

Interactive environmental education: Developing an African village exhibit



Abstract

Although public awareness of climate change has increased recently, key indicators show insufficient remediation. Our sponsor, CERES, works to educate the public about the effects of climate change on water and food security, and about environmental justice issues, such as conflict mineral mining. Our goal was to develop and test an African village exhibit to promote a personal understanding of the interconnected impacts of these problems on Australians and Africans. We researched exhibit design and studies of these environmental issues in both regions, then we developed and tested activities and signage for the exhibit, which will inspire more sustainable behaviors.

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December 14, 2016



Environmental and social injustice: Global threats

Climate change is one of the world's most pressing issues, threatening social, economic, and political stability across nations and continents.¹ The Intergovernmental Panel on Climate Change (IPCC) recognizes that this issue is largely aggravated by human action, and the increasing number of resultant natural disasters are having severe impacts on water and food supplies in many countries, including Africa and Australia.^{2,3} As discussed by Funk et al., Africa struggles to adapt to climate changes in its northern region, where a shortage of natural water supply, along with fluctuations in rainfall and lack of water management, are having detrimental effects on both water and food security.⁴ On a similar note, conflict mineral mining can have negative effects on the environment and can contribute to social injustice, particularly in Africa.⁵ Mines in the Democratic Republic of the Congo, which produce minerals used for electronic devices consumed in Australia, are an example of operations that fund wars and human rights violations.⁵

Although Australia faces similar climate issues to Africa, Australians are able to use technology, politics, and economic channels to help mitigate the effects that Africans must deal with using only limited resources.⁶ Despite an increase in climate change awareness in Australia, there has not been a noticeable change in action, as suggested by the continued worsening of greenhouse gas emissions (CO₂ equivalent), which are reported by the Australian Government's Department of the Environment and Energy (Figure 1).^{7,8} In order for people to change their behaviors and act sustainably, they need to see the effects of climate change as a personal and a global issue, let their emotions inspire them to act, and see the connections

between their actions and struggles and those of people around the world.^{9,10}

CERES Community Environment Park is an organization in Brunswick East, Melbourne, working to raise awareness of global issues, such as climate change, sustainability, and social injustice, through exhibits, educational programs, and community enterprises. The park is currently developing mini "villages," outdoor exhibits that educate visitors about the social justice and sustainability problems faced by Aboriginal Australians, Africans, Indians, and Indonesians, and that promote understanding and awareness of related issues in Australia. Prior to this project, CERES had already built the main infrastructure of an African village exhibit, including a mud brick hut, a well, and a shelter; however, the village had only been used for guided school tours, as it lacked stand-alone signage and activities in which unguided visitors could engage (Figure 2).

Our team worked on the development of an educational exhibit at CERES Community Environment Park, focusing on climate change impacts and solutions in order to further increase global concern and

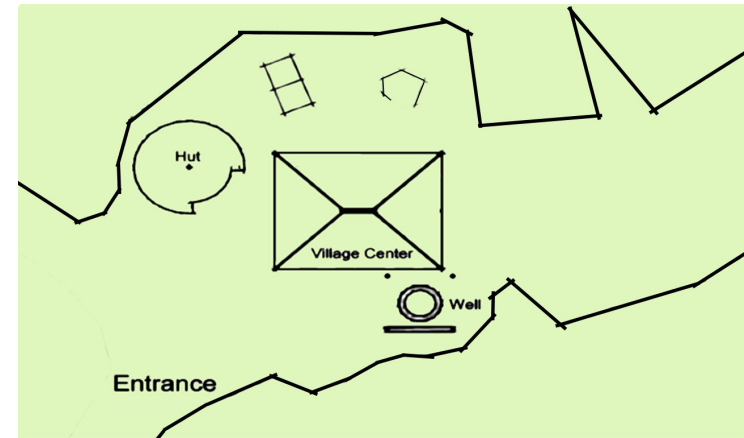


Figure 2. Overview of African village with existing infrastructure.

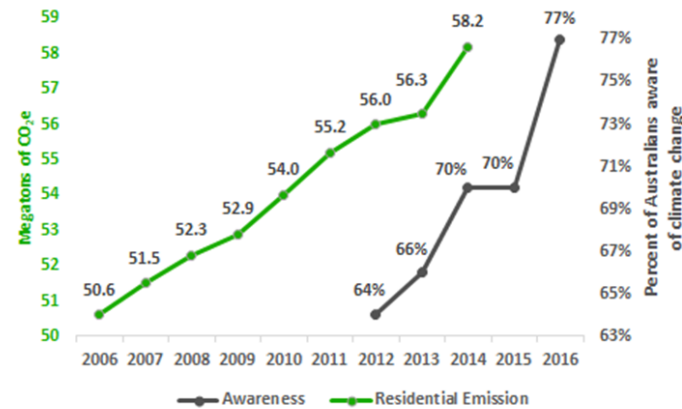


Figure 1. Increasing awareness may have little impact on behaviors that cause CO₂e emission.^{7,8}

activism. We focused on the African village exhibit to present climate change issues in arid regions, food and water security, and the mining of conflict minerals, specifically minerals used in mobile phones. We utilized an approach of eliciting emotions and establishing personal connections to motivate Australian visitors to action, a strategy that psychologists suggest for inducing behavioral change in people.^{9,10}

Furthermore, we wanted to not just focus on problems, but also emphasize promising strategies or projects being implemented by Africans to combat these issues, showing that such measures are achievable. McCombs has argued that individuals respond well and are more motivated to learn when shown that positive results already being realized.¹¹ We hoped to relate the exhibits to similar problems occurring in Australia, and to show how the actions of local people can affect other Australians, as well as those in Africa. Establishing these relationships and connections will make the message more impactful to Australians, as individual interest increases attention and the will of people to learn.¹² The goal of these villages is to show people the impacts of the environmental and social justice issues occurring in these countries and the connections that can be made between them. Thus, through the information presented in the village, we

hope to motivate change to more sustainable behaviors and to promote action to be taken against climate change and social injustice.

Our group had five objectives (Figure 3) for designing an effective exhibit on sustainability education in the African cultural village at CERES. Because our exhibit was to be used as an educational tool to motivate change in behavior, we conducted background research on climate change impacts on water and food security, as well as the social impacts of conflict minerals in Africa and Australia. Our first objective was to measure Australian awareness and knowledge of the environmental issues occurring in both their own country and Africa, specifically regarding general climate change, water and food security, and the social and environmental impacts of mining. The second objective was to research the educational content related to each of these issues that we want to present in the village exhibit, as well as some solution strategies currently being implemented in Africa in response. Our third objective was to identify effective strategies for designing interactive educational exhibits, which we would incorporate into our display, as well as to identify the goals and design criteria for the exhibit. Once we identified these educational concepts and effective design strategies, our fourth objective was to design and develop the core activities and their actual layout within the exhibit. Finally, our fifth objective was to test the exhibit with CERES staff and visitors and made recommendations for future development and implementation based on their feedback. By incorporating interactive learning principles and relating the issues of Africa to Australia, we hoped to make the displays and topics be informative and engaging to the Australian visitors. In presenting the



Figure 3. Project objectives

real-life impacts of these issues in Africa and relating them on a more personal level to Australians, we hope the village provokes emotions that resonate with and motivates the visitors to change. In addition, by providing real-world solutions occurring in Africa and suggesting manageable lifestyle changes for Australians in our display, visitors can learn how they can positively change their own behavior to be a part of a global solution.

Background: Climate change is a global issue

Several organizations around the world are working to raise awareness and address the impacts of climate change. Many museums and science centers have developed exhibits on environmental sustainability and social justice issues that are designed to raise public awareness and inspire behavior change. This section provides an overview of findings on Australian public awareness of climate change, general causes and impacts of climate change in Australia and Africa, and conflict mineral mining in Africa.

Impact of climate change in Australia

There is a strong consensus among climate scientists that global warming is occurring as a direct consequence of the release of greenhouse gases from human activities, especially the burning of fossil fuels,

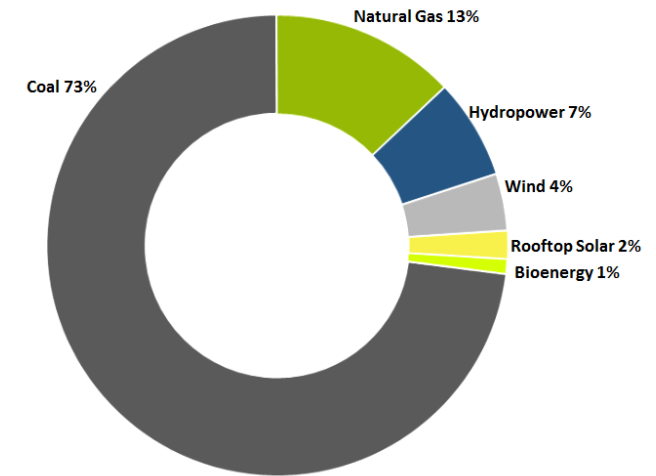


Figure 4. Electricity generation across Australia

causing significant increases in CO₂ levels and average global temperatures over the last century.¹³ A change of 1°F (0.56 °C) over 100 years can have a dramatic impact on ecosystems and human civilization.

