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Sustainability education in a botanical garden promotes environmental knowledge, attitudes and willingness to act

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ABSTRACT

Creating behavior change to mobilize transitions toward sustainability is a significant challenge of our time. Inspired by the United Nations Food and Agriculture Organization's Farmer Field School, we developed a novel community-based education program to engage people in local sustainability topics. In the Sustainable Communities Field School (Field School) program, advertised as team building tours, participants from local organizations are guided by instructors through University of British Columbia Botanical Garden, while receiving verbal and experiential education on topics of food systems and choices, biodiversity conservation, water conservation, and waste reduction. We found that after the Field School program, participants were significantly more knowledgeable about environmental issues, more connected to nature, showed greater intentions and willingness to engage in sustainability actions compared to garden visitors from the general public who did not go through the program. The results suggest that interactive sustainability education in a botanical garden setting can be a useful education model to mobilize public engagement on sustainability.

Abbreviations: FS: field school; GV: garden visitors; SPEC: society promoting environmental conservation; UBC: University of British Columbia

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Sustainability; conservation; environmental attitudes; environmental education; pro-environmental behavior

Introduction

Human activity has caused adverse impacts on earth's ecosystems and created a myriad of environmental problems (Sathaye et al. 2007), at such unprecedented levels that we have ushered a new geologic period called the Anthropocene (Zalasiewicz et al. 2010). More than 80% of earth's surface has been altered by human activity, two-thirds of major marine fisheries are overexploited (or depleted), and global biodiversity loss in the face of a changing climate provides expected and unexpected threats to current and future populations (Estes et al. 2011; FAO 2013; Folke et al. 2004).

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Supplemental data for this article can be accessed here.

Given that human action is at the center of environmental issues, sustainable development ultimately depends on changing human behavior. However, promoting public engagement and individual action remains a challenge for governments, organizations, and institutions worldwide (Gifford 2011; Weber and Johnson 2012; Whitmarsh, Lorenzoni, and O'Neill 2012). There is an exciting opportunity for changemakers to explore effective and innovative ways to promote responsible consumption and resource management, and to implement sustainable strategies and practices across private and public life (Lubchenco 1998; Raskin et al. 2002).

Education in nature: botanical gardens as a venue for sustainability education

Psychologists, anthropologists, and ecologists have long maintained that human connection with nature is a large determinant of people's worldview and behavior (Bateson 1979; Rees 2002; Walker et al. 2004). In a culture where environmental problems are caused by a growing disconnection from the natural world (Suzuki and McConnell 2007), botanical gardens are uniquely situated to provide a contribution to sustainability education and global conservation while fulfilling their horticultural goals. The majority of botanical gardens around the world already promote research, plant conservation, and public education through their courses, tours, and events (Dodd and Jones 2010). Interest in education for sustainable development has grown with gardens around the world working to broaden audiences and diversify programs (Williams et al. 2015). With over 3300 botanical institutions and public gardens around the world receiving over 240 million visitors per year (Botanic Gardens Conservation International 2018), there is a tremendous, yet untapped opportunity for gardens to re-connect communities with the natural world, illustrate the web of connections and motivate individual attitude and action toward a more sustainable future.

Factors that facilitate behavior change

Pro-environmental behavior is defined as any action that enhances the quality of the environment, regardless of intent (Steg et al. 2014). Research has shown that pro-environmental behavior is determined by a number of factors such as knowledge, attitudes, social norms, culture and infrastructure (DiGiacomo et al. 2018; Gifford, Kormos, and McIntyre 2011; Kahneman 2011; Namazu, Zhao, and Dowlatabadi 2016; Nolan et al. 2008; Steg and Vlek 2009; Weber and Johnson 2012; Wu, DiGiacomo, and Kingstone 2013). The natural environment also plays a role in shaping behavior (Nisbett and Ross 2011). Recent studies suggest that nature has beneficial effects on cognition, well-being, and behavior (Berman et al. 2008; Chawla 2015; Pretty 2004; Wells and Evans 2003; Zelenski, Dopko, and Capaldi 2015). Building on past work on behavior change (Jackson 2005; Schultz, Oskamp, and Mainieriv 1995; Stern 2000), here we focus on how sustainability education in nature influences knowledge, attitudes, and pro-environmental behavior.

Roles of knowledge and education

Many models of behavior change focus on information provision and education. For example, increases in knowledge are associated with pro-environmental actions (Darnton 2008; Hines et al. 1987; Schwartz 1992; Stern et al. 1999). Having the knowledge can further empower individuals to engage in pro-environmental actions. For example, knowledge about recycling programs and sorting guidelines has been associated with increased recycling behavior (De Young 1989; Schultz, Oskamp, and Mainieriv 1995). Knowledge in the form of consumption feedback has been effective in reducing household energy consumption (Allcott and Rogers 2012; Nolan et al. 2008; Owens 2000). Trust in the source of information and poignant storytelling using relatable

examples, along with engaging hands-on activities, can help engagement, comprehension, and retention of information (Jackson 2005; Mckenzie-Mohr 2008).

