Escaping the Gap: Escape Rooms as an Environmental Education Tool

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ABSTRACT

Environmental education (EE) pedagogy is in need of reform due to the dissonance between individuals' values and their actions, the value-action gap. To examine an innovative way to address this phenomenon, I designed an escape room focused on sustainable consumption habits that aimed to reduce the gap in young adults. I then surveyed study participants to further understand their learning experience and what information they retained. The escape room increased the sustainable values and behaviors of participants and decreased the number of participants exhibiting the value-action gap. The changes were statistically significant. Metaphorical puzzle design, hands-on experiences, and interaction with friends as well as strangers all influenced participants' changes in values, behaviors and their gap. Escape rooms have potential to be effective tools in environmental education to empower students and decrease the value-action gap, but consistency and immersive factors of the escape room need redesigning. Future direction includes different themed rooms, testing with different age groups and increasing accessibility to the public.

KEYWORDS

Value-Action Gap, Individual Action, Consumerism, Learning Experience, Simulations

INTRODUCTION

Despite the wider acceptance of anthropogenically accelerated climate change and stronger values towards the environment, many do not adopt more sustainable lifestyles or pro-environmental behaviors. Values are beliefs or concepts that guide behaviors (Batersleben, Murtagh and Abrajamse 2012), while pro-environmental behaviors are one's conscious act to minimize their impact on the natural world in the name of environmental protection (Corraliza and Berenguer 2000, Jensen 2002). Some people may understand the importance of resolving environmental issues, but they feel that their individual actions would have little impact if societal structures do not change (Macnaghten and Jacobs 1997). These attitudes are compounded by their distrust or lack of familiarity with scientific information and strategies of governments and institutions, removing them from environmental problems and political actions, and reducing their sense of agency (Macnaghten and Jacobs 1997, Jensen 2002, Flint 2013). Sense of agency is the fine line of the value-action gap where one's values prompt awareness and urgency in executing actions onto the world (Jeannerod 2003). The value-action gap between environmental knowledge and pro-environmental behavior is grounded in a lack of sense of agency.

Environmental education (EE) should instill awareness and knowledge of environmental challenges, and promote pro-environmental attitudes, decisions, skills and participation (EPA 2018). Effective EE can lead to positive environmental attitude in students (Bradley, Waliczek and Zajicek (1999). Current EE curricula is trying to integrate more creative ways to engage students, however, most curricula heighten awareness and belief in environmental problems but fail to cultivate students' ability to strategize solutions and behave pro-environmentally. If done right, EE can provide an important bridge across the value-action gap (Kollmuss and Agyeman 2002, Gupta and Ogden 2006).

The struggle to effectively link content and pedagogy to behavioral change in students suggests that EE should explore different approaches. In light of this, UNESCO's "Decade of Education in Sustainable Development" (DESD) proposes new educational qualities that all EE curricula should implement: pairing holistic, values-driven knowledge with critical thinking, problem-solving and decision-making (Calder and Clugston 2007). Furthermore, EE should utilize multiple methods, like experiences, in addition to in class teaching, as additional tools to model

processes (Cairns Jr. 2003, Calder and Clugston 2007). With the DESD goals in mind, innovative and informal experiences as EE tools could be explored, such as escape rooms.

Escape rooms, puzzle or challenge-filled simulation activities designed around a backstory in which participants work in teams to escape, are popular recreational activities that have been increasingly used as training tools due to their interactive learning qualities, making them a plausible environmental educational tool (Wiemker, Elumir and Clare 2015). Game designs vary in time limit, escape paths, challenge type and hint availability. Escape rooms allow participants to think critically and work together to solve problems, offering a means of engaging in the active learning that DESD wants to cultivate. Millennials also prefer informal learning experiences due to their flexibility and because the activities generally engage and heighten students' interests (Taylor 1983, Oblinger 2004). The immersive environment an escape room provides can be a powerful tool in EE, as it is likely to arouse behavioral change (Anderson 2013). The need to find solutions to the values-action gap is imperative, and experiences like the escape room can be a useful and accessible supplementary EE tools. Yet no research has been done on this.

To address this gap in the literature, I asked: How does an escape room focused on eco-consumption habits affect the sustainable values, behaviors and agency in young adults? To answer this, I ask three sub-questions:

1.) How does the escape room experience affect participants' values and behaviors regarding sustainability in one month's time?
2.) How does the escape room experience affect participants' value-action gap and sense of agency regarding sustainability in one month's time?
3.) How do specific escape room elements affect participants' learning experience?

I hypothesized that my study subjects would have medium to high environmental values, but most would exhibit the value-action gap. I further predicted that the escape room would elicit an increase in sustainable behaviors compared to the control group that did not undergo any treatment; this can lead participants to express more "positive" responses to their sense of agency towards individual sustainable action.

BACKGROUND

Environmental education pedagogy

Environmental education originated in the 18th to 19th century, and has seen great progress and integration within national planning documents and strategies in recent decades (Palmer 2009). EE has been established as education for sustainable development, where people not only understand the interdependence of life on this planet, but also develop awareness, values and attitudes to make conscious sustainable decisions; whether these ideals are actually implemented into education systems and curricula is another issue. In the 1990s, only 7% of schools in the United Kingdom had any sort of EE due to lack of resources and staff motivation (ibid). However, schools are increasingly employing different EE pedagogy to encourage pro-environmental values and behaviors. One major type is field courses, where students leave the typical classroom setting to directly interact with nature (Bogner 1998). Another type is school-based initiatives, which tend to have a specific pedagogical or content focus. Although many of these initiatives have shown to increase environmental knowledge, attitudes and behaviors, most are short-term initiatives only and cannot show longitudinal results (Rickinson 2001). There are also long-term courses like AP Environmental Science implemented into curricula, but there has yet to be a study to show the lasting influence of these courses.

The environmental values-action gap

Although more education systems are implementing EE, the values-action gap persists. Personal and situational factors affect this gap, such as a lack of money and time or conforming to social norms (Kollmuss and Agyeman 2002, Gupta and Ogden 2006, Batersleben, Murtagh and Abrajamse 2012).

One reason for environmental inaction relates to individuals' perceptions of whether individual action, also known as bottom-up strategies, can positively impact environmental problems compared to structural – top-down, governmental and economic system level – changes (Macnaghten and Jacobs 1997, Straughan and Roberts 1999, Cairns Jr. 2003). It is true that governments and institutions establish laws and policies that support technological advancements

combating climate issues (de Coninck and Revi 2018). Furthermore, large scale corporate enterprises and entire economic sectors generate more pollution than do personal households. However, many studies also highlight the importance of individual action. Agenda 21 states that sustainable processes must have the public take part in decision making for them to be considered legitimate, and social and economic changes can only be secured if the public is fully committed to live sustainability (de Coninck and Revi 2018). Otherwise, these policies will not be well-received. Individuals can take action by engaging in daily sustainable activities as well as indirectly affect structural systems by what they consume and purchase–smart consumption–and by participating in policy issues (Macnaghten and Jacobs 1997, de Coninck and Revi 2018).

Improving EE

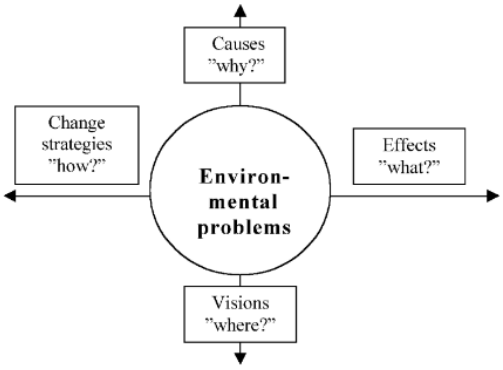

Figure 1. Figure from Jensen 2002. Illustrates four key elements to educating on environmental problems.

Although many schools have successfully inspired pro-environmental values and behaviors with their students, there are still fundamental flaws in many curricula. One prominent problem is that most EE pedagogy focuses primarily on the causes and effects of environmental problems, but fails to address the "how" and "where" of these issues, the strategies for change and visions for the future, respectively (Jenson 2002). Additionally, different students will react to different pedagogy depending on gender, socio-economic background, initial perceptions, and what environmental issues they find important. Even the order in which information is presented can be an influential factor (Rickinson 2001). Studies found that females tend to care more about environmental issues in general, while males are less interested and are more technologically oriented. Socio-economic background is also found to influence the education that can be received

as well as what issues students will care more about. Finally, the way information is presented can hinder students' learning. Students become more confused if they learn of strategies and behaviors – "how?" – without having underlying knowledge of why it is so important to adopt these behaviors (ibid).