After surveying a portion of the Australian population on their beliefs regarding climate change and its effects, the Climate Institute found that 77% of respondents believed that climate change is a real issue and is already having adverse impacts on the world in 2016. This finding is up by 7% from 2015, and by 13% from 2012.⁷ Although one might expect that citizens who are aware of this issue would make shifts in their behavior, a 2015 Global Carbon Project report ranked Australia 14th on the global carbon emission list, with Australia emitting 0.38 billion-tons of CO₂ in 2014-2015.¹⁴ To support its high standard of living, nearly 86% of Australia's energy is generated from burning fossil fuels.¹⁵ Origin Energy, Australia's leading gas supplier, found that 73% of the country's energy is created from coal, and 13% created from natural gas (Figure 4).¹⁵

The Australian Department of the Environment and Energy recognizes that Australia faces a wide range of negative effects as a result of climate change.¹⁶ The rising sea levels and the increasing frequency and intensity of storms threatens coastal communities. In addition, the changing patterns of rainfall and the increasing likelihood of prolonged drought threaten the agricultural production and the livelihood of many inland communities. Deforestation is also a growing concern, as the felling of trees increases the salinity and infertility of soil, intensifies desertification due to erosion, and causes a decrease in biodiversity. In a similar manner, the dryness of forests combined with rising temperatures and winds makes forests more prone to catching and spreading fires.¹⁷

Water and food security in Australia and Africa

Australia is the driest inhabited continent in the world, followed by Africa, as reported by the Planning Institute of Australia and the World Wildlife Fund.^{18,19} The Global Food and Water Crises Research Programme at Future Directions International states that Australia occupies about 5.6% of the world's landmass, but only receives 1% of its available freshwater, and 70% of the country's mainland is classified as arid or semi-arid.^{20,21} In contrast, the United Nations Environment Program (UNEP) recognizes that Africa has abundant water resources, yet still suffers from water shortages, especially in its Northern territories, where supplies exist but are difficult to access.²² This shortage of water forces people to resort to difficult methods of obtaining drinking water from sources that are not of high quality, quantity, or convenience, such as hand pumps, river beds, ponds, etc. (Figure 5).

Climate change drove up the global temperature approximately 0.5 °C between 1970 and 2010.²⁴ This global increase has been marked by scientists as the leading cause of a greater frequency of extreme



Figure 5. Digging for drinking water in a dry river bed.²⁴

weather events, longer and more severe droughts, an expansion of the globe's tropical belt, and heat waves.²⁴ The International Disaster Database shows an increasing number of people affected by natural disasters annually in Africa, with 78% of the people between the years 2000 and 2015 by drought alone (Figure 6).³

Studies on plant behavior under drought conditions show that there is a drastic increase in plant mortality rates, which reduces the production of valuable resources to both humans and the environment. In some instances, a lack of photosynthetic uptake means an ecosystem can become an area of CO₂ production.²⁵ As a result of the impact of climate change on water availability and plant health in the world, food security

throughout Africa is also a growing issue. In sub-Saharan Africa, the area with the highest proportion of malnourished populations in the world, the Food and Agriculture Organization of the United Nations (FAO) estimates that one-third of people suffer from chronic hunger.²⁸ Ethiopia faces a similar struggle, where chronic food insecurity affects 10% of the population.²⁷ Funk et al. note that since 1980, there has been a downward trend in rainfall across eastern and southern Africa and a 15% decline in rainfall in food-insecure countries during main growing seasons.⁴ This trend affects staple crops, such as teff, maize, barley, and sorghum.⁴ Declining rainfall and drought are primarily attributed to the warming of the Indian Ocean.⁴ This

lack of consistent rainfall has had detrimental effects on the ability of households in this region to meet their food needs.

Similarly, climate change greatly affects Australia in terms of agricultural production and socioeconomic

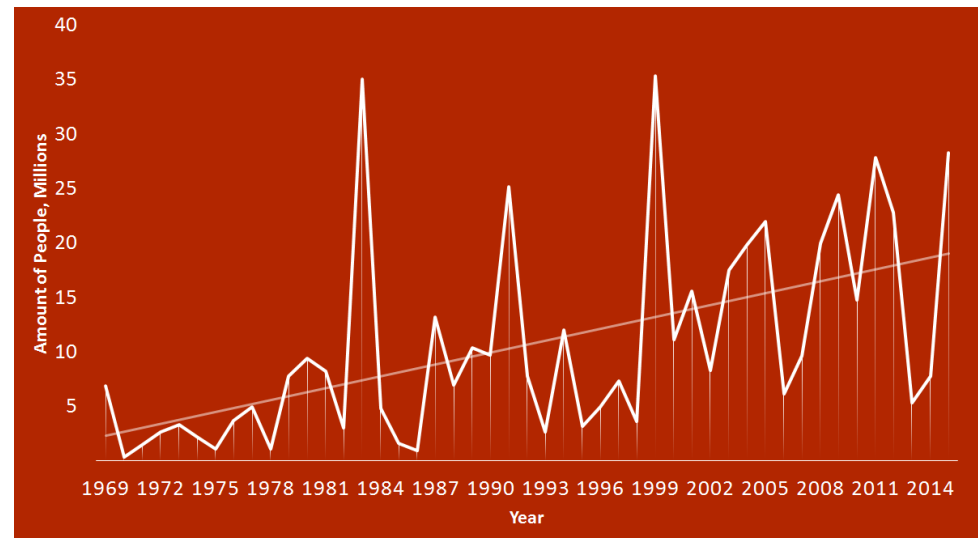


Figure 6. Growing trend of affected people due to natural disaster in Africa from 1969-2015.³

policies. Low rainfall, high temperatures and evaporation rates, and recurring drought are costing farms profit and forcing farmers to turn to more extreme and limiting “coping strategies,” according to Ross Kingwell with the Department of Agriculture in Western Australia, a region that has experienced a decrease in winter rainfall by 10-20% over the last thirty years; further declines are expected to have drastic effects on crops, reducing plant and livestock production.²⁸ However, the decline in agricultural production is not the only food issue concerning Australians. OzHarvest, a charity organization that collects food that would be wasted from businesses, found that Australians waste around 4 million tons of food each year.²⁹ This accounts to between eight and ten billion Australian dollars of wasted food.²⁹ Similar to African populations, Australians also need to adapt to more sustainable methods of food production and management in order to mitigate the harmful effects on their population.

Conflict minerals in Africa and Australia: Mines of injustice

Beyond environmental issues, Africa faces challenges of social injustice, one of them being in the form of conflict minerals. These are minerals, such as gold, diamond, and coltan that are extracted in inhumane conditions, by slave or child labor, for example. Many modern electronic devices contain high-performance metals, such as tantalum, refined from coltan ore. A study on global supply chains of coltan conducted by Moran et al. found that, in the year 2000, the price of the mineral increased significantly.³⁰ Capitalizing on easily minable surface deposits, people of the Democratic Republic of the Congo (DRC) began extracting coltan to sell.³⁰ Over the years, the region has seen significant conflicts and violations of human rights perpetrated by violent groups funded, at least in part, by forced labor and the conflict minerals market, as pointed out by Ayres in

2012.⁵ Halting the production and sale of these minerals from the DRC will not remedy the underlying reasons for conflict, but will deal a financial blow to the perpetrators. Although Australians may seem far removed from this conflict, they have an effect on the industry as both consumers and producers. Between 2000 and 2008, Australia’s share of coltan production dropped from 47% to 30% while the DRC’s rose from 12.5% to 21%, marking a supply chain shift toward social injustice, as indicated by Smith.³¹ Manufacturers, although aware of conditions surrounding the mining of minerals like coltan, continued to source the product from where it was cheapest, foregoing traceable and accountable routes.⁵ Moreover, the ignorance of consumers funds atrocities like this because they are unaware of the repercussions in other communities that are aligned with the materials in their phone. In an article for Human Rights Watch, Birgit Schwarz examines an additional environmental impact of conflict minerals, discussing the degradation of the water supply and ability to grow crops in a Malawian village because of mining.³² Through the development of the African educational village, we hope to teach people more about the sources of their phone materials, as well as the impacts of climate change on regions that do not have the technology required to combat its effects.

Project approach and outcomes

The overall goal of this project was to design an effective exhibit in the African cultural village at CERES that educates and inspires people to take action against environmental and social injustice. Our team researched the literature and collected data from surveys to determine Australian awareness and concern about environmental issues within Australia and Africa. We also conducted roundtable discussions with African immigrants to gather personal stories and perspectives of the impacts of conflict mineral mining and climate change on food and water security. With

these data and the literature review discussed previously, the team designed the African village exhibit and developed several activities related to water, food, and conflict minerals. Once the designs were developed into prototypes, we tested the prototype activities and signage, and gathered feedback for improvements that could be made in future iterations. As this project completed only a portion of the CERES Cultural Villages Master Plan, this team set forth further recommendations and guidelines for future development and implementation of the African village. We identified five objectives to accomplish this goal, which will be elaborated upon in this section, and created a simplified visual representation of these objectives (Figure 7).

Objective 1: Measure Australian awareness and knowledge of environmental and social justice issues occurring in Australia and Africa.

In order to learn about Australians’ awareness of these specific environmental issues affecting Australia and Africa, the team developed, piloted, and administered a survey to assess specific knowledge regarding the causes and effects of climate change and mining on the environment and people.

Developing and piloting the survey instrument

Our initial survey contained 29 questions, with the first four asking demographic questions, such as gender, age, and if they have ever lived in another country. The second section, questions 5-16 asked about awareness of environmental issues occurring in Australia, including general climate change issues and

how climate change is affecting water, food supplies, and farming, as well as any issues with mining. These questions were all phrased with a standard “Are you aware of any issues (of a specific topic) that can be attributed to climate change?” followed by “If yes, what issues?” to prompt specific responses. The final two questions in this section ask “Have you taken any action against any of these issues?” followed by “If yes, what actions have you taken?” These questions then repeated to assess specific knowledge regarding Africa.