Role of environmental attitudes

Research shows that personal values, attitudes, and beliefs determine the motivation to express concerns about the environment and the adoption of behaviors that are in line with those values and attitudes (Crompton 2010; Schultz, Oskamp, and Mainieriv 1995). People who engage in pro-environmental behavior typically have pro-environmental attitudes (Bamberg and Möser 2007), and people with strong pro-social values or biospheric values are more likely to engage in pro-environmental behavior (Schultz et al. 2007; Stern et al. 1999). Strong environmental attitudes can instigate legislative and infrastructural changes which can further reinforce these attitudes and behavior change over time (Tibbs 2011). Importantly, environmental attitudes and knowledge will have a varying effect on behavior depending on social and geographic contextual factors (Braun, Cottrell, and Dierkes 2017).

Role of nature

Nature provides a range of psychological benefits for adults and children as a result of exposure (Cox et al. 2017; de Vries et al. 2003; Ulrich et al. 1991). These benefits include reducing fatigue and stress (Berg and Berg 2007; Gidlöf-Gunnarsson and Öhrström 2007), and enhancing memory and attention (Barton and Pretty 2010; Berman et al. 2008; Kaplan and Kaplan 2011; Pretty 2004; Wells 2000; Wilson et al. 2009). Moreover, nature exposure speeds up hospital recovery time and reduces the use of painkillers (Bringslimark, Hartig, and Patil 2009; Cohen-Cline, Turkheimer, and Duncan 2015; Maller et al. 2006; Ulrich 1984). For these reasons, access to nature has been established as a critical component of a healthy, livable, and thriving city (City of Vancouver 2012; de Vries et al. 2003). Having a connection with nature is also associated with environmental attitudes, concern, and behavior (Dunlap et al. 2000; Nisbet et al. 2009; Schultz et al. 2004), which are identified as one key factor in pro-environmental behavior (Dietz et al. 2009; Stern et al. 1999). In a study with five botanical gardens in the UK, there was a positive relationship between ecological knowledge and environmental attitudes in visitors to botanical gardens, as the visitors showed stronger environmental attitudes after their visit to the gardens (Williams et al. 2015).

The current study

The goal of the current study is to examine the impact of a sustainability education program delivered in a botanical garden on people's environmental knowledge, attitudes, intentions and willingness to act. We evaluated the Sustainable Communities Field School (FS) program in Vancouver, Canada, which was jointly developed in 2015 by the University of British Columbia (UBC) Botanical Garden and the Society Promoting Environmental Conservation (SPEC) an environmental non-profit organization. Established in 1916 as Canada's oldest university botanic garden, it features over 500 different types of rhododendrons, 95 maples, 75 magnolias, and a variety of mountain ash, woody vines and climber plants. Over the past 100 years, the mission of the UBC Botanical Garden is to curate and maintain a documented collection of temperate plants for the purposes of education, research, conservation, community outreach and public display. Thus, the UBC Botanical Garden provides a unique outdoor environment for the FS program.

The FS program is modeled after the United Nations Food and Agriculture Organization's Farmer Field School, which started in the 1980s to help farmers reduce pesticide use, and improve land and water management. The UN Farmer Field School gained popularity due to its

focus on participation and empowerment to build farmers' capacity to make decisions that ultimately reduce pesticide risks and improve farmer health (Friis-Hansen and Duveskog 2012; Najjar, Spaling, and Sinclair 2013; Settle et al. 2014). Inspired by this successful model of sustainability education, our FS program delivers a verbal and interactive sustainability experience to participants. Advertised as a team-building retreat, the program is designed to engage employees of local businesses and organizations in topics of sustainability in nature. Participants in the FS program are led by instructors on a tour and receive verbal education.

The following four sustainability topics provided the foundation of the FS curriculum: (i) food systems and choices, (ii) biodiversity conservation, (iii) water conservation, and (iv) waste reduction. These four domains were selected by local and global sustainability policy goals, as well as the available features of the botanical garden. The FS curriculum was inspired by the City of Vancouver Greenest City 2020 Action Plan, which includes zero waste (goal 5), clean water (goal 9), and local food (goal 10) (City of Vancouver 2012). Expanding globally, these topics of the FS program also link to the Sustainable Development Goals of zero hunger (goal 2), clean water (goal 6), responsible consumption and production (goal 12), and life on land (goal 15) (United Nations Development Programme 2018). The current study is unique because it is a rigorous evaluation to measure the impact of the FS program on participants' environmental knowledge, attitudes, intentions and willingness to act. Specifically, we surveyed participants before vs. after their visit, and surveyed a separate group of regular garden visitors (GV) who did not go through the FS program, as a control group.

Methods

Participants

A total of 315 participants took part in the study. There were two distinct groups: FS participants and regular GV who did not receive the FS tour. There were 196 FS participants (47 males, 123 females, 26 undisclosed; mean age = 40 years old, SD = 15; 12.5% completed high school, 12.2% college, 26.1% university, and 12.7% with graduate degrees) who were employees in local businesses and organizations recruited by the FS marketing team. Of this group, 90 FS participants filled out both pre- and post-visit surveys, but overall 146 FS participants completed the pre-visit survey and 140 FS participants completed the post-visit survey. As a control group, there were 119 GV (30 males, 66 females, 23 undisclosed; mean age = 39 years old, SD = 17; 18% completed high school, 10% college, 22% university, and 21.7% with graduate degrees) who were recruited at the botanical garden. Both groups came to the garden voluntarily. None of the GVs filled out both pre- and post-visit survey, and 40 completed the pre-visit survey and 79 completed the post-visit survey. As such, we opted to use a between-subjects design for data analysis. The study was approved by UBC Behavioral Research Ethics Board.

