



Investigating the Influence of Sustainability Workshops on Behavior: An Experimental Study

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Investigating the Influence of Sustainability Workshops on Behavior: An Experimental Study

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A Thesis in the Field of Sustainability
for the Degree of Master of Liberal Arts in Extension Studies

Harvard University

May 2025

Abstract

With the increasing intensity of climate change, there is a growing need to identify effective interventions to promote pro-environmental behavior (PEB). An experimental study evaluated the effectiveness of a multi-component intervention consisting of environmental education, a carbon footprint analysis, an action planning activity, and social interaction combined into a live-virtual workshop format on fostering PEB among individuals already engaged in the climate space. The final analytic sample was composed of 146 participants, divided into a waitlist control group and a treatment group. Data were collected through baseline and follow up surveys and supplemented by optional virtual interviews. The results revealed that the treatment group incorporated twice as many new sustainable actions than the control group post-intervention across the six behavioral categories ($M = 1.38$ vs. $M = 0.75$, $p = .006$). The treatment group noted that the carbon calculator was the most impactful aspect of the intervention (31.5%, $n = 23$). Although the intervention increased PEB, it did not influence overall environmental knowledge. Both groups exhibited similar intrinsic motivations, environmental concern and social responsibility, as well as extrinsic barriers, financial and time constraints. Of those in the treatment group, 46.5% ($n = 20$) shared intervention learnings with their communities suggesting that the intervention may have a more wide ranging impact beyond the direct participants. Overall, the research findings support the concept that a workshop can promote PEB in individuals with preexisting high levels of sustainability knowledge and engagement.

Acknowledgments

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Onwards and upwards!

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Chapter I

Introduction

*"Never doubt that a small group of thoughtful, committed citizens can
change the world; indeed, it's the only thing that ever has."*

—Margaret Mead

The rate of climate change has been and is accelerating at a remarkable pace, posing an urgent threat to the planet and its inhabitants. Since record-keeping of the Earth's surface temperature in 1850, global temperatures rose approximately 0.11 degrees Fahrenheit (0.06 degrees Celsius) per decade until 1975 when the rate more than tripled to 0.36 degrees Fahrenheit (0.20 degrees Celsius) per decade (National Centers for Environmental Information, 2024). The rate acceleration is indicative of the intensifying impact that human activities have made and continue to make on the environment. Moreover, there are currently no signs of substantial global warming mitigation as 2024 was the warmest year on record, with all ten of the warmest years taking place during the last decade (National Centers for Environmental Information, 2024).

The United Nations Development Programme (2024), in collaboration with the University of Oxford, expanded on their previous "People's Climate Vote" survey, now reaching 77 countries and representing 87% of the global population. This was the largest global standalone public opinion survey on climate change at the time. The survey found that 56% of the respondents thought about climate change on a daily or weekly basis, with 53% more worried about climate change than the year before. Despite the fact that

the majority of individuals exhibit at least a basic understanding and awareness of climate change, this has not translated into significant action to counter the problem.

The Intergovernmental Panel on Climate Change (2022) stated that, although immediate action must be taken by all sectors in order to circumvent climate change, Working Group III Co-Chair Priyadarshi Shukla noted that 40-70% reduction in greenhouse gas emissions could be reached by 2050 if lifestyle and behavior changes were facilitated by policies, infrastructure, and technology. This is a silver lining in a predominantly dire situation as behavior changes could allow for not only decreased emissions but also wider, enduring societal changes.

This begs the question: how can we more effectively translate awareness into action? Previous literature suggests that no singular intervention type is successful in prompting long-term pro-environmental behavior changes (Rau et al., 2022). However, an intervention that combines multiple, tested behavior change methods may prove to be successful in promoting sustained climate action.

Research Significance and Objectives

This research addressed the critical need for individuals across the globe to translate climate awareness into climate action. From August 2023 to December 2024, I worked as the Director of Community at The Carbonauts, a sustainability-focused startup company. The goals of this group were multi-faceted with the principal focuses being on building “eco-innovative cultures for Fortune 1000 clients via cohort-based workshops and climate community via their events series” (The Carbonauts, n.d.-b). During the time that I spent at the company, I was fascinated by the potential that these workshops had in shifting mindsets from climate awareness to climate action. Although these workshops

were primarily implemented in large corporations, the teachings within the workshops are universal.

My fascination metamorphosed into the presented research. Despite the fact that The Carbonauts collected attendee feedback on a regular cadence via surveys with embedded Net Promoter Scores, a customer satisfaction metric, there had not been a formal research study delving into the behavioral workshop effects. The purpose of my research was to investigate the ability of these workshops to drive sustainable behavior, with the added curiosity of whether or not they also affected knowledge. Furthermore, the assessment of motivations and barriers to action was of interest as a means of potentially catalyzing further change.

As my department focused on community building within the climate space, a broad gathering of individuals with an interest in sustainability spanning from the novice student to the accomplished professional, it was apparent that this is a novel subset of the general population. Besides the high levels of motivation that The Carbonauts' community exhibited to advance the climate field, these individuals also presented exceptional levels of eco-proficiency. This introduced an interesting opportunity to assess the frequently cited sustainability "knowledge-action gap" with a group that had a high degree of knowledge in the space (Knutti, 2019). If this research could uncover a verified technique to bridge this gap, it could be indicative of a broader, efficacious intervention. Moreover, many of these passionate individuals could be in a position to share learnings with the community at large, making them possible vectors for a wide-ranging societal influence.

The objectives of my research were:

- To conduct a workshop intervention consisting of live-virtual environmental education, a carbon footprint calculator teaching, an action planning activity, and social interaction with a convenience sample
- To evaluate whether the workshop intervention had an effect on participants' sustainable actions and/or knowledge over a one month period compared to those who did not take the intervention
- To identify common barriers that prevent participants from taking climate action
- To determine common factors that motivate participants to engage in climate action
- To assess whether participants spread the workshop learnings to the broader community

Background

This literature review provides an overview of behavior change interventions that, if combined, could point to a novel treatment method.

The Theory of Critical Mass

At such a vital point in the climate crisis, it leaves many wondering how their individual actions could possibly make a difference at scale. Approximately 47% of Americans agreed with the statement “the actions of a single individual won’t make any difference in global warming,” as illustrated in Figure 1 (Leiserowitz et al., 2024). This sense of powerlessness may be especially prominent in individuals who are not in high-

power positions like government officials or corporate executives since they do not have direct control over major policy or business decisions.

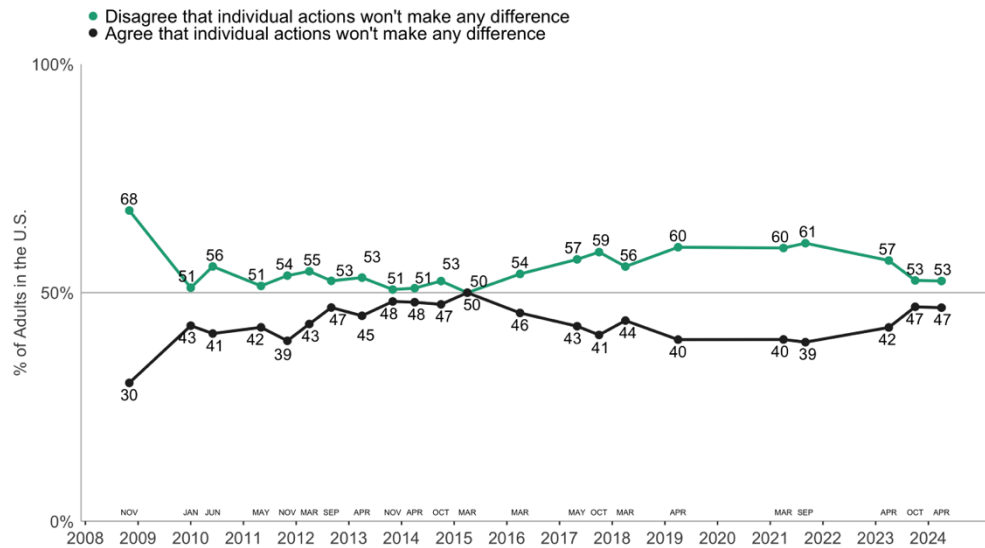


Figure 1. Belief that individual actions can mitigate climate change.

Note. The percentage of Americans who believe individual actions can make a difference in the context of climate change by year. Adapted from (Leiserowitz et al., 2024).

However, the literature suggests that small groups can spark social convention changes and that the power of these groups stems from their commitment to the cause and not from their affluence or authority (Centola, 2013; Xie et al., 2011). The theory of critical mass encompasses the belief that when a minority group of committed individuals reaches a certain size, “critical mass” (CM), then this would lead to a societal shift from the current social norms, and post-tipping point, it is believed that the views of the minority rapidly spread to the rest of the population, leading to large-scale behavior change (Centola et al., 2018). This theory suggests that individual actions, even in a small subset of the population, can make a large-scale difference if the group reaches CM and remains dedicated to their beliefs.

Centola et al. (2018) ran an experimental study, based on past theoretical and qualitative research, testing what percentage of the population would need to be reached in order to hit CM. Participants took part in paired naming tasks which led to recognized conventions within groups. After this, “confederates” (committed minorities) were introduced into communities in order to test how they would affect the previously agreed upon social conventions. They found that, if the committed minority made up at least 25% of the population, the community was significantly more likely to change their views to align with the minority. The overall CM levels throughout the ten groups were summarized with the gray points indicating when the CM was less than 25% and the black points indicating when the CM was at least 25% (Figure 2).

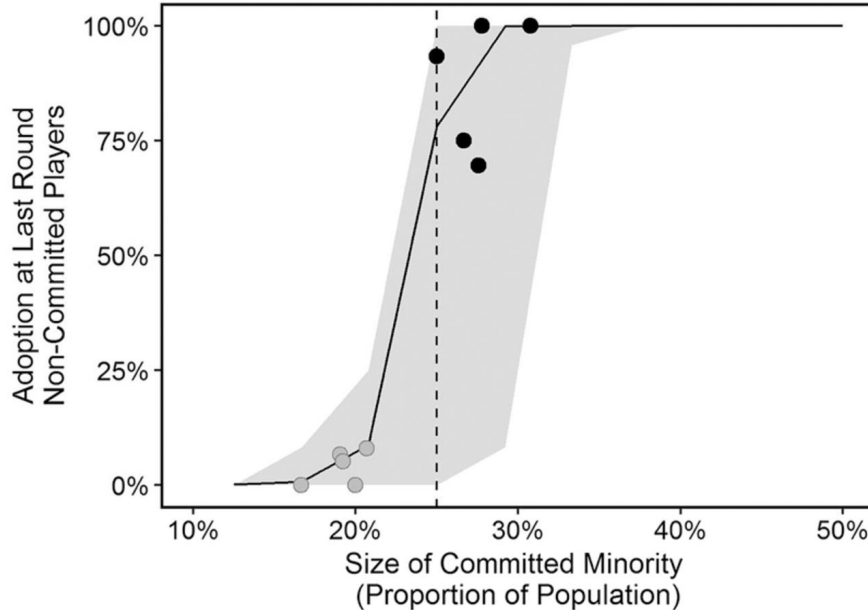


Figure 2. Optimal critical mass size.

Note. This figure illustrates the proportion of the committed minority in relation to the empirical trial population, and the percentage of the majority that adopts the conventions introduced by the minority. Adapted from (Centola et al., 2018).

The theory of critical mass indicates that societal shifts are possible even with a small subset of the population. Perhaps taking climate action individually, without any interaction with others, would not do much to move the needle, but even a small group of passionate individuals have the potential to make a considerable change.

Pro-Environmental Behavior Frameworks

Pro-environmental behavior (PEB) aims to reduce environmental harm and alleviate climate change and diminished biodiversity (Piao & Managi, 2024). Throughout the years, there have been a multitude of models utilized to explain the relation between environmental knowledge/awareness and PEB. The earliest models were created in the 1970s and were of linear nature, assuming that environmental knowledge would lead directly to environmental attitudes which would then lead directly to PEB (Kollmuss & Agyeman, 2002). However, the literature highlighted a significant attitude-behavior gap in individuals with Rajecki (1982) describing four predominant reasons: direct experience having a larger effect than indirect experience, social norms, attitude change over time, and attitudes being measured in a broader scope than specific behaviors.

The theory of reasoned action described how attitudes and subjective norms may impact behavior (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). They found that attitudes and behavior need to be measured on a similar scope or there will be inaccuracies. They surmised that attitudes shape intentions but do not directly control actions and intentions consist of both our personal attitudes and social expectations. In brief, they found that actions are determined by belief of consequences and perception of others' expectations. Ajzen (1985) expanded on this in the theory of planned behavior by including how perceived control may serve as a behavioral influencer (Figure 3). This

paradigm is one of the most popular frameworks utilized to describe PEB (Sawitri et al., 2015; Tian and Liu, 2022).

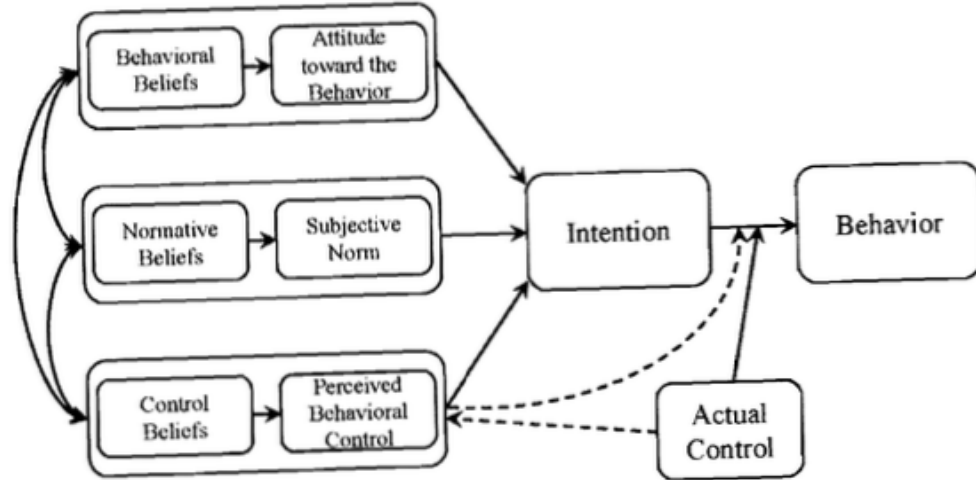


Figure 3. The theory of planned behavior.