This pilot survey contained open-ended forms of questions related to climate change, water and food security, and conflict mineral mining and was initially distributed to nine Worcester Polytechnic Institute (WPI) students. During pilot testing, we were given feedback that the phrasing of these questions, using “Are you aware of...” would imply the existence of issues and compel people to make up issues on the spot, rather than assessing their actual knowledge, and that the format of the survey was repetitive. In the final survey, we restructured the survey to ask one question about Australia, followed by one question about Africa, re-phrased as “Can you think of...” to result in a more accurate representation of the Melbourne population’s knowledge. With this rewording, people were more apt to respond “no,” rather than making up issues that they were not knowledgeable about. This pilot survey contained open-ended forms of questions related to

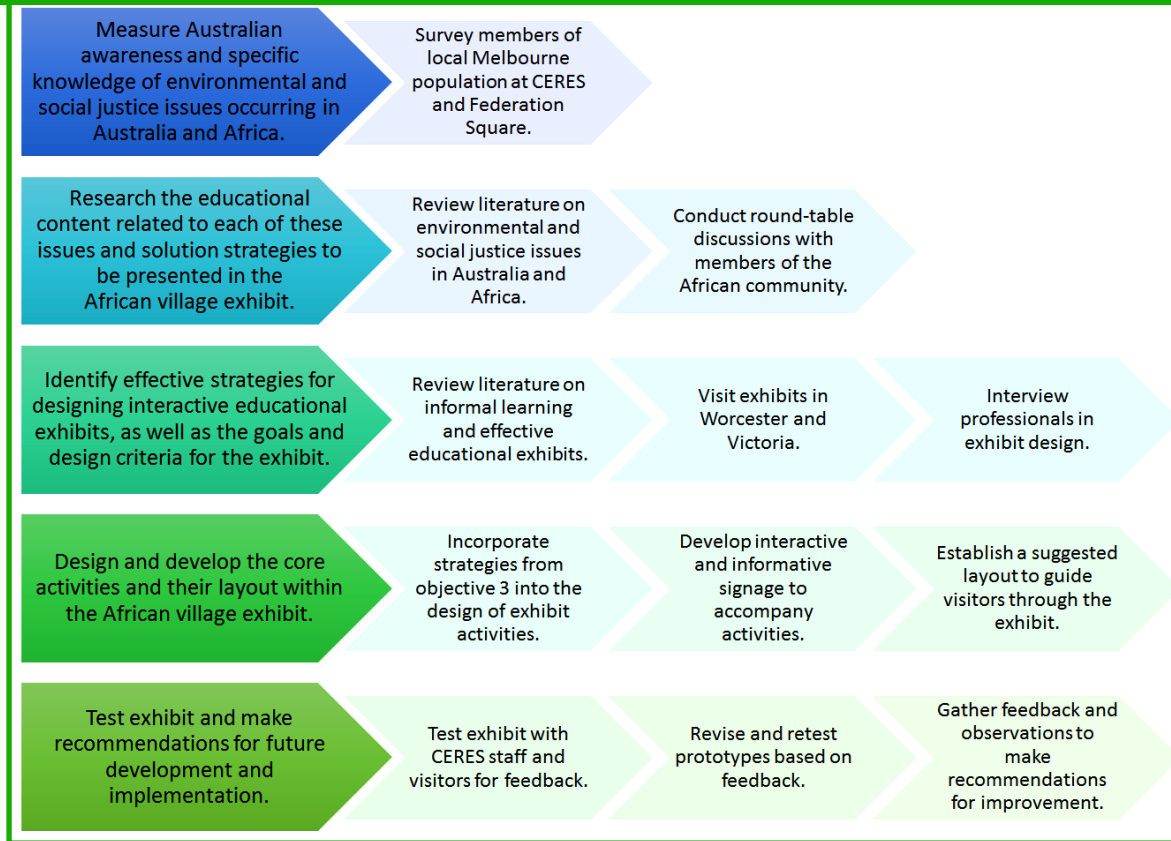


Figure 7. Schematic of project goals, objectives, and methods.

climate change, water and food security, and conflict mineral mining was initially distributed to nine Worcester Polytechnic Institute (WPI) students, refined as described, and then pilot tested again with 8 CERES visitors. These pilots were used to refine questions and ensure readability and comprehensibility of the phrasing and format.

The final survey contained 19 questions, both closed and open-ended, that were administered face-to-face with participants. In the final survey version, the first three questions were demographic questions, asking the participant for their age, whether they have ever spent six or more consecutive months in a coun-

try other than Australia, and if yes, where. This question was to establish whether or not they have acquired outside perspectives or perspectives relevant to Africa. Compared to the pilot survey, the question regarding gender was removed, as the team did not think it was relevant to assessing the knowledge of the population. Questions four through eight asked about the visitor’s beliefs in climate change, and its attributions to environmental issues, then expanded to the general causes and effects of climate change in Australia and Africa. The question “Do you believe in climate change?” was added between the pilot test with CERES visitors and the actual administration of the survey, as a few pilot participants did not believe in climate change and then did not believe that any of the environmental issues we were asking about could be attributed to climate change. In the final survey,

if the person responded “no” to this question, the interviewer did not ask the next two questions related to climate change. The third set of questions assessed participant’s knowledge of issues with water, food, and mining in each area, asking participants to list specific issues that they have either experienced or are aware of, as well as any actions that they have taken to combat climate change or environmental issues. The final section of the survey focused in on the issue of conflict minerals, specifically asking visitors of their knowledge of the minerals in mobile phones and the implications that these minerals have on the people and environment in the places they are mined.

The phrasing of the questions was formulated to target specific knowledge on topics of interest rather than simply measuring awareness of these issues. A full set of the questions used to survey is available in Supplementary Materials C: Survey Questions.

Participants and administering the survey

After the survey was developed, we surveyed 104 members of the Melbourne population at two locations over two days. 52 people were CERES visitors and 52 people were visitors at Federation Square. In recruiting our participants, we only selected adults over the age of 18 for questioning. The average age of participants was 39. When surveying at CERES, we identified the main entrance and the organic market to be appropriate locations that were well-suited to surveying in terms of background noise, volume of foot traffic, and so forth, which allowed surveyors to approach nearly all passersby at both locations. At Federation Square, surveys were conducted at the entrance to and on the front steps. We read to the selected adults a preamble that introduced the goals and nature of our project, informed them that their participation was entirely voluntary, and that their answers would remain anonymous. Surveys lasted for approximately three minutes each. The participants were personally interviewed so that we could ask open-ended questions without influencing the participant's responses. Questions and responses were delivered orally and recorded in

writing by the interviewer, as the interviewer carried a sheet with dedicated spaces for responses. Some of the questions allowed only “yes” or “no” selection, while others had space to write any answers given by participants. We were more successful with survey responses in the CERES market and on the front steps of Federation Square, where visitors were likely to sit, compared to the main entrance of CERES or the entrance to Federation Square, where people were walking through. The answers were also later coded into more standardized responses, allowing us to compare the response rate between similar question, such as the ones asking about water and food security in Australia and Africa.

Coding and analyzing the survey results

Following the collection of all data, answers were coded based on common responses. For example, answers relating to issues with water such as “lack of,” “shortage,” or “drought” were all classified as “drought or shortage.” This method allowed us to

reasonably condense the number of response categories. Results for the most common responses on each topic are presented below.

Survey results regarding effects of climate change

Of people surveyed, 96% believed in climate change (Figure 8). When asked to identify factors that caused climate change, the most popular responses were “emissions” and “human-general” with 49% and 25%, respectively. Of those who answered “yes,” 100% believed climate change contributed to environmental issues.

Although nearly all respondents believed climate change exists and has impacts on environmental issues, their knowledge did not extend much further than this; over a quarter of respondents could not supply specific details about the effects of climate change in their own country, and nearly half failed to do so regarding the continent of Africa (Figure 9). When asked to identify a negative consequence

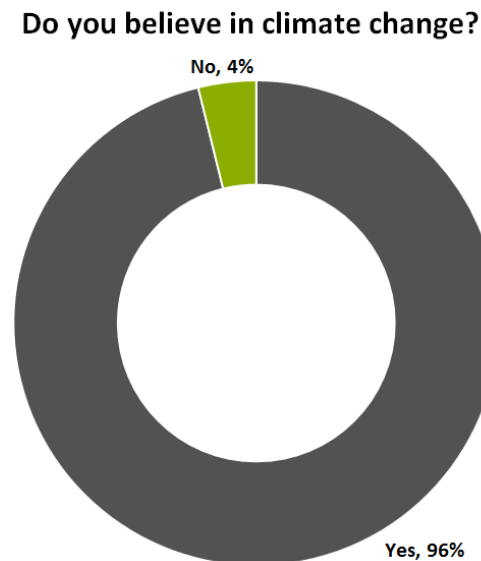


Figure 8. Climate change beliefs of respondents.

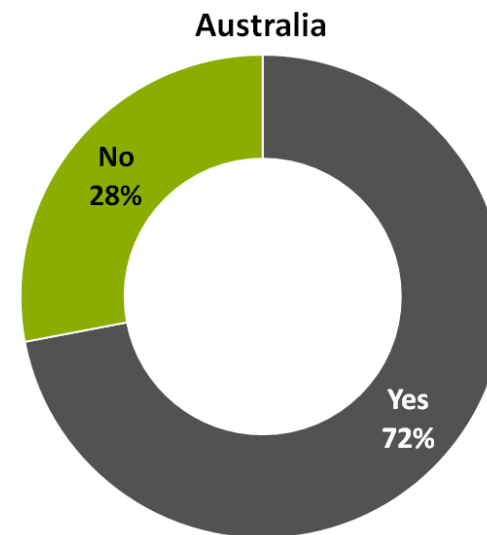
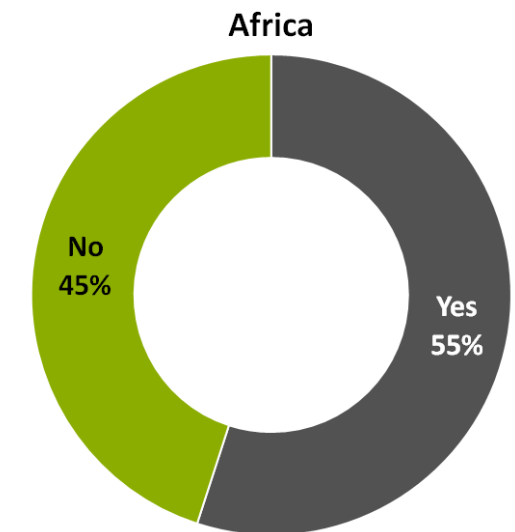


Figure 9. Percentages of respondents able to identify specific effects of climate change in Australia and Africa, respectively.



related to the effects of climate change in each region, the most common response for Australia was “weather changes,” and the most common response for Africa was “water security.” This emphasizes the uneven resource distribution between Australia and Africa, as Australia is a drier region than Africa, but access to water is not as limited.