Survey design

The goal of the survey was to evaluate the impact of the FS program on participants' environmental knowledge, attitudes, intentions and willingness to engage in pro-environmental actions. The pre-visit and post-visit surveys are shown in Appendix A. The survey measured four components described below.

Environmental knowledge

The FS program involved four key topics: sustainable food systems, biodiversity conservation, water conservation, and waste reduction. We tested participants' knowledge on these topics after

the tour and compared it to GV who did not receive the FS tour (see Appendix B). The test was only administered in the post-visit survey to avoid priming FS participants of specific topics before the tour.

Environmental attitudes and intentions to act

To assess environmental attitudes and intentions to act, we used four well-established and commonly used psychometric scales (see Appendix B). The Eco-Centrism (EC) scale measures the degree to which people are nature-oriented and likely to engage in conservation behaviors (Thompson and Barton 1994). The Shortened Revised New Ecological Paradigm (NEP) is widely used for measuring general environmental attitudes through statements which assess a person's beliefs about humanity's ability to upset the balance of nature and the right to rule over the rest of nature (Dunlap et al. 2000). The Shortened Nature Relatedness (SNR) scale is designed to measure the strength of people's connection with nature which is associated with well-being and participation in ecologically sustainable behavior. Form the short-form Nature Relatedness Scale (NR-6), we selected two statements which represent a self identification and connection with nature (Nisbet and Zelenski 2013). We chose these two items specifically because they assess two important dimensions directly relevant to the FS program: the awareness of the impact of one's own actions on the environment, and one's relationship to nature. The final scale is the Intentions to Act (ITA) which examines people's willingness to take specific actions to address climate change (Bord et al. 2000).

The participants rated each statement on an 11-point Likert-scale, indicating how strongly they agree (10) or disagree (0) with the statement. Only one statement (the so-called 'ecological crisis' facing humankind is greatly exaggerated) was reverse coded. We randomized the order of the 13 questions in the pre-visit and the post-visit surveys, and kept the same order for all participants, to minimize the chance of recalling their previous answers.

Willingness to engage in pro-environmental behaviors

To examine whether the FS program changed people's willingness to act, we identified five actions in four sustainability domains (water, waste, food, and biodiversity) covered in the curriculum (see Appendix B). The actions were carefully selected in the survey to ensure that they were relevant to the local context and to the FS curriculum: water actions (Attari 2014; Gilg and Barr 2006), waste actions (Ebreo and Vining 2001; Simmons and Widmar 1989), food actions (Aschemann-Witzel et al. 2015; Seyfang 2006), and biodiversity actions (Jacobson, McDuff, and Monroe 2015; Monroe 2003). Participants were asked to select the actions they were most willing to do, and they could select multiple actions in each domain. We also included a sixth 'other' option in case people wanted to list other actions.

Demographics

Previous studies have shown that gender, age, and education can correlate with environmental attitudes and behavior (Kollmuss and Agyeman 2002; Williams et al. 2015), we thus collected information on gender, age, and education level as demographics. We also collected answers on the four questions (e.g. name of the first street they lived on as a child), so that we could match the same participant from the pre-visit and the post-visit surveys.

Procedure

The FS marketing team reached out to local businesses and organizations to invite their employees to participate in the FS program. As a result, there were seven groups (each group ranging from 20 to 60 participants) who came to the garden, with a total of 196 FS participants. Each

group was led by two instructors (one from UBC Botanical Garden and one from SPEC) to tour the garden while receiving verbal education about sustainability issues and participating in team-building activities. At the same time, 119 regular GV who toured the botanical garden by themselves in groups of two to six were also surveyed.

Field School tour

Electronic pre-visit surveys were emailed to participants a week before their visit (using fluidsurveys.com), but less than 5% of the participants filled out the online survey. The majority of participants completed a paper copy of the pre-visit survey upon arrival to the garden.

After completing the pre-visit survey, FS participants were introduced to the FS team, the tour goals, and a brief agenda of the tour. To ensure that each group received the same tour and curriculum and to make our FS tour replicable by other researchers and gardens, we documented the instructor scripts, the number of tour stops, the activities during the tour, and their locations in the garden (Appendices C and D). The entrance and the exit of the garden were in the same location, where participants completed the pre-visit survey before the tour and the post-visit survey after the tour. At each stop, the instructor delivered a verbal presentation of the discussion topics, and asked the group to participate in the activities. Each tour lasted around three hours.

Regular garden visitor tour

As a control group, 119 regular GV were recruited for the study on a voluntary basis at the botanical garden. A table was set up at the entrance/exit during mid-day (1–5 pm), in the same summer period as the FS tours. GV were approached by research assistants near the entrance/exit, in order to recruit people who just arrived at or were about to leave the garden. The table contained the surveys, garden advertisements, and education materials to draw people's attention. Organic apples and chocolate snacks were offered as an incentive for people to participate. Upon agreeing to participate, GVs were asked to indicate whether they had just arrived, or finished their visit to the garden on this trip, and then they completed the survey. GVs were also asked whether they had gone through the food garden and the Greenheart Canopy TreeWalk. The majority of GVs who completed the post-visit survey had gone through the food garden, while a small percentage had also done the Greenheart Canopy TreeWalk (i.e. they had gone through stops 1 to 12). During the study there was limited signage on plant labeling throughout the garden, so GVs could not have gained answers to the knowledge questions. In fact, the only signage available in the garden was the Latin names of the plants. This ensured that FS participants and GVs had similar exposures to the garden environment, so the biggest difference between the two groups was the FS tour.