Note. Adapted from (Ajzen & Cote, 2008, p.301).

Hines et al. (1987) conducted an assessment of PEB literature in order to develop their model of responsible environmental behavior. They found that predicting PEB or, as Hines et al. refer to it, responsible environmental behavior, involves numerous interconnected variables as seen in Figure 4. Their research suggested that the intention to act is influenced by factors such as knowledge, action skills, and personality factors.

Hines et al. (1987) reported that knowledge of environmental problems and action strategies is a prerequisite to taking action, as are general action skills. A desire to act is necessary and relies heavily on personality factors such as attitudes, locus of control, and sense of responsibility. Situational factors, including economic constraints and social pressures, can either hinder or promote environmental actions. For example, if an individual has the desire to purchase an electric vehicle but lacks the financial resources,

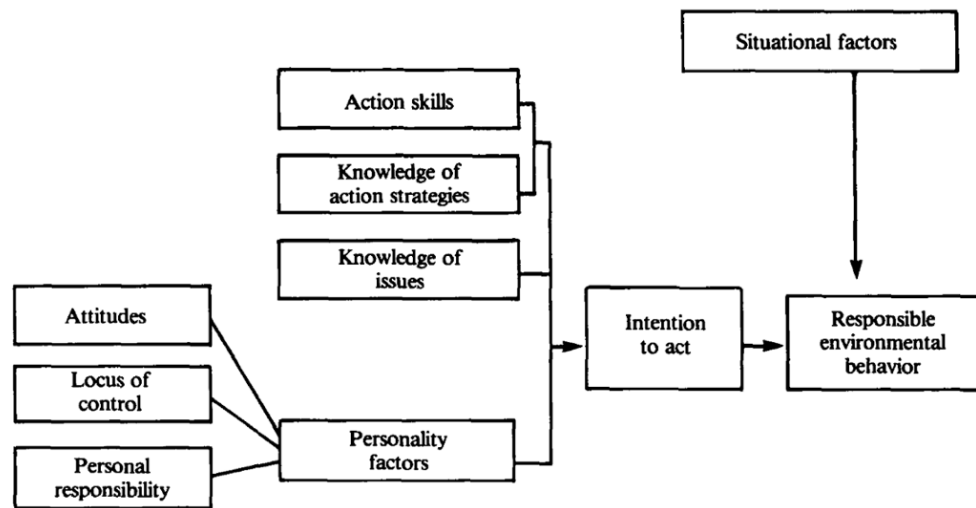


Figure 4. Predictors of responsible environmental behavior.

Note. Adapted from (Hines et al., 1987).

then this is a hindrance. On the other hand, supportive social pressures may allow individuals who do not already have the desire and the personality traits associated with PEB to take action. They also explained that verbal commitment to action made it more likely that an individual would act.

The Hines et al. (1987) model revealed that knowledge, skills, and some personality components can be influenced by environmental educators. Their research emphasized that, although the route of skills, knowledge, and personality factors is preferred, in some instances manipulating situational factors may produce more rapid results.

Two decades after the Hines et al. meta-analysis, Bamberg and Möser (2007) conducted a similar study. Although most findings reflected the earlier research, they also found that a person's intention to take climate action interplays between personal and

social factors and actual behavior. Moreover, personal values are directly tied to intentions, and awareness of climate issues indirectly influences individuals' intentions. They found that awareness is a culmination of moral and social norms as well as feelings of guilt.

Blake (1999) referred to the “value-action gap,” similar to the knowledge-action gap, in the context of environmental policy. He pinpointed individuality (intrinsic barriers), responsibility (parallel to “locus of control”), and practicality (social and institutional constraints) as predominant hindrances to PEB (Figure 5).

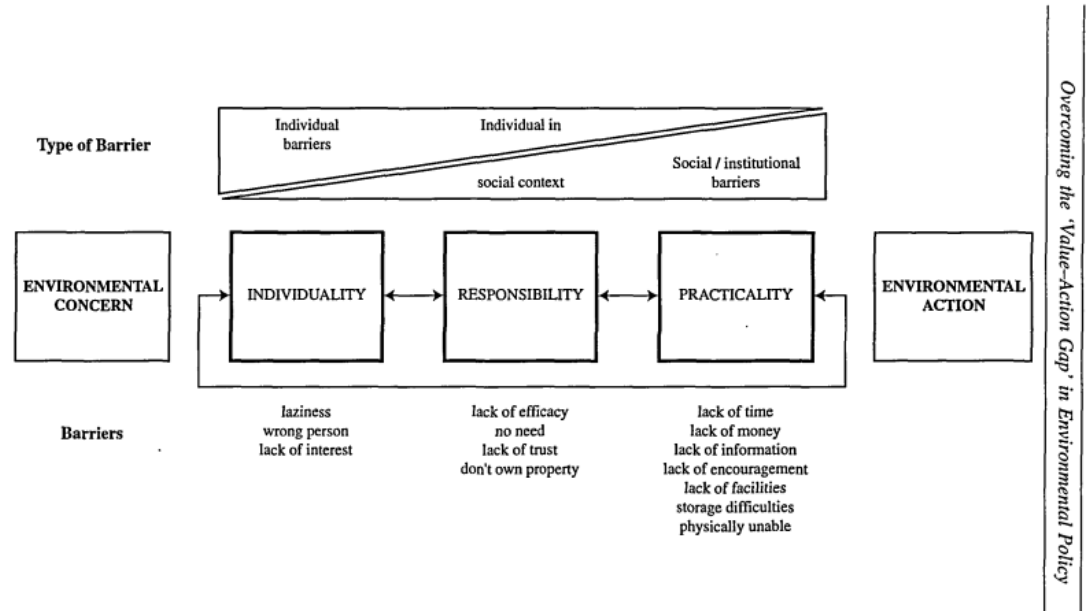


Figure 5. Barriers between environmental concern and action.

Adapted from (Blake, 1999).

Quimby and Angelique (2011) noted that, in individuals engaged in the climate space, major barriers to action also included time constraints, costs, absence of social support, limited community infrastructure, and discouraged feelings while motivators included money, changing social norms, education, and institutional and infrastructure

support. Additionally, in their open-ended survey responses, a deficient efficacy, which encompasses an individual's belief that they can make a difference, was frequently cited as a barrier to PEB. Gifford and Nilsson (2014) examined the interconnectedness of personal and social factors influencing PEB and concern, identifying 18 key influences including spending time in nature as a child, environmental knowledge, certain personality traits, a sense of personal responsibility, and setting goals, amongst others.

Kollmuss and Agyeman (2002) developed their own model, building off of various previous models (Figure 6). They did not illustrate a straightforward relationship between environmental knowledge and PEB. Instead, they coined the term “pro-

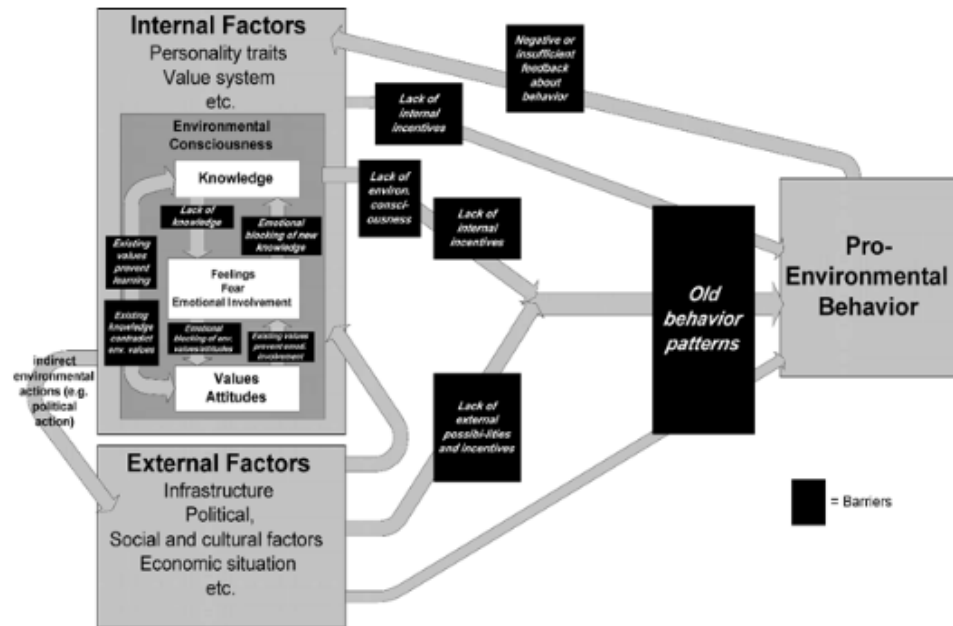


Figure 6. Factors influencing pro-environmental behavior.

Note. Adapted from (Kollmuss & Agyeman, 2002).

environmental consciousness” which encompassed environmental knowledge, personal values, attitudes, and emotional connection. They showed that PEB can happen through

intrinsic factors, extrinsic factors, or a combination of both. Their belief was that education does not automatically equate to behavior change and that the literature frequently neglects to note established habits as a barrier to change.

In short, the literature exhibits a broad range of aspects that either motivate or hinder PEB, from intrinsic factors (personal values, attitudes, emotions) to extrinsic factors (social norms, financial limitations). Overall, there is an emphasis that environmental knowledge does not guarantee PEB. Due to this consensus, it has become necessary to identify other ways to promote PEB in the general population.

Pro-Environmental Behavior Change Interventions

Several strategies for promoting pro-environmental behavior have been documented. Abrahamse (2019) evaluated nine types of PEB interventions and their effectiveness including providing general information, giving personalized information, incorporating message framing, offering feedback, setting goals, making commitments, utilizing a “block leader,” social modeling, and using social norms. She found that supplying general information and framing messages tailored to people’s beliefs typically exhibited minimal behavior changes. Although these interventions were seen to raise awareness and influence attitudes, they translated into minimal action. The incorporation of general information was only seen to be effective in highly motivated individuals, while message framing altered attitudes and intentions, not behavior. She established that tailored information, social modeling, and social norms were moderately effective in promoting behavior change. Goal setting was also found to be moderately effective, especially when combined with other interventions like feedback. These approaches typically produced measurable but incremental changes in PEB. One of the most

effective interventions that Abrahamse (2019) found were from “block leaders,” trusted individuals from a similar social circle. Commitment making, particularly in public, and providing feedback, especially if given frequently, were also seen as effective strategies to promote PEB. She noted that public commitments could lead to long-term behavioral effects and regular feedback allowed individuals to maintain motivation.

Schultz (2014) also found that showcasing cognitive dissonance (highlighting inconsistencies between an individual’s attitudes and behaviors), goal setting, social modeling (demonstrating the desired behavior), providing prompts, and convenience, amongst others, were effective motivators depending on the context. The different contexts for promoting PEB he outlined were based on motivation and barriers: low motivation with low barriers (use modeling and social norms), low motivation with high barriers (use incentives and competitions), high motivation with low barriers (use prompts and feedback), and high motivation with high barriers (use commitments and facilitate convenience). Additionally, Grilli and Curtis (2021) found that outreach and relationship building, including workshops, training, and community engagement, had one of the highest success rates for promoting PEB of over 80%, while education and awareness alone had the lowest success rate of ~66%.

Environmental Education

Environmental Education (EE) can play a significant role in both enhancing awareness and empowering individuals to take action by making informed decisions. For instance, in a case study conducted in the Philippines, a single additional year of schooling that incorporated environmental education significantly increased the tendency to engage in PEB by 3.3% (Hoffmann & Muttarak, 2020). Another case study focusing

on a one-year intensive EE university course found that graduates had an average reduction of 2.86 tons of CO₂ per year post-class (Cordero et al., 2020). Beyond this, particular educational strategies can increase the efficacy of behavior change programs. Among individuals who already engage in PEB, learning that emphasized connection to other people increased motivation to participate in PEB, especially for more difficult behaviors (Cooke et al., 2016). Moreover, by focusing on shaping self-identity rather than simply providing information, EE is more likely to foster long-term PEB (McGuire, 2015). Active learning methods, especially involving discussions, feedback, and positive social interactions, have also been seen to effectively promote PEB (Melin, 2012).

Commitments

Making commitments is a well-known method for establishing and maintaining behavior change. Notably, it has been cited as an effective intervention for both short and long term impact, especially in conjunction with other interventions such as feedback and reminders (Lokhorst et al., 2013). The effectiveness of commitment making is seen across various industries. For example, in the agricultural sector, public commitment making in combination with personalized information was effective in promoting conservation efforts in farmers (Lokhorst, 2009). In the hospitality industry, when guests made a specific commitment to reuse their towels and received a pin to showcase their commitment, they were 25% more likely to reuse towels and hung over 40% more used towels compared to guests who did not make commitments (Baca-Motes, 2013). Additionally, goal setting as well as written commitments have been seen to positively influence PEB (Osbaldiston & Schott, 2012; Werner et al., 1995).

