Encouraging Sustainability via VR

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Team member contributions: As described in the proposal, the team's goal was to evenly distribute the workload in designing, executing, and reporting this final project. All team members assisted in revising the project aims and methods after receiving feedback on the proposal, as well as recruiting and screening participants for the focus group and interviews. Anne took a lead facilitating the focus group, for which Dina took notes and Max took photos and audio recording. For the interviews, Max created the initial questionnaire, whereas Dina and Anne came up with a script and interview guide. Throughout the interviews, Dina served as the point of communication between the research team and the client, who iterated on the product as participants encountered particular problems in the VR experience. The team cycled through roles as facilitators/interviewers and note takers for the 5 interviews conducted, and each called one to two participants for the one week follow-ups. Analysis of focus group, interview, and competitive review data was done in group meetings with all members present, as was the preparation of the final presentation slides and this report.

I. Executive Summary

This report details our research project carried out in service to the MIMS capstone project group *VR the Change*, a virtual reality (VR) application designed to serve as an intervention to promote individual sustainable behaviors in the home. In consulting with our client, we selected and executed a focus group, evaluative interviews, and a competitive review all aimed at understanding behavioral change toward sustainability as well as the specific impact of *VR the Change* and its unique qualities given the novel platform of VR.

Some major findings were specific to the current VR product, such as the inextricability of usability from VR content presentation, the potentials of awe-inducing nature stimuli, and the power of prompting reflection on everyday life. Other findings were more general to behavioral change including the importance of social & cultural networks, and the ability to gradually engage in a cause. Given the habit formation nature of the topic as well as the VR platform we also suggest a focus on younger audiences and positioning *VR the Change* within the larger ecosystem of VR gaming.

We expand on these findings and discuss their limitations here, as well as explore directions for future work to improve *VR the Change* or similar VR product endeavors. Finally, we reflect on our own methodological insights gained throughout this project, and include copies of research materials in attached appendices.

II. Project Background

VR the Change is a MIMS Capstone Project and a virtual reality experience. It is intended to serve as a narrative intervention for behaviors that contribute to climate change. It is a

gamified, educational application in which a person's home practices and the environmental consequences of their behavior are bridged with the narrative of a monarch butterfly migration from Canada to Mexico.

VR was selected as an appropriate medium for this intervention due to its unique storytelling capabilities. VR has also been shown to have an encouraging effect on perspective-taking and empathy (Ahn et al., 2016; Bailey et al., 2015; Gehlbach et al., 2015; Oh et al. 2016). And while climate change is controversial, the motivating factors for improving sustainable practices can be monetary, social, or otherwise. The development team wanted to explore an array of potential influences to encourage people, regardless of opinions on climate change, to take on sustainable practices within the home, as it is our end-behavior that bears consequence on the planet.

III. Research Goals and Questions

Our initial research questions covered the impact of *VR the Change* on behaviors and attitudes related to environmental sustainability, usability of the *VR the Change* experience, and marketability of the concept of the product. After consulting with the course instructor and our client, we more narrowly scoped our research questions to focus only on the behavioral change and sustainability components, focusing on the following three research questions:

1. What kind of influence could *VR the Change* have on people's environmental behaviors?
2. What kind of influence could *VR the Change* have on people's environmental attitudes?
3. How can the affordances of VR be leveraged to support environmental sustainability?

IV. Methods

We chose three methods aimed at addressing the research questions above from different perspectives in order to triangulate our data: a focus group, evaluative interviews, and a competitive review.

A. Focus Group

Method rationale

We conducted a focus group to gain an understanding of people's general experiences and perceptions of behavioral change in their own lives. Drawing on Baxter et al.'s assertion, "Focus groups are particularly well suited to answering questions that explore attitudes, feelings, and beliefs about a topic, elicit concerns" (Baxter et al., 2015, p.342), we chose the focus group to investigate people's beliefs about how changes to attitudes and practices occur, what sources influence those changes, and what barriers exist that stand in the way of change. We utilized the focus group method for "idea generation" (p.101) about concepts which we could then use to evaluate *VR the Change's* potential influence on attitudes towards environmentally sustainable practices. By having a group discussion, rather than individual interviews, we were able to prompt a deeper array of reflections as people built off of one another's ideas through "synergy" (Baxter et al., p.362) and differentiated the kinds of "problems, challenges, frustrations, likes, and dislikes" (p.101) they had regarding attempts to incite changes in people's lives. We also incorporated individual activities, such as having each person write down their thoughts before sharing, in order to avoid group-think.