Results

We used a between-subjects 2 (time: pre-visit vs. post-visit) $\times$ 2 (group: FS participants vs. GV) ANOVA to examine each of the following measures. All statistical tests were done in R (R Core Team 2017). There were 90 matched FS participants (the same person who filled out both pre-visit and post-visit surveys), and the within-subject analysis for the FS participants is presented (Appendix E).

Environmental knowledge

To examine environmental knowledge, the correct answer to a question was coded as 1 and the incorrect answer as 0. The percent of correct answers for each question for the FS participants and GV was calculated and compared (Figure 1). A chi-square test with Yates correction was used to assess differences between the two groups. Results showed that significantly more FS

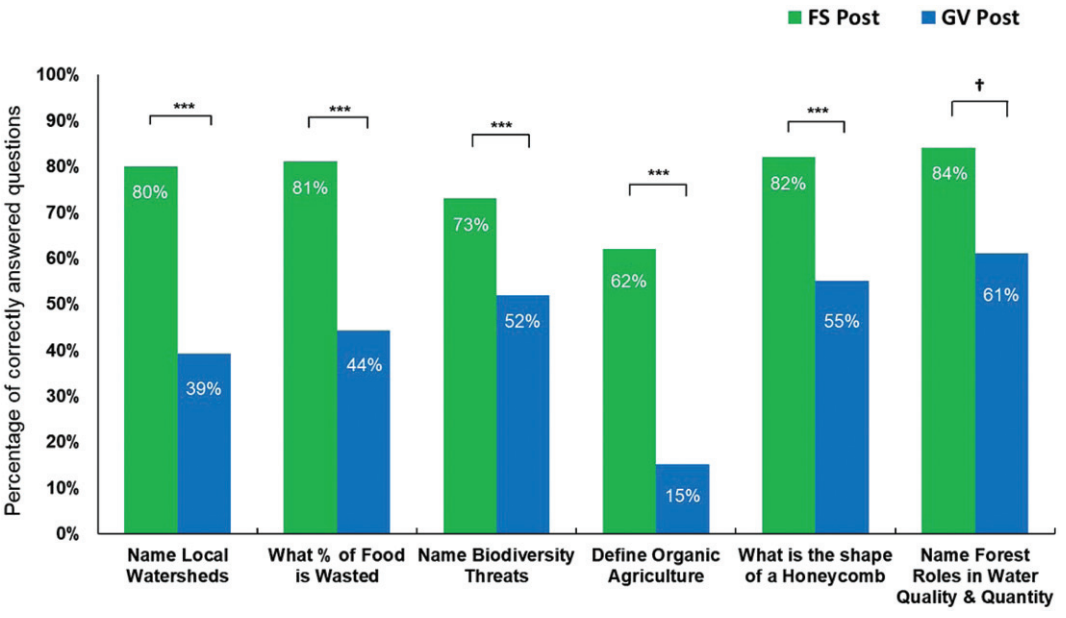

Figure 1. Knowledge measured as percentage of participants who correctly answered each question among the Feld School participants and regular garden visitors. FS: Field School participants; GV: garden visitors; Post: post-visit. ($^{\dagger}p < .1$, $^{***}p < .001$.)

participants answered five knowledge questions correctly compared to GV participants (local drinking watersheds [$x^2(1) = 35.25$, $p < .001$], percentage of food waste [$x^2(1) = 30.32$, $p < .001$], biodiversity threats [$x^2(1) = 9.60$, $p < .001$], organic agriculture definition [$x^2(1) = 43.07$, $p < .001$], and the shape of a honeycomb cell [$x^2(1) = 17.54$, $p < .001$]). For the sixth question 'Name forest roles in water quality and quantity', the difference between the two groups was marginally significant [$x^2(1) = 10.90$, $p = .09$]. These results suggest that FS participants were more knowledgeable about environmental issues after the tour than GV who did not receive the FS program.

Environmental attitudes and intentions to act

To examine environmental attitudes and intentions to act, we conducted a 2 (time: pre-visit vs. post-visit) × 2 (group: FS participants vs. GV) between-subjects ANOVA on the ratings of the four psychometric scales. The average ratings are shown in Figure 2. The internal reliability of the scales was examined via Cronbach's alpha. All four scales had an acceptable reliability: EC $\alpha = .68$, NEP $\alpha = .65$, SNR $\alpha = .71$, and ITA $\alpha = .65$.