Survey results regarding water issues

When asked about water issues in Australia and Africa, the most common response for each region was “drought or shortage,” with fifty-one percent and forty-nine percent of respondents believing this was an issue in Australia and Africa, respectively. Only fourteen and seventeen percent of respondents were unable to state any issues related to water in Australia and Africa, respectively. These data suggested that respondents were concerned with drought and water shortages, and recognized that this was an issue in both Australia and Africa. The similarities and differences in water related issues between regions (Figure 10) were drawn upon during exhibit design to make comparisons between the two regions, especially in regards to uneven resource distribution and coping methods.

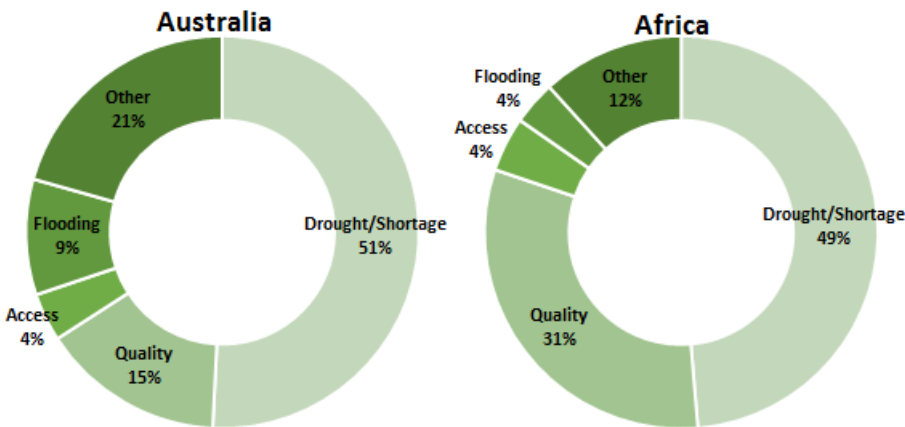


Figure 10. Water issues in Australia and Africa.

Survey results regarding farming and food supply

When asked about farming and food supply issues in Australia and Africa, one third of people believed that “environmental/climate” effects on farmers were the largest issue. Only nine and seven percent of people believed “quantity” of food was an issue with farming or food supply for Australia and Africa, respectively (Figure 11). Contrasting these two results revealed that there was not much depth to people’s understanding of the effects of climate change on food security. While respondents realized that climate change has negative impacts on farmers and food supply, they were largely unable to respond with specific examples of these issues. However, our survey results did indicate that people believe Australia and Africa face similar issues, which was used to draw comparisons during exhibit design.

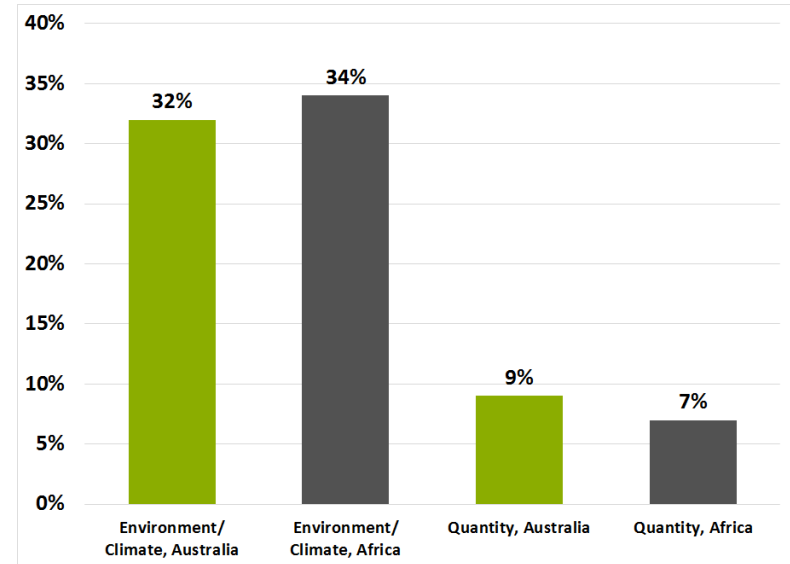


Figure 11. Issues with farming and food supply in Australia and Africa.

Survey results regarding mining

When asked about effects of mining on the people or environment in each region, eighty-nine percent of respondents gave the answer “damaging the environment” in Australia and forty-one percent gave “exploiting locals and workers” in Africa, making these the most common responses for each region. Eighteen percent of respondents failed to identify any issues with mining in Australia and thirty-seven percent failed to list any issues in Africa. Based on these results, we concluded that the people we

surveyed were well-informed about mining issues in their own country, but significantly less informed about mining issues elsewhere. We attributed this lack of knowledge to the difference in mining effects in each region, as mining in Australia hurts the environment, but mining in Africa more heavily affects people themselves. People in Australia may consider themselves removed from the social aspect of this issue. As coltan is one of the minerals of concern to us and is heavily involved in the production of electronic devices such as mobile phones, we were interested in understanding if people were aware of these social justice issues. We asked respondents to list any features or characteristics that they considered when purchasing a mobile phone. Only three percent of respondents expressed that they considered environmental concerns when purchasing, and none considered social justice concerns, making it clear that most people are unaware and do not consider how the minerals used to make their phones are obtained (Figure 12).

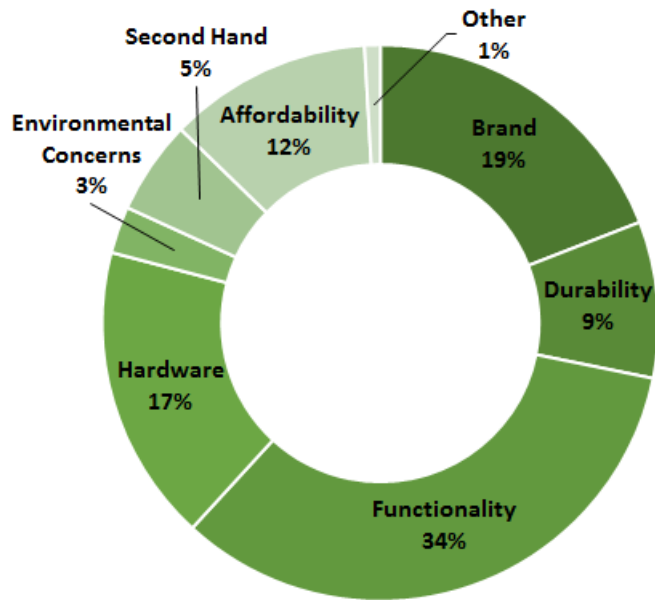


Figure 12. Features considered by Melbourne population when purchasing a new mobile phone.

Objective 2: Research the educational content related to each of these issues and solution strategies to be presented in the African village exhibit.

In order to familiarize ourselves with the four issues and their implications in both Australia and Africa, the team conducted extensive background research and roundtable discussions with native Africans now living in the Melbourne area. The survey results revealed insight not only into topics to be researched further, but also into how well aware of these topics Melbournians were. Once the pertinent issues were known, the team members conducted research to prepare for discussions with African immigrants about these issues. Through these

discussions, the team was able to get personal stories and perspectives on the issues of climate change, water security, food security, and conflict mineral mining in Africa.

Gathering personal stories through roundtable discussions

Our liaison at CERES arranged four separate discussions to be held over the first three weeks of our project work. The number of participants in each meeting varied from one to eight people. All four members of the team attended the first two discussions, while only two members attended the second two discussions because there were fewer participants. The first and fourth discussions occurred at the University of Victoria Library, the second at an Ethiopian cafe in the Footscray Suburb of Melbourne, and the third at CERES itself. Participation in these discussions was entirely voluntary and participants had the right to review any material or quotations published in this report. During the discussions, one team member acted as the discussion leader, while the other(s) took notes on the conversations and had secondary participation. If circumstances allowed and permission was granted, audio of the interviews were recorded for later reference and analysis, as was done in the first two discussions. Interviewees were prompted with pre-developed questions, such as if they could think of any direct effects of climate change that they observed in Africa, or asking how they acquired water and food in their communities. These questions, regarding their personal observations on the four issues and their day-to-day lives in their home countries, can be found in Supplemental Materials E: Pre-developed Questions for Roundtable Discussions. Once in-depth conversations began, interviewers based follow-up questions on current discussion topics to retrieve personal anecdotes and clarify cultural differences. Although each discussion was led by one team member, each member present

participated in conversational aspects of the discussion. Notes on these discussions can be found in Supplemental Materials F: Notes from Roundtable Discussions.

Conversations in the first and fourth discussions revolved heavily around the issue of water security, where we were able to get personal experiences about how the participants acquired their drinking water within their cities and villages. The participants in the first discussion were from Sudan and Ethiopia, but had traveled to other countries within Africa on their journeys to Australia as children or teenagers. These students shared experiences that they remembered from their childhood, that they heard from relatives still in Africa, and that they observed when they visited in more recent years. Many of them noted that they remember parents or grandparents travelling to the river and carrying water back to their communities in large containers, or having hand-pump wells in their villages. However, since many of these participants were living in cities during their childhood, they described having water imported to them in small, prepackaged plastic bags that they had to buy from the grocery store. In a similar manner, the participants in the fourth meeting also discussed how water security was a critical issue in their villages. These participants spoke of how water was imported into their refugee camps in large containers, and how people needed to go to a container in the center of the village everyday to get their daily supply. Incorporating these experiences into our exhibit design, we highlighted the need to travel to get water and to carry it back to communities as part of the educational content to be included in the village, emphasizing the great lengths that some people must go to for this basic need.

The participants in the fourth discussion also talked about their issues with food security in the refugee camps and in the villages that they lived in beforehand. One participant was a refugee with his family, and spoke of how there was never lunch served at the school he walked an hour to and from every day. He also said that some days there was no

food to go home to, so his family would go without dinner as well. The other member of this discussion worked as the head chef for the U.N. who worked in a refugee camp in Kenya. He mentioned how difficult it could be at times to feed over a hundred people each day with meager supplies, referring specifically to a time where a flood prevented any food from being brought into the camp, and how proud he was to have found a way to provide for the camp. Knowing that he was better off than many others, he would give away his food chip, that was given to him as a reward for his work, to those who needed additional food more.