Recruitment strategy

Participants for the focus group were recruited from the research team members' contacts, either socially or through shared work/school experiences. The team screened participants by phone or in person by asking a few questions, including about a recent experience resulting in some form of behavioral change - the full screener is included in appendix A. Criteria for inclusion centered around ability to engage in thoughtfully answering the question, not too shy or sparse of an answer, but also not too overbearing, as well as availability for the one hour scheduled period for the focus group. We also recruited several participants who had experience with advocacy and communications work, who would be likely to have thought about how to shift people's attitudes and behaviors from a professional as well as personal perspective.

Description of research activities

The focus group included a self-introduction period, drawing of mental models of their personal information-influence networks, a modified card sorting exercise on barriers to practicing sustainable behaviors, and group discussion throughout. Prior to the introductory phase, all participants were given their reward (a cookie) in order to build trust, and offered the chance to participate in a VR experience at the time of their choosing. Participants took time to draw out their sources of influence, shared with the group and reflected on themes, then each discussed a critical event where they had shifted their attitudes or behaviors. The facilitator followed up on participant discussion with probes asking for greater elaboration and alternative opinions, and with prompts that reframed what the participant had said in the form of a question to the group, paused to offer participants the chance to speak, and checked for understanding, per Baxter et al. She also directly elicited comments from participants who had been quieter, and tried to highlight potential shared concepts and points of divergence in order to incorporate

participant feedback. The group organizers had put together cards with potential barriers to sustainable behavior, which the facilitator read to the group and then asked for their additions, eliciting their own language and framing, which were added to new cards. Participants were then each given three markers with which they could indicate the three barriers they felt represented the greatest challenges to sustainable behavior, and were asked to group concepts they felt overlapped together. They were given the option to put a marker across multiple items if they were grouped together, and to put multiple markers on one item to indicate its importance, though no participants performed this later action, with each placing all three markers on different cards. Participants then discussed their rationale for their choices. This concluded the group meeting and participants were thanked for their participation.

B. Evaluative Interviews

Method rationale

The VR product experience was paired with semi-structured interviews to gain high-fidelity understanding of participant's interactions with and responses to *VR the Change*. Interviews are desirable to "get information about attitudes, beliefs, feelings, and emotional reactions," "get answers to open ended questions," and "gather detailed and in-depth responses" (Baxter et al., p112). The research team believed that this methodology had the potential of addressing, in part, all of our research questions.

Recruitment strategy

The participants for the evaluative interviews were recruited primarily through the research team members' contacts and other connections in an attempt to achieve some diversity

in age, profession, and set of values/beliefs. The team screened participants via an online initial questionnaire, asking participants to share the frequency of engaging in certain behaviors. An excess of some behaviors are viewed as unsustainable in practice, and these inquiries were purposefully buried among other behaviors not related to sustainability (see Appendix C). Participants were also asked about the frequency with which they played video games, because VR as a platform has been strongly marketed toward gamers, and as a platform can be received differently by such a demographic. Additionally, participants were asked to share their top three values when consuming or purchasing certain products, as a means to gauge how environmentally conscious they may already be. Our intent was to screen for particularly environmentally conscious people; however, this proved to be an insurmountable challenge given our recruitment pool was limited by time, lack of participant compensation, and the necessity of physical colocation to experience VR.

Description of research activities

Participants tended to have limited VR experience. To diminish a novelty effect and potential overwhelming nature of playing with emerging technology, we placed participants in a functionally similar VR experience developed by Valve, *The Lab*. This way, they would be able to acquaint themselves with movement and interaction controls before entering *VR the Change,* as well as adjust to being in a virtual world. Participants were then placed into *VR the Change*, and were instructed to think aloud their thoughts primarily pertaining to the content rather than usability issues with the experience. Participants were notified that the experience was not created by professionals, and was currently in the stages of development. The research team

remained mostly quiet, only speaking when the participant could be in danger in physical space, and to assist in overcoming usability issues or bugs (e.g. teleporting through a wall).