For EC, there was no main effect of time [$F(1, 396) = 0.29$, $p = .58$, $\eta_p^2 = .0007$] or group [$F(1, 396) = 1.44$, $p = .23$, $\eta_p^2 = .003$], but there was a significant interaction between time and group [$F(1, 396) = 9.07$, $p = .002$, $\eta_p^2 = .022$]. This suggests that FS participants showed an increase in EC after the tour, but the GV showed a decline. For NEP, there was no main effect of time [$F(1, 396) = 1.52$, $p = .21$, $\eta_p^2 < .001$], condition [$F(1, 396) = 0.02$, $p = .86$, $\eta_p^2 = .003$], or interaction between time and group [$F(1, 396) = 1.48$, $p = .22$., $\eta_p^2 = .002$]. For nature relatedness, there was no main effect of time [$F(1, 397) = 0.10$, $p = .74$, $\eta_p^2 < .001$], but a marginal effect of group [$F(1, 397) = 2.83$, $p = .09$, $\eta_p^2 = .002$], and a significant interaction between time and group [$F(1, 397) = 9.73$, $p < .001$, $\eta_p^2 = .009$]. This suggests that the FS participants showed an increase in nature relatedness after the tour, but the GV showed a decline. Finally, for intentions to act, there was no effect of time [$F(1, 397) = 3.63$, $p = .05$, $\eta_p^2 = .009$], or group [$F(1, 397) = 1.89$, $p = .16$, $\eta_p^2 = .004$], but a significant interaction between time and group [$F(1, 397) = 9.11$, $p = .002$,

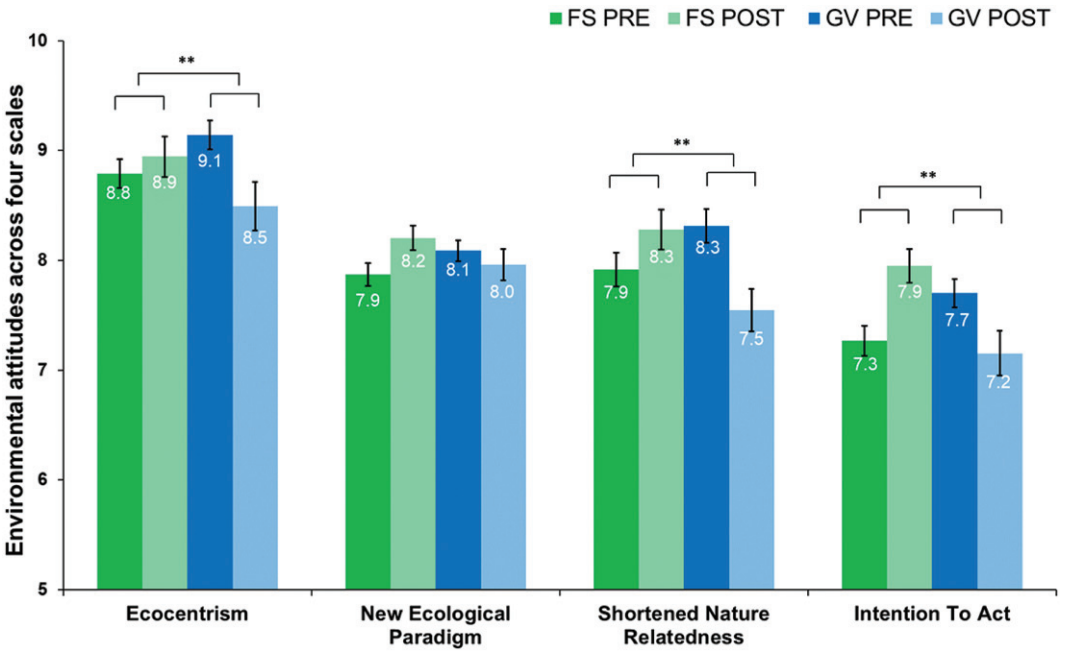

Figure 2. Average ratings on the four scales between the two groups before and after the visit. FS: Field School participants; GV: garden visitors; Pre: pre-visit; Post: post-visit. (Error bars reflect ±1 SEM; $^{**}p < .01$.)

$\eta_p^2 = .022$]. This suggests that the FS participants showed an increase in intentions to act after the tour, compared to GV.

Willingness to engage in pro-environmental behaviors

The percentage of participants who were willing to engage in pro-environmental actions before vs. after their visit was used to compare willingness to engage in sustainable actions between FS and GV participants. A chi-square test with Yates correction was used to assess differences between the groups. For water conservation (Figure 3), one action (do less laundry) showed a significant difference where FS participants showed an increase in willingness after the visit [$x^2(1) = 5.16$, $p = .02$], but for GV the increase was marginal [$x^2(1) = 2.91$, $p = .08$].

For waste reduction (Figure 4), one action (choosing items with low packaging) showed a significant increase in willingness for the FS group after the tour [$x^2(1) = 5.03$, $p = .02$].

For sustainable food choices (Figure 5), one action (grow your own food) showed a difference, where FS participants marginally increased their willingness [$x^2(1) = 2.77$, $p = .09$], but GV marginally decreased their willingness [$x^2(1) = 3.28$, $p = .06$] after their visit.

For biodiversity conservation (Figure 6), marginally more FS participants were willing to buy forestry certified paper after the tour [$x^2(1) = 1.91$, $p = .1$], compared to GV whose willingness decreased after the visit [$x^2(1) = 3.93$, $p = .04$]. Moreover, marginally more FS participants were willing to volunteer for a nature group [$x^2(1) = 2.76$, $p = .09$], and significantly more FS participants were willing to donate to nature conservation [$x^2(1) = 5.76$, $p = .01$] after the tour.