Escape rooms as an environmental education tool

Having knowledge of environmental issues and pro-envienmental values does not necessarily drive behavioral change; experiencing and engaging in the behavior is what pushes behavior into habit (Cortese 2003, de Conink and Revi 2018, Kraft-Todd et al. 2018). Kollmuss and Agyeman (2002) found that professional environmentalists chose their path due to experiences of environmentalism and education, specifically from being immersed in nature and participating first-hand in environmental activism. Escape rooms may be a viable educational tool to implement into EE pedagogy because escape games involve immersion, team work, and problem solving, which are important skills to promote in EE (Bradley, Waliczek and Zajicek 1999, Cortese 2003, Calder and Clugston 2007). Immersive games, like escape rooms, not only keep students engaged, especially in higher education, but also helps link knowledge to real world applications and increase retention of information over time (Randel et al. 1992, Hansen 2000, Oblinger 2004). Games also have the element of failure, which various studies note can enhance the learning experience and effectively instill information, but could also cause students to lose interest if they do not have motivation, or have varying levels of interest in the concept of playing games to learn (Taylor 1983, Squire 2005). Finally, the subject matter on which a game is based upon can also affect a game's effectiveness—games related to math tend to gain students' interest the most while social science had little interest shown (Randel et al 1992).

Methodology

An escape room with a consumption habit focus

Mass consumption – both on a structural and an individual level – is a leading cause of environmental degradation and climate change (Batersleben, Murtagh and Abrajamse 2012).

Materialism, in which individuals' self-identity and well-being is defined by their material possessions (Tang and Hinsch 2018), is one reason for mass consumption, and that fuels overproduction which puts stress on natural resources and our environment. Albeit American consumers show concern for the environment and say they are willing to take actions that promote sustainability, actual behaviors often do not match these statements (Gupta and Ogden 2006). When individuals were given educational interventions on skills in food purchase planning, there was a significant decrease in food waste (Romani et al. 2018). Promoting environmental consumerism, where consumers purchase items with environmental concerns, can help curb the exacerbation of climate change and be one step of many to reach a sustainable future. Many innovative EE initiatives focus on one particular content area rather than having a broad and therefore potentially diluted and ineffective program. Locality should also be addressed in EE curriculum to illicit more immediate awareness and urgency (Rickinson 2001, Calder and Clugston 2007).

Focus Group Discussions and Interviews

Postgame focus group discussions, or debriefing, on concepts learned and comments, has received mix reviews for whether to include in experiments relating to educational games (Randel et al. 1992). Discussions are known to be important components to learning (Macnaghten and Jacobs 1997), but they can become confounding variables when included in experiments evaluating games. Did the results come from the game itself, or due to the group discussion? However, since questionnaires show little correlation between self-reports of behavior and actual observed behavior (Steg and Vlek 2009), discussions are still important in gaining insight on how certain features of the game led to specific results (Rickinson 2001).

Study system

The UC Berkeley campus is known to be very environmentally conscious, ranking in the top 10 in Sierra Magazine's "Coolest Schools" in 2015 (Berkeley Sustainability 2015), and most students on campus believe climate change is real. Studies find that individuals are more likely to adopt pro-environmental actions if they know their actions will effectively decrease environmental

deterioration and that these actions are the social norm. Individuals are also positively influenced if they are able to adopt the behavior (Straughan and Roberts 1999, Batersleben, Murtagh and Abrajamse 2012).

METHODS

Study subjects

Study subjects included students from ESPM 50AC ("Introduction to Culture and Natural Resource Management"), a class with an enrollment of 452 undergraduates from across the University of California, Berkeley (UC Berkeley) campus. Those who participated received extra credit for the course. There were fifty subjects that participated in the escape room in total, seven of whom were recruited through personal networks, and the rest were students of ESPM 50AC. Participants ranged from freshmen to graduated students of UC Berkeley, all of which are considered young adults. One reason I chose to do an escape room focused on consumption is because it is an everyday behavior that students can relate to and learn from. All subjects filled out a sign-up form as well as a pre-experiment survey via Qualtrics survey software in order to participate in the experiment during Spring 2019. There were 11 escape room time slots in total to accommodate 11 groups of 5, and the slots were given on a rolling basis to subjects that successfully signed up and filled out the pre-survey first. In order to factor in how team dynamic affects results, I purposefully created groups with all friends, all strangers, or a mixture of both (Table 1).

Table 1. Team combinations of Escape Room Groups. Creating different team dynamics.

Team Combination(s)	Count
One friend group	3
Two friend groups	1
One friend group + stranger(s)	4
Two friend groups + stranger	1
All strangers	2

ESPM 50AC students who signed up but did not get a chance to participate in the escape room became subjects of the control group, and were also able to receive extra credit by completing

a pre- and post-survey without experiencing the escape room. This group served as a baseline to compare to the escape room treatment group's results.

The treatment group participated in an escape room. The overall learning experience went as follows: once the group finished experiencing the 30-minute escape room, they participated in a 10-minute discussion before the moderator explained what each puzzle means and how they were supposed to solve each puzzle. The moderator then sent 5 follow-up questions via email to be answered within a week's time. One month later, all participants were sent a post-survey. The control group only completed the pre-survey and post-survey.

Escape room set up

The escape rooms were set up in classrooms on the UC Berkeley campus between March 19th and March 22nd. Each group had 30 minutes to solve four puzzles in the room to escape. The backstory of the escape room was as follows:

> *We are in the year 2020, where UC Berkeley still hasn't met their Zero Waste by 2020 goal. You are all captured by a bunch of mad scientists because they want to figure out why this wasn't achieved. They believe only the environmentally conscious elite should be able to exist. You must prove you are worthy of being kept alive by escaping the room, which so happens to be our guard's break room. The guards make rounds every 30 minutes, so that's your time limit. Escape or be killed.*

The escape room had a moderator—in this case myself—who acted as a jail mate and stayed in the room with the subjects to take notes on interactions (conflicts and teamwork), completion times, puzzle solutions, hints given (for consistency), and any other observations. The moderator could give two hints as well, and hints are given in exchange for a 30-second massage. Each puzzle was supposed to teach a sustainable consumeristic behavior as well as an underlying sustainable value (Appendix D).

Puzzle 1: Crossword puzzle

The groups were divided into a team of three and a team of two via a rock paper scissors game. This served as a quick, initial team bonding activity. The team of three entered the room

first and were chained together by one leg each to a heater that was on. The chain was held together by a lock with a four-alphabet code, which they had to unlock in order to leave the jail area. Inside the jail area was a crossword puzzle, partially filled in. All the crossword puzzle answers were in articles scattered around the room outside of the jail area. The groups were to work together to figure out all the answers. Four answers, all of which would spell out a number, were bolded by their boxes. On the side of the crossword puzzle there was a code "H 8 Y 25", giving the correlation between numbers and alphabets (more explicitly the code means A is to the number 1 as well as 27, Z to the number 26), and the participants had to decipher this code to unlock the lock and escape the "jail" area.

The metaphorical meaning behind this puzzle represented developed versus developing countries—those inside the jail, closest to the heater, were those in developing countries; they felt impacts of climate change first and most extremely, but they also knew what the problems to solve were. Those on the outside were developed countries. They did not feel the impacts as extremely, but have the answers, or the means to, help these developing countries escape. The behavior this puzzle aimed to teach was to encourage participants to research current world events because everything is interconnected. The underlying value represented was that individual actions impact others, and eventually, the general population will face the consequences as well.

Puzzle 2: Sewing puzzle

A ripped diary in the middle of the room recounting various ways past groups had tried to escape but failed. The second half of the diary was crumpled in a tipped over mixed paper bin. From these excerpts participants could discover that someone must dress as a guard and that the guard uniform needed a badge on it for them to successfully escape. This puzzle required them to sew a badge onto a military uniform, which represented a sustainable consumeristic behavior. The greater value in this is the idea of repair, reuse and repurpose; rather than replacing slightly damaged items, participants had to try to repair them or use them for other purposes, reducing waste and combating overproduction.

Puzzle 3: Sorting Trash puzzle

This puzzle was in lieu of the second puzzle. The moderator had a badge that needed to be sewn onto a military jacket. Once the group members realized and vocalized this, the moderator offered them the badge if the individuals sorted a bin full of trash correctly. There were four bins (corresponding to the on-campus bins): a compost bin, a mixed paper recycling bin, a cans and bottles recycling bin, and a smaller landfill bin. The trash items I chose were an assortment of the most commonly mistaken trash material, such as aluminum foil and lined paper cups. I obtained the bins as well as this information from the on-campus Cal Zero Waste department.

I felt that it was important to have a smaller landfill bin, but have plenty of landfill trash so the landfill bin was overflowing to emphasize correct trash sorting. The underlying bigger picture was to be mindful of the trash they generated. With the demonstration of overflowing trash from the landfill bin, this served as an means of stressing the consequences of the trash that is produced through consumption.

