, communicating with students about career opportunities, and communication with students about how their careers in E-STEM fields can help others (Sherman-Morris and McNeal 2016; Hurtado et al. 2010; Wolfe and Riggs 2017; Mourad et al. 2018; Olson and Riordan 2012). Mentoring has proven to be a valuable method for assisting school-aged students, especially those from underrepresented backgrounds, in being more engaged in school and more successful in careers (Lindt & Blair, 2017). Research indicates that mentoring provides key social support and helps students cultivate the positive identity needed for success in environmental and STEM fields (Reid, Ross, & Yates, 2016; Mourad et al., 2018; Olson & Riordan, 2012; Ong et al., 2011). Mentoring programs can also serve to provide needed academic and even financial support, which is often important to the success

of underrepresented minority and low-income students (Wolfe & Riggs 2017). That mentorship was a component of a number of programs in this study aligns with prior research on environmental organization pathway programs, which cite that 17.4% of such programs included a mentoring component (Taylor, 2018c).

While the majority of the environmental pathway programs interviewed lack robust statistical frameworks for monitoring the success of their methods, they are in fact using an approach with a wide-spread support in the academic literature, i.e., mentoring. While the effectiveness of the organizations' mentorship efforts are unknown, generally mentorship is one of the more powerful methods in engaging youth in future academic and professional careers and has the potential to cultivate a variety of social and academic supports necessary for student success (Irby et al., 2017). Peer mentorship in particular has been demonstrated to be a method of providing students with underrepresented identities a core group of individuals in environmental science with whom they may be able to identify (Good, 2000).

Environmental organizations mentioned a number of methods for preparing students for the next step in their pathway toward environmental fields. Of the preparation methods mentioned, those that build leadership skills and self-efficacy may be particularly important for promoting diversity within the field. Self-efficacy is a precursor to action competency in environmental education, i.e., taking formal education and turning into actionable steps. In 1977, the first intergovernmental conference was held in Tbilisi, Georgia, by UNESCO, to establish the goals and tenets of environmental education. The resultant Tbilisi Declaration established as two guiding principles the importance of learners having "a role in planning their learning experiences and making decisions" (self-efficacy) and "developing critical thinking and problem-solving skills" (leadership) (UNESCO 1978). Prior research on pathway programs within environmental organizations cites that 23.4% reported having leadership or career development components (Taylor, 2018c). One literature review indicates that self-efficacy is an infrequently cited objective of K-12 pathway programs (Cagle et al., 2018). Programs should consider building self-efficacy and leadership activities into their program curriculums to ensure short-term and long-term effects in promoting student engagement with environmental education.

Evaluation Techniques and Resources Used

Of the programs interviewed, the most frequently mentioned techniques used for evaluating the success of the program were pre- and post-tests for students (62.5%) and pre- and post-surveys of the students (56.25%). However, when organizations were asked about their recruitment strategies, methods for preparing students for the next step in their environmental pathway, and teaching methods, 82% of programs reported that

they were not using evidence-based techniques to support those program components. While other programs were uncertain if their methods were backed with statistically validated data, two programs reported that they had some data on successful techniques.

I would say we have some strong personnel here that are well seasoned in the field. And that is really a tremendous value. Because those individuals are creating the opportunity. But program wide, is there something that specifically addresses it? No, I would say probably not [2018, Interview 1].

At least at this point, it's more of a self-reflection, so it's less about looking at change and the participants content knowledge or ideas of the forest preserves, and more about what they got out of the program [2018, interview 14].

We are relentlessly trying to improve our program quality. But you know there is one thing I wish we could really do, is be able to more accurately quantify the impact of our program, and we are always looking for insights on that one [2018, Interview 3].

We've been part of a couple of different studies. The Youth Program Quality Assessment one is probably the one that is the most validated. We're also part of the Neon School Study, in which they are doing pre and post surveys with our kids that have validated our success. Last year they were kind of working out the kinks, so we'll have some good pre and post data. Our program was pretty unique so we only got post data. [2018, Interview 8].

We have a peer reviewed scientific research project, SPSS, and over 100 surveys [2018, Interview 15].

I've been focusing and paying for researchers, and we're also in a pilot study for outdoor schools in the state of Oregon to look at some common measurement tools to actually get some validated data...I'll be curious to see how that turns out [2018, Interview 8]

Moreover, after reviewing interview transcripts, vocabulary commonly used among those with training (e.g., by non-profit organizations or academic instances) in diversity, equity, and inclusion was seldom used. For example, the terms and phrases "racism," "sexism," "systemic inequality," "systemic," "cultural competence" were not used in any interviews. The term "equity" was used three times over two interviews, and the term "inclusion" was used five times over three interviews.

The majority of the representatives interviewed stated that they did not use or know of statistically validated techniques for recruiting program participants, i.e. recruitment techniques that are effective for their target audiences as measured by statistical tests. Because the programs do not have measurements of their recruitment

success among different sub-groups, this suggests that many K-12 pathway programs may be neglecting to reach potential participants of the intended demographic. For example, if a pathway program aims to recruit participants of low socioeconomic status, if their recruitment method is primarily digital they may be failing to reach those that do not have reliable internet access. While quantitative evidence is not the only meaningful kind, empirical studies on recruitment practices may support programs in identifying blind spots in their current methods and in reaching previously overlooked participants (Stern et al. 2014).