After completing *VR the Change*, participants were interviewed briefly in a semi-structured format by the research team. Questions ranged from talking about the experience, how they felt, how relatable the experience was to their lives, and who they might speak to about this experience, if anyone (see Appendix D); follow-up questions and probes were employed by interviewers. A week after this interview, the research team followed up with each participant, asking them to reflect on whether the experience affected their week in some way and whether they spoke with others about the experience (see Appendix E). Participants were compensated with a cookie and an opportunity to explore other professionally developed VR applications after the interview.

C. Competitive Review

Method rationale

The lack of sustainable practices by individuals in their homes is not a new phenomenon, nor is the attempt to address this deficiency with various forms of media and research intended to encourage positive behavioral change. In order to gain a better understanding of the successes and shortcomings of these surrogate products, we conducted a competitive review of their features and relevance to *VR the Change*. We also believed that a competitive analysis was appropriate, as "no product is so revolutionary that there is not someone out there from which to learn," especially considering that the issue of environmental sustainability is a longstanding one (Baxter et al, 2015).

Competitor selection strategy

We chose four products that had an educational and/or advocacy goal, two of which were specifically about climate change and environmental sustainability, but were different media forms (a novel — *Flight Behavior* — and documentary film — "An Inconvenient Truth"), and two of which were applications in Virtual Reality (The Body VR and Ahn et al.'s perspective taking VR research project from 2016).

Description of research activities

We looked at each individual surrogate product for its unique features, design strengths and weaknesses, and any hardware requirements as they compared to those of *VR the Change*. These ranged from more subjective evaluations to more objective aspects (e.g. whether content is interactive). We also assessed the presence of selected core features, focusing especially on level of accessibility [See Appendix F]. We added an intermediate "maybe" category, designated with a ~ , to indicate the ways in which these features may be only partially present. We initially had other qualities, such as visual imagery, text, and haptics, but deleted them when we decided these were not core features of the experiences.

V. Key Research Findings

Inextricable usability

Theme: We found that usability remains tightly interwoven with presentation of content, and how effective that presentation could be in engendering contemplation and potential behavior change. This also came up in our usability study of surrogate product The Body VR, where participants frequently struggled to take in and recall information because they were

distracted by understanding how the environment worked, and the fact that it often did not work in expected ways.

Recommendation: Incorporate iterative/agile process of testing and development for both usability and narrative simultaneously, as they are closely linked.

Power of awe & nature

Theme: This aspect was a strength of *Flight Behavior*, which imagines the personal impact on one woman and her town when monarch butterflies reroute their migration due to climate change and unexpectedly descend on a small Southern town. Similarly, "An Inconvenient Truth" uses sweeping images of large scale environmental change which, at least according to film critic Roger Ebert, incited behavioral changes of the type desired. Multiple interview participants spoke about the sweeping landscapes in the monarch portion of the VR the Change experience, expressed the desire to spend more time in that element, and spoke about it to friends. Additionally, research in psychology has suggested inducing feelings of awe can contribute to prosocial behavior (Piff et al. 2015), and this is particularly apt for *VR the Change*'s goal of behavioral change toward sustainable practices.

Recommendation: Take advantage of the awe-inspiring qualities of immersive nature scenery, perhaps by allowing for more time and exploration in these scenes and improving their fidelity.

Recognition and reflection

Theme: During the focus group, participants spoke about the impact of learning about an alternative way of approaching a concept or set of practices and seeing directly how that could fit into their lives - the importance of contextualizing abstract ideas in their daily environments, for

example, when one participant's supervisor scolded her for not separating garbage into different bins. Learning about something from an external source, such as a podcast, book, or a loved one's comments, caused participants to begin to examine their behaviors and attitudes differently going forward. While in the experience and in the following interviews, several participants said variations on "I do this at home," and reflected on the extent to which tasks in the experience matched their daily chores. Several participants specifically mentioned the running water in the sink - that it was a "pet peeve" of theirs, or that they felt guilty to leave it running. This element of recognition and reflection is clearly central to VR the Change, and one participant specifically noted in his follow up interview that after going through the experience he reflected on how full his refrigerator was at home (one of the tasks in the experience) and tried to keep it more full to save energy.

Recommendation: *VR the Change* should continue to match and incorporate things people recognize from their daily lives. In future variations, the team should perhaps research additional areas where people struggle with environmental sustainability in their daily lives (e.g. transportation) and add those in. We found that some tasks were relatively rote and deeply familiar to people (such as the sink), while others were somewhat surprising or provided more context (such as the refrigerator and sorting the garbage). The development team could further work to identify the tasks that both resonate most deeply *and* provide opportunity for new reflection and behavior change.