Puzzle 4: Smart Grocery Consumerism puzzle

The last puzzle involved choosing the most environmental grocery products to figure out a keypad code on a phone to "unlock" the door and successfully escape. There were various components to aid this process. First, on the back of the ripped diary page was a grocery list, which listed the grocery products (meats, lettuce, tomato, mayo) that corresponded to the order of the keypad. "Meats" and "Lettuce" were written in blue and "Tomato" and "Mayo" were written in green. The blue font corresponded to a blue grille cipher found in the mixed paper trash can that gave hints about which meats and vegetables were more environmentally sustainable. The grille cipher matched an article that read "water use meat of hamburger" and "too much CO_2 emissions", which instructed readers to choose chicken and a locally grown pack of vegetables. A green grille cipher gave hints to which tomato and mayo product to choose, which suggested choosing a tomato that had no packaging and a mayo product that had a palm oil certified sign on it. With these hints, participants would choose the most environmentally friendly products and use the corresponding numbers on the products to decipher the correct keypad code.

The behavior I promoted here was smart consumerism. The bigger picture was that there are various things to think about when consuming, from where the product comes to the disposal of the components afterwards. The message is that individual action is important in consumption

because by supporting products that are ethical and environmental, it can shift businesses to realize what the public demands.

Hint Mechanism

In each puzzle, the moderator could give two hints. I tried to keep each treatment group experience consistent by offering hints at the same time mark if the participants seemed to be struggling and also made sure to give the same hints. The mechanism was that one person had to give the moderator a 30 second massage as they gave a hint to the group on how to advance forward.

The meaning behind the massage was to symbolize sacrifice. A participant had to sacrifice 30 seconds of their time to give a massage to benefit the team. This was similar to taking 30 extra seconds to do an environmental action; it may have seemed inconvenient in the moment, but in the long run, it was for the benefit of participants' health and the environment.

Data collection methods

I used pre- and post-game surveys, consisting of closed and open-ended questions. I also asked the treatment groups to answer open-ended questions right after the escape room experience. To measure escape room effectiveness, I calculated the change in each subject's environmental values, behaviors, and sense of agency, providing insight into the gap between their values and actions. I used participants' open-ended answers to interpret reasons for these changes. In addition, I analyzed participants' evaluations of their escape room experience to determine elements of the escape room worth keeping and those that may need redesigning.

Change in values, behaviors and agency

Participants answered a pre-survey before the escape room and a post-survey one month after their escape room experience. The pre- and post-surveys include identical Likert-scale questions—eight measured values and ten measured behavior—to see how each subject's environmental values and behaviors change (Appendix A). Although the distance between each Likert value is not the same ("strongly disagree" to "disagree" may not be the same as "disagree"

to "neither disagree nor agree"), the values are averaged for a general overview of each subject's environmental values and behaviors. Since the Likert answers are from a scale of 0 to 4, with 0 being the most non-environmental answer and 4 being the most environmental, I averaged their environmental values and behaviors into a low scoring group [0 to 1.33], medium scoring group (1.33, 2.67], and high scoring group (2.67, 4]. In the post-survey, additional questions on the reason for a change in behavior or value were added for further discourse analysis.

A subject's agency was categorized by the difference in their levels (low, medium or high) of values to behaviors, which illustrates their value-action gap as well as the change in their open-ended answers to the question "Do you feel empowered to affect change towards a sustainable future? Explain." This was asked in the pre-survey, after the escape room, and in the post-survey. A gap would mean participants have a higher category of values than behaviors. I had four types of gaps, a large gap (high value to low behavior), a small gap (high or medium value to medium or low behavior, respectively), no gap (value equals behavior), and reverse gap (low value to high behavior). Their open-ended answers were also categorized as positive empowerment (highlighted in green), mixed empowerment (highlighted in yellow) and no empowerment (highlighted in red). This was determined by their wording, from direct indications of "yes", "no" or "maybe" to how they supplemented the answers (See Appendix E).

Escape Room Experience

Right after the escape room experience, each group of five came together to chat about two discussion questions:

1. What sustainable consumeristic habits did you learn from this escape room?
2. What do you envision the future to be like in 2030, and how do you think you would have impacted this?

From the first question, I gauged which puzzles influenced each person most immediately, while the second question offered a glimpse of how the immediate experience may have influenced the subject's agency or empowerment to affect change. Instigating students to envision the future in terms of climate change is also an important component of EE (Jensen 2002). The tone of their

discussions offers insight to how their values and behaviors may change. For example, a more optimistic group discussion on individual action could have led that group to exhibit an increased change in behavior.

Five follow-up questions were emailed to each participant for in-depth and anonymous (to other groupmates) answers (See Appendix C). Questions identify their opinions on their most and least favorite experience, teamwork experience, thoughts on learning experience, and influence on empowerment to affect change.

In the post-survey, an open-ended question will specifically ask what part of the escape room did they remember when doing a certain behavior. This will shed light on which puzzle had more impact and again show efficacy of whether the experience created a stronger impression and influenced them.

RESULTS

Changes in Values and Behavior Scores

I obtained data from 45 treatment group participants and 39 control group participants. Due to differences in group sizes, I ran a two-sample, one-tailed T-test for unequal variances in Excel for the two groups' value differences, which yielded a p-value of 0.318756. With a standard alpha of 0.05, I failed to reject the null hypothesis (means of the two groups are equal) and concluded there is no statistically significant difference between the means of the two groups' changes in values. This means the escape room treatment did not significantly increase the subjects' value scores.

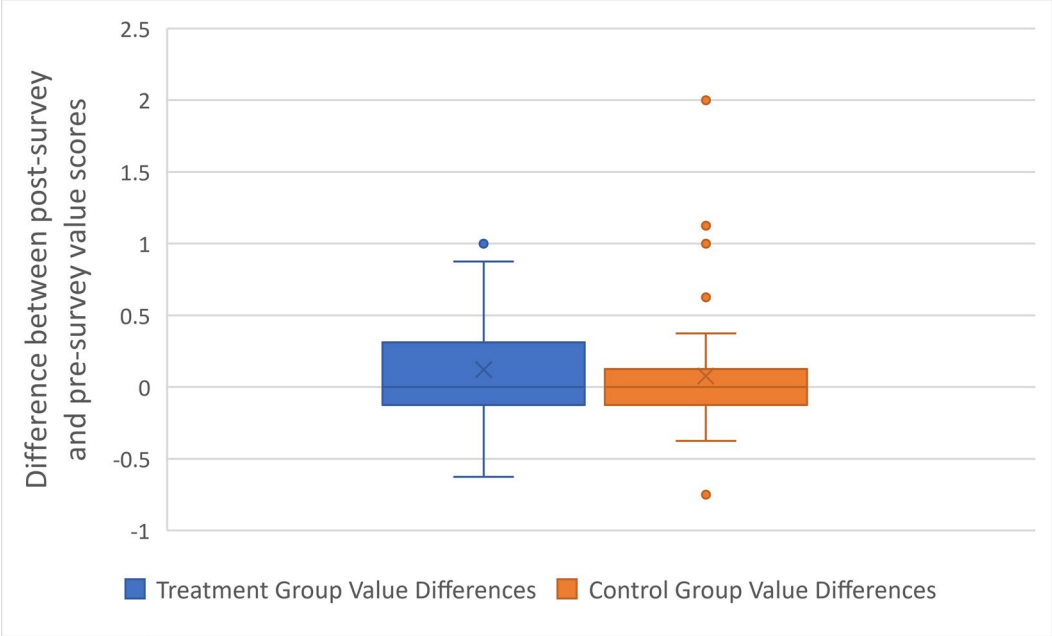

Figure 2. Distribution of value differences for Treatment vs Control Group. The mean of value differences for both groups seem quite equal, with treatment group with some more distributions.

I, again, ran a two-sample T-test with unequal variances on the two groups for their behavior differences, which yielded a p-value of 0.001699. With an alpha of 0.05, I rejected the null hypothesis (means of the two groups are equal) and conclude there is statistically significant difference between the means of the two groups' changes in behaviors. This means the escape room treatment did significantly increase the subject's behavior scores.