Also related to food security, the two participants in the second discussion were both from Ethiopia, having immigrated to Australia within the last five years. This conversation revolved heavily around their experiences specific to Ethiopia, including the increasing temperatures and decreasing agricultural production that they are facing. These participants were very thorough in describing how the changing climate has shortened their rain-season to three months and reduced the agricultural production of their four main staple crops, which they identified as teff, maize, barley, and sorghum. One subject in particular that came up in discussion was the Grand Ethiopian Renaissance Dam (GERD), which is currently being built to help Ethiopia's water and food security, as well as to reduce deforestation and increase the economy in this country.

The GERD was proposed by the Ethiopian Government in 2009 and swiftly moved into the construction phase in 2011 (Figure 13). This group described the heavy reliance that Ethiopians have on wood for heating, cooking, and building homes, emphasizing the nega-

tive impacts that this reliance is having on the forests in the region. Since much of Ethiopia's population relies on wood burning instead of electricity for everyday life, the production of power from GERD could replace this energy source and regional deforestation would decrease greatly, as discussed by a researcher at Virginia Tech's Center for Leadership in Global Sustainability (CLiGS).³³ The Ethiopian government has stated that the reservoir and dam will help mitigate flooding and drought in downstream regions, making water supply more predictable and flood seasons safer. Veilleux, who conducted a case study on water conflict surrounding the dam, found that with retraining from seasonal farming techniques to more reliable methods, farmers could use a more predictable water supply to grow a greater quantity and more diverse set of crops, all increasing food security of the region.³⁴ We incorporated information about this dam into our exhibit design, as we wanted to present a development designed to combat water and food scarcity in Africa, and the participants were especially passionate and hopeful about this development.

When asked about the topic of climate change,

participants in the first and second meetings discussed that while it is a prevalent topic to many living in Australia, the knowledge of the general public in Africa is very limited. Even though some people in Africa are aware of climate change, there has been little action taken against it because there are more immediate worries and needs, such as obtaining water and food, and being protected from political conflicts.

Our third discussion was very different from the rest, involving a man from Kenya. This meeting focused more on the design of the exhibit than the issues to be presented in the exhibit. The team was able to walk him through the African village at CERES as it initially stood, and he contributed ideas of culturally relevant displays that should be included in the exhibit, such as the addition of the "big five" animals, and emphasized the need for color to be added throughout the village. He suggested researching traditional African painting styles from different regions, as well as adding a harder red clay for the walking area, as that is more representative of the ground color in many regions of Africa.

The one topic of our project that was not touched upon during our discussions was the subject of conflict minerals; the reason for this is because it is a very region specific issue in Africa and no participants had lived in those areas. Even without information on minerals, the discussions were still fundamental in helping us build an idea of what life is like in specific African communities. By synthesizing the information and notes that we took, we were able to gather our ideas for the next sequence of our project which revolved around how best to convey all the concepts mentioned above.



Figure 13. Grand Ethiopian Renaissance Dam, 5 January 2016.³⁵

Objective 3: Identify effective strategies for designing interactive educational exhibits, as well as the educational goals and design criteria for the exhibit.

In order to identify effective strategies, the team reviewed literature on informal education, design methods, and criteria for effective exhibit design. In addition, we visited exhibits in both Worcester and Victoria. When visiting these exhibits, we focused on the different layouts and signage used to guide the visitor, as well as the various displays and interactive exhibits implemented to educate the visitors while keeping them engaged and immersed in the experience.

Taking a hands-on approach to education

Once we identified the educational concepts that we wanted to include in the village, revolving around the issues of climate change, water and food security, conflict minerals, and potential solution strategies that we had researched and discussed, we needed to determine which methods of presentation are the most effective in engaging, informing, and motivating visitors. Numerous organizations around the world, including CERES, often utilize informal and

interactive educational approaches within exhibits to engage their audiences and increase levels of knowledge about environmental issues and methods of sustainability. Such organizations aim to make a lasting impact that will encourage visitors to change their own behaviors, as well as to educate and inspire others.

Designing an effective educational exhibit: Principles of design

As researched by Schwan, Grajal, and Lewalter, educational exhibits and museums are powerful learning settings because of their ability to promote a variety of concepts to a large number of visitors and to encourage public understanding and engagement.³⁶ Exhibit professionals often consider several design strategies and criteria to ensure that the exhibit is effectively educational and meaningful. Figure 14 synthesizes some of these criteria found in the literature on successful exhibit design.³⁷⁻³⁹

The first criterion relates to the aesthetics of the display, as a pleasing structure and design initially attracts the visitors to the exhibits and guides them into it. This could be accomplished through using attractive and thematic colors throughout the exhibit, such as the signs that we painted for the African village. In a similar manner, the second criterion focuses on having a clear, direct pathway to easily guide the visitors through the exhibit. The National

Research Council (NRC) discusses the importance that the exhibit space and layout has to a visitor, stating that “the environment--both large-scale characteristics of the institution and small-scale features of exhibits and programs--helps to guide or mediate the visitor’s attitudes or perspectives, their relationship with the content and the institution.”³⁹ Furthermore, the NRC explains that in addition to laying out the exhibits and guiding the visitors through, physical or conceptual maps “contribute to a learner’s comfort” and allow them to “make more informed choices about what to attend to.”³⁹

The third criterion focuses on the informational aspect of the display; content must stimulate, interest, and engage a variety of visitors. This could be accomplished through an interactive experience, accompanying interpretive materials or captivating visuals, such as labels, signs, and audio-guides contribute significantly to a visitor’s understanding and interaction.³⁷ Expanding on this idea, the exhibit must appeal to the interests, knowledge, and experiences of all demographics of visitors, because visitors may have different motivations for attending the exhibit.⁴⁰ Visitors with varying interests or motivations might desire different types of interactives or displays; whereas children may prefer interactive stations, those interested in the purely informational aspects might prefer static displays or heavy signage. In a study on interactive exhibits with school children, Rennie and McLafferty found that students were “more likely to learn the scientific ideas and principles that the curators intended if they were engaged in investigatory rather than fantasy forms of play.”³⁹ This criterion also allows for recognition of the valuable role that parents have in their children’s learning, especially in informal settings. The NRC notes that parent participation “improves the quality of child engagement with exhibits,” as they tend to “focus their explanations on the functions and mechanics of the exhibit, connecting the exhibit with real phenomena, and making connections for formal science ideas.”³⁹



Visually Appealing



Clearly Defined Layout



Engage a Variety of Visitors

Figure 14: Criteria for effective exhibit design.

Broaden and build: Using emotions to inspire action

In order to motivate visitors to act on the issues presented, it is necessary to evoke emotions and establish personal connections between the visitors at CERES and the issues at hand, emphasizing ways in which climate change is affecting them personally or how their actions are affecting people around the world. The NRC notes that exhibits are “often designed to elicit participant’s emotions or sensory responses” in order to make the experience impactful, relatable, or memorable.³⁹ This approach aligns with Hidi and Renninger’s proposal that development of a substantial personal interest is sparked by personal relevance to the issues at hand, meaningful tasks, or the presentation of surprising information.⁹ In a similar manner, Barbara McCombs argues that learners are motivated to learn and act on “tasks that they perceive as personally meaningful, or relevant in some way,” which can be accomplished through the creation of activities that help the visitor feel “competent, in control, and connected to others.”¹¹ Fredrickson’s broaden-and-build theory states that “distinct positive emotions widen the array of thoughts and actions that come to mind.”¹⁰ Fredrickson claims that interest, classified as a positive emotion, “creates the urge to explore, take in new information and experiences, and expand the self in the process.”¹⁰ Furthermore, “the exploration prompted by the positive emotion of interest creates knowledge and intellectual complexity, and the savouring prompted by contentment produces self-insight and alters world views.”¹⁰ David Carter applies this theory and Frederickson and Johnson’s study on own-race bias to suggest that “this heightened awareness of others may influence people’s values, attitudes, and actions.”⁴¹

Identifying design ideas by visiting successful exhibits

In addition to the literature on informal learning and effective exhibit design, our team reviewed designs and displays that have demonstrated success in exhibits in both Worcester, Massachusetts, and Victoria, including the Worcester Ecotarium, the Werribee Zoo, and the Melbourne Zoo. Prior to leaving Worcester, we corresponded with the Ecotarium’s Exhibit Manager, who gave us a better understanding of the implementation and evaluation of interactive exhibits.

This included sending us files on interactive exhibit design and the stages that the Ecotarium goes through in designing and implementing prototypes, a process known as “rapid prototyping” involving evaluation and revision that we used to test our own exhibits. Through our sponsor, we reached out to an exhibit-design professional, Yvette Finlay, at the Werribee Zoo who gave us a tour through portions of the zoo relevant to our project, such as the African villages, and answered our questions about exhibit design and the types of signage that she found successful at Werribee. Yvette suggested we focus our attention on visual aspects of the display to make the visitor feel immersed in the exhibits, and to reduce the use of outside material to keep the observer absorbed in the scene. As suggested, we implemented design ideas that used recycled material and a rustic appeal to present the layout of our exhibit, as had been done at Werribee (Figure 15). Further notes from our conversation and interaction with elements of the zoo are presented in Supplemental Materials H: Notes from Discussion with Exhibit-Design Professional. At the Melbourne Zoo, we discussed the various aspects and efficacy of the gorilla campaign with a member of the educational department, who attributed its success in getting people to recycle mobile phones to the variety of resources available to visitors interested in helping the gorillas, including the numerous pamphlets, different signs, website, and boxes where people could recycle their mobile phones. We took the information gathered from these experiences and used it to define the design specifications for our exhibit.

Once methods for effective exhibit design had been established, we determined the design specifications and criteria for the exhibit. Discussion with our sponsor, time and budgetary constraints, and availability of resources helped to build these guidelines for our design.



Figure 15. Example of signage from Werribee Zoo.

The exhibit had to be created using materials that do not require a lot of maintenance and can withstand varying weather conditions, because it is an outdoor exhibit. The materials used for the activities had to be of low cost, as CERES had no budget allotted for the project and limited supplies on hand. Similarly, since the process required revision based on feedback, the displays for the prototype had to be simple to make and easy to replace as the project was revised. Finally, the materials had to be relatively difficult to break or remove from the exhibit, as the area will not be staffed and has had vandalism issues in the past.