Change is social and gradual

Theme: In our focus group, participants repeatedly mentioned those around them as having a profound influence on their attitudes and behaviors. Similarly, in our interviews,

participants highlighted the way friends' behaviors could directly impact them. Peer pressure as a social good is a common technique of technological health interventions, such as Fitbit, that encourage sharing for mutual support and friendly competition. Participants also highlighted the way change often took place for them over time, as they saw something repeatedly reinforced by different aspects of their lives, suggesting that a long term vision is necessary to connect to a wider ecosystem of efforts to support a shift in attitudes and practices. "An Inconvenient Truth" and *Flight Behavior* both focus on the power of social and community norms in shifting someone's practices over time.

Recommendation: VR the Change could integrate some level of social sharing into the experience itself - anything from encouraging participants to share badges of accomplishment or VR selfies among the monarchs on social media to shifting the information presented about energy savings to reflect how you as an individual contribute to larger changes in your neighborhood, city, state, country, etc.

Rational understanding + care = change

Theme: Several interviewees expressed confusion about the relationship between the home tasks and the butterfly migration. While the same participants claimed to already practice sustainable behaviors and be knowledgeable about environmental concerns, they still felt the link between the behaviors and the butterfly's experience was tenuous. At the same time, they expressed a feeling of joy and awe in regards to the butterfly portion of the experience. During the focus group, many people spoke about change coming not from rational understanding alone, but often from a combination of facts and expertise and emotional attachment. This combination is nascent in *VR the Change* as it stands, with both facts and emotional connection built in in the

form of informative slides about sustainable behaviors and the butterfly migration experience.

Recommendation: The development team should further play up the connections between the tasks and the butterfly experience, fleshing out the links without overwhelming participants with further reading - perhaps through an animation or other experiential aspect.

Universal Accessibility Areas for Improvement

Theme: We did not yet conduct research with individuals with various disabilities, but a set of core features in our competitive review revolved around the accessibility of the experiences provided by the products. *VR the Change*, like other VR experiences, is currently heavily dependent on the audio and visual ability of the user, as well as the ability to interact with hand controllers.

Recommendation: As much as possible, we encourage the development team to provide alternatives to visual and audio experience such as descriptive audio and subtitles. The ability to teleport in the environment is helpful to those unable to move around the room, but perhaps an alternative interaction method to the hand controllers could be explored. We also recommend conducting future user research with individuals with disabilities to confirm the usability and positive experience by these individuals.

VI. Research Limitations and Future Work

Our primary limitations revolved around limitations in time, location, and resources, which overlapped with usability issues that arose due to the ongoing nature of development, where participants encountered bugs and other usability concerns. It was difficult to recruit people who fit our profile without funding for participation incentives and in a limited time span

in the Bay Area; additionally, the fixed location of the VR equipment meant we were unable to engage remote participants. Due to resource constraints, we avoided doing a diary study, which could have offered more fine grained information about participants' behaviors. However, such a study might also have the confounding effect of creating its own prompt, and thus might have required a control group of even more participants.

A further complication in the research we conducted was trying to match the participant population with a suitable target audience of *VR the Change*. The participants recruited through connections of the research team generally did not have much room for improvement with their at-home sustainability practices - though as we describe in our reflection and relatability finding above this did not mean no value could be gleaned by users in this group. With additional resources and time, there would be much to gain from repeating the focus group and evaluative interview methods with participants who do not already have an understanding of sustainable practices.

In addition to future work that might target a broader cross-section of the population and more participants who are not currently engaged in environmentally sustainable behavior, future research might also investigate opportunities to expand VR the Change or embed it within a wider system of experiences. In order to determine what experiences might be most resonate and effective in terms of promoting long term behavioral change before development has taken place, future researchers might use paper prototyping or scenario based surveys, as well as field research and interviews, to generate further ideas for iteration and expansion.