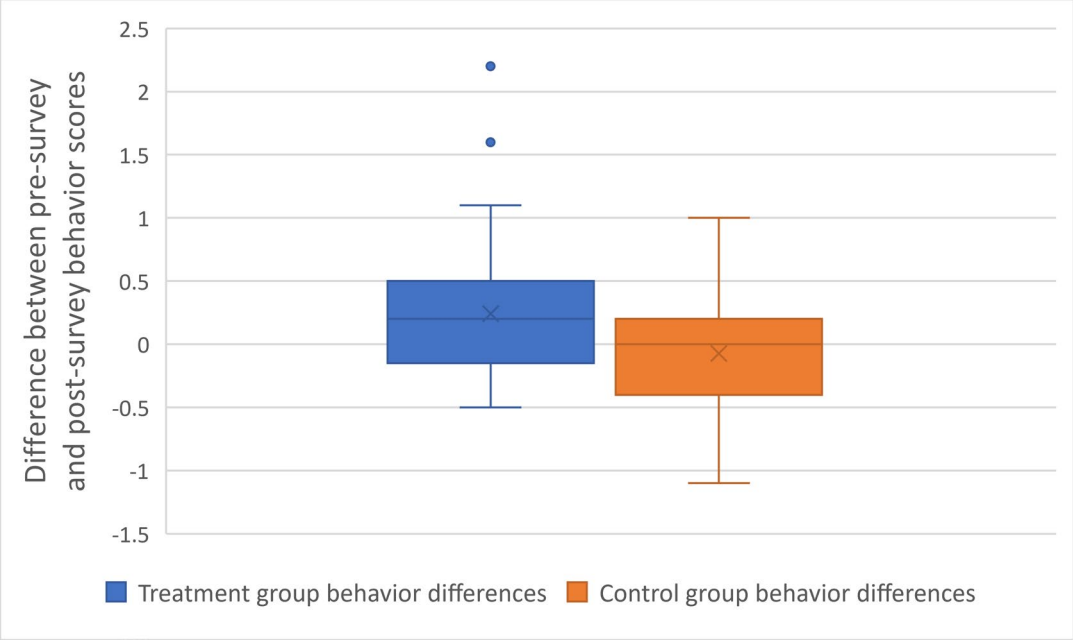

Figure 3. Distribution of behavior differences for Treatment vs Control Group. The treatment group visually has a higher mean difference.

Although there is no statistical significance in the value change among the treatment group, almost half of the treatment subjects had an increase in values and 62% had an increase in behaviors from pre- to post-survey (Figure 4). For the control group, the change in values seemed to remain equally dispersed, but interestingly most control subjects exhibited a decrease in sustainable behavior. Only the values question "I believe it is possible to stop global temperatures from rising 1.5 °C" had an average decrease among treatment groups.

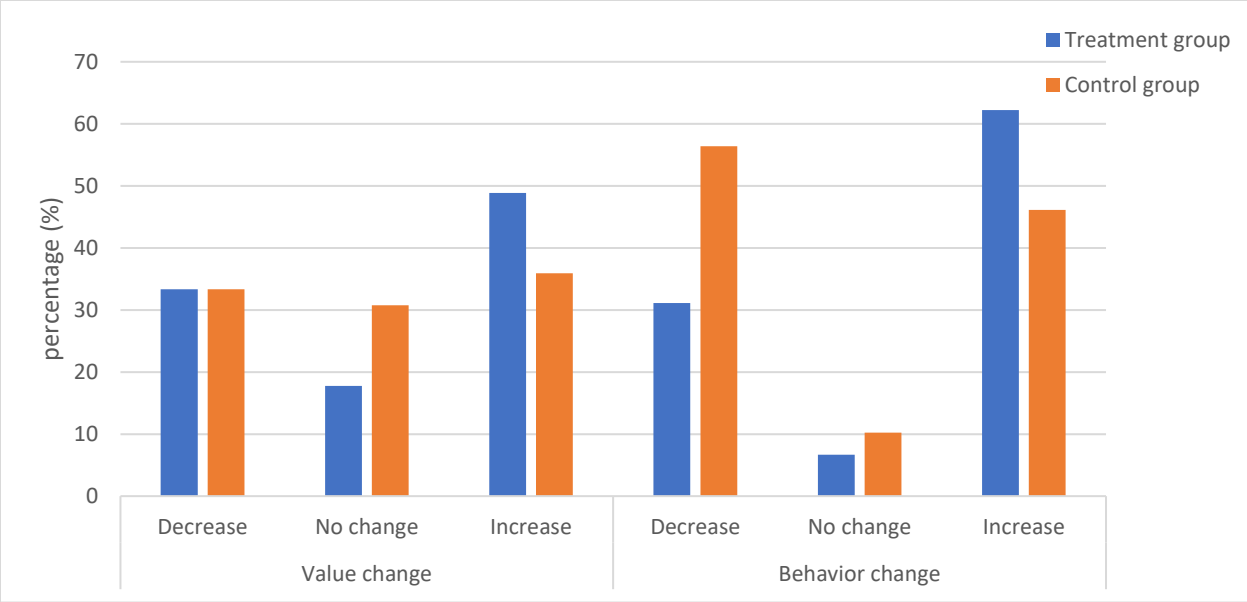

Figure 4. Change in Values and Behavior in Treatment vs Control Group. There is positive change in behavior and values for the treatment group.

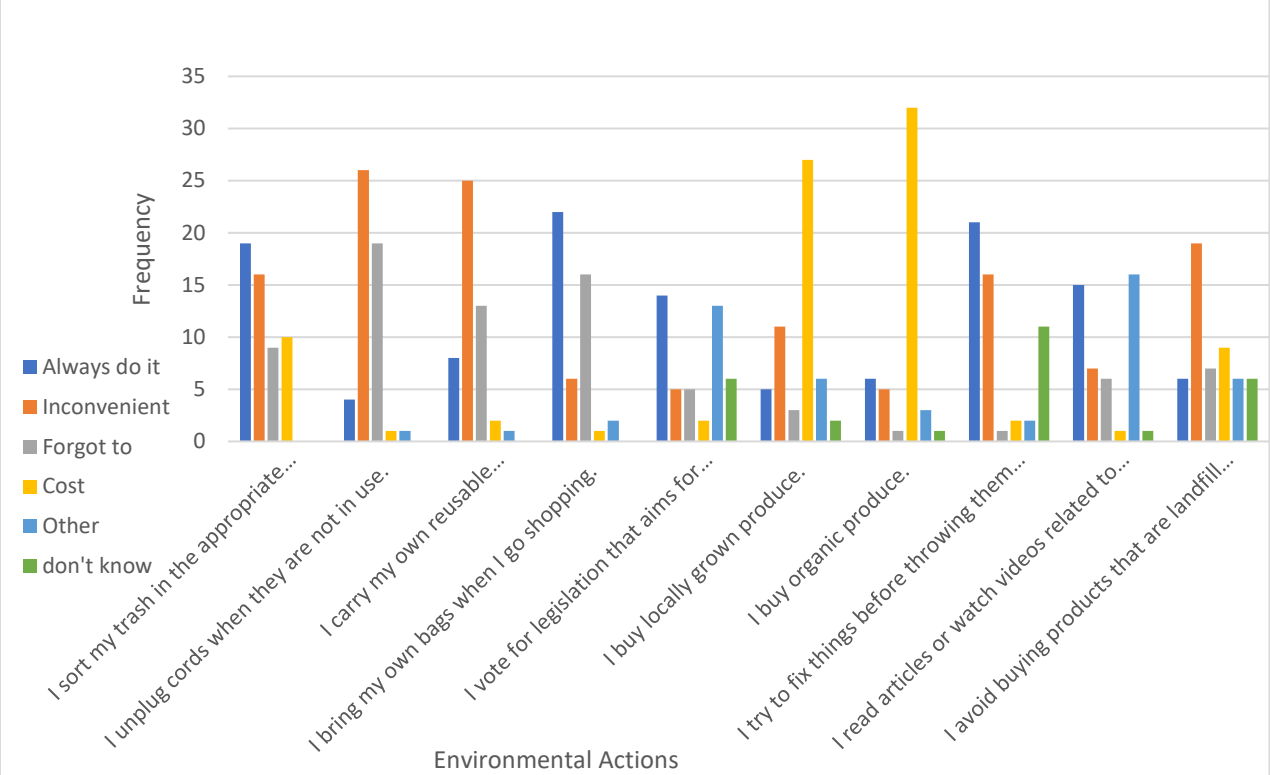

Figure 5. Distribution of Reasons Why Treatment Subjects Don't Do Certain Sustainable Actions. Inconvenience is the most common reason (136 of 500 multiple choice responses) for not doing a sustainable action. "I always do it" is the next most common (120 responses). See Appendix B to read the entire list of "environmental actions".

Disregarding those who responded "Always do it", participants did not unplug cords, carry their own reusable items, and avoid buying products with landfill material mostly because it was inconvenient. Cost was the main reason why subjects did not buy locally grown and organic produce. Many also chose "other" as their reason for not voting for environmental legislations and reading articles or watching videos related to the environment. Unfortunately, I was unable to obtain more information on what "other" meant (Figure 5).

Another dimension I observed was team dynamic. Those in the Friends + Strangers group were most positively affected by the escape room in terms of change in values and behaviors. Those who were strictly with only strangers or only friends showed that results are similar in terms of the percentage of decrease and increase of value and behavior change (Figure 6).