Social Influence

Social influence refers to how an individual's behavior can impact the behavior of others through facets such as social media, social norms, and peer pressure. Social influence, especially social norms, can have a notable impact on PEB, more so than information-based interventions (Tilyard, 2011). Social norms can facilitate behavior change by prompting individual actions to align with group expectations. Further, Nguyen-Van et al. (2021) conducted a meta-analysis that found that internal social influence was the most effective motivation followed by extrinsic social influence, network connection, and trust in institutions. This research illustrates that social factors, both internal and external, can affect the likelihood of individuals engaging in PEB.

However, although social norms have a substantial effect on PEB, they tend to be overlooked in survey-based research, which leads to an underestimation of their impact on behavior change (Thøgersen, 2014). It has also been understood that knowledge does not alone create PEB change, rather incorporation into a community that is concerned about climate change, along with high levels of self-efficacy and pro-environmental values can lead to increased PEB (Estrada et al., 2017). Simply put, interventions focused on disseminating information and not socially engaging individuals, tend to be less effective in catalyzing behavior change.

Carbon Footprint Calculators

Carbon footprint calculators have become increasingly popular digital tools to measure and reduce personal greenhouse gas emissions (Aytac, 2023). These calculators are typically based on lifestyle information including expenses, transportation, and dietary choices. By inputting lifestyle information into the calculator, users are able to

receive personalized outputs which would effectively allow them to self-regulate their emissions. The overall concept is to provide users a clear understanding of their environmental impact and, ideally, encourage them to adopt more sustainable behaviors.

Carbon calculators can have various designs including Excel sheets, websites, and apps (Dreijerink & Paradies, 2020). Across the web, there are a myriad of choices (see examples in Figure 7 and Figure 8). For many of these choices, the tool not only calculates emissions but also offers actionable insights, sometimes offering incentives.

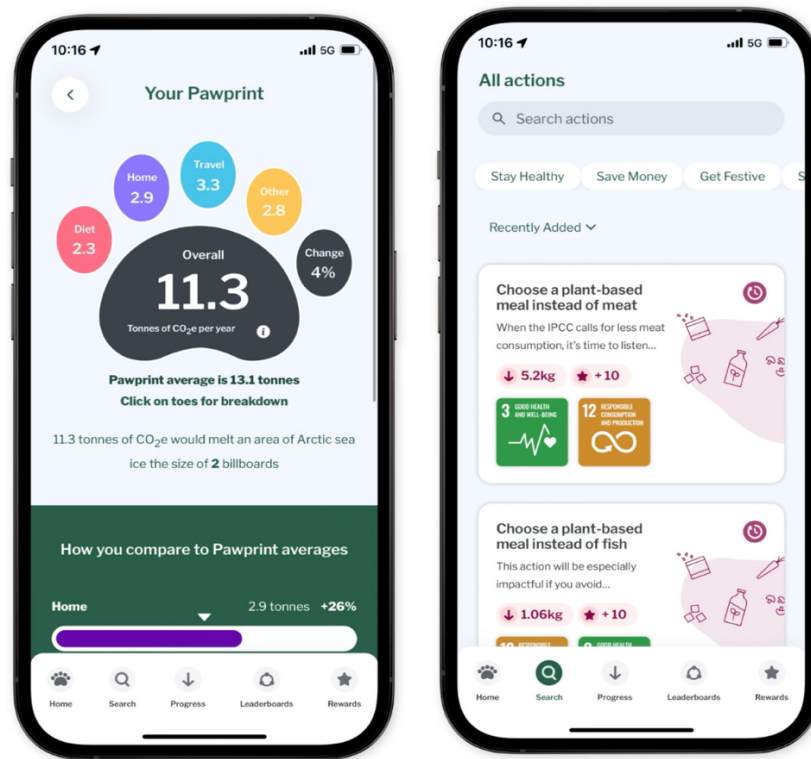


Figure 7. The Pawprint app.

Note. Adapted from (Pawprint, 2025).

Many of the apps incorporate varying levels of gamification in order to encourage behavior change. For example, the app Pawprint (2025) calculates emissions based on

diet, home, and travel. On top of this, it also compares users to others who have taken the assessment, suggests specific actions to take, and awards users with “Pawpoints” which can be used to vote for verified charities or enterprises that the app donates to each month.

Another example of a digital carbon footprint calculator is from the United States Environmental Protection Agency (2025), a government organization. This website uses data from a user’s home energy, transportation, and waste disposal habits to calculate their footprint. The tool also offers personalized results and demonstrates how simple actions can affect emissions by allowing users to incorporate reduction strategies within their impact categories as they take the assessment. Similarly to the Pawprint app, this site shows users how they compare to others, specifically those in the United States.

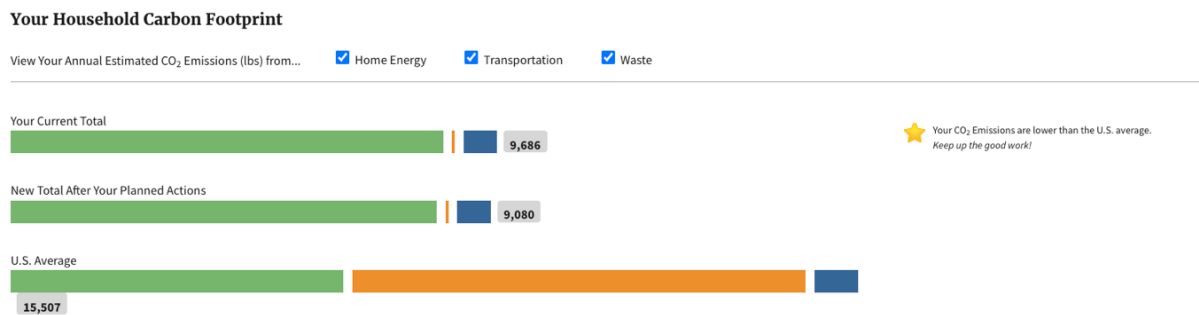


Figure 8. The EPA’s carbon footprint calculator.

Note. Adapted from (United States Environmental Protection Agency, 2025).

Across the various examples, it is clear that there are no standard impact categories in carbon calculators as the depth of emissions analyses vary widely. However, the calculators with the most impactful outputs include the largest household emissions

areas that, in the United States, are housing (15-30%), transportation (20-40%), and food (10-30%) (Jones & Kammen, 2011).

Carbon Footprint Calculators and Behavior Change

The effectiveness of carbon footprint calculators in driving behavior change is a topic of considerable debate. While these calculators generally raise awareness about sustainability, their impact on actual behavior change may not always follow (Büchs et al., 2018; Gram-Hanssen & Christensen, 2012). Yet, various studies have documented raised awareness alongside diminished footprints as a result of behavior change (Aichholzer et al., 2012; Laakso & Lettenmeier, 2016; Lin, 2016). Enlund et al. (2023) found that, even if behavior change is noted, the longevity of these changes is often short-lived; they initially observed a 10% reduction in an individual's footprint which then faded in the weeks post-treatment. This suggests that while short-term behavior changes from carbon calculators may be apparent, maintaining those changes may require additional or prolonged interventions.

Biørn-Hansen et al. (2022) found that some carbon calculators may be too general for those already knowledgeable about the environment, that the challenges were not engaging enough, and that the gamification feature was not effective without additional social context. This demonstrates that it is essential for carbon calculators to be personalized, engaging, and incorporate a social dynamic in order to be more effective. Collins et al. (2020) conducted a large-scale survey with 4,245 respondents, revealing mixed perceptions about carbon footprint calculators. While 91% of respondents found a calculator useful for understanding what a carbon footprint is and 78% felt motivated by it to take action, only 23% believed that the calculator provided enough actionable

insights to make significant changes in their lives and reduce their emissions. This survey highlights a gap between providing knowledge that leads to awareness versus knowledge that leads to action.

Although the number of carbon calculators is increasing as is the interest in their ability to affect behavior, research regarding their efficacy remains understudied and inconclusive (Dreijerink & Paradies, 2020). In brief, it seems that these tools have been successful in increasing general knowledge and awareness, but their behavioral effects require additional study. In order to create significant PEB change, implementing carbon footprint calculators alongside established behavior change interventions may result in a more effective treatment.

Research Questions, Hypotheses and Specific Aims

My central research questions and the corresponding hypotheses revolved around the influence of a multi-component treatment, which involved multiple tested behavior change interventions, on the conduct of individuals already engaged in the sustainability space. These queries were interrogated by the following:

- Research Question 1: To what extent does a workshop session influence pro-environmental behavior in individuals already engaged in the sustainability space?
 - Hypothesis 1: Individuals exposed to the sustainability workshop (i.e., treatment group) exhibit more new sustainable behaviors one month post-intervention compared to a control group.
- Research Question 2: To what extent does a workshop session influence environmental knowledge in individuals already engaged in the sustainability space?

- Hypothesis 2: Individuals in the treatment group exhibit more environmental knowledge one month post-intervention compared to a control group.

In addition to my primary goals, I explored the drivers and hindrances that participants may encounter by investigating the following:

- Exploratory Question 1: What are the motivations and barriers that impact climate action among individuals engaged in the sustainability space?

My final question examined the propensity for those in the treatment group to share their learnings with the general community. The purpose of this was to understand whether participants could act as “committed minorities” in relation to the theory of critical mass (Centola et al., 2018) and was studied by:

- Exploratory Question 2: To what extent will those in the treatment group share the information provided in the intervention with the broader community?

Specific Aims

To complete my research, I needed to:

1. Recruit individuals established in the sustainability community and randomize them into a treatment group and a waitlist control group.
2. Survey the treatment and control group participants one week pre-treatment in order to capture baseline sustainability behaviors and knowledge as well as participant demographics. Additionally, perceived motivations and barriers to taking action were captured.

3. Run a multi-component intervention consisting of environmental education, a carbon footprint calculator assessment, an action planning activity, and social interaction with the treatment group.
4. Survey the treatment and control group one month post-intervention in order to assess changes in behavior and knowledge as well as inclination of the treatment group to share intervention findings with others.
5. Conduct an optional virtual interview one week post follow-up survey in order to supplement the survey results with additional qualitative results.
6. Analyze the data quantitatively through statistical software and qualitatively through thematic analyses.
7. Identify the most commonly cited motivations and barriers both quantitatively through the survey and qualitatively through the interviews.
8. Assess the percentage of the treatment group that shared intervention learnings with the community and how they shared learnings through qualitative analysis.
9. Measure changes in behavior and knowledge in both the test and control groups quantitatively.

Chapter II

Methods

This research incorporated a multi-component approach utilizing a live-virtual workshop that combined environmental education, personalized carbon footprint analysis, and the development of individual action plans. To measure outcomes, baseline surveys before the workshop and follow-up surveys one month after were conducted, supplemented by optional virtual interviews.

The study targeted individuals who had already been participating in the climate space, aiming to increase their propensity to engage in climate action. The climate space refers to any sustainability-centered industry such as renewable energy or public transportation. The surveys captured participants' demographics, sustainability practices, self-reported environmental knowledge and attitudes, driving forces behind their environmental choices, and barriers they faced in implementing sustainable behaviors. Prior to beginning participant recruitment, the study was submitted to and approved by the Institutional Review Board at Harvard University. All participants received and signed a consent form (Appendix 5) through email before enrollment. Data analysis was done quantitatively through IBM SPSS Statistics (Version 29) and qualitatively through a thematic analysis utilizing NotebookLM (Google Labs, 2025).

Participants and Procedures

Participants were recruited via email through The Carbonauts' database, HubSpot and Squarespace, as well as through my personal LinkedIn and the Harvard Extension School Student Sustainability Club's (HES3C) WhatsApp group (Appendix 4). All participants were 18 years or older, fluent in English, and cognitively able to partake in the study. The aim was to compile a convenience sample of highly engaged individuals who were motivated to contribute. This would allow for higher survey response rates and higher participation throughout the full extent of the research study, including the intervention. Additionally, it was of interest to see if the intervention utilized in this research would have an impact on individuals who were already likely taking climate action in their personal lives and who likely already exhibited high levels of environmental knowledge. Individuals were recruited to participate in November 2024. Of note, data collection began immediately following the results of the 2024 United States presidential election. The recency of this major political event may have skewed some of the initial findings.

Participants were given the opportunity to enter a raffle in order to receive one of four \$50 e-gift cards which they received approximately two weeks post-data collection. A total of 166 participants signed online consent forms via email and were enrolled in the study. Participants were then randomly allocated into the treatment group or the waitlist control group which consisted of 83 participants each. The control group participants were given the opportunity to participate in the workshop post-study, after their initial waitlisting.

The Intervention

The utilized intervention was a one hour live-virtual workshop titled “Sustainability Plan” which was created by The Carbonauts and implemented through Zoom (version 6.2.5) (Figure 9). The company typically used this workshop in a private capacity as an employee engagement tool for large corporations with the goal of lowering individuals’ emissions both in and out of the office. Beyond the “Sustainability Plan,” the company had also created more specific workshops focused on impact areas such as food, plastic use, and travelling by plane. For five years now, the company has run hundreds of workshops, engaging almost 2,000 individuals (S. Blew, personal communication, January 27, 2025).

During this workshop, a Carbonauts teacher (Figure 10) engaged with students through the chat and discussions. For the duration of the Zoom call, participants were also prompted to keep their cameras on to facilitate a community atmosphere. The instructor ran through a slideshow detailing what a carbon footprint is, how to use a carbon footprint calculator, how to understand your footprint, the most impactful areas for you to take action, how to make your personal sustainable action plan, and, at the end, there was time for questions. There were multiple breaks in order to take the carbon footprint calculation, to create the action plan, and to send additional resources at the end of the call. I monitored the workshop as the teaching assistant in order to make sure all materials were sent and to answer any study-related questions.