VII. Reflections on Research

We believed, to a degree, that user research methodologies would be wholly transferable to a virtual reality platform. An assumption we had going in was that usability needed to be assessed prior to an evaluation on the content matter of the experience. From prior knowledge, we knew recruitment would be challenging, given a lack of funding and general misalignment with schedule availability. For these reasons, we began our screening and recruiting processes early, but were still constrained by the semester timeline. As a team, we value the importance of quality user research, as we believe it attempts a good-faith effort to humanize, contextualize, and understand consumers and their needs. The methodologies we used were all new to us, bringing with them excitement and anxiety. We found that participants were happy to have their voices heard and appreciated, bringing a sense of intimacy and value to our work. Indeed, this process (although frustrating at times) was fulfilling.

Conducting research upon a technology as immersive as VR is challenging. While VR as a technology has been around since the 80s, appropriate heuristics have yet to be developed that would allow for standardized analysis of it. Relatedly, the analysis of VR on a content level cannot be separated from analysis on a usability level; attributing cognitive disconnects within those domains as a result is furthermore challenging. In attempting to assess the merit of *VR the Change*, we focused our inquiries on the content and not the usability of the product; however, that meant conducting research on a product with unknown usability issues upon a platform that is novel to most people. Discerning whether participant's struggles were due to the novelty of the technology or inherently problematic design was difficult to assess; whether some struggles could be overcome through experience over time was another challenge the research team faced

when synthesizing our results. While the development team was made aware of usability issues throughout the evaluation studies and addressed them accordingly, any of these challenges could have been mitigated by having a longer timeline for usability concerns to be specifically addressed, and established standards by which to evaluate VR applications.

Recruitment was its own challenge, given the nature of the content and the research questions we had. In wanting to assess the merit of the product, it would be ideal to run an array of people with diverse attitudes and behaviors relating to environmentally sustainable behavior; however, given the immobile nature of our product, our geographical location in the progressive Bay Area, our lack of financial incentive for participants, and common scheduling hurdles made it difficult to ascertain such diversity. Should we run additional studies in the future, ascertaining some form of funding and hoping the HTC Vive hardware (or an alternative platform) becomes increasingly consumer-friendly would surely contribute to a more diverse range of participants.

It was an interesting and challenging endeavor to prioritize and address the many possible directions for user research of *VR the Change* within the constraints of the course and working with a product still under development by a client also constrained by time and resources. While we had many ideas when proposing our project, we consulted with our client project team to determine their most pertinent areas of exploration, which was the impact and behavioral change components of the product itself. We therefore used the highly customized 'evaluative interviews' method as we believed it could provide a necessary minimum of usability feedback for the client to iterate on, while still focusing on the impact of the experience's content. We view this type of mediation and decision making as a valuable learning experience given

development and research teams very likely do not experience perfect communication but have shared goals.

VIII. References

1. Ahn, S. J. G., Bostick, J., Ogle, E., Nowak, K. L., McGillicuddy, K. T., & Bailenson, J. N. (2016). Experiencing nature: Embodying animals in immersive virtual environments increases inclusion of nature in self and involvement with nature. Journal of Computer‐Mediated Communication, 21(6), 399-419.
2. Bailey, J. O., Bailenson, J. N., Flora, J., Armel, K. C., Voelker, D., & Reeves, B. (2015). The impact of vivid messages on reducing energy consumption related to hot water use. Environment and Behavior, 47(5), 570-592.
3. Baxter, K., Courage, C., & Caine, K. (2015). Understanding your users: A practical guide to user research methods. Morgan Kaufmann.
4. Gehlbach, H., Marietta, G., King, A. M., Karutz, C., Bailenson, J. N., & Dede, C. (2015). Many ways to walk a mile in another's moccasins: Type of social perspective taking and its effect on negotiation outcomes. Computers in Human Behavior, 52, 523-532.
5. Oh, S. Y., Bailenson, J., Weisz, E., & Zaki, J. (2016). Virtually old: Embodied perspective taking and the reduction of ageism under threat. Computers in Human Behavior, 60, 398-410.
6. Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the small self, and prosocial behavior. Journal of personality and social psychology, 108(6), 883.

IX. Appendices

A. Focus group screener

B. Focus group guide

C. Interview preliminary questionnaire

D. VR experience & interview guide

E. Follow-up call guide

F. Competitive Analysis grid

Appendix A: Focus group screener

Briefly describe focus group activity and purpose, that it is not an experiment or an attempt to change anyone's mind, but that we are looking to understand people's experiences and attitudes, as well as available times and compensation (cookie and VR).