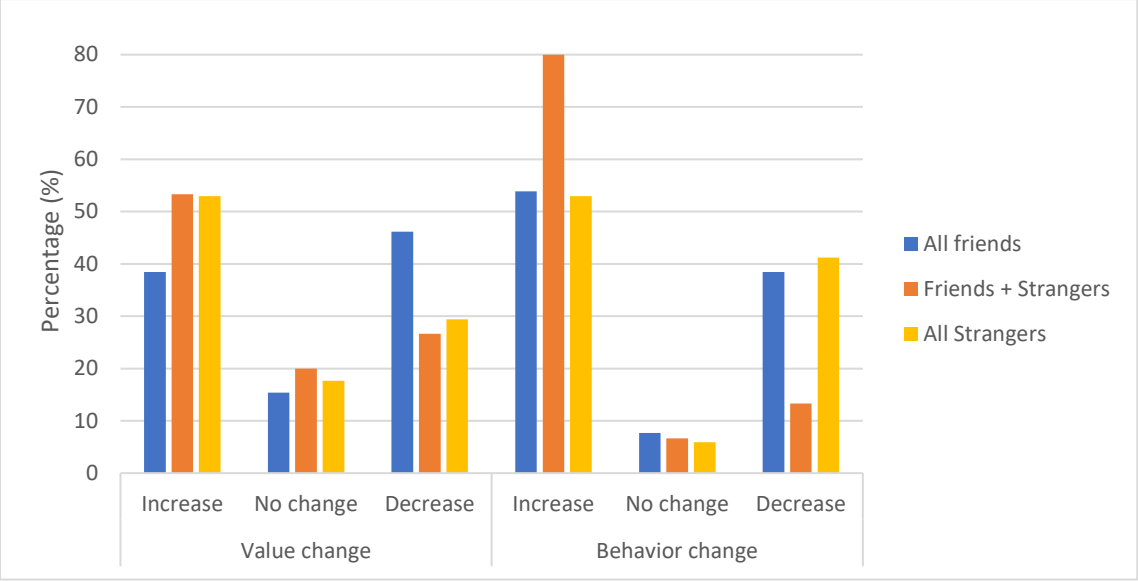

Figure 6. Team dynamic's effect on values and behavior change. Friends + Strangers group had the highest increase in behavior and values change. All Strangers and All Friends groups showed similar increase in behavior and values.

Change in Value-Action Gap and Sense of Agency

There was an increase in the amount of people with "no gap" from pre- to post-treatment, compared to the control group (Figure 7). Only one person in the treatment group had no gap in the medium scoring groups, the rest were all in high scoring groups. Still, from this we can see those with small gaps remain the majority.

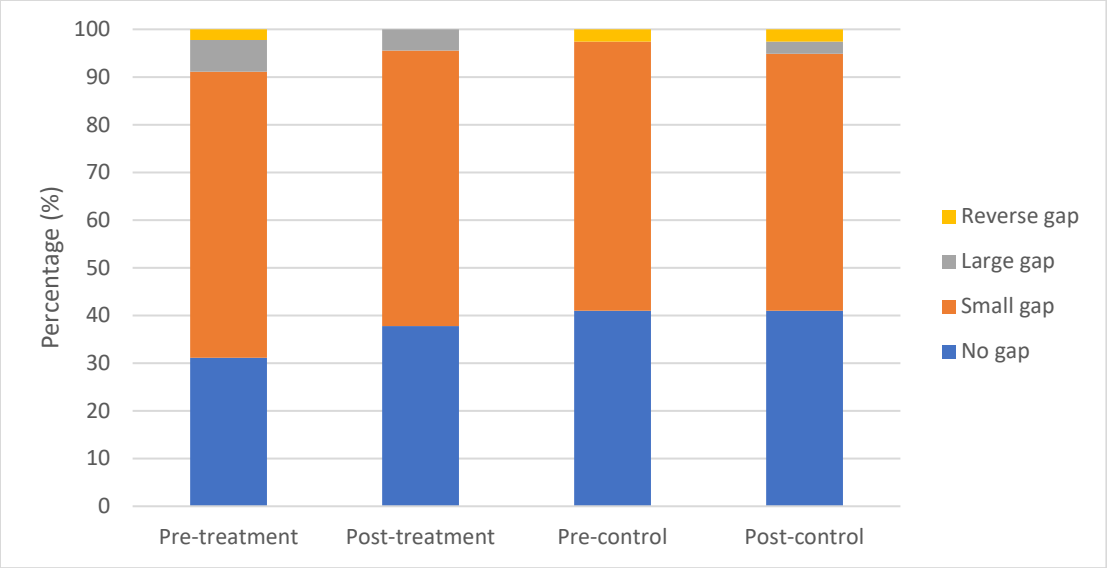

Figure 7. Gap Level Distribution in Pre- and Post-surveys for Treatment vs Control Group. There no gap group increased in percentage from pre-treatment to post-retreatment, but stayed the same for the control group. The biggest group for all four stages is the small gap group.

Table 2. Frequency of Change in Value-Action Gap from Pre- to Post-Survey in Treatment and Control Group. Used to calculate the chi-square to see efficacy in treatment group's significance in decreasing gap from pre- to post-survey.

	Treatment Group	Control Group	Total
Increased Gap	2	7	**9**
No Gap Change	24	26	**50**
Decreased Gap	19	6	**25**
Total	**45**	**39**	**84**

I ran a chi-square test in Excel on the change in value-action gaps from pre- to post-survey for both treatment and control group, which gave a p-value of 0.00987. With an alpha of 0.05, I rejected the null and concluded the treatment group's higher decrease in value-action gaps is statistically significant.

DISCUSSION

Games and simulations have received academic attention in its effectiveness to educate environmentalism to students, but there have been no studies on escape rooms as environmental education tools. The difference of an immersive, hands-on learning experience may be an

important tool to promote sense of agency and decrease the value-action gap phenomenon. The treatment group showed a statistically significant increase in behavior scores and decrease in their value-action gap. Team dynamic, personal factors and specific components of the escape room will now be analyzed to interpret the results found above.

Changes in Values and Behavior Scores

Insignificance of change in value score

There was no statistical significance in the change of value scores for the treatment group. This is most likely due to an already environmentally conscious campus. In the post-escape room discussions, many students noted they had never recycled or composted until they came to UC Berkeley. Most participants, both in control and the treatment group, had high value scores, and thus the changes in the value scores were not significant.

Heightened Awareness and Behavior Change

The statistical significance in the change of behavior scores for the treatment group shows that the escape room learning experience increased people's sustainable actions. The actions that are directly learned in the escape room are sorting trash, buying local produce, repairing items, reading articles or watching videos about sustainability (outside of school), and avoiding products that produce landfill waste. All sustainable behaviors increased on average, but only behaviors of "sorting trash" and "buying organic produce" decreased among the treatment group. This contradicts with the open-ended answers because the puzzle on sorting trash was the most referenced in follow-up questions and the most remembered one month following the escape room experience (25 out of 45 participants mentioned it). I believe this decrease in sorting trash could be a result of participants' heightened awareness of whether they are sorting trash correctly or not. One female participant wrote in their post-survey:

> *"I… thought about that trash sorting part, and it made me more motivated to actually understand how to properly sort trash/recyclables."*

Although she stated she would sort trash properly, she rated herself from "always" sorting trash in the pre-survey to only "often" sorting trash in the post-survey. This decrease could have been due to her increased awareness of trash sorting leading her to realize more often when she did not sort trash correctly, thus lowering her score. Otherwise, this could have been due to human error—she could have forgotten her initial answer. This error could have applied to any of the answers given and is a limitation that comes with this type of data collection.

Changes in the Value-Action Gap and Sense of Agency

Feeling Educated versus Empowered

In most open-ended answers, participants noted gaining new knowledge on environmental issues, values or behaviors, like labels having palm oil certified signs to which type of trash goes into which bin. The idea of having more sustainability knowledge led to both positive and negative impacts on treatment group participants' empowerment to affect change. A few participants expressed feeling more empowered with their newfound knowledge, whether in sorting trash or realizing how developing countries are impacted more extremely, and they did exhibit a decrease in their value-action gap. Some even found empowerment in realizing they now could affect and teach others with this knowledge as well.

> *"I do feel more empowered as an individual to make an impact towards a sustainable future. I now have to knowledge to educate people around me about sustainability, and I will lead by example."*

Environmental psychologists note that emotions are a motivator for environmental behavior (Steg and Vlek 2009). It seems that a few participants expressed lack of empowerment because to them, the knowledge is just information. There was a lack of emotional stimulation.