The teacher often used comparatives and storytelling to illustrate the impact of an individual’s actions such as saying that, although purchasing a reusable water bottle does lower your personal emissions, categories like flying have a much larger impact. The

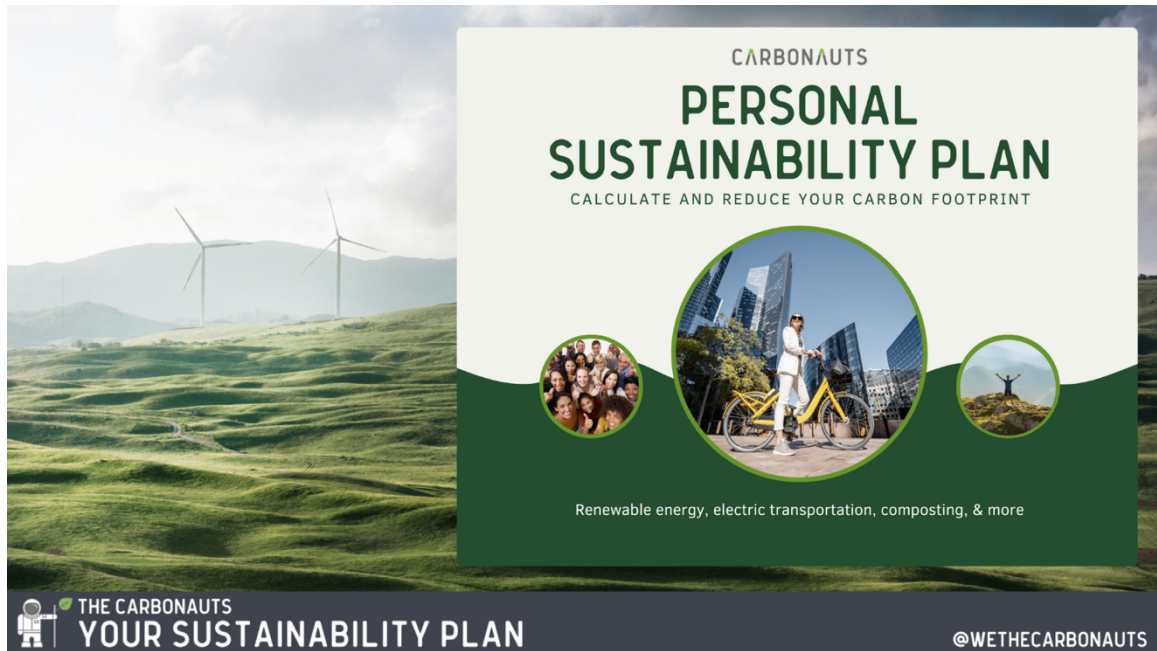


Figure 9. The “Sustainability Plan” workshop.

Note. Adapted from (The Carbonauts, personal communication, November 21, 2024).

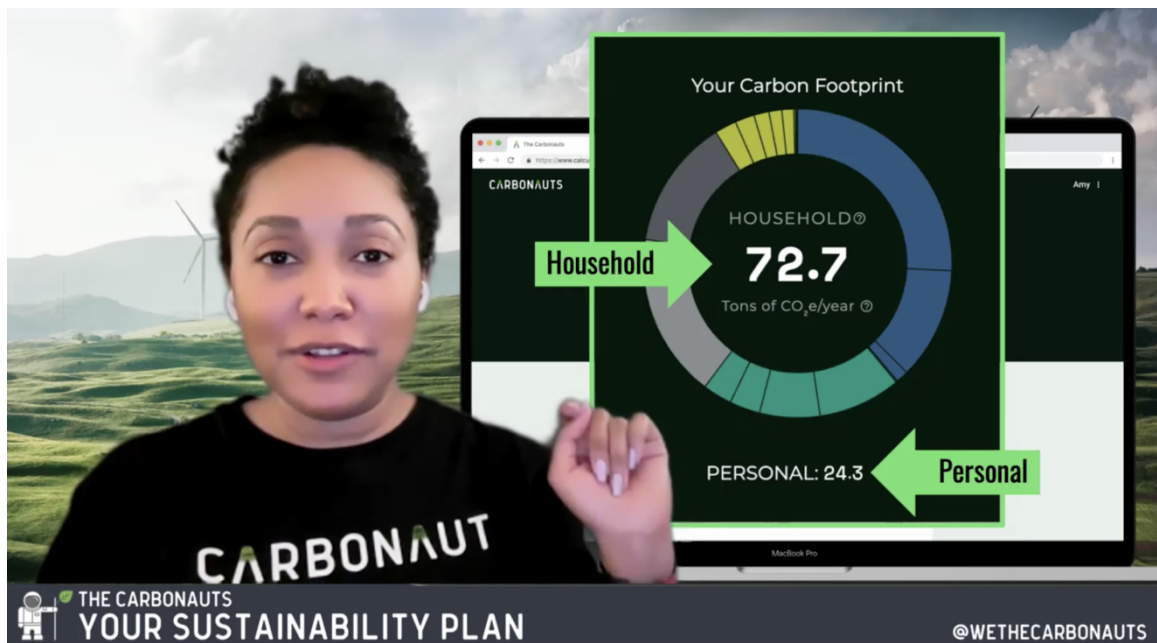


Figure 10. The instructor teaching the workshop.

Note. Adapted from (The Carbonauts, personal communication, November 21, 2024).

teacher explained that the emissions from a single person's roundtrip flight from Los Angeles to Asia equates to 100,000 disposable water bottles. Another example used in the workshop was asking participants what the footprints of chicken and beans are if the footprint of beef is 100 units. Participants were given the opportunity to guess and then the answer of ten units for chicken and two units for beans was revealed. The purpose of comparing actions in this way was to make it clear which actions were worth investing time and resources in.

The most impactful action areas were broken up into "The Big Six": increasing efficiency and getting renewable energy in the home, driving less and driving electric, eating plant-rich and reducing food waste, reducing and optimizing flying, purchasing carbon offsets, and shifting social norms. At the end of the call, additional resources were sent about each of "The Big Six" categories along with further reading and a tool kit. Within each impact area, various specific actions were given as examples to help enable participants to take action. For example, within the "increasing efficiency and getting renewable energy" category, switching to a utility green power program, utilizing community solar, and installing rooftop solar were all provided as possible next steps. There was also an emphasis on addressing barriers that participants noted, such as financial limitations, where the teacher highlighted which actions can cause savings in the long run as well as addressing available government incentives. In the final category of "The Big Six," shifting social norms, there was a stress on sharing learnings from the workshop with others as well as actions that you are taking or would like to take in order to inspire collective action. Overall, the primary purposes of the live-virtual education

were to create a sense of community with others in the workshop and to educate participants on which actions have the largest impact on an individual's emissions.

The Carbon Footprint Calculator

The carbon footprint calculator in this workshop was adapted by The Carbonauts from the CoolClimate Calculator, developed by researchers at the University of California, Berkeley (CoolClimate Network, n.d.). This calculator took into account users' specific geographic locations as well as household income when calculating footprints (The Carbonauts, n.d.-a). Participants calculated their footprints near the start of the workshop after the teacher explained how to use the calculator. The categories of this calculator were divided into home, food, transport, and spending. At the end of the assessment, the user was given their total footprint as well as a breakdown by category (Figure 11).

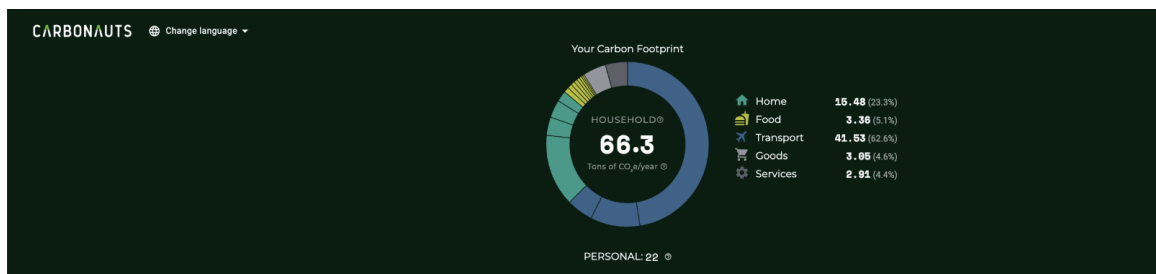


Figure 11. The carbon footprint calculator utilized in the workshop.

Note. Adapted from (The Carbonauts, n.d.-a).

The carbon calculator collected data about home energy use including housing type (owned/rented), square footage, electricity provider and consumption, current renewable energy sources and percentage, natural gas consumption, usage of heating oil

and propane, and water consumption amount. The food category analyzed dietary choices and consumption patterns such as diet type (omnivore/pescetarian/vegetarian/vegan), weekly servings of various proteins (beef, lamb, pork, poultry, eggs, seafood), dairy products, fruits, vegetables, grains, meat alternatives, snacks, and drinks. It also factored in composting habits and food waste management. The transport category took into account vehicles owned (engine type, fuel efficiency, mileage), public transit usage (bus, rail systems) with distance traveled, and air travel frequency with flight durations. The spending category measured monthly expenditure on goods and services. Each question detailed well-defined examples to ensure accurate reporting.

Once results were calculated, the teacher compared the carbon footprint in metric tons of carbon dioxide equivalent (CO₂e) per year to other individuals who completed the assessment as well as to individuals in the United States, Europe, and India. The teacher emphasized that while footprints vary, the primary sources of emissions typically come from home energy use, food choices, and transportation. These were the areas that the workshop focused on with no judgment about individual results. The purpose of the carbon calculator assessment early in the workshop was to help participants quantify exactly where their emissions were at and help them clearly see the biggest areas for reduction opportunities.

The Action Plan

The action plan utilized in this research was adapted from The Carbonauts and input into Qualtrics (<https://www.qualtrics.com>). Within the action plan, participants were asked to select which specific actions they would like to do going forward and the time frame that they would like to implement them. The time frame options were one

month, six months, or one year or longer. The reasoning for these large variations in time was due to some actions requiring minimal effort and spending power such as switching to a plant-based diet versus actions that required significant effort and financial support such as purchasing an electric vehicle. The actions included in this plan mirrored what was taught in the workshop.

The action plan was divided into several sections that can be viewed in Table 1.

Table 1. The action plan sections.

Section	Actions
Reducing home energy and water use	Switching to LED bulbs Installing low-flow showerheads Installing smart thermostats Getting a house audit
Reducing home energy emissions	Switching to utility green power Switching to community solar Getting rooftop solar
Reducing food emissions	Moving to a more plant-rich diet Starting to compost Focusing on reducing food waste
Reducing driving emissions	Cutting down on short driving trips Switching to a hybrid vehicle Switching to a plug-in hybrid vehicle Switching to an electric vehicle
Reducing flying emissions	Skipping flights Stacking two trips together Flying economy Searching for greener flights using Google Flights
Offsetting your footprint	Offsetting some emissions Offsetting all emissions Offsetting more than all emissions (Climate+)

The purpose of the action plan was to prompt participants to make clear commitments with timelines since the literature shows that when individuals make

commitments, they are more likely to take action (e.g., Abrahamse, 2019; Baca-Motes, 2013; Lokhorst, 2009; Lokhorst et al., 2013; Osbaldistron & Schott, 2012; Werner et al., 1995).

Entry and Exit Surveys

The surveys were created in Qualtrics and sent to the participants via email. The specific questions can be found in Appendix 1 and Appendix 2. Not all questions were analyzed but could be at a later date. The baseline survey was given to both the treatment and control groups approximately one week before the intervention. Taking around 15 minutes to complete, this survey collected demographic information, baseline sustainability behaviors, baseline environmental knowledge and attitudes, motivations for taking action, and barriers to taking action. All data were self-reported and the responses to all surveys were anonymous and coded to protect the participants' information.

The follow-up survey was administered approximately one month post-intervention. Again, taking around 15 minutes to complete, this survey differed slightly between the treatment and control groups. The same questions from the baseline survey were repeated (minus the demographic information) although it now tracked only new sustainable actions taken. It also inquired whether or not the frequency of the previously reported actions had changed. Additionally, if the participant took new actions, it asked what prompted these changes to see if there was a clear link between the workshop or aspects within the workshop and behavior change. The treatment group was also asked how helpful they found the workshop and the various components making up the workshop (the carbon calculator, the action planning activity, the group interaction, and the additional resources provided) as well as whether the workshop directly gave them

additional knowledge, whether they felt confident applying what they had learned, and if they had shared their learnings with others. The primary purpose of these surveys was to assess whether the workshop had made a clear impact on behavior and knowledge.

The Optional Interviews

The week after the follow-up survey, participants were given the option to engage in a 30 minute Zoom (version 6.2.7) interview in order to collect additional qualitative data. Both groups were asked to go further in-depth about their motivations and barriers to action as well as being asked if anything outside of the study had prompted them to make changes (see Appendix 3 for the interview guide). The treatment group was asked about the specific aspects of the workshop, if they could attribute any changes in behavior directly to the workshop, if they had shared any workshop learnings, and what opportunities the workshop had for improvement. The control group was asked if they had considered taking additional actions, what influenced whether or not they took action, what resources would help them make more sustainable lifestyle changes, if they would be interested in a sustainability-focused workshop and what would be valuable for them to see a workshop like that, and what actions they would prioritize taking if they created an action plan on their own. The primary purpose of these interviews was to collect additional qualitative information that may not have been captured in the surveys. All interviews were transcribed by Fireflies.ai (Fireflies.ai, 2025) and kept anonymous.

Data Analysis

Quantitative analyses were conducted via SPSS. Independent sample t-tests were utilized to compare the treatment and control groups' knowledge and sustainable

behaviors. Additionally, descriptive statistics were used to analyze demographic data, the motivations and barriers that participants noted, whether or not the treatment group shared learnings with their community, and what the groups reported caused them to make behavior changes.