- What is your job?
- What are your hobbies?
- Do you have experience with marketing / communication / advocacy (in a professional or volunteer capacity)?
- Tell me about the last time that you changed your opinion on towards an issue?
- Can you think of a time you substantially changed your behavior based on something you heard, saw, or experienced? What was that?

Appendix B: Focus group guide

Welcome everyone, thanks for coming. For this group, we'll discuss how attitudes and behaviors form and change. All ideas are useful and please speak one at a time. Your individual experiences may be different - please respect each other's experiences and thoughts - it's OK to disagree but please don't critique each other. We will be audio recording this activity and taking pictures for our project. This will last until 6pm.

Introduction (Name, Job, Pronouns) – 5 min

(Have nametags)

Map of sources of influences around issues of public interest: e.g. daily news

Have sharpies and paper

-- 5 min to draw your map

-- 10 min to share with new color to revise

Discussion

Can you tell us about a recent time that their opinion or behavior changed based on something they heard, saw, or experienced (doesn't need to be the one from before) - 15 min discussion (2 min write notes, then share out)

Exercise

What are the biggest barriers you face to improving the environmental sustainability of your behaviors? (you write down yours first - 2 min, here are the ones we came up with, what others are there? - 3 min, we'll give you 3 post it notes and feel free to distribute them on the things you think are the greatest barriers, please discuss your thought process as you do it) - 20 min

- Cost
- Inconvenience
- Sentiment / tradition
- Not knowing about alternatives
- Don't think our actions will make a difference
- Not wanting to face the harsh truth

Final Thoughts

Do you have any final thoughts? 5 min

Appendix C: Interview preliminary questionnaire

1. List three problems in the world you are most concerned with.
2. Estimate how many hours per week you spend doing the following activities: Watch TV (on a television), Read printed material (books, magazines), Spend time on a computer, Use a mobile device (phone, tablet, etc), Play video games.
3. Estimate how frequently you do the following activities: Look at your utility bill(s), Go shopping for new clothes, Use a washing machine/dryer, Purchase fuel for a vehicle.
4. Of the list below, rank your top three (1 most important) factors when purchasing food. (Appearance, Cost (to you), Environmental Sustainability, Expert Reviews, Labor Practices of Producer, Nutritional Value, Peer Recommendations).
5. Of the list below, rank your top three (1 most important) factors when purchasing technology. (Appearance, Cost (to you), Environmental Sustainability, Expert Reviews, Labor Practices of Producer, Technical Specifications, Peer Recommendations).
6. Choose the mode of transportation you most commonly use for your daily commute. (Walking, bicycle, personal car, bus, train, carpool, other).
7. Briefly describe how you use water.
8. In the next two weeks, which days and times would you most likely be available to come to South Hall at UC Berkeley South Hall for a 1 hour study visit?

Appendix D: VR tutorial, experience & interview guide

VR Tutorial and Experience

Greet participant, explain they will spend about 20-30 minutes in VR and 30 minutes interviewing immediately afterward. Both will be recorded via video and written notes. Confirm they're okay continuing. If at any time during the VR experience they feel nauseous, or feel uncomfortable in the interview, they can stop & that is OK.

[Ask any questions about their responses to the pre-visit questionnaire here]

Unity scene should be pre-loaded. Should it not be, open Unity from the desktop, and open file "VR the Change Bedroom." It should be the most recent file that has been opened, and so the first one listed. The file itself takes ~10 minutes to load without an indication of progress, sometimes causing Unity to hang, and requires Unity to be force quit. Patience is your best friend, but in the event that it is taking particularly long, do not hesitate to force quit and restart the application. In order to initiate the program, click the Play button toward the top-center of the program.

Moderator: [*Holding a controller*] "This is one of the hand controllers for the VR experience. You will have one in each hand. There are a few buttons you will be able to use - the touchpad to use with your thumb, and the trigger button underneath to use with your index finger. There are

other buttons but you won't need to use them. At the start of the experience, a narrator will go into further detail about the controllers. Listen for her throughout your experience."

Place the VR headset on the participant's head, explain they can adjust straps on sides for a snug but comfortable fit. Have them make a fist with each hand to put their hand through the loop and have them grasp the controller.

Confirm they're okay to continue.