> *"'Empowered' may not be the correct word; 'educated' may be more appropriate… I don't really think an individual can affect change towards a sustainable future beyond his/her own share as one of eight billion people. But I think I am less likely to make the wrong choice out of ignorance."*

The Social Norm and Change in Value-Action Gap

The idea that other people also care about the environment and are taking action can affect change in the value-action gap, particularly in motivating greater sustainable action (McKenzie-Mohr 2000, Steg and Vlek 2009, Kormos, Gifford and Brown 2015). I believe a team with a mixture of friends and strangers was an important component of the escape room that explains the decrease in the value-action gap. When asked if they felt more empowered, some participants indicate feeling empowered because they noticed others behaving sustainably as well. Most of those who felt less empowered due to the social norm were in all friends groups:

> *"I do not feel empowered because I know that there are not enough people contributing to the cause. The extra 30 seconds to walk to a recycle bin isn't going to make much a difference when somewhere on campus, people are throwing out several bags of trash that are going to the landfill."*

The participant that wrote this comment was in a team comprised of four male friends. Although they spoke positively about the escape room experience during the post escape room discussion, there was less enthusiasm in discussing about what they envision the future to be like. Rather, I had to prompt them with many follow-up questions but received mostly curt responses. On the other hand, those who experienced the escape room with some or all strangers tended to have a positive increase in behaviors and empowerment while referencing the social norm.

> *"Knowing that one more person is contributing to create a more livable environment will enable me to make more change and pass on this enlightened mindset."*

The reinforcement of random people on campus being aware and taking action was a motivation for others to do the same.

Other Reinforcements Affecting Gap Change

Some participants mentioned that they felt empowered knowing that individual actions are practical and make a significant difference. In most of the end-of-experience discussions, both groups conclude that both top-down and bottom-up are important. I believe that those who held a

high belief of needing top-down strategies had less of a decreased gap, since the escape room could not effectively show them how top-down strategies are getting better for their individual actions to matter. Sustainable development is difficult to achieve since top-down organizations' goals do not align with the environment's (Flint 2013). Without seeing how structural entities are tangibly developing towards sustainability, these participants may not have an increase in sense of agency despite learning that individual action is important. Finally, two people mention that the lack of accountability and incentive make it hard for them to feel greater agency to take sustainable actions.

Escape Room Experience

Metaphors and Representations in Puzzle Design

Most treatment group participants noted that the meanings and metaphors behind each puzzle as an important part of their learning experience. The "developed versus developing" metaphor, the representation of the small landfill bin, and the 30-second-massage sacrifice were three designs that were mentioned the most in follow-up answers.

> *"[The] worst experience was being chained to the heater… understanding the meaning behind being chained to the heater made me understand the whole idea better."*

The metaphor of developed versus developing countries was the third most memorable part of the escape room when asked in the post-survey. Furthermore, the order in which the information was presented also played a key part in the impact of these metaphors. The participants were given the meanings behind each puzzle after finishing the escape room. Many found this sequence as "impactful," "rewarding," and "memorable" because they were given the opportunity to reflect on their experience in a different light, and this contrast makes it more memorable.

Another positive aspect of this design was that it stimulated creativity in the treatment participants. When asked what could be changed about the escape room, three people came up with entirely new ideas for the escape room. Here is one example:

> *"I would make the room full of chairs and leave barely any space to walk because I think this can be a great representation of the situation that animals in the wild or in the ocean are suffering - their habitats are full of trash, making them hard to move and/or survive due to human impacts."*

This shows the potential of the escape room to not only educate, but also to further promote students to strategize their own ways of educating others and utilizing their creative mindset. Thus, the lack of immersion, or low-budget design, of the escape room can be seen as a positive point to give students room to be creative. However, there should still be a refinement of immersive design to get people into the mindset of the backstory.

Hands-On Learning Experience

The puzzle that was most memorable one month later was the trash-sorting puzzle. Many consumers often have environmental intentions; they just do not know how to put them into practice (Gupta and Ogden 2006). The physical aspect of sorting the trash and getting immediate feedback allowed participants to learn directly how to put intentions into action. Sorting trash is likely the most common action compared to sewing, grocery shopping and reading environmental news. As one person noted in their follow-up answers, right after the escape room they had to throw trash away and immediately remembered the sorting trash puzzle. This experience was regarded as positive since those who mentioned the sorting trash puzzle also mentioned they knew better when to recycle or compost.

Sewing is also a more hands-on behavior that was immediately learned. Though, only two people mentioned it as something they remembered one month later, and this may be because only one person can participate in the sewing during the escape room experience. Also, during the escape room experience, the role of sewing was usually allocated to someone who already knew how to sew. This means most people probably did not get to learn the skill.

Limitations and Future Directions

There are several limitations to be noted. First, I did not measure participants' initial environmental background knowledge. Before wanting to affect change on people's values and

behaviors, they first must have the knowledge on why this change is important (Rickinson 2001). Furthermore, those who receive environmental education earlier tend to show more positive sustainable attitudes (Bradley, Waliczek and Zajicek 1999). One participant felt distanced from the escape room experience because he felt he did not have enough environmental knowledge to help. This negative feeling decreased his involvement and feeling of empowerment. So, creating consistency in the environmental knowledge of all participants before going into the escape room could be something to change in the escape room learning experience.

Another limitation related to consistency is the time constraint. Not all the teams finished the puzzles in the escape room, and that could have affected their hands-on learning experience for behaviors. Furthermore, splitting the group also meant that some people may not have participated in certain aspects of the room, and could only listen to how things would have been done. This could have affected a person's escape room experience negatively. I also did not have a rigid script when giving hints or when describing all the puzzles, and thus some groups might have gotten certain information during the discussions that other groups did not. This makes making generalizing statements on the escape room difficult.

One last limitation is that the pre- and post-surveys were all self-reports, meaning I had to assume all participants accurately reflected their actual values and behaviors and had somewhat similar understanding of all questions and choices. This assumption has mixed reviews for statistical accuracy (Kormos, Gifford and Brown 2015), and my results may not be the most accurate representations, especially with a smaller sample size. I did try to cover this limitation by asking open-ended questions, but I think I should have asked more straightforward questions to gauge what specific components of the escape room affected a participant's mindset to take action, or I should have added follow-up interviews after the post-survey to gain more perspective on certain answers.

Implementing the escape room for different age groups may be important to consider in future studies. In general, people's environmental values and attitudes develop at early ages, and by adolescence, most will have some understanding of environmental issues and form their own opinions on their position (Bradley, Waliczek and Zajicek 1999). It may be interesting to see if an interactive, immersive experience could have a more long-term influence on students if they were exposed to it earlier on in their education.

One topic of interest in this study was bottom-up versus top-down solutions to tackle sustainable issues. Treatment group subjects were split so that some felt discouraged and unempowered to take individual action because they believe top-down solutions were more effective. Others felt empowered, but also felt top-down is still an important approach. Thus, a future direction to an escape room design could be elaborating and motivating students to strategize and think about how they could impact top-down strategies as an individual. One difficulty of implementing top-down strategies is needing to devise a constant feedback loop between the top-down and bottom-up policies; it is not one or the other, but a harmonious relationship between both (Cairns 2003). Therefore, another route is to implement a puzzle that could elaborate the difficulties of implementing top-down strategies and highlight the need for both, and we could see if that improves individual action.

Broader implications

As mentioned by many study participants in discussions following the escape room experience, attaining a sustainable future requires both bottom-up and top-down strategies; it requires not only educating awareness, but also encouraging action as well (de Coninck and Revi 2018). There is no single solution, and so it is important to explore all the ways to encourage more sustainable awareness and behaviors. Escape rooms can be implemented into environmental education, but they are also part of the entertainment industry. This allows this type of education to be accessible to the public even if they may not have access to or even want to receive the education. Escape rooms blend the idea of gaming and hands-on learning, which are two education methods that are still being explored today. This paper sheds light on physical simulations as part of the education process, which may be interesting to compare to strictly virtual learning spaces that many EE curricula are trying to push as well. How important is it for students to physically act out behaviors? Again, escape rooms are not the say-all to a better environmental education, and different geographic regions and school cultures may warrant different ways to educate their students. This study hopefully not only serves as a basis study for future experimentation on hands-on simulations in the environmental education realm, but also motivates others to think of other tools and ways to encourage sustainable behavior.

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APPENDIX A: Pre-survey

Default Question Block

Thank you for your interest in my senior thesis Escape Room Experiment. You must fill out this survey by 11:59 PM Monday (3/18) to qualify for a spot. The survey will take at most 10 minutes to complete. Please take the time to answer each question completely and thoughtfully. Not doing so could negatively affect the data collected! Your responses are very much appreciated.

If you have any questions or comments about the survey, please email me at helenachang@berkeley.edu!

What is your email address?

Indicate your level of agreement with the following statements regarding your environmental values.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
I believe climate change is a real issue.	○	○	○	○	○
I believe climate change is a pressing issue.	○	○	○	○	○
I believe climate change is accelerated by human activity.	○	○	○	○	○
I believe in a top-down approach in solving environmental problems. (i.e. it is on the government or larger entity to push for solutions.)	○	○	○	○	○
I believe in a bottom-up approach in solving environmental problems (i.e. it is on the individual to take action.)	○	○	○	○	○
I believe it is possible to stop global temperatures from rising 1.5 °c.	○	○	○	○	○
I believe humans should care about the natural world.	○	○	○	○	○
I believe what I choose to purchase/consume impacts climate change.	○	○	○	○	○

Indicate your level of agreement with the following statements regarding your environmental behaviors.