Comparing percentages of participants willing engage for all 20 actions across the 4 domains (Figures 3–6) it was found that the waste reduction domain had the highest rate of willingness to act. The lowest percentage of overall willingness to act was found in the biodiversity conservation domain. A within-participant comparison for the 90 matched FS participants was shown in Appendix E. Regression analyses were shown in Appendix F.

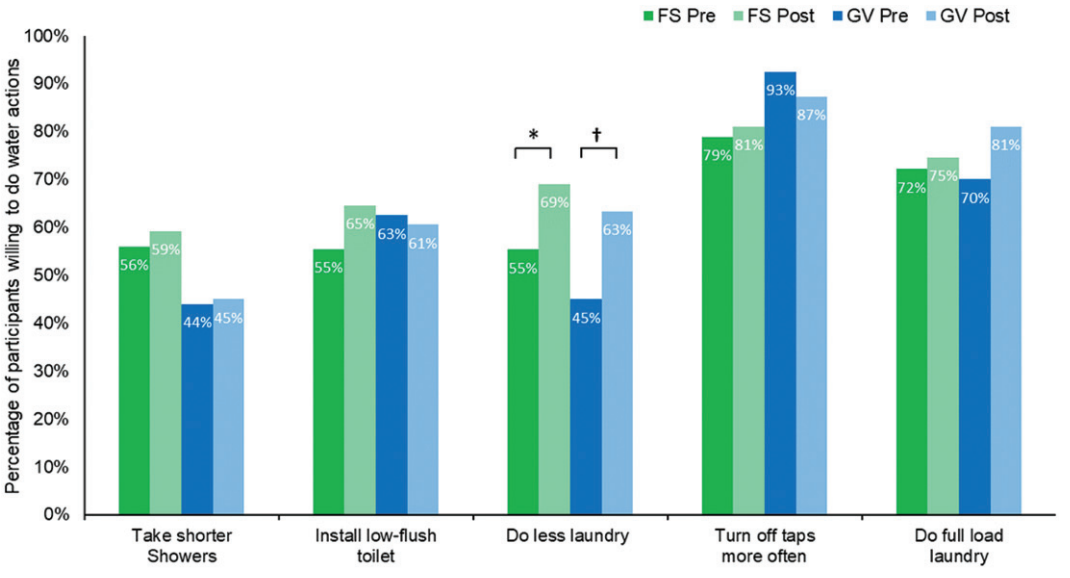

Figure 3. Percentage of participants willing to engage in water conservation actions. FS: Field School participants; GV: garden visitors; Pre: pre-visit; Post: post-visit. ($^{\dagger}p < .1$, $^{*}p < .05$.)

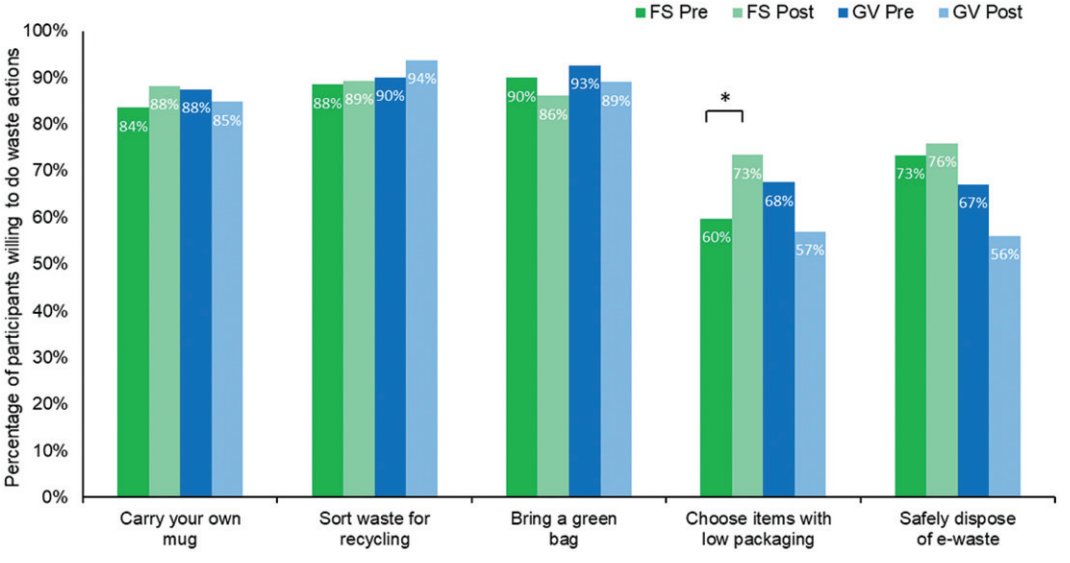

Figure 4. Willingness of participants to engage in actions to reduce waste. FS: Field School participants; GV: garden visitors; Pre: pre-visit; Post: post-visit. ($^{*}p < .05$.)

General discussion

The current study examined the impact of the FS program on environmental knowledge, attitudes and willingness to engage in pro-environmental behaviors. FS participants were surveyed before and after the tour, as well as regular GV who went through the garden but did not receive the FS tour. Overall results showed that FS participants increased their environmental attitudes, and showed greater willingness to engage in specific pro-environmental behaviors after the tour. These results suggest the FS program can be an effective sustainability education model to increase the capacity of people to engage in pro-environmental behaviors.