In order to satisfy the wide and changing demographic that attends CERES, as defined by our third design principle, we focused on making the exhibit “family-friendly” and therefore targeted children and accompanying parents or guardians. Display elements required a minimum comprehension age, around the primary school level, yet contained components complex enough to engage an adult audience. This required presentation of key concepts in multiple forms, interactive elements for children, and more in-depth displays and supplementary text components for adults.

Objective 4: Design and develop the core activities and their layout within the African Village exhibit.

With the design goals, objectives, and specifications defined above in mind, we synthesized the information collected and opinions from our background research, surveys with the Australian public, and roundtable discussions with Africans to determine the central messages connected to water and food security, conflict minerals, and climate change to be presented through our exhibit. We designed a series of activities centered around these

issues, and created prototypes of these activities to test in the African village.

In our prototypes, we wanted to present how people in Africa access and ration water; compare how much water is used by people in Australia to the amount in Africa; how climate change is affecting agricultural production in countries such as Ethiopia; how much food is wasted by Australians each year; and how conflict mineral mining is affecting people and the environment. Furthermore, we wanted to present simple changes in behavior that Australians can make in order to help mitigate some of these effects, such as conserving water, reducing food waste, and recycling mobile phones. Incorporating our research on effective exhibit design strategies, we created several activities and signs to convey these central messages and to encourage change in everyday behaviors.

In order to properly develop and improve our exhibit, we adopted a method known as “rapid-prototyping,” a process that involves analyzing, modifying, and retesting based on user feedback. The team developed the prototypes with materials that were found right at CERES and therefore did not require a budget, including cardboard, paper, plywood, rocks, and paint. While most of the prototypes were developed using cardboard and paper, to be easily revised and replaced, the final exhibits will be created in wood or on tin lids so that they would not get ruined by the rain. As advised by the expert at the Werribee Zoo, we used cheap and rustic resources such as cardboard, scrap wood and recycled materials; not only do these materials fit into our rapid-prototyping criteria, they can also emulate typical elements available in a rural African area that relies heavily on the use of recycled/rustic items. This approach allows the visitors to have a more immersive experience within the African Cultural Village. In accordance with the design criteria, most of the exhibits were tied, glued, or cemented to the station that it belonged at to prevent visitors from removing pieces from the exhibit.

Developing initial prototype interactives and signage

To satisfy the third criterion of effective exhibit design, our group created several activities related to water, food, and conflict minerals which were engaging for children, with nearby interactive signage providing more information on each of these issues. In developing the signage for the exhibit, we tried to promote the principles and underlying concepts surrounding the environmental issues presented rather than accumulated facts, a strategy emphasized by Warburton to reinforce key concepts and their environmental and social implications.³⁵ As discussed above, we wanted the content presented on the signs and conveyed through the activities to be informative of the issues occurring in both Australia and Africa, as well as to provide possible changes that visitors may make in their own behavior to make a difference. In doing so, the children at the exhibit can interact with the activities and the parents can read the information and teach their children about the issues occurring in Australia and Africa, as well as encourage easy changes that they can make in their own lives to help combat these issues. These stations were created using cheap and recycled material, engaging and informative to the visitors, and were difficult to vandalize or remove.

Activities 1-4: Presenting water scarcity

In order to introduce the problems related to water scarcity, we integrated four main activities using the well as the main attention draw. We wanted to emphasize how little water some people in Africa have access to use and to compare this to the amount of water that Australians use each day. We used information from the roundtable discussions and the educational programs at CERES to present that some people in Africa need to travel up to an hour each day to collect water for themselves and their communities.

Further, as gathered from our roundtable discussions, we introduced the need for some people in Africa to ration their water usage, as water gathered in a community container is often limited. We hoped these activities and signs would evoke emotions in the visitors by encouraging them to imagine living without a reliable water source or having to ration water, and motivate them to be more conservative about their usage.



Figures 17 and 18. Signage accompanying well activity.

Activity 1: Well activity

In the first activity, the participant lifted two buckets of differing sizes and weights from the well in order to compare the water usage between Africa and Australia each day. The buckets were filled with concrete to mimic the weight of water, and fastened to the well so they could not be removed from the exhibit (Figure 16). These buckets represent the 17:1 ratio between water usage by people in Australia and people in Africa, as explained on accompanying signage (Figures 17 and 18). Through this activity, we wanted to convey how much more water people in Australia use each day (340 liters), and how little



Figure 16. Activity 1: Well activity.

some people in Africa are able to use (20 liters).^{42,43} We thought using a physical representation of this ratio would be the most effective in helping people understand the significant difference between these amounts of water usage, especially when it is applied on such a large scale.

Activity 2: Bead activity

Building on this first activity, we created a second activity that asked visitors to ration their daily water amount between tasks such as taking a shower, washing dishes, drinking and cooking, etc. Beads were provided on a string so that visitors could “ration” how much water they were using for each task, in order to demonstrate how much more conservative some Africans have to be with their water usage compared to Australians (Figure 19). In this activity, “Australia” had 68 beads representing the 340 liters of water that the average person in Australia uses everyday, while “Africa” only had four beads to



Figure 19. Activity 2: Bead activity.

represent the 20 liters of water that some people in Africa have.^{42,43} Accompanying signage describes that some people in Africa may have to walk up to an hour to get water each day to carry back to their community, and asks visitors to imagine being limited to the amount of water that they can carry on their heads, a difficult scenario that many people in Africa face every day. It also asks if they could imagine living with 3% of their current water usage, again to emphasize that some people in Africa do not have enough water to complete basic everyday tasks that

some people may take for granted. In this activity, we hoped to evoke emotions in some of the visitors, and establish personal connections between the people in Australia and people experiencing these scarcity issues in Africa.

Activity 3: “What can you do?”

Additionally, an interactive sign (Activity 3) posted nearby the well and bead activities provides simple changes that visitors can make in their own behaviors to help conserve water. In this activity, the visitor would spin up the circles (Figure 20) to learn more information about how each of these seemingly small changes make a large difference in the amount of water a person may use in a day. These changes include

shortening showers, turning the tap off when washing hands or brushing teeth, not running washing machines or dishwashers half-full, and installing a rainwater tank to collect and reuse rainwater. We posted this activity near powerful representations (such as the beads activity) in order to motivate people to act, providing some positive changes that they can make to help conserve water or be more aware of their water usage.



Figure 20. Activity 3: "What can you do?"

Activity 4: Dam Activity

Also relating to water and food scarcity, and inspired by conversation with the African immigrants, we developed a station that provided information on the Grand Ethiopian Renaissance Dam, a promising

development on the Nile River that will benefit Ethiopians economically and in terms of water and food security. For the interactive portion of this station, we built a dam-table using layered wood with different cut-outs. The visitor would pour water from the holding tank at the beginning of the river and, as it filled and flowed through the river, move different pieces of wood representing dams to provide water to the farms that surrounded the branches and



Figure 21. Activity 4: Dam activity.



Figure 22. Sign providing information about the GERD.

lakes (Figure 21). If the visitor put the dam in the first slot, the water would fill the irrigation channels and provide water to the first farm plantations. The overflow holes in the dam would ensure that the river would not flood the surrounding "villages," but rather flow through to the next village. Accompanying this exhibit, we created signage to provide information about the potential benefits of the dam to Ethiopians, including provision of hydroelectric power, more stable water and food supply, and a reduction in deforestation from wood-burning, and a map with its location along the Blue Nile River (Figure 22).

Activities 5 and 6: Presenting food scarcity and waste

When presenting issues of food security, we wanted to highlight the staple crops of Ethiopia, and the impacts that the changing climate and fluctuating rainfall seasons are having on agricultural production in this area, as gathered from our discussions and background research. We also wanted to encourage a change in Australian visitor behavior by pointing out how much food Australians waste each year.

Activity 5: Harvesting activity

In this activity, the visitor pretends to harvest poles representing a stalk of each of the crops from the ground and collect them in a nearby box, as if he or she were a farmer (Figure 23). This activity was largely inspired by a similar planting activity at the Werribee Zoo, with it adapted as a harvesting activity to present the issue of food scarcity and issues experienced by farmers. In addition, we wanted to emphasize food value and waste by describing how climate change is reducing crop production in countries such as Ethiopia, as described in our research and roundtable discussions, and then pointing out that Australians waste an average of four million tons of food each year.²⁹ We believed this comparison is especially powerful and makes visitors consider how much food they waste in their own lives. Accompanying signage on one side brought attention to the issue of food scarcity in Africa, largely due to fluctuating rain season. We hoped to elicit emotions and concern in visitors by sharing that children in Africa may not



Figure 23. Activity 5: Harvesting activity.



Figure 25. Activity 6: Staple crops of Ethiopia

have lunch all day at school, and may come home to find that there is no food for dinner either, an experience that was shared by a discussion participant. Lastly, we encouraged visitors to reduce their food waste and consider growing their food in a home or community garden, as we wanted to present simple things that visitors can do to help (Figure 24).

Activity 6: Staple crops of Ethiopia

In relation to the crop planting activity, we created an interactive sign to educate people about barley, sorghum, maize, and teff--the four staple crops in Ethiopia that were discussed in our second meeting (Figure 25). In this activity, the visitor could spin the outer circle of the sign to reveal one of the four crops and the importance of its production in Ethiopia, as well as see a picture of what it actually looks like when it is growing.



Figure 24. Food security facts

Activity 7: Presenting conflict mineral mining

Regarding conflict minerals, the team wanted to present how conflict mineral mining is negatively affecting both people and the environment in countries in Africa, and how Australians contribute to these violations by furthering the demand for items such as mobile phones. The seventh activity involved a sandbox and several flip-doors, where a child could dig for painted rocks representing gold, coltan, diamond, and coal in a sandbox (Figure 26). Upon finding the minerals, the parent or adult could lift a panel on the sign nearby to learn more about what each of them is used for and the issues surrounding conflict mineral mining (Figure 27).