I also conducted separate thematic analyses of the interview transcripts using NotebookLM for both control and treatment groups, along with analyzing open-ended survey responses to identify recurring themes if any were established. This tool was utilized to capture broad, interpretive themes while I reviewed the transcripts for more subtle themes and to capture quotes that could supplement the overall thematic analysis. After reviewing themes, I decided how to format and rename them if necessary. The “Step-by-Step Guide for Using AI in Qualitative Research and as a Methodological Method” was followed (Christou, 2023).

Chapter III

Results

Overall, the surveys effectively captured participants' demographics, sustainability practices, self-reported environmental knowledge and attitudes, driving forces behind their environmental choices, barriers they face in implementing sustainable behaviors, and whether or not they shared workshop learnings with others.

Participant Descriptives

Participant demographics were acquired in the baseline survey in order to gather a deeper understanding of the individuals in the study (Table 2). Participants were asked their gender, education level, household income, student status, and geographic information.

The total sample included 146 participants ($n = 69$ treatment and $n = 77$ control) who completed surveys at baseline, and 114 participants ($n = 43$ treatment, $n = 71$ control) who completed surveys post-treatment. Treatment participants were on average 48.2 years old ($SD = 13.62$) while control participants were on average 43.2 years old ($SD = 11.08$). For geographic location, the state breakdown was as follows: Northeast (ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD), Southeast (VA, WV, KY, NC, SC, TN, GA, FL, AL, MS, AR, LA), Midwest (OH, IN, IL, MI, WI, MN, IA, MO, ND, SD, NE, KS), Southwest (TX, OK, NM, AZ), West (CO, WY, MT, ID, WA, OR, UT, NV, CA, AK, HI), and participants outside of the United States were asked to specify their

Table 2. Sociodemographic characteristics of participants at baseline.

Baseline characteristic	Treatment Group		Control Group		Full sample	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Gender						
Female	42	60.9	52	67.5	94	64.4
Male	26	37.7	24	31.2	50	34.2
Non-binary/third gender	1	1.4	1	1.3	2	1.4
Education Level						
Some college or associate degree	4	5.8	1	1.3	5	3.4
Bachelor's degree	27	39.1	38	49.4	65	44.5
Master's degree	33	47.8	35	45.5	68	46.6
Doctorate degree	5	7.2	3	3.9	8	5.5
Household Income						
Less than \$50,000	9	13.2	9	11.8	18	12.5
\$50,000-\$74,999	8	11.8	7	9.2	15	10.4
\$75,000-\$99,999	11	16.2	12	15.8	23	16.0
\$100,000-\$149,999	12	17.6	11	14.5	23	16.0
More than \$150,000	28	41.2	37	48.7	65	45.1
Student Status						
Not a student	56	81.2	64	84.2	120	82.8
Full-time student	2	2.9	3	3.9	5	3.4
Part-time student	11	15.9	9	11.8	20	13.8
Geographic location						
Northeast	16	23.2	16	20.8	32	21.9
Southeast	4	5.8	3	3.9	7	4.8
Midwest	1	1.4	3	3.9	4	2.7
Southwest	1	1.4	5	6.5	6	4.1
West	35	50.7	38	49.4	73	50.0
Outside of the U.S.	12	17.4	12	15.6	24	16.4

country. The countries mentioned were Australia, Cameroon, Canada, France, Germany, Honduras, Mexico, Netherlands, Northern Ireland, Puerto Rico, Spain, and the United Kingdom. The second most reported country after the United States was Canada with eight participants. Overall, 83.5% ($n = 122$) of participants were located within the United States and 16.4% ($n = 24$) were located outside of the United States.

Besides the reports found in Table 2, participants were asked about how many years they had been involved in the sustainability space, their current industry, and their current occupation. For the treatment group, participants were in the sustainability space for an average of ~8.8 years (SD = 8.27) while in the control group, participants were similarly involved for an average of ~8.5 years (SD = 8.61). The top industries reported were the same for the treatment group and the control group with professional services/consulting (treatment n = 16, 23.2%; control n = 22, 28.6%), non-profit/NGO (treatment n = 10, 14.5%; control n = 11, 14.3%), and technology/IT (treatment n = 10, 14.5%; control n = 8, 10.4%) mentioned. For both groups, the “other” category also made up a significant portion of responses as the treatment group was (n = 16, 23.2%) and the control group was (n = 19, 24.7%). However, there were no clear themes emerging in the treatment group’s open-ended responses. For the control group, the only emerging theme was “entertainment.”

There were no clear occupations that emerged as especially significant for either group. Of note, both groups shared the majority of their top occupations. The treatment group’s top occupations were sustainability manager/director (n = 7, 10.1%), environmental consultant (n = 7, 10.1%), project manager (n = 6, 8.7%), and unemployed (n = 6, 8.7%). For the control group, the top occupations were also sustainability manager/director (n = 15, 19.7%), project manager (n = 10, 13.2%), and environmental consultant (n = 6, 7.9%). For both groups, the highest response rate landed under the “other” category with the treatment group (n = 37, 53.6%) and the control group (n = 32, 42.1%). There were no significant themes in the open-ended responses for either group,

but the most reported area was “architect and engineer” for the treatment group and “business leader and entrepreneur” for the control group.

Quantitative Findings

When looking at changes in sustainable behaviors and knowledge of individual sustainable actions from pre- to post-treatment, I found no significant differences between the two groups at baseline. Post-treatment, the 42 participants who received the workshop intervention ($M = 1.38$, $SD = 1.08$) compared to the 71 participants in the control group ($M = 0.75$, $SD = 1.21$) demonstrated significantly more new behaviors taken, $t(111) = -2.79$, $p = .006$. There was no significant effect on knowledge of individual sustainable actions, $t(112) = 0.78$, $p = .435$ with the control group ($M = 3.94$, $SD = 0.92$) reporting slightly higher levels of knowledge than the treatment group ($M = 3.81$, $SD = 0.73$).

Post-intervention, the treatment group was asked what prompted their sustainable behavior changes, if anything. They could select multiple options. Of this group, 31.5% cited the carbon calculator results ($n = 23$), 26% cited an increased awareness ($n = 19$), 23.3% cited workshop insights ($n = 17$), 12.3 % cited the action planning process ($n = 9$), 9.6% cited financial considerations ($n = 7$), 8.2% cited new information or resources ($n = 6$), 6.8% cited changes in personal circumstances ($n = 5$), 6.8% cited influence from peers/community ($n = 5$), and 4.1% cited “other” ($n = 3$). The treatment group was also asked whether they had shared or implemented any workshop learnings in their community. Of those surveyed, 53.5% said no ($n = 23$) while 46.5% said yes ($n = 20$).

In the follow-up survey the control group was also asked what had prompted their sustainable behavior changes, if they had made any. Like the treatment group, they could

select multiple options. Of this group, 19.3% cited new information or resources (n = 17), 17% cited increased awareness (n = 15), 15.9% cited workshop insights (n = 14), 14.8% cited carbon calculator results (n = 13), 8% cited financial considerations (n = 7), 8% cited an action planning process (n = 7), and 1.1% cited changes in personal circumstances (n = 1).

In the baseline survey, the treatment and control groups were able to select all of the motivations they had to engage in sustainable behaviors. The treatment group selected environmental concerns (n = 65, 89.0%), social responsibility (n = 61, 83.6%), health benefits (n = 50, 68.5%), professional interest (n = 43, 58.9%), financial savings (n = 24, 32.9%), and other (n = 4, 5.5%). The “other” category had no clear themes. The control group selected environmental concerns (n = 76, 86.4%), social responsibility (n = 69, 78.4%), health benefits (n = 59, 67.0%), professional interest (n = 57, 64.8%), financial savings (n = 39, 44.3%), and other (n = 9, 10.2%). The “other” category most frequently cited intergenerational equity.

In the baseline survey, the treatment and control groups were also able to select all of the barriers they faced in completing sustainable actions. The treatment group selected lack of financial resources (n = 41, 56.2%), limited access to sustainable products or services (n = 30, 41.1%), lack of time (n = 26, 35.6%), lack of knowledge (n = 20, 27.4%), social or community norms (n = 18, 24.7%), and other (n = 14, 19.2%). The “other” category most frequently cited a lack of infrastructure and limited control as a renter. The control group selected lack of financial resources (n = 49, 55.7%), limited access to sustainable products or services (n = 25, 28.4%), lack of time (n = 36, 40.9%), lack of knowledge (n = 20, 22.7%), social or community norms (n = 13, 14.8%), and

other (n = 18, 20.5%). The “other” category most frequently cited a lack of infrastructure for sustainable transportation and limited control as a renter.

Qualitative Findings

Overall, 31 individuals participated in the optional 30-minute interview: 12 from the treatment group and 19 from the control group. Separate thematic analyses were conducted for each group due to differing interview questions.

Treatment Group Thematic Analysis

Table 3 illustrates the themes and subthemes captured from the 12 treatment group interviews. When discussing motivations, interviewees expressed deep environmental concern and felt personally responsible to take action. One interviewee highlighted that the recent election increased their sense of personal responsibility. Interviewees also expressed a desire to preserve the environment for future generations and often drew inspiration from their community’s environmental efforts. Community support was noted as an enabler of individual action and facilitated broader climate advocacy. One interviewee noted, “I’m fortunate that a lot of folks in my community are oriented towards that [climate action] so there’s a level of sharing best practices and reinforcement.”

The most commonly cited barriers to action were financial and time constraints. Time constraints were further intensified if childcare responsibilities were cited. Additionally, interviewees mentioned insufficient infrastructure such as electric vehicle charging and access to composting facilities as hindrances. Lack of information on specific actions and technologies available to reduce their footprint was identified as

another barrier, while social dynamics were also listed as a major deterrent especially when it came to family dynamics. One interviewee mentioned experiencing “friction with people” who did not make similar sustainable choices and felt “patronized” when others complimented their sustainable choices while not making them themselves. This led to feelings of isolation and being “othered” as well as feeling “dehumanized” and “stereotyped.”

Table 3. Treatment group thematic analysis.

Theme	Subtheme
Motivations	Personal Values
	Intergenerational Equity
	Community Influence
Barriers	Financial Constraints
	Time Constraints
	Infrastructure Limitations
	Social Dynamics
	Information Access
Workshop Experience	Carbon Calculator Insights
	Knowledge and Awareness
	Group Interaction
	Format Limitations
Action Planning	Action Planning Activity
	Accountability Needs
	Future Improvements
Community Engagement	Communication Efforts
	Communication Challenges

When asked about the workshop as a whole, the carbon calculator was cited as the most influential tool since it allowed participants to see the extent of their footprints. Many interviewees were surprised with their results with one stating “it shocked me how much carbon I could emit... it made me think about my impact and want to change it.”

Interviewees also cited that the workshop reinforced existing knowledge while also providing a clear understanding of their environmental impact and specific actions they could take to reduce it. The group interaction within the workshop was generally mentioned as a positive aspect with interviewees citing feeling a sense of community, validation, healthy competition, and reduced feelings of loneliness. One participant stated, “it was comforting to know that there’s room for improvement even if we’re already the ones at the front line doing the work.” However, a few mentioned that the chat could be distracting at times. When it came to workshop limitations, some expressed that the condensed format inhibited their ability to absorb all of the information and engage in deeper discussions. Some suggestions cited were to extend the workshop duration and to offer more in-depth modules on specific topics.

Within the workshop, interviewees stated that the action planning activity helped them identify specific steps to take and to commit to a timeline. However, there was a general consensus that the action plan did not keep them accountable. Many had forgotten about the measures they committed to taking. Suggestions from interviewees included quarterly check-ins, automated reminders, more personalized recommendations, and the incorporation of progress tracking systems in order to maintain momentum.

Post-workshop, many interviewees shared knowledge with family, friends, and colleagues. Some also planned to incorporate the information into their professional work with one interviewee stating that they would “share specific ways to think about your carbon footprint on [their] website and blogs.” However, interviewees also highlighted the difficulties of discussing sustainability with other, less engaged individuals. These difficulties included not wanting to make others feel guilty about their behaviors, wanting

to avoid tension, and not aligning with the desires and beliefs of immediate family members as well as the broader community. One interviewee noted that individuals in the Southeast United States are generally not promoters of sustainable practices. Additionally, the same interviewee cited family need hurdles stating “my kids sometimes won’t eat anything but chicken nuggets or sausage.”

Control Group Thematic Analysis

Table 4 lists the themes and subthemes captured by the 19 control group interviewees. Their motivations closely mirror the treatment group respondents as interviewees expressed a sense of responsibility for the planet, a love for nature, a strong desire to mitigate the harmful effects of climate change, and a need to create a sustainable future for other generations. The control group also noted that since many interviewees work in the climate space, their motivations align with their career as well.

Table 4. Control group thematic analysis.

Theme	Subtheme
Motivations	Personal Values
	Intergenerational Equity
	Career Alignment
Barriers	Financial Constraints
	Time Constraints
	Infrastructure Limitations
	Living Situation
	Behavioral Patterns
	Societal Factors
Support Needs	Information Access
	Financial Support
	Community Support
	Practical Tools

Financial and time constraints were the most cited barriers for the control group. Interviewees mentioned the high costs of electric vehicles, solar panels, and home energy upgrades as unfeasible to most. Additionally, balancing work, family, and other commitments was thought to lead to overwhelmed feelings and action paralysis. Infrastructure challenges such as a lack of electric vehicle charging stations, a lack of convenient composting facilities, and unavailable public transportation were common barriers. One interviewee explained that “if there are no buses or trains in between cities I want to go to or it is too time consuming, I’ll have to take a flight”. The control group explained that living in rented apartments or shared housing caused limited control over energy efficiency and waste management practices which was cited as a common frustration. The interviewees also explained that breaking established habits and routines made adopting more sustainable practices challenging. Finally, consumerist culture and a lack of widespread urgency hindered prioritizing climate action with one interviewee noting, “the world is not built to promote sustainable habits.”