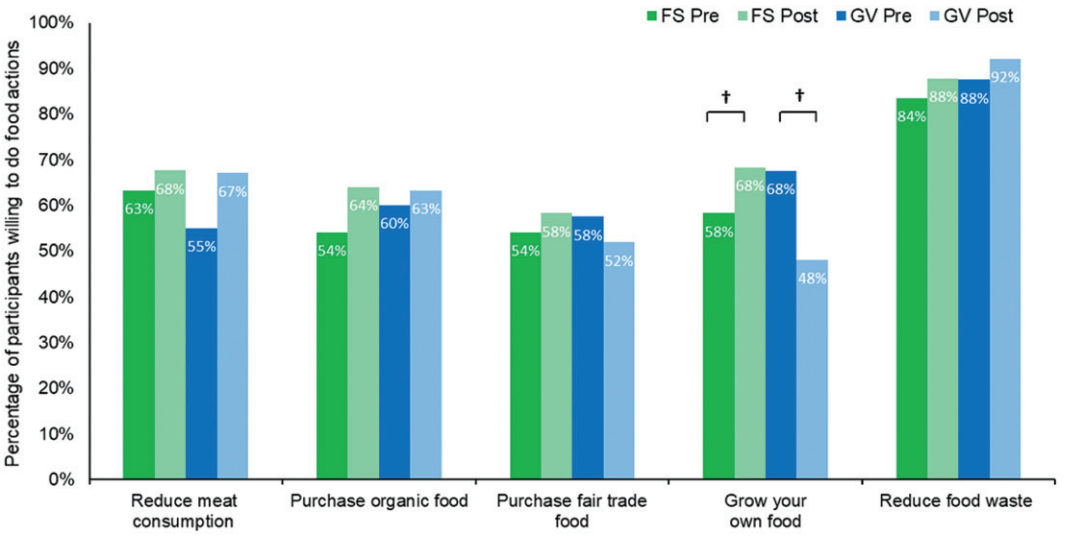

Figure 5. Willingness of participants to engage in sustainable food actions. FS: Field School participants; GV: garden visitors; Pre: pre-visit; Post: post-visit. ($^{\dagger}p < .1$.)

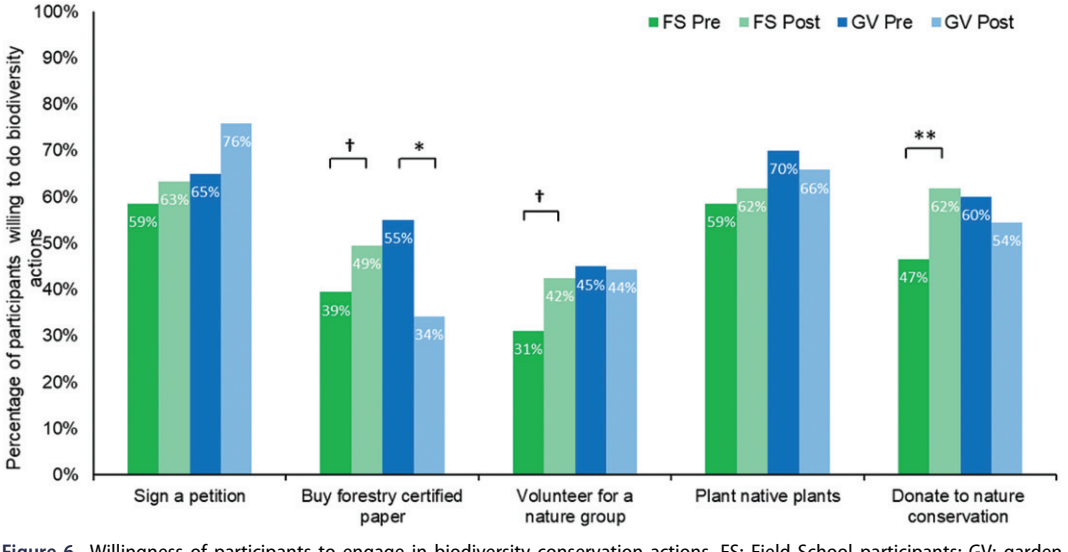

Figure 6. Willingness of participants to engage in biodiversity conservation actions. FS: Field School participants; GV: garden visitors; Pre: pre-visit; Post: post-visit. ($^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$.)

The increase of environmental knowledge in FS participants was not surprising because the instructors specifically raised the six questions during the tour and provided the answers, whereas GV did not receive such information. The FS tour contained verbal discussions of the sustainability topics, and included group activities, and interactions between group members. It is currently not possible to tease apart which factors explained the changes in knowledge, attitudes, intentions and willingness to act. The differences between FS participants and GV were quite varying. The FS participants showed the biggest differences (41%) in the local watershed question and in the organic agriculture question (47%), and the smallest differences were in the biodiversity threats question (21%) and the forest roles question (23%). The names of local watersheds and the definition of organic agriculture do require more specific knowledge, in

which case the FS curriculum could be more useful, whereas biodiversity threats and forest roles are general knowledge and can be reasoned.