The designs of the prototypes and accompanying signage can be found in Supplemental Materials I: Designs for Prototypes and Signage, with additional pictures of the prototypes and accompanying signage in Supplemental Materials J: Additional Pictures of Prototypes and Signage.



Figure 26. Sandbox for conflict minerals activity.

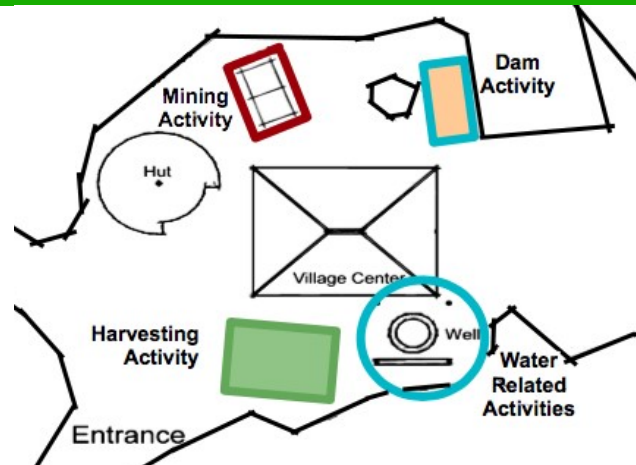


Figure 28. Model of the exhibit layout and prototypes.

Designing the layout of the exhibit

Once we determined the activities to be included in our village, we decided upon the desired layout of the exhibit and developed signage to clearly mark and navigate through the stations, a key strategy in designing an effective exhibit. As it initially stood, the village did not define any paths or specific layout to be taken; our group determined the placement of the stations within the exhibit so that people could move easily from one station to the next. Because the

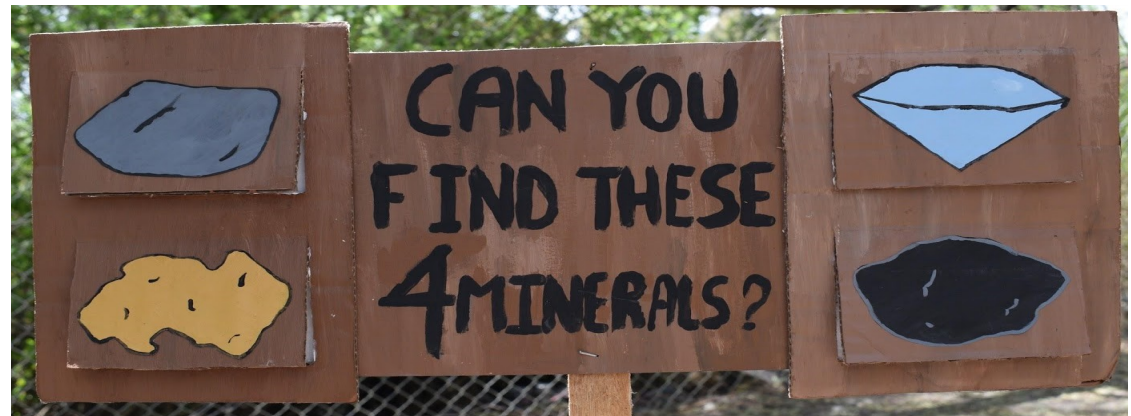


Figure 27. Sign with flip-doors for conflict minerals activity.

exhibit has two possible entrances, from the Aboriginal village or from the Indian village, stations were developed so that the order in which they are visited will not impact the experience of the visitor (Figure 28). In an attempt to invite people into the exhibit and immerse people in the African culture, we created a “Welcome to the African Village” sign that included a painted map of Africa and the “Big 5” animals (Figure 29).



Figure 29. “Welcome to the African Village” sign at the entrance to the African village.

Objective 5: Test exhibit and make recommendations for future development and implementation.

Once we designed and developed the initial prototype interactives and signage, the team tested the exhibit with project advisors, CERES staff, and CERES visitors.

Testing the prototype with visitors

Following the design and the development of the initial prototype of our exhibit components, we used formative evaluation techniques, as defined by Screven, to assess the graphics, labels, and interactives within our exhibit (Figure 30).⁴⁴ In accordance with this method of evaluation, the team made several small revisions to the signage after each of the first two iterations of testing. Initial testing was conducted with project advisors, CERES staff, and park visitors. Children were not solicited directly; instead, we approached their parents or guardians and asked them to give consent and supervise their children during the testing process. The most appropriate locations within the park to approach groups for prototype evaluation were the market and the playground area, since people tend to congregate in these areas.

On the first day of testing, the team guided the advisors and our sponsors at CERES through the exhibit, taking them through each station and explaining the key messages that we want each display to convey. They made some suggestions regarding repositioning some signs to help the flow of the exhibit, fixing some spelling mistakes, rephrasing the wording on some signs, and developing additional signage to make the activities more clear. For example, after testing the well activity (Activity 1) with our advisors and sponsors, they pointed out that while our intent was to show the ratio of water used, it was confusing and was

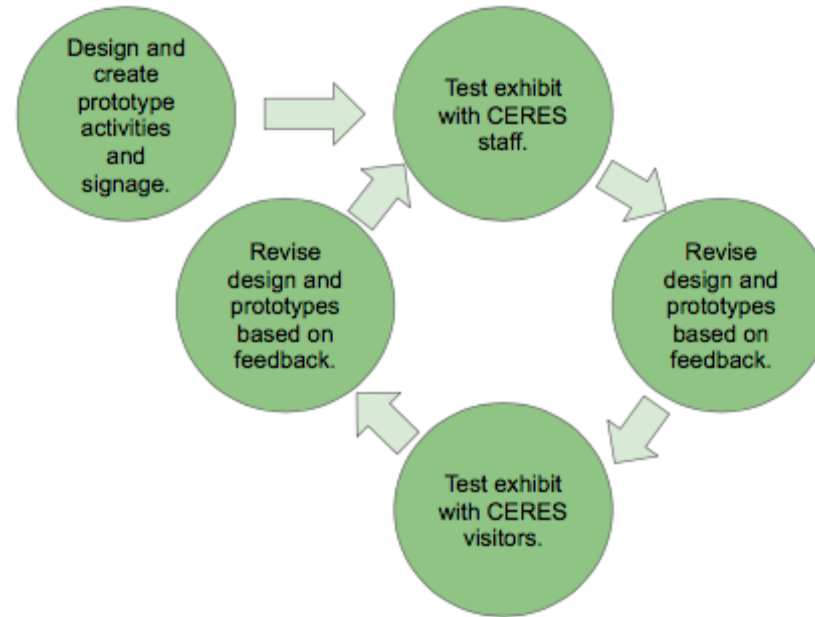


Figure 30. Rapid prototyping model of revising and retesting.

assumed to be the actual amounts of water used. To address this, we added a sign to explain this ratio and provided more information on water usage in each region. The team made these changes as suggested prior to the second iteration of testing, which involved CERES staff members and visitors who either walked into the village or were invited by one of the group members. In addition, our sponsor suggested playing culturally relevant music to invite the visitors into the African exhibit and help with cultural immersion, so we added this for the second and third days of testing.

On the second day, the team guided the visitors and staff through the exhibit, ready to answer any questions that they may have had or explain any activity as necessary. This approach allowed us to understand what transitional signage or additional explanations need to be included in future implementations of the exhibit. Participants suggested creating signage to clarify instructions for the activities, as some expressed hesitation in engaging in some activities. In

response, we added a sign on the box used to collect the “harvest” in the harvesting activity (Activity 5) to emphasize that the crops should be collected in the box at this station.

On the third day, the visitors went through the exhibit unguided while the team noted observations, but were still available for questions and clarification. The purpose of the unguided testing was to see the paths that the visitors naturally took through the village without our influence. During the second and third days of testing, the team took notes on the different levels of interaction at each station of the exhibit. The general engagement levels, ease of use, and emotional response when completing each activity were recorded for several of the participants. We also spent time noting the

fidelity of the designs. The team member that was observing used a standardized form to collect this information, which can be found in Supplemental Materials K: Standard Observation Sheet for Prototyping. In addition, the team asked participants a series of debriefing questions at the conclusion of their experience which were later used to gather a list of suggestions and recommendations.

Observations of visitors

When brought to the village, most of the visitors entered from the northwest, walking along the main path from the market or playground, but a few entered from the southeast facing the other villages. Visitors generally took the same pathway through the exhibit, circling from the harvesting activity to the conflict mineral activity around the village center. Most of the visitors stopped at each of the four main stations, interacting with each activity and reading most of the

signs. Children and parents alike enjoyed the interactivity of each station and activity, stopping at each for several minutes and engaging with most or all activities. Children seemed to show great interest in the more hands-on activities, specifically the mineral mining and the dam activities. At the mineral activity, children often stayed at the box until they found all of the rocks, with the parents flipping up each of the doors as the child found each type of mineral. Children seemed to get excited each time they found a new color rock. Similarly, children loved playing with the water in the dam activity, waiting as the river and irrigation channels filled up, and then watching the water flow out when the dam was removed. Parents showed more interest towards the activities containing more information, such as the well and beads activities, and the “What can you do?” sign. Parents often read the descriptions aloud while their children played with the corresponding activities, such as lifting the buckets from the well and sliding the beads back and forth.

Visitor feedback

Following completion of all of the activities, the team used semi-structured, face-to-face interviews to gather visitor feedback on the the exhibit, as well as any recommendations to be made to the activities. Through these evaluations, we sought feedback regarding the general success of the exhibit in conveying the educational concepts of each activity, as well as feedback on the formats, text, displays, and deliverance of key messages in the display. We also wanted to know how informative, fun, and engaging the activities were for a diverse set of people. Specific questions included were “Are there any improvements in general (format, text, display) or related to the activities that you would like to recommend?” and “Did you find the exhibits engaging and interactive?” In order to assess whether we conveyed the desired concepts or motivated a change in human behavior, we asked “What do you think are the key messages

presented in this exhibit?” and “Did the exhibit make you think about your beliefs or inspire you to make changes to your lifestyle in any way?” Additional debriefing questions can be found in Supplemental Materials L: Additional Debriefing Questions for Prototyping and were used to assess the efficacy of each interactive element presented in the exhibit.