Moderator: "You will begin in a bedroom in a virtual home. You can move around in two ways. First, you can physically walk, turn your head, or any other typical motion - there is a limited place space so if you see a transparent blue wall you know you are out of bounds and should take some steps backward to return to the center of the room. The second way to move is to press and hold on your right touchpad and point to a location, upon releasing the touch pad you will teleport to that location. We recommend this method of locomotion to avoid bumping into walls in the physical space. Try this out now, teleporting to a location in the room.

You can also interact with some objects in this room. You can try pointing at something and pressing the trigger button on your right hand. You can also go up to some objects and press and hold the trigger button to push or pull them.

On your left hand you will see a grid-like display. Each image of the display represents something in the room. Can you tell me what you think the first icon represents?"

Wait for response - correct them if they're wrong.

Insert instructions for accomplishing first task. Include whether they notice anything different.

Moderator: "For the remaining 20 minutes I'd like you to explore and interact with the room on your own. I will stop you if you are about to run into something or otherwise hurt yourself, as well as if the program encounters an unexpected error. Otherwise I will remain silent until the end."

Once 20 minutes have passed.

Moderator: "Okay you've finished this portion. I'm going to help you take off the VR equipment now."

Take controllers and headset.

<u>Post-VR Interview Guide</u>

Moderator: "Now we'll move into the interview portion. I'd like to remind you there are no incorrect answers and we are hoping for your honesty. We did not build this experience, we are simply helping to evaluate it. All of your responses will be reported anonymously, but you don't have to answer any question if you don't feel comfortable doing so."

Interview questions:

- How are you feeling?
- Can you tell me about what you just experienced?
- What were your favorite parts? Your least favorite parts?
- Was this a memorable experience? Why/why not?
- How relatable was this experience?
    - Some parts more than others?
- How do you think this experience will influence you?
- Given the option, would you return to this experience again?
    - Would you recommend this experience to anyone you know? Anyone in particular? Why?
- Is there anything you thought I would ask that I didn't?
- Anything else you'd like to share?

Thank participant for coming - give them a cookie, and let them know we will contact them by phone for a short follow up in one week. Ask for their phone number.

Appendix E: Follow-up call guide

1. Under what circumstances did you think back to the experience? Describe those times.
2. Did you tell anyone about the experience? Who? What did you say?
3. Has anything come up about the experience since the interview that you'd like to share?

Appendix F: Competitive Review Grid

	VR the Change	*Flight Behavior*	An Inconvenient Truth	The Body VR	Ahn et al.
Design strengths	Immersive, requires full attention, gamifies best practices in sustainability to make the link to everyday life, awe-inducing nature scenery	Single mode (reading) may allow for less distraction and more focus - since people imagine visuals rather than are provided with them they are inherently required to connect the material to their existing mental models, strengthening impact	Music, facts, description, images combine to make a point	Multiple modes (short interactive films, 3D anatomy viewer), self-guided	Involves both VR and in person physical engagement to promote embodied reactions and experience
Design weaknesses	Some instructions required given bugs exist (e.g. teleporting through wall), not yet distributed beyond development team	Requires a longer amount of time and higher level of literacy / willingness to stick with it, May not resonate with people in very different situations from the characters [< - too plot oriented? i think it's relevant...] Set path through the material, No interactive component	No interactive component Emotional resonance of music / dramatic effect may overwhelm details of potential alternatives	Virtual reality/interactive component distracts users from fully exhibiting the narrative/educational content	Requires outside intervention to perform physical engagement, no narrative component, only ocean acidification experience currently distributed beyond lab
Requirements	Only accessible with HTC Vive hardware	Accessible to anyone who can purchase a book or borrow one from a library	Available to stream on a variety of digital services, originally accessible in theaters	Requires HTC Vive, Occulus, or Samsung Gear VR hardware	Requires customized VR hardware in Stanford VHI lab
Core features (educational)					
Interactive content	✓	✗	✗	✓	✓
Physical interaction	✓	✗	✗	✓	✓
Self-paced	✓	✓	~	~	~
Direct connection to daily practices	✓	✓	~	✗	✗
"Game-like" qualities	✓	✗	✗	✓	✓
Accessible to people without hearing ability	✗	✓	✓	✗	✗
Accessible to people without visual ability	✗	✓	✓	✗	✗
Accessible to people without leg movement abilit	✓	✓	✓	✓	✓
Accessible to people without hand movement ab	✗	✓	✓	✗	✓
Accessible to people without reading ability	~	✓	✓	✗	✓
✓ Total	6	7	5	4	6