An unexpected result was the decline in the attitude measures and willingness to act for the GV after the visit. This decline could indicate that after visiting the botanical garden, people felt less nature-oriented or connected to nature, and showed lower intentions to act, compared to before their visit. While it is possible that without the tour the GV may become more complacent with nature after their visit, and thus become less concerned about the environment and less motivated to act, it is also possible that sampling differences of the visitors (different visitors who filled out the pre-visit and post-visit surveys) can account for the decrease in these measures. Although we cannot explain this decline, the results suggest that merely accessing nature may not be enough to raise environmental awareness and promote public actions.

Among the 20 pro-environmental actions identified for the water, waste, food, and biodiversity domains, FS participants showed an increase in the willingness to engage in six actions compared to GV. The six actions were: do less laundry, choose items with low packaging, grow your own food, buy forestry certified paper, volunteer for a nature group, and donate to a nature conservation group. This can be explained by the FS curriculum and activities. For example, the goal of the coffee cup activity was to unpack the amount of energy and materials that go into the production of a to-go cup of coffee, so participants may be more willingness to buy items with low packaging because of this activity. Discussing the benefits of organic food practices and learning about food waste in the food garden, and sampling of edible flowers, may have motivated participants' willingness to grow their own food and reduce food waste. Discussion of the ecosystem services forests provide on the canopy walk may have increased participants' willingness to buy forestry certified products. Learning about the SPEC organization and the fact that one of the instructors was from SPEC may have increased the willingness to volunteer for a nature group or donate to nature conservation.

The actions in the willingness to act scale differed in terms of the cost and effort involved, which could determine the impact of the FS program. For example, more FS participants were willing to do less laundry after the FS tour in the water domain, which required less cost and effort. However, this was not the case for the other domains. More FS participants were willing to grow their own food after the FS tour in the food domain, which would require more effort and cost. This increase in willingness may be driven by the food garden tour in the FS curriculum. More FS participants were willing to buy forestry certificated paper, volunteer for a nature group, and donate to nature conservation after the FS tour in the biodiversity domain, which would again require more effort and cost. This increase in willingness may be driven by the activity on the roles of forest and the mention of the partnership with a non-profit organization in the FS curriculum.

Many gardens already incorporate education and community outreach within their other horticultural goals, which makes gardens unique spaces for nature education. While this study demonstrates that our botanical garden can provide a useful platform to engage local communities on sustainability issues, it is also important to acknowledge the diversity of botanical gardens around the world and the various forms they can take: From lush gardened ecosystems with local and exotic plants, to more stylized beds and greenhouses. Similarly, it is important to note that botanical gardens are mini curated representations of nature (Heyd 2006), and the diversity of plants and other garden features could have varying impacts on visitor experiences, their connection with nature and understanding of biodiversity.

Limitations and directions for future research

The current study had several limitations. First, we could not employ random assignment between the two groups, since FS tours were arranged and recruited from the organizations

ahead of time, whereas the GV spontaneously visited the garden and paid the entrance fee themselves. As a better control group, future studies should randomly assign participants to serve in the FS condition or the control condition, and compare their responses afterwards. Second, we could not control for the group sizes and visit durations between the FS participants and GV. FS group sizes were much larger and the tour was around three hours, whereas GV tended to show up in small groups and spent less time in the garden. Third, FS participants were all employees from the same organization, whereas GV tend to be family members or groups of friends. It is unclear whether GV would show the same effects after the FS tour because they may come to the garden for leisure and not education purposes. Fourth, we did not measure actual behavior in the current study, since all measures were self-reports. A key recommendation for future studies is to measure actual behaviors in the four sustainability domains. Fifth, the current study only measured changes after the tour, so it's unclear how long the effects last. Future studies should examine the longevity of the effects of the FS program. Sixth, not many participants completed both pre- and post-visit surveys. This could be due to a number of reasons, including a lack of willingness to complete surveys, a rush to leave the garden for home, and missing answers on the survey so we could not match their responses. Future studies should make the survey shorter to save time, or provide rewards for completing the survey. Future studies should also include a pre-visit knowledge test to ensure that the two groups were not different before the tour, as well as increasing pre-visit survey completion rates while standardizing survey completion time. Finally, we do not know which aspect of the FS program caused the effects. Future research could unpack and test each component of the program (i.e. an education tour with or without the Canopy TreeWalk) to identify the changes in knowledge, attitudes, intentions and willingness to act.

Conclusion

This study examined the impact of the FS program in a botanical garden on environmental knowledge, attitudes, intentions and willingness to act. Our results showed that after the FS tour, participants were more knowledgeable about sustainability issues, more connected to nature, and more willing to engage in sustainability actions, compared to regular garden visitors who did not receive the FS tour. Our study revealed new benefits of nature within a botanical garden environment, building upon previous research that shows that being in nature has beneficial effects on well-being, cognition, and behavior (Berman et al. 2008; Chawla 2015; Pretty 2004; Wells and Evans 2003; Zelenski, Dopko, and Capaldi 2015). However, our study had several limitations regarding random assignment, cleaner control of the two groups, behavioral measures, the longevity of the effects, and the specific components of the FS tour that resulted in the impact. Our study suggests that community-based research and education collaborations, such as the FS program, can provide important opportunities for botanical gardens and nature-based organizations to have a direct contribution to sustainability education.

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No potential conflict of interest was reported by the authors.

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