All of the visitors who tested the exhibit found the activities and displays to be very engaging, and provided constructive feedback on areas for improvement. In our interviews, several parents mentioned that the water activities (well and beads activities) were the most “inspirational,” causing them to think more critically about their own lifestyles and water usage. For example, many reflected on the amount of laundry they do and the long showers that they often take, and were shocked by how many liters of water each task required. Several people mentioned wondering how they compared to the average person in Australia in terms of their water usage, while noting that they likely use more water than they think they do daily. They also expressed the power of directly comparing the different levels of water available for a person in each region. Many participants also discussed the conflict mineral mining activity as being another “inspirational” activity, either noting that they have more than the average number of mobile phones or making the connections between their electronic devices and the conflict and social justice issues contributed to by their demand.

When asked about the key takeaways or messages presented in the village, many people expressed that the overall exhibit emphasized how fortunate people in Australia are to have the resources that they do and the importance of valuing what we have, especially regarding water usage and participation in sustainable behaviors. In addition, people stated that it helped them to understand the livelihoods of some people in Africa and how their actions affect people and environments around the world. One woman in particular described how important she believed it to be that children begin understanding these issues and

cultural differences. Children often believe that everyone around the world has the same experiences that they have. The visitor expressed that the exhibits did a good job of comparing Australia and Africa, especially with the things that we take for granted, such as water and food security. Feedback and recommendations for the overall exhibit and individual activities have been developed in Table 1.

Visitor suggestions for improvement

In addition for the feedback that we gathered through our interviews, we asked visitors for suggestions related to the text, displays, format, or activities that we could improve to make the exhibit more successful and impactful. Since the exhibit is self-guided, open to the general public, and there will not be anyone there to answer questions or explain the reasoning behind each activity, visitors recommended the development of some transitional signage to establish connections throughout the stations. This could be accomplished by introducing the topics presented in a sign near the entrance, and displaying a map of the whole village with symbols for each station. Another recurring request throughout testing was the desire for more information about some of the issues in Africa, as well as a map with the countries of Africa labeled. For the crop harvesting activity, for example, people requested more information about food scarcity and Ethiopia specifically, as children may have questions and parents expressed interest in learning more. In addition, several participants expressed hesitation in engaging with the interactives, so additional or more clear and explicit instructions should be posted for each activity. Finally, many visitors suggested adding information of how the village is currently used with CERES excursion groups, as people were curious about the mud-brick hut and the village center. Specific responses to the prototype debriefing survey have been gathered in Supplemental Materials O: Responses to Prototyping Debriefing Questionnaire.

Table 1. Summary of feedback and recommendations by activity or sign.

Our recommendations

As time constraints did not allow the team to implement additional cycles of revision and retesting, we synthesized feedback and observations to create a list of recommendations for further improvement and implementation at CERES. Overall, we believe the exhibit satisfied the three criteria for effective design that we identified in our research: the exhibit attracted visitors, allowed visitors to walk through the exhibit in a suggested pathway, and each station was engaging and interactive.

We recommend adding additional signage at each station to provide more information and instructions throughout the exhibit. This could potentially be integrated into the CERES Chook application, so interested visitors could refer to the app for additional information. In terms of making the exhibits permanent and weather-proof, the signs and interactives should be made out of wood and recycled tin, with the information and illustrations painted on. In addition, red clay and elephant grass could be included in the village in order to further represent additional aspects of African villages, and provide a more culturally immersive experience for the visitor. Also related to this immersion aspect, we believe large cut-outs of the “big five” animals would be a thematic and culturally relevant addition to the village. Finally, we propose the partnership between CERES and Bead-WORKS, an organization that supports women in Kenya by selling handmade bead items, which could be presented in the African village with the beads activity and sold in the CERES gift shop.

Description	Overall Exhibit Display	Well Activity	“What can you do?”
Visitor Feedback	<ul style="list-style-type: none"> -Visitors found the activities very interactive and engaging. 	<ul style="list-style-type: none"> - Very popular exhibit, children loved trying to lift the heavy Australia bucket. - Children often attempted to pull the buckets out, the frame also was strained and wobbled. 	<ul style="list-style-type: none"> - Children enjoyed spinning the circles around while the parent read the information underneath.
Visitor Suggestions	<ul style="list-style-type: none"> - Parents and older children would like to have more information on Africa and specific issues, as well as more instructions for each activity. -People were very curious about the infrastructure and wanted more information about the mud hut and the village center structure. 	<ul style="list-style-type: none"> - People were unsure about what to do, since they had to look into the well to read the signs and see buckets. 	<ul style="list-style-type: none"> - Some people expressed interest in having more involved recommended changes.
Our Recommendations	<ul style="list-style-type: none"> - Make the final exhibits with painted wood or tin, and make those weather and child proof. - Create a large map of Africa with the countries labeled. - Acquire red clay, elephant grass, and other culturally immersive aspects to include in village. 	<ul style="list-style-type: none"> - Provide clear instructions by placing signs on the sides and making ropes more attractive and visible. -Strengthen the well’s frame. -Place wooden cut-outs of Africa and Australia on the rope ends of each respective bucket - Add eyehole screws with knots in the rope to limit its movement. 	<ul style="list-style-type: none"> - Change circles to raindrop shapes to be more relevant. -Develop tiers of action from simple lifestyle changes to larger scale projects.

Dam Activity	Conflict Mineral Activity	Beads Activity	Harvesting Activity
<ul style="list-style-type: none"> - Visitors found this very interactive and fun. - Children loved playing with the water and watching it fill up and flow out when a dam was removed. - Children tried to drink the water. 	<ul style="list-style-type: none"> - One of the most popular activities, as children loved playing in the sandbox and wanted to find all of the rocks. - Parents were able to flip up the signs as the children discovered them. 	<ul style="list-style-type: none"> - Parents loved how well it compared water usage in both regions. - Seemed to be the most “inspirational” activity, as parents mentioned that it got them to think more about their water usage. 	<ul style="list-style-type: none"> - Children and parents loved it. - Parents were very interested in learning more about the crops via the wheel.
<ul style="list-style-type: none"> - Some visitors did not understand that they had to place the dams in the holes. - People knew about all the impacts dams cause, both good and bad, but wanted a sign explaining it and why it is a good idea for Ethiopia’s case. 	<ul style="list-style-type: none"> - Children tried to remove the rocks from the box/exhibit they need to be attached. -Some children couldn’t tell which rocks were which make it more obvious. 	<ul style="list-style-type: none"> - Since it was balanced on the bench, it was difficult for shorter children to reach. - Order of the tasks made it difficult to allot the correct number of beads to some tasks. 	<ul style="list-style-type: none"> - Crops were too big for the smaller children to carry. - Some people thought it was a maze due to maize crops sign being near the entrance. -The wheel could be confusing where to spin.
<ul style="list-style-type: none"> - Add more clear signage on what to do/how to do it, and that the water is not potable. - Integrate negative environmental effects and water allocation rights of building a dam, and show how it is the most feasible solution for the people in Ethiopia. - Make a bigger model with continuous flow that children could crawl on or put the activity on a shorter table so children can reach. 	<ul style="list-style-type: none"> - Glue or cement rocks to the bottom of the sandbox to prevent children from taking them. -Introduce a small trowel or archaeologist style brush so they can brush their finds. 	<ul style="list-style-type: none"> - Enlarge the sign or reorder the pictures so people were able to fit the required number of beads above its picture. - Make more reachable for kids. 	<ul style="list-style-type: none"> - Make crops smaller and, if possible, lighter. - Don’t place maize crops near the entrance. -Add direction to the spinning wheel so it’s more obvious what need to be spun.

Conclusion

In this project, we created seven core activities with accompanying signage to present the environmental and social justice issues relating to climate change, water and food security, and conflict mineral mining in an African village exhibit. We successfully prototyped and tested this exhibit with CERES staff and visitors, and used the observations and feedback collected during these evaluations to make recommendations for improvements and future developments.

Through the process of creating the prototypes, we learned how to develop interactive and informative activities and signs with a limited budget, which we accomplished by using recycled materials. In addition to fitting within our design criteria, these materials allowed us to better represent the aesthetic of select African communities. During our initial survey testing, we were excited when our results supported our initial belief that people were not as aware of the issues in other countries as they were of those happening in Australia. In addition, we discovered during our discussion with the African students at the University of Victoria that there is a very large pool of human resources we suggest CERES works with in future.

We were struck by our experience talking to people who had grown up in such a different environment than we ourselves had, and believe they could use their knowledge and experiences to further the cultural immersion aspect of the village. The students showed great passion and interest in the project and we expect that a partnership with CERES, and potentially future WPI groups, to complete the village would be extremely productive. Since our project focused on one of the three villages in development, we believe CERES has two future project paths: the development and prototyping of the Indian village, and the finalization of the entire village project. We concluded with the intent that our recommendations will be clear but have enough malleability that they can be built upon

and personalized by any groups that come after us. Through our prototyping, we saw people start to consider their own privileges in comparison to others; this observation showed our success in achieving our overall project goal to create an exhibit that inspired people through establishing connections.



Figure 31. The team at Werribee Zoo.

Acknowledgements

We would like to acknowledge several people for their contributions to this project, including:

- Our sponsors Shane French and Subik Baso at CERES Community Environment Park, for their friendship, wonderful advice, and support throughout this project.
- The entire CERES Education team, for testing and providing helpful feedback to our exhibit, and making the office such an enjoyable place to be.
- Yvette Finlay from Werribee Zoo, for her valued advice on designing an effective and culturally immersive African village exhibit.
- The participants from our roundtable discussions, for sharing their powerful personal stories and experiences with us.
- Our survey and pilot test participants, for their help in understanding the knowledge of the Melbourne population and providing useful suggestions to include and improve our exhibit.
- Our advisors, Professor Lorraine Higgins and Professor Erin Ottmar, for their valuable insight and dedication to the success of our project.

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Supplemental Materials for this project (raw data, research instruments, and additional project references, background, and outcomes) can be found at <http://www.wpi.edu/E-project-db/E-project-search/search>, using key words from the project title.