The K-12 pathway programs represented in this study did not use a consistent metric for evaluating program success. Efforts into creating cross-cutting assessment tools for environmental education programs are underway. Standardized program evaluation scales such as ee21 (created by Marc Stern and Robert Powell) and DEVISE (created by the National Science Foundation) offer opportunities for comparing data across a wide array of environmental K-12 pathway programs. By using such tools, K-12 pathway program directors can extend beyond anecdotal evidence and site-specific surveys. Evaluation scales that can be used by multiple pathway programs of different types have the potential to facilitate communication between programs to promote development of best practices for recruitment, teaching, and evaluation techniques.

Implications for Practitioners

Practitioners can use this research to guide their environmental education pathway program objectives and evaluation methods. Pathway programs may consider including "enhancing diversity" as an explicit program objective and design recruitment efforts, pedagogical techniques, and evaluation techniques around the mission of supporting individuals from marginalized populations as they navigate the next step in their environmental science pathway. When establishing mentoring as a component of an environmental education program, organizers should consider following research-supported guidelines to make these efforts most effective for participants and should obtain intensive training themselves. Finally, practitioners of environmental pathway programs should be aware of the standardized resources that exist for program evaluation and utilize efforts to collaborate and share best practices with related organizations to better serve the participants.

Future Research

This study lays a foundation for future work into the structure and evaluation of environmental science pathway programs at the K-12 level. After identifying the most popular techniques for engaging participants (mentoring, education, self-efficacy, and leadership skills), there

is an opportunity to collaborate and share best practices within disciplines to develop the most effective pathway program possible. Additionally, this work presents the need for current environmental science pathway programs to move toward a universal, statistically validated evaluation system that will facilitate programs to share outcomes and best practices. More research is needed to determine which recruitment and teaching techniques are most effective at preparing students for the next step in the pathway.

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Lexi Caldwell is a Biology and AP Environmental Science teacher in Durham, NC. She received her Bachelor of Science in Biochemistry and Molecular Biology from the University of Richmond and her Master of Arts in Teaching from Duke University. Caldwell has conducted basic research in the evolutionary adaptations of alpine flower species, as well as translational research in hepatitis B virology and liver cancer biology.



Dr. Nicolette L. Cagle is faculty in the Nicholas School of the Environment at Duke University. She also serves as the Director of Undergraduate Diversity, Equity, & Inclusion and the Director of the Communications Studio in the Nicholas School. Dr. Cagle has a background in ecology, natural history, environmental education, and environmental communication; and she has published articles encompassing a diverse array of topics, from snake species habitat relationships to comprehensive pedagogical approaches to significant life experiences in environmental fields.



Born in Gainesville Florida, **Ilan Bubb** received his M.E.M. in Coastal Environmental Management from Duke University. Currently the National Coral Fellow for Saipan, CNMI, Ilan is working to integrate fire management within the island's three priority watersheds into established coral conservation priorities and goals. In doing this he will fill in knowledge gaps regarding the connection between upland fires and the sedimentation of coral reefs. In addition Ilan will work with Saipan's Bureau of Environmental and Coastal Quality to implement best management practices to facilitate fire suppression, erosion control and invasive species removal.



Madi Evans is a high school Chemistry teacher in Durham, NC. She received her undergraduate degrees in Biology and Psychology from the University of North Carolina at Chapel Hill and her Master of Arts in Teaching from Duke University. Evans has conducted basic research on the brain basis of emotions and peer relationships on psychological outcomes.



Savannah Horton is a Natural Resource Specialist for the Texas General Land Office. Before taking this position, Ms. Horton completed her Masters of Environmental Management degree at Duke University. Ms. Horton has a particular interest in community-based environmental management.



Jia Jiang currently works as an analyst for Ping An Technology in Shanghai, China. Before taking this position, Ms. Jiang completed her Masters of Environmental Management degree at Duke University. Ms. Jiang has an interest in inclusive solutions to environmental concerns, and has particularly focused on climate change and transportation and atmospheric pollution in urban areas.



Appendix A. Sample of email script sent to prospective interviewees.

Hello [name of prospective interviewee],

My name is [name of interviewer] and I am a [position of interviewer] at the Nicholas School of the Environment at Duke University. I found this contact email on your website sciencegals.org

My team and I are conducting research on best practices in environmental education K-12 diversity pathway programs. Would you be willing to schedule and participate in a 30-45 minute recorded interview to facilitate research on the goals, approaches, and best practices of environmental K-12 diversity pathway programs? In the interview, you will be asked a series of questions, to be answered from your perspective as an expert in the field. Again, the interview should last 30-45 minutes and will be recorded. Your name will not be associated with the data collected, and all responses will be reported in aggregate.

If you are willing to participate or have any questions, please reply to this message or email the head of the project, [name and email of PI here].

Sincerely,

[Name of interviewer]