When asked what types of support would be needed to adopt more sustainable habits, the interviewees mentioned a strong desire for more accessible information on specific sustainable actions to take, especially in their local communities, including clear cost-benefit analyses. Despite high knowledge levels in this group, there was difficulty translating awareness into action. Many also noted that more community-based efforts including workshops and support groups to share knowledge, resources, and cultivate a sense of collective action would increase motivation. More practical tools like user-friendly apps would simplify which actions to take with one interviewee stating “the tools

I want to know about are the ones I don't know of yet". Additionally, interviewees stressed that tax credits and rebates would increase the feasibility of taking action.

Chapter IV

Discussion

The results identified in my research supported Hypothesis 1 as the treatment group participants exhibited statistically significant increases in sustainable behaviors compared to the control group—the treatment group participants incorporated twice as many new behaviors. Yet, there were no significant differences in general environmental knowledge post-treatment between the two groups, which did not support Hypothesis 2 that environmental knowledge would increase.

Behavior Change

The adoption of new sustainable behaviors by the treatment group may have been due to the multiple interplaying behavior change interventions presented within the workshop. Given the target group of individuals already integrated into the sustainability area, it is an important finding that improvements are possible even with an experienced audience. The applied treatment was meant to target both intrinsic and extrinsic factors that had been noted in past frameworks (e.g., Kollmuss & Agyeman, 2002). The carbon footprint calculator results were the most identified driver for PEB among the treatment group, supporting previous research that they are effective tools in creating behavior change (e.g., Aichholzer et al., 2012; Laakso & Lettenmeier, 2016; Lin, 2016). Within this tool, it incorporated personalized information and feedback which are known to increase PEB (e.g., Abrahamse, 2019; Melin, 2012). On top of this, the carbon footprint

calculator exercise highlighted cognitive dissonance, an effective means of promoting PEB, as many treatment group interviewees conveyed their surprise at the extent of their carbon footprints even when they believed they were living sustainably (e.g., Schultz, 2014).

The intervention's action planning activity included the behavior change strategies of goal setting and commitment. These methods have been proven to be effective at increasing PEB (e.g., Abrahamse, 2019; Baca-Motes, 2013; Lokhorst, 2009; Lokhorst et al., 2013; Osbaldiston & Schott, 2012; Werner et al., 1995). Although the EE component of the intervention primarily incorporated general information, research indicates that this may be an impactful behavioral approach when utilized with a highly motivated group (e.g., Abrahamse, 2019). This workshop's inclusion of active learning methods that highlighted discussions and positive social interactions likely also influenced results (e.g., Grilli & Curtis, 2021; Melin, 2012). Whether running the intervention within a climate-concerned community enhanced or lessened the intervention's effectiveness will require further study (e.g., Estrada et al., 2017).

Knowledge

While the treatment did effectively promote PEB, it did not have an effect on knowledge of sustainable actions. This finding contrasts with some of the previous carbon footprint calculator literature, with several studies citing increased knowledge, but not behavior (e.g., Büchs et al., 2018; Gram-Hanssen & Christensen, 2012). This may be because the sample exhibited a high level of pre-existing environmental knowledge. However, the treatment group did note that workshop insights were a motivator in taking climate action which suggests that, although their overall environmental knowledge

levels were not affected, they did still gain insights from the intervention. This indicates that knowledge may have been gained but not enough to increase overall environmental knowledge or that the knowledge gained was not about individual sustainable actions. Treatment participants also noted that the intervention reinforced existing knowledge so that it may have acted as more of a prompt than a means of knowledge gain. This aligns with prior work showing that providing prompts promotes behavior change (e.g., Schultz, 2014). In order to have a more substantial impact on environmental knowledge, it may be necessary to incorporate suggestions from the treatment group such as expanding the length of the workshop or providing more in-depth modules on specific topics.

Motivations and Barriers

As seen in the interview thematic analyses, the treatment and control groups were aligned in their fundamental motivations for engaging in sustainable behaviors and have significant overlap in their barriers to taking action. They both prioritized environmental concerns and upholding a sense of responsibility toward future generations as well as emphasizing financial and time constraints as primary barriers. However, the treatment group reported increased awareness of their personal carbon footprint and a greater understanding of where they can make impactful changes, potentially due to the intervention. That said, some treatment group participants still emphasized a need for additional information. The treatment group also emphasized the value of the group interaction to foster a sense of community and facilitate shared learnings, areas that the control group cited a desire for support.

The primary barriers cited among both groups were financial resources, limited access to sustainable products or services, and lack of time. In the interviews, they also

noted insufficient infrastructure, lack of information, social dynamics, societal factors, difficulties breaking habits, and a lack of control in a rental environment. All of these barriers were reflected in the literature to an extent (e.g., Blake, 1999; Kollmuss & Agyeman, 2002; Quimby & Angelique). This suggests the continued need for intrinsic and extrinsic support.

The primary motivators captured were environmental concerns, social responsibility, and health benefits. In the interviews, participants also noted the desire for intergenerational equity, community support, and career alignment. Financial savings were also indicated as a motivator which aligns with the literature (e.g., Quimby & Angelique, 2011). However, financial savings were not one of the predominant motivators which may indicate that this sample is more motivated by intrinsic factors meaning that incentive-based interventions may not be as effective in a similar sample.

Based on the motivations and barriers captured in this research, it may be of interest to create a workshop-based intervention that highlights behaviors that have high cost savings and low implementation time. It may also be advantageous to incorporate social support which might alleviate eco-anxiety that could be caused by environmental concerns. Additionally, emphasizing health benefits that might be gained from making more sustainable choices may be an effective motivator.

Shared Learnings

A significant number of individuals in the treatment group shared learnings with their community. This is notable since these individuals may go on to act as “block leaders,” trusted individuals within their social circles, which are known to be a highly effective means of creating pro-environmental behavior change (e.g., Abrahamse, 2019).

This supports the concept that individuals in the climate space may have the propensity to share their learnings with others and/or that the intervention was a motivator to do so. Future workshops may look to stress the benefits of knowledge sharing in order to expand PEB change to the broader community.

Limitations

Although this research revealed significant findings, it is important to note its limitations. Firstly, the behaviors illustrated were all self-reported. There are several faults that can be associated with this point. Koller et al. (2023) found that, when individuals self-report their PEB, there may be measurement error, order effects bias, and social desirability bias. Measurement error is simply reporting behaviors that differ from an individual's actual behavior, either deliberately or not. Individuals may have experienced memory errors since the study ran over the course of a month. Order effects bias may have occurred in the surveys based on the order of the questions posed. Participants were also asked to explain what behavioral goals they had set for the future which could have led to a question-behavior effect, meaning that participants may have reported heightened behaviors in the follow-up survey even if they did not happen (e.g., Koller et al., 2023). The participants were told broadly what the study was addressing which may have led to demand characteristics in which participants indicate responses based on what they believe the study is trying to prove. Interestingly, when asked what prompted control group participants to take new PEBs, they cited workshop learnings and carbon calculator insights. This suggests that control group participants may have sought out similar interventions as the ones mentioned in the study after they became aware of these interventions or reminded of them. Follow-up work should keep this point in mind.

Additionally, there may have been social desirability bias, where individuals were more inclined to report positive behaviors due to the positive stigma associated with doing so. Especially since the participants were predominantly recruited from The Carbonauts' database and the intervention was developed by The Carbonauts, this may have been a significant limitation. In a meta analysis from Kormos and Gifford (2014), they found that self-reported PEB and actual PEB have a medium correlation and 79% of the behavioral differences cannot be described by what individuals say they do. Overall, self reported behavior may not be the most accurate means of capturing actual behavior but, due to the time constraints of this research, this was the selected route.

The convenience sample used in this research was of a smaller scale so the results may not be as representative as a larger scale study would be. Additionally, if the general ability of the intervention to change PEB and knowledge was to be assessed, the sample would need to be more representative of the general population in their demographics. Individuals who took a sustainability-centered workshop and/or a carbon calculator assessment in the past were not excluded from the study. This is due to the fact that workshops and carbon footprint calculators are not standardized. Even so, there may have been some repeated information or interventions. Of those who took the treatment, not all participants were able to stay for the entire extent of the intervention and were not excluded from results. This may have skewed findings since not all participants experienced the entire intervention. Within the surveys, not all possible sustainable actions could be provided so the quantitative analysis was not able to capture all actions noted in the open-ended responses. As discussed earlier in the research, participants were enrolled a few weeks after the results of the United States 2024 presidential election. The

data collected may have been skewed as the election results could have influenced participants' responses and engagement levels. Despite the limitations noted in this research, this study provides information that may point to an intervention that can effectively influence PEB.

Questions for Further Research

This research analyzed the impact of the treatment over a one month time period. However, the long-term effectiveness of interventions, including the carbon footprint calculator, are not well known and may be short lived (e.g., Enlund et al., 2023). It is therefore of interest for future research to assess whether there are enduring behavioral impacts. Additionally, the interviews also found that the action planning activity, which focused on making written commitments, was not useful in keeping individuals accountable since there were no follow ups. In order to keep extended momentum up, it could be beneficial to add in a regular cadence of feedback, reinforced commitment, and social support since both the cited research and the interviews expressed a need for more frequent check-ins and support (e.g., Abrahamse, 2019; Melin, 2012). The interviewees also suggested quarterly check-ins, automated reminders, and systems to track progress.

The interviews revealed that the condensed format of the intervention hindered participants' abilities to be fully engaged. Further research may find it of interest to conduct longer workshop sessions or sessions broken up by specific topic to see if the results may be more significant. Future research may also be interested in conducting a similar intervention with individuals that have no prior experience with sustainability-focused workshops or carbon footprint calculators as the results may be more notable. Additionally, the interviewees stressed the importance of intergenerational equity. Future

research may aim to bring together youth and adults to engage in learning in order to promote intergenerational responses to climate change.

The data indicated that financial barriers were among the most cited hindrances. However, almost half (45.1%) of all participants in the study had a household income of over \$150,000 which is significantly larger than the \$80,610 average household income in the United States in 2023 (Guzman & Kollar, 2024). This leads to additional research questions to investigate such as, at what household income level do financial barriers to climate action dissipate? Further studies seeking to standardize carbon calculator assessments as well as more complex PEB interventions may assist in comparison studies.

Since social dynamics were only captured in a small portion of this study and tend to be overlooked in most survey-based research, it would be beneficial for continued research to investigate how to use social factors to increase the efficacy of the intervention (e.g., Thøgersen, 2014). Further research of the intervention effects on individuals who learned about the study from participants sharing would be useful in understanding how primary treatments may be able to affect broader communities.

Conclusions

My research investigated the efficacy of a multi-component intervention in promoting PEB among individuals already within the climate space. The findings showed that even among individuals with high levels of environmental knowledge and engagement, a treatment with EE, commitments, feedback, and social interaction can positively influence PEB, as the treatment group adopted twice as many new sustainable actions relative to the control group. Moreover, the carbon calculator was cited as the

most influential aspect of the intervention. However, the intervention had no effect on overall environmental knowledge.

Perhaps notably, the collected data also showed that those who experienced the workshop treatment shared learnings with the community. This suggests potential for a primary intervention to have influence beyond those who directly experience it. Taken together, my research shows that individuals engaged in the climate space are able to adopt additional climate action through a multi-component treatment, although they still experience structural barriers regardless of their motivation or income. The effectiveness of this intervention indicates that personalized feedback in combination with environmental education, commitments, and social support may be an efficacious treatment, especially in those with already high levels of knowledge.

Appendix 1

Baseline Survey

Table 5. Baseline survey questions.

Question	Responses
INTRODUCTION: Thank you for participating in this study. This survey aims to understand your current sustainability knowledge and behaviors. Please answer the following questions based on your current habits and intentions.	
SURVEY CODE CREATION: To maintain anonymity while allowing us to track your responses across surveys, please create your unique survey code using the following questions. Please write down this code, as you will need to use the same code for the next survey.	
What are the first two letters of the street you currently live on?	[Open-ended response]
What is your 2-digit birthday (just the day), excluding the month and year? For example, if your birthday is June 6, please write 06.	[Open-ended response]
SECTION 1: BASELINE SUSTAINABILITY BEHAVIORS This section assesses your current engagement with sustainability practices across different aspects of daily life, including home energy use, transportation, and food choices. Understanding your current behaviors helps establish a baseline for measuring the effectiveness of sustainability initiatives.	
Are you currently engaging in or have completed any of the following individual sustainability behaviors? (Please select all that apply) [Once the respondent selected one of the following, they were directed to specific actions within each category]	• Reducing home energy and water use • Reducing home energy emissions • Reducing food emissions • Reducing driving emissions • Reducing flying emissions • Offsetting your footprint • None of the above
Reducing home energy and water use (Please select all that apply)	• Switching to LED bulbs • Installing low-flow showerheads • Installing smart thermostats

	• Getting a house audit • Other (Please specify)
Reducing home energy emissions (Please select all that apply)	• Switching to utility green power • Switching to community solar • Getting rooftop solar • Other (Please specify)
Reducing food emissions (Please select all that apply)	• Moving to a plant-rich diet • Starting to compost • Focusing on reducing food waste • Other (Please specify)
Reducing driving emissions (Please select all that apply)	• Cutting down on short driving trips • Switching to a hybrid vehicle • Switching to a plug-in hybrid vehicle • Switching to an electric vehicle • Other (Please specify)
Reducing flying emissions (Please select all that apply)	• Skipping flights • Stacking two trips together • Flying economy • Searching for greener flights using Google Flights • Other (Please specify)
Offsetting your footprint (Please select one)	• Offsetting some of my emissions • Offsetting all of my emissions • Offsetting more than all of my emissions
What barriers do you face in completing sustainable actions? (Please select all that apply)	• Lack of time • Lack of financial resources • Lack of knowledge • Limited access to sustainable products or services • Social or community norms • Other (Please specify)
SECTION 2: ENVIRONMENTAL KNOWLEDGE AND ATTITUDES This section evaluates your understanding of sustainability concepts, your confidence in implementing sustainable practices, and your motivations for engaging in environmental actions. Your responses will help better understand the relationship between knowledge, attitudes, and behavior change.	