	Never	Seldom	Sometimes	Often	Always	N/A
I sort my trash in the appropriate receptacles when they are available.	○	○	○	○	○	○
I unplug cords when they are not in use.	○	○	○	○	○	○
I carry my own reusable utensils/dishes/containers when purchasing food/drinks.	○	○	○	○	○	○
I bring my own bags when I go shopping.	○	○	○	○	○	○
I vote for legislation that aims for conservation and reduction of anthropogenic emissions.	○	○	○	○	○	○
I buy locally grown produce.	○	○	○	○	○	○
I buy organic produce.	○	○	○	○	○	○
I try to fix things before throwing them out to buy a new one.	○	○	○	○	○	○
I read articles or watch videos related to climate change (not for school work).	○	○	○	○	○	○
I avoid buying products that are landfill material.	○	○	○	○	○	○

Do you feel empowered to affect change towards a sustainable future? Explain.

What is your age?

- ○ under 18
- ○ 18-19
- ○ 20-21
- ○ 22-25
- ○ 26-30
- ○ over 30

What year are you at UC Berkeley?

- ○ Freshman
- ○ Sophomore
- ○ Junior
- ○ Junior Transfer
- ○ Senior
- ○ Super Senior (5+)
- ○ Graduate student
- ○ Graduated

What is/are your major(s) and minors?

What is your family household size? (Please include yourself)

What is the income of your family's household?

- ○ Less than $25,000
- ○ $25,000 to $49,999
- ○ $50,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 to $249,999
- ○ $250,000+

Which best describes where you currently live?

- ○ Student dormitory
- ○ Non-affiliated UC apartments
- ○ Living at home with family
- ○ Fraternity Housing
- ○ Sorority Housing
- ○ Co-op
- ○ Other, please specify

Please specify your ethnicity/race:
(Mark all that apply)

- ☐ Asian/Pacific Islander
- ☐ Caucasian
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native American or American Indian
- ☐ Other, please specify:

What gender do you identify with?
(check all that apply)

- ☐ Female
- ☐ Male
- ☐ Other, please specify:
- ☐ Prefer not to answer

Thank you for completing the surveys. Take a screenshot of this page and upload it to receive your Extra Credit.

APPENDIX B: Post-survey

Berkeley
UNIVERSITY OF CALIFORNIA

Default Question Block

Thank you for participating in my senior thesis experiment and for answering the final survey! The survey will take at most 10 minutes to complete. Please take the time to answer each question completely and thoughtfully. Not doing so could negatively affect the data collected! Your responses are very much appreciated.

For ESPM 50AC students: In order to receive extra credit, you must fill out this survey, take a screenshot of the last page and upload the screenshot to bcourses by 11:59 PM, Sunday (4/21). The survey will close after Sunday (4/21).

For non-ESPM 50AC students, please also answer by Sunday (4/21) to ensure less variability in data responses, thank you!

If you have any questions or comments about the survey, please email me at helenachang@berkeley.edu!

What is your email address?

Indicate your level of agreement with the following statements regarding your environmental values.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Stro Ag
I believe climate change is a real issue.	○	○	○	○	(
I believe climate change is a pressing issue.	○	○	○	○	(
I believe climate change is accelerated by human activity.	○	○	○	○	(
I believe in a top-down approach in solving environmental problems. (i.e. it is on the government or larger entity to push for solutions.)	○	○	○	○	(
I believe in a bottom-up approach in solving environmental problems (i.e. it is on the individual to take action.)	○	○	○	○	(
I believe it is possible to stop global temperatures from rising 1.5 °c.	○	○	○	○	(
I believe humans should care about the natural world.	○	○	○	○	(
I believe what I choose to purchase/consume impacts climate change.	○	○	○	○	(

Indicate your level of agreement with the following statements regarding your environmental behaviors.

	Never	Seldom	Sometimes	Often	Always
I sort my trash in the appropriate receptacles when they are available.	○	○	○	○	○
I unplug cords when they are not in use.	○	○	○	○	○
I carry my own reusable utensils/dishes/containers when purchasing food/drinks.	○	○	○	○	○
I bring my own bags when I go shopping.	○	○	○	○	○
I vote for legislation that aims for conservation and reduction of anthropogenic emissions.	○	○	○	○	○
I buy locally grown produce.	○	○	○	○	○
I buy organic produce.	○	○	○	○	○
I try to fix things before throwing them out to buy a new one.	○	○	○	○	○
I read articles or watch videos related to climate change (not for school work).	○	○	○	○	○
I avoid buying products that are landfill material.	○	○	○	○	○

What elements of the escape room did you think about when you did a particular behavior. Please elaborate the situation.

	know how	Inconvenient	Cost	Forgot to	I always do it
I sort my trash in the appropriate receptacles when they are available.	☐	☐	☐	☐	☐
I unplug cords when they are not in use.	☐	☐	☐	☐	☐
I carry my own reusable utensils/dishes/containers when purchasing food/drinks.	☐	☐	☐	☐	☐
I bring my own bags when I go shopping.	☐	☐	☐	☐	☐
I vote for legislation that aims for conservation and reduction of anthropogenic emissions.	☐	☐	☐	☐	☐
I buy locally grown produce.	☐	☐	☐	☐	☐
I buy organic produce.	☐	☐	☐	☐	☐
I try to fix things before throwing them out to buy a new one.	☐	☐	☐	☐	☐
I read articles or watch videos related to climate change (not for school work).	☐	☐	☐	☐	☐
I avoid buying products that are landfill material.	☐	☐	☐	☐	☐

Indicate why you did not do the particular environmental behavior if applicable.

Do you feel empowered to affect change towards a sustainable future? Explain.

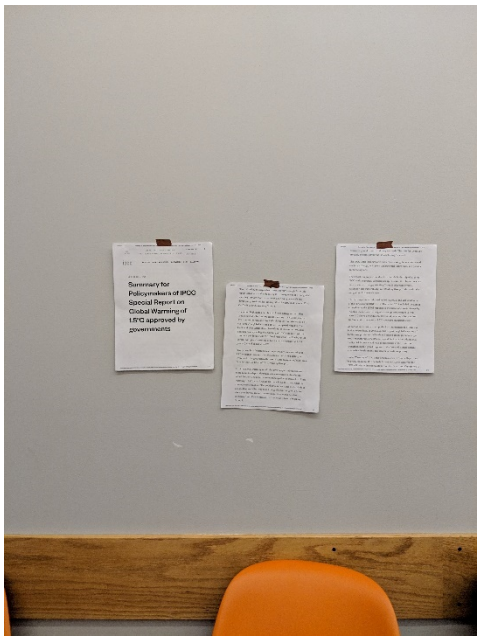
Thank you for completing the survey. For ESPM 50AC students, take a screenshot of this page and upload it to bcourses to receive your Extra Credit. Thank you all again and happy Earth Month!

APPENDIX C: Follow-up questions after escape room experience:

1. What was the best and worst experience for you in the escape room? How did it affect how you felt about the experience and what you would have learned?
2. What would you have tried to change in terms of strategy or teamwork?
3. What would you change about this escape room and debrief to further your learning experience?
4. What skills did you learn on how to consume and live more sustainably?
5. Do you feel more empowered as an individual to make an impact towards a sustainable future?

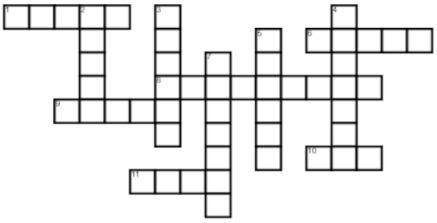
APPENDIX D: Photos of the escape room set up

Puzzle 1:



1. fifty / By 20__, oceans will have more plastic mass than fish. (oceans)
2. third / Pollution in China can change weather in the US. Almost a ___ of air pollution in San Francisco actually comes from China.
3. eighty / ___% of the items in landfills could be recycled.
4. million / In 2017, 124 ___ people are in crisis levels of hunger due to conflicts and climate disasters. (mercy corps)
5. twenty / From 2030-2050, climate change is expected to kill an additional ___-five hundred thousand people. (mercy corps)
6. sixty / up to ___ percent of global greenhouse gas is caused by the stuff we consume. (grist)
7. quarter / Americans make up about 5% of the world´s population, produce 30% of the world´s waste but use a ___ of the world´s natural resources.
8. household / Between 60-80 percent of the impacts on the planet come from ___ consumption. (grist)
9. adapt / Limiting warming to 1.5 c gives people and ecosystems room to ___ and remain below the risk threshold. (IPCC)
10. one / 8 million tonnes of plastic is dumped into oceans every year, which equates to dumping a garbage truck of plastic every ___ minute. (oceans)
11. five / We must reach net zero carbon emissions by 20_0 so climate change does not become irreversible. (IPCC)