How would you rate your knowledge of individual sustainable actions?	• Not knowledgeable at all • Slightly knowledgeable • Moderately knowledgeable • Very knowledgeable • Extremely knowledgeable
How well do you understand the impact of individual sustainable actions on reducing carbon emissions?	• Not well at all • Slightly well • Moderately well • Very well • Extremely well
How important is reducing your personal carbon footprint to you?	• Not at all important • Slightly important • Moderately important • Very important • Extremely important
How much do you agree or disagree with the following statement: Individuals can make a difference in reducing environmental damage.	• Strongly disagree • Somewhat disagree • Neither agree nor disagree • Somewhat agree • Strongly agree
Have you taken any workshops or educational programs focused on individual sustainability behaviors in the past? [If yes, the respondent was directed to additional questions]	• No • Yes
What was/were the format(s)? (Select all that apply)	• In-person • Live-virtual • Asynchronous (self-paced)
When did you last complete a workshop or educational program focused on individual sustainability behaviors?	• Within the last 6 months • 6-12 months ago • 1-2 years ago • 2+ years ago
Have you calculated your personal carbon footprint in the past? [If yes, the respondent was directed to an additional question]	• No • Yes

When did you last calculate your personal carbon footprint?	• Within the last 6 months • 6-12 months ago • 1-2 years ago • 2+ years ago
What are your motivations for engaging in sustainable behaviors? (Please select all that apply)	• Environmental concerns • Financial savings • Social responsibility • Health benefits • Professional interest • Other (Please specify)
Have you set any future sustainability goals?	• No • Yes
[If yes, the respondent was directed to an additional question]	
What specific sustainability goals have you set?	[Open-ended response]
SECTION 3: DEMOGRAPHIC INFORMATION This section collects demographic information to help understand how sustainability behaviors and attitudes may vary across different groups. All survey responses will be kept anonymous and confidential. This information will only be used for aggregate statistical analysis and will not be linked to individual respondents in any way.	
What is your age?	[Drop down selection ranging from 18 to Greater than 85]
What is your gender?	• Male • Female • Non-binary / third gender • Prefer not to say • Other (Please specify)
What is your education level?	• High school or equivalent • Some college or associate degree • Bachelor's degree • Master's degree • Doctorate degree
What is your household income?	• Less than \$50,000 • \$50,000 - \$74,999 • \$75,000 - \$99,999 • \$100,000 - \$149,999 • More than \$150,000

What industry do you currently work in?	• Healthcare • Education • Technology/IT • Government/Public Sector • Professional Services/Consulting • Manufacturing/Industrial • Energy/Utilities • Non-profit/NGO • Construction/Real Estate • Financial Services • Other (Please specify)
Are you currently a student?	• No • Yes, full-time • Yes, part-time
What is your current occupation?	• Sustainability Manager/Director • Environmental Consultant • Professor/Teacher/Educator • Researcher/Scientist • Policy Analyst/Government Official • Engineer • Government/Policy • Urban/Regional Planner • Project Manager • Unemployed • Other (Please specify)
How many years have you been involved in the sustainability space?	[Drop down selection ranging from Less than 1 to Greater than 50]
What is your current geographic location?	• Northeast (ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD) • Southeast (VA, WV, KY, NC, SC, TN, GA, FL, AL, MS, AR, LA) • Midwest (OH, IN, IL, MI, WI, MN, IA, MO, ND, SD, NE, KS) • Southwest (TX, OK, NM, AZ) • West (CO, WY, MT, ID, WA, OR, UT, NV, CA, AK, HI) • Outside of U.S. (Please specify the country)
Thank you for completing the survey. Your responses are valuable in helping us understand your current sustainability behaviors. If you have any additional comments or insights, please feel free to share them via email (alf329@g.harvard.edu).	

Appendix 2

Follow-up Surveys

Table 6. Treatment group follow-up survey questions.

INTRODUCTION: Thank you for continuing with this study. This survey aims to assess whether or not the sustainability workshop, carbon calculator, and action planning may have influenced your knowledge, attitudes, and behaviors over the past month. We are interested in understanding any changes that may or may not have occurred following your participation in these activities.	
SURVEY CODE ENTRY: Please enter the code you created in the previous survey. This code maintains your anonymity while allowing us to link your responses. [This section is the same as the baseline survey so I will not repeat]	
SECTION 1: WORKSHOP PARTICIPATION This section helps us understand your level of engagement with the workshop and its components. We are interested in your experience with different aspects of the workshop, regardless of whether you found them helpful or not.	
Did you attend the full workshop session?	• Yes, I attended the entire session • I attended most of the session (more than half) • I attended some of the session (less than half) • No, I was unable to attend
Please rate your experience with the workshop components.	
How helpful did you find the workshop?	• Not helpful at all • Slightly helpful • Moderately helpful • Very helpful • Extremely helpful
How helpful did you find the carbon calculator exercise?	• Not helpful at all • Slightly helpful • Moderately helpful • Very helpful

	• Extremely helpful
How helpful did you find the action planning activity?	• Not helpful at all • Slightly helpful • Moderately helpful • Very helpful • Extremely helpful
How helpful did you find the group interaction?	• Not helpful at all • Slightly helpful • Moderately helpful • Very helpful • Extremely helpful
How helpful did you find the resources provided?	• Not helpful at all • Slightly helpful • Moderately helpful • Very helpful • Extremely helpful
How much do you agree with the following statements?	
I gained new knowledge about reducing my carbon footprint.	• Strongly disagree • Somewhat disagree • Neither agree nor disagree • Somewhat agree • Strongly agree
I feel confident applying what I learned to my daily life.	• Strongly disagree • Somewhat disagree • Neither agree nor disagree • Somewhat agree • Strongly agree
The workshop increased my understanding of environmental impacts.	• Strongly disagree • Somewhat disagree • Neither agree nor disagree • Somewhat agree • Strongly agree
The carbon calculator helped me understand my lifestyle impacts.	• Strongly disagree • Somewhat disagree • Neither agree nor disagree

	• Somewhat agree • Strongly agree
The action plan motivated me to make more sustainable choices.	• Strongly disagree • Somewhat disagree • Neither agree nor disagree • Somewhat agree • Strongly agree
SECTION 2: BEHAVIOR CHANGES This section tracks any new sustainability actions you've taken or changes in your existing practices over the past month, particularly those from your action plan.	
Over the past month, have you initiated any NEW sustainability actions in the following categories? (Please select all that apply) [Once the respondent selected one of the following, they were directed to specific actions within each category]	• Reduced home energy and water use • Reduced home energy emissions • Reduced food emissions • Reduced driving emissions • Reduced flying emissions • Offset your footprint • None of the above
Reduced home energy and water use (Please select all that apply)	• Switched to LED bulbs • Installed low-flow showerheads • Installed smart thermostats • Got a house audit • Other (Please specify)
Reduced home energy emissions (Please select all that apply)	• Switched to utility green power • Switched to community solar • Got rooftop solar • Other (Please specify)
Reduced food emissions (Please select all that apply)	• Moved to a plant-rich diet • Started to compost • Focused on reducing food waste • Other (Please specify)

Reduced driving emissions (Please select all that apply)	• Cut down on short driving trips • Switched to a hybrid vehicle • Switched to a plug-in hybrid vehicle • Switched to an electric vehicle • Other (Please specify)
Reduced flying emissions (Please select all that apply)	• Skipped flights • Stacked two trips together • Flew economy • Searched for greener flights using Google Flights • Other (Please specify)
Offset your footprint (Please select one)	• Offset some of my emissions • Offset all of my emissions • Offset more than all of my emissions
For behaviors you reported in the previous survey (such as skipping flights, composting, etc.), have you made any significant changes in frequency or intensity? Please describe any increases or decreases:	[Open-ended response]
What, if anything, prompted these changes? (Please select all that apply)	• Workshop insights • Carbon calculator results • Action planning process • Increased awareness • Financial considerations • New information or resources • Changes in personal circumstances • Influence from peers/community • Other (Please specify)

If you faced any barriers to maintaining or increasing your sustainable behaviors, what were they? (Please select all that apply)	• Lack of time • Lack of financial resources • Lack of knowledge • Limited access to sustainable products or services • Social or community norms • Other (Please specify)
SECTION 3: ENVIRONMENTAL KNOWLEDGE AND ATTITUDES This section assesses any changes in your understanding and perspectives about sustainability over the past month. [This section is the same as Section 2 of the baseline survey so I will not repeat, except it does not ask if there was a recent workshop or carbon calculator taken and it does not ask about future sustainability goals]	
SECTION 4: WORKPLACE AND COMMUNITY INTEGRATION This section explores whether you have applied any workshop concepts in your workplace or in your community. We are interested in understanding if and how workshop learnings may have influenced your actions in either of these settings.	
Have you shared or implemented any workshop learnings in your workplace? [If yes, the respondent was directed to an additional question]	• No • Yes
How have you shared or implemented any workshop learnings in your workplace?	[Open-ended response]
Have you shared or implemented any workshop learnings in your community?	• No • Yes
How have you shared or implemented any workshop learnings in your community?	[Open-ended response]
SECTION 5: FUTURE PLANS: This section explores your sustainability intentions moving forward.	
What sustainability goals, if any, have you set for 2025?	[Open-ended response]
What resources or support would help you achieve these goals?	[Open-ended response]

Thank you for completing both surveys in this study. Your responses are valuable in helping us understand how sustainability behaviors evolve over time. If you have any additional comments or insights, please email them to alf329@g.harvard.edu.

Table 7. Control group follow-up survey questions.

INTRODUCTION: Thank you for continuing with this study. This survey aims to understand any changes in your sustainability knowledge, attitudes, and behaviors over the past month. Please answer based on your experiences during this time period.	
SURVEY CODE ENTRY: Please enter the code you created in the previous survey. This code maintains your anonymity while allowing us to link your responses. [This section is the same as the baseline survey so I will not repeat]	
SECTION 1: BEHAVIOR CHANGES This section tracks any new sustainable actions you've taken or changes in your existing practices over the past month. Please only report new actions or significant changes to your previous behaviors. [This section is the same as Section 2 of the treatment group survey so I will not repeat with the exception of the question below]	
What prompted any new actions or changes? (Please select all that apply)	• I took a workshop • I used a personal carbon calculator • I created a sustainable behavior action plan • Increased awareness • Financial considerations • New information or resources • Changes in personal circumstances • Influence from peers/community • Other (Please specify)
SECTION 2: ENVIRONMENTAL KNOWLEDGE AND ATTITUDES This section assesses any changes in your understanding and perspectives about sustainability over the past month. [This section is the same as Section 2 of the baseline survey so I will not repeat, except it does not ask about future sustainability goals]	
SECTION 3: FUTURE PLANS This section explores your sustainability intentions moving forward. [This section is the same as Section 5 of the treatment group survey so I will not repeat]	

Thank you for completing both surveys in this study. Your responses are valuable in helping us understand how sustainability behaviors evolve over time. If you have any additional comments or insights, please email them to alf329@g.harvard.edu.

Appendix 3

Interview Guide

Table 8. Interview questions for the treatment and control group.

Question	Follow-up
What motivates you to engage in sustainable behaviors?	How have these motivations changed, if at all, over the last month? Example: I used to be motivated primarily by financial savings but now I am more motivated by environmental concerns.
What barriers do you face in trying to adopt more sustainable habits?	Can you elaborate on specific challenges you've encountered?
How do you feel your community supports (or doesn't support) your sustainability efforts?	Are there any changes you would like to see within your community to help you adopt more sustainable behaviors?
Has anything outside of this study prompted you to make changes in your environmental practices recently?	Can you share any specific examples?
What role do you think individuals can play in addressing climate change?	Can you share your perspective on the importance of collective action? What about individual action? How might the impacts differ?

Table 9. Additional interview questions for the treatment group.

Question	Follow-up
Now I am going to ask you about aspects of the study that may have impacted your understanding of your carbon footprint.	How did these tools help you better understand how your behaviors contribute to overall climate change issues?

• Can you start by telling me the impact of the workshop? • How about the impact of the carbon calculator? • How about the impact of the action planning activity? • How about the impact of the group interaction? • How about the impact of the additional provided resources?	
Since attending the workshop, what changes, if any, have you made in your life that you attribute directly to the workshop?	What specific actions have you taken?
How has the action plan been useful in maintaining or tracking your sustainability commitments?	How do you think the action plan could be improved?
What suggestions do you have for improving the sustainability workshop as a whole or the carbon calculator within the workshop?	Were there any components of the workshop that felt especially helpful or not helpful?
How did the workshop affect your approach to sustainability, personally or in your community?	Have you shared what you learned with others in your community or workplace? If so, how?

Table 10. Additional interview questions for the control group.

Question	Follow-up
Over the past few months, have you considered taking additional steps to reduce your environmental impact?	What factors influenced your decision to take action or not?
Would you be interested in attending a sustainability workshop?	[If yes] What specific information or tools would be the most useful to you in such a workshop?
What resources do you think would help you make more sustainable lifestyle changes?	Do you feel these resources are accessible to you now?

If you were to create your own sustainability action plan, what actions would you prioritize?	How confident do you feel about being able to follow through on a plan like this? What support would you need to create and implement a plan like this?
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Appendix 4

Recruitment Materials

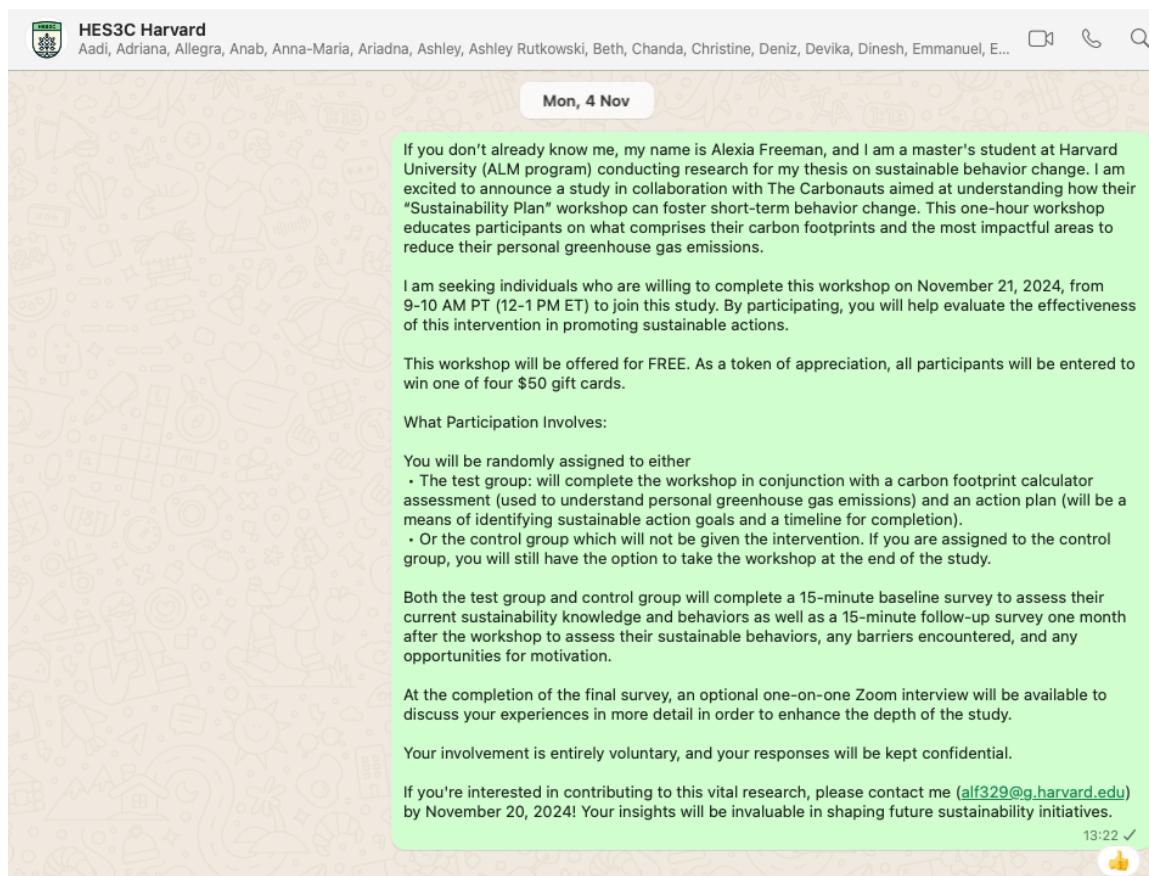


Figure 12. WhatsApp recruitment.

Note. Adapted from (A. Freeman, personal communication, November 4, 2024).

I hope this email finds you well! My name is Alexia Freeman and I am a master's student at Harvard University conducting research for my thesis on sustainable behavior change. I am excited to announce a study in collaboration with The Carbonauts aimed at understanding how their "Sustainability Plan" workshop can foster short-term behavior change. This one-hour workshop educates participants on what comprises their carbon footprints and the most impactful areas to reduce their personal greenhouse gas emissions.

I am seeking individuals who are willing to complete this workshop on **November 21, 2024 from 9-10 AM PT (12-1 PM ET)** to join this study. By participating, you will help evaluate the effectiveness of this intervention in promoting sustainable actions.

This workshop will be offered for **FREE**. As a token of appreciation, all participants **will be entered to win one of four \$50 gift cards**.

What Participation Involves:

- You will be randomly assigned to either
 - The test group which will complete the workshop in conjunction with a carbon footprint calculator assessment (used to understand personal greenhouse gas emissions) and an action plan (used as a means of identifying sustainable action goals and a timeline for completion).
 - Or the control group which will not be given the intervention. If you are assigned to the control group, you will still have the option to take the workshop at the end of the study.
- Both the test group and control group will complete a 15-minute baseline survey to assess their current sustainability knowledge and behaviors as well as a 15-minute follow-up survey one month after the workshop to assess their sustainable behaviors, any barriers encountered, and any opportunities for motivation.
- At the completion of the final survey, an optional one-on-one Zoom interview will be available to discuss your experiences in more detail in order to enhance the depth of the study.

Your involvement is entirely voluntary, and your responses will be kept confidential.

If you're interested in contributing to this impactful research, **please reply to this email (alf329@g.harvard.edu) by November 20, 2024**.

Thank you for considering this opportunity to help shape sustainability efforts!

Best Regards,

Alexia Freeman

Harvard University Extension School ALM Candidate in Sustainability

Figure 13. Email recruitment.

Note. Sent to The Carbonauts' database via email through HubSpot and Squarespace. Adapted from (A. Freeman, personal communication, November 4, 2024).



Alexia (Lexi) Freeman

Event Sustainability Manager at Three Squares Inc. | Pursuing Master's in Sustain...
3mo · Edited

...

If you don't already know me, my name is Alexia Freeman, and I am a master's student at [Harvard University](#) conducting research for my thesis on sustainable behavior change. I am excited to announce a study in collaboration with [The Carbonauts](#) aimed at understanding how their "Sustainability Plan" workshop can foster short-term behavior change. This one-hour workshop educates participants on what comprises their carbon footprints and the most impactful areas to reduce their personal greenhouse gas emissions.

I am seeking individuals who are willing to complete this workshop on November 21, 2024, from 9-10 AM PT (12-1 PM ET) to join this study. By participating, you will help evaluate the effectiveness of this intervention in promoting sustainable actions.

This workshop will be offered for FREE. As a token of appreciation, all participants will be entered to win one of four \$50 gift cards.

What Participation Involves:

You will be randomly assigned to either

- The test group: will complete the workshop in conjunction with a carbon footprint calculator assessment (used to understand personal greenhouse gas emissions) and an action plan (will be a means of identifying sustainable action goals and a timeline for completion).
- Or the control group which will not be given the intervention. If you are assigned to the control group, you will still have the option to take the workshop at the end of the study.

Both the test group and control group will complete a 15-minute baseline survey to assess their current sustainability knowledge and behaviors as well as a 15-minute follow-up survey one month after the workshop to assess their sustainable behaviors, any barriers encountered, and any opportunities for motivation.

At the completion of the final survey, an optional one-on-one Zoom interview will be available to discuss your experiences in more detail in order to enhance the depth of the study.

Your involvement is entirely voluntary, and your responses will be kept confidential.

If you're interested in contributing to this vital research, please contact me (alf329@g.harvard.edu) by November 11, 2024! Your insights will be invaluable in shaping future sustainability initiatives. ❤️

[#sustainability](#) [#researchstudy](#) [#behaviorchange](#) [#harvarduniversity](#) [#thecarbonauts](#) [#climateaction](#)



50 · 10 Comments

Figure 14. LinkedIn recruitment.

Note. Adapted from (Freeman, 2024).

Appendix 5

Consent Form

Study Title: Investigating the Influence of Sustainability Workshops on Behavior: An Experimental Study

Researcher: Alexia Freeman

Faculty Advisor: Dr. Max Bazerman

Key Information

The following is a short summary of this study to help you decide whether to be a part of this study. More detailed information is listed later in this form.

This research, conducted by a master's student at Harvard University for their thesis, aims to evaluate how a virtual sustainability workshop, combined with a carbon footprint calculator and action plan, influences individuals' adoption of environmentally friendly behaviors over a short period of time. The one-hour workshop titled "Sustainability Plan" educates participants on what comprises their carbon footprints and the most impactful areas to reduce their personal greenhouse gas emissions. The carbon footprint calculator will be used to understand personal greenhouse gas emissions and the action plan will be a means of identifying sustainable action goals and a timeline for completion.

All participants will take a 15-minute baseline survey to assess their current sustainability knowledge and behaviors. Participants will be randomly assigned to a test group or a control group. The test group will take the workshop, carbon footprint calculator assessment, and create an action plan. Both the test group and the control group will complete one 15-minute follow-up survey one month after the workshop to assess their sustainable behaviors, any barriers encountered, and any opportunities for motivation. Optional one-on-one Zoom interviews will be available after the follow-up survey for those who wish to share more about their experiences as this will aid in the depth of the study findings. Participation is entirely voluntary, and your responses will remain confidential. As an incentive, all participants will be entered to win one of four \$50 gift cards. For questions, please contact Alexia Freeman at alf329@g.harvard.edu.

Why am I being invited to take part in a research study?

We invite you to take part in a research study because you are engaged in the sustainability space. You are 18 years or older, a fluent English speaker, and have the cognitive capacity to participate.

What should I know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- Your participation is completely voluntary.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- Your refusal to participate will not result in any consequences or any loss of benefits that you are otherwise entitled to receive.
- You can ask all the questions you want before you decide.

Why is this research being done?

This research aims to evaluate how a virtual Sustainability Plan workshop, paired with a carbon footprint calculator and action planning, influences short-term pro-environmental behaviors in individuals interested in the sustainability space.

How long will the research last and what will I need to do?

We expect that you will be in this research study for approximately one month, during which you will complete an initial survey (approximately 15 minutes), followed by one additional follow-up survey (approximately 15 minutes), and potentially participate in a one-hour workshop. You will also have the choice to take part in one optional Zoom interview at the end of the study (approximately 30 minutes).

We don't believe there are any risks from participating in this research.

Will being in this study help me in any way?

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include increased knowledge from the workshop and benefitting further research in the climate change field.

What happens if I do not want to be in this research?

Participation in research is completely voluntary. You can decide to participate, not participate, or discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Your alternative to participating in this research study is to not participate.

What happens if I say yes, I want to be in this research?

If you agree to participate, here's what to expect:

- Initial Survey: All participants will take a 15-minute baseline survey to assess their current sustainability knowledge and behaviors.
- Workshop: You may be selected to join a one-hour virtual workshop conducted via Zoom, where you will learn about your personal carbon footprint and how to create sustainable action goals and a completion timeline.
- Follow-Up Survey: After the workshop, you will receive one follow-up survey via email one-month post-workshop. The survey will take about 15 minutes to complete.
- Optional Interview: At the end of the study, you will have the opportunity to participate in one optional one-on-one interview via Zoom to discuss your experiences and insights regarding the workshop and your sustainable actions. This interview will last approximately 30 minutes.

Throughout the study, you will interact with the research team, including the master's student from Harvard University conducting this research. The research will primarily be conducted online via Zoom for the workshop and interviews, with the initial and follow-up surveys sent to your email. The entire process will span about one month, and participation in the follow-up surveys will help us gather valuable insights about the short-term impact of the workshop on sustainable behaviors.

What happens if I say yes, but I change my mind later?

You can leave the research at any time; it will not be held against you. If you decide to withdraw, any data collected up to that point will be retained for analysis unless you request that it be discarded. You

will not be asked to explain your reasons for withdrawal, and your decision will be respected without any impact on your relationship with The Carbonauts or Harvard University.

The sponsor will provide the following study-related item for you at no cost during participation in the study: a one-hour long Sustainability Plan workshop which includes the carbon footprint calculator and action plan. If you are not chosen to participate in the original group, you will have the option to take the workshop post-study.

If I take part in this research, how will my privacy be protected? What happens to the information you collect?

Efforts will be made to limit the use and disclosure of your personal information to only those who need to review it for research purposes, including the research team and authorized personnel at The Carbonauts. All data collected during the study will be anonymized to protect your identity. While we cannot guarantee complete confidentiality, we will implement stringent security measures to safeguard your information, such as password protection and secure data storage. Your information may be inspected by the Institutional Review Board (IRB) and other representatives of Harvard University, as well as any other relevant parties involved in overseeing the research. Overall, your privacy is a priority, and all reasonable steps will be taken to protect your information throughout the research process.

Your information as part of this research will not be used or distributed for future research studies, even if all your identifiers are removed.

Your name and identifying information will be removed from any data you provide before they are shared with other researchers. Researchers cannot easily link your identifying information to the data.

It is your choice whether or not to let researchers share your data for research in the future. If you say “yes,” you can change your mind later. If you say “no,” you can still fully participate in this study.

If you change your mind and no longer wish to have us store or share your data, you should contact Alexia Freeman (alf329@g.harvard.edu) We will do our best to honor your request and to retrieve any data that have been shared with other researchers. However, there may be times we cannot. For example, if we do not have a way to identify your data we will not be able to retrieve them.

In addition, if the data have already been used for new research, the information from that research may still be used. We will delete any data we have or are able to retrieve.

Please initial, check, or mark next to your choice:

☐ YES, use my data in other research studies
☐ NO, do NOT use my data in other research studies

Raffle/Lottery – If you agree to take part in this research study, we will enter you into a raffle.

If you agree to take part in this research study, you will get the chance to win one of four \$50 gift cards for your time and effort. If you are one of the winners, you will be notified via email approximately two weeks following the completion of the study.

The data from this study may be used for further workshop improvement.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at alf329@g.harvard.edu.

This research has been reviewed and approved by the Harvard University Area Institutional Review Board ("IRB"). You may talk to them at (617) 496-2847 or cuhs@harvard.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

☐ You are 18 years or older, a fluent English speaker, and have the cognitive capacity to participate.

☐ You have read the "Key Information" section and understand that you can withdraw from the study at any time without penalty.

Signature

Date

Figure 15. The consent form for participants.

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