Crossword of the day #8

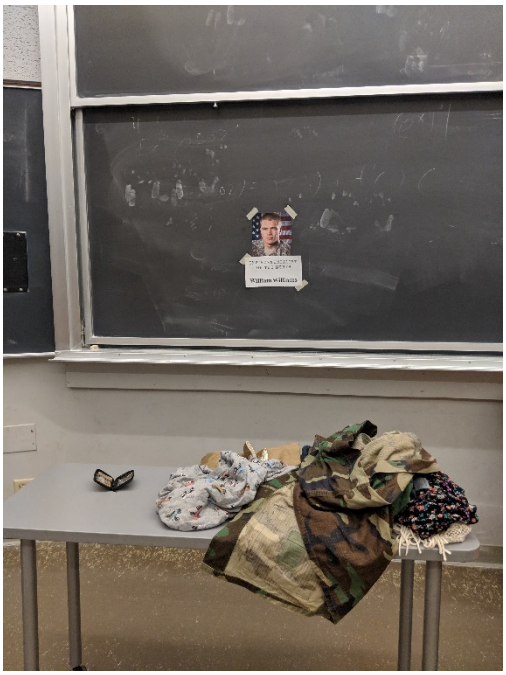


Y 25

ACROSS
1 By 20__, oceans will have more plastic mass than fish.
6 Up to ___ percent of global greenhouse gas is caused by the stuff we consume.
8 Between 60-80 percent of the impacts on the planet come from ___ consumption.
9 Limiting warming to 1.5 c gives people and ecosystems room to ___ and remain below the risk threshold.
10 8 million tonnes of plastic is dumped into oceans every year, which equates to dumping a garbage truck of plastic every ___ minute.
11 We must reach net zero carbon emissions by 20_0 so climate change does not become irreversible.

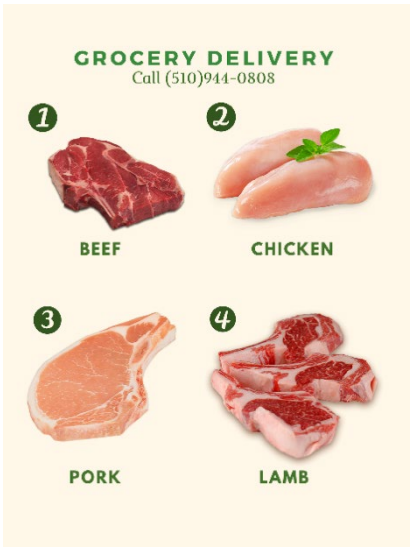
DOWN
2 Pollution in China can change weather in the US. Almost a ___ of air pollution in San Francisco actually comes from China.
3 ___% of the items in landfills could be recycled.
4 In 2017, 124 ___ people are in crisis levels of hunger due to conflicts and climate disasters.
5 From 2030-2050, climate change is expected to kill an additional ___-five hundred thousand people.
7 Americans make up about 5% of the world´s population, produce 30% of the world´s waste but

Puzzle 2:

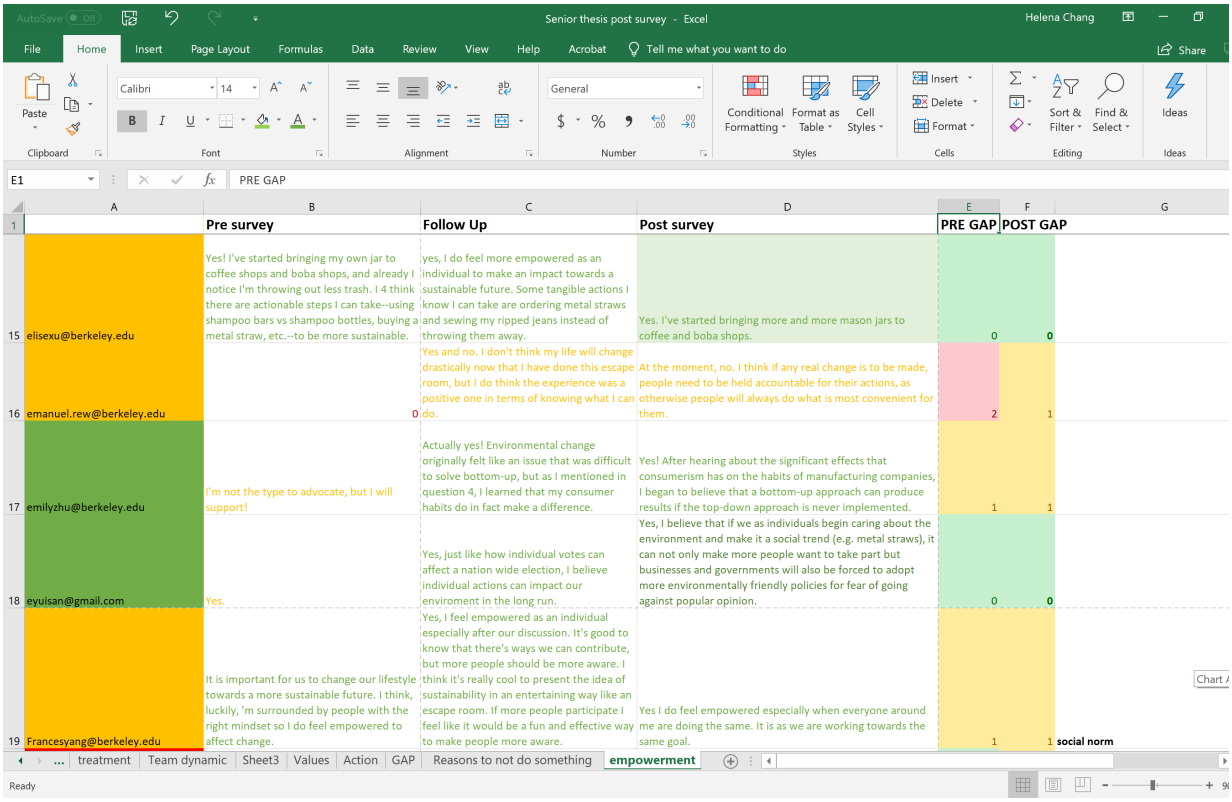


Puzzle 3:

Puzzle 4:



APPENDIX E: Labeling of Empowerment and Gap Values



Senior thesis post survey - Excel

	A	B	C	D	E	F	G
1		Pre survey	Follow Up	Post survey	PRE GAP	POST GAP	
15	elisexu@berkeley.edu	Yes! I've started bringing my own jar to coffee shops and boba shops, and already I notice I'm throwing out less trash. I 4 think there are actionable steps I can take--using shampoo bars vs shampoo bottles, buying a metal straw, etc.--to be more sustainable.	yes, I do feel more empowered as an individual to make an impact towards a sustainable future. Some tangible actions I know I can take are ordering metal straws and sewing my ripped jeans instead of throwing them away.	Yes. I've started bringing more and more mason jars to coffee and boba shops.	0	0	
16	emanuel.rew@berkeley.edu	0	Yes and no. I don't think my life will change drastically now that I have done this escape room, but I do think the experience was a positive one in terms of knowing what I can do.	At the moment, no. I think if any real change is to be made, people need to be held accountable for their actions, as otherwise people will always do what is most convenient for them.	2	1	
17	emilyzhu@berkeley.edu	I'm not the type to advocate, but I will support!	Actually yes! Environmental change originally felt like an issue that was difficult to solve bottom-up, but as I mentioned in question 4, I learned that my consumer habits do in fact make a difference.	Yes! After hearing about the significant effects that consumerism has on the habits of manufacturing companies, I began to believe that a bottom-up approach can produce results if the top-down approach is never implemented.	1	1	
18	eyuisan@gmail.com	Yes.	Yes, just like how individual votes can affect a nation wide election, I believe individual actions can impact our enviroment in the long run.	Yes, I believe that if we as individuals begin caring about the environment and make it a social trend (e.g. metal straws), it can not only make more people want to take part but businesses and governments will also be forced to adopt more environmentally friendly policies for fear of going against popular opinion.	0	0	
19	Francesyang@berkeley.edu	It is important for us to change our lifestyle towards a more sustainable future. I think, luckily, 'm surrounded by people with the right mindset so I do feel empowered to affect change.	Yes, I feel empowered as an individual especially after our discussion. It's good to know that there's ways we can contribute, but more people should be more aware. I think it's really cool to present the idea of sustainability in an entertaining way like an escape room. If more people participate I feel like it would be a fun and effective way to make people more aware.	Yes I do feel empowered especially when everyone around me are doing the same. It is as we are working towards the same goal.	1	1	social norm

Sheet tabs: ... | treatment | Team dynamic | Sheet3 | Values | Action | GAP | Reasons to not do something | empowerment

Ready