May 2018

Environmental Sustainability and Energy Efficiency
SMART Lessons for EduVentures Trust

Julia Mary Decker
Worcester Polytechnic Institute

Katherine Eleanor Kowalczyk
Worcester Polytechnic Institute

Ryan Gilbert McLaughlin
Worcester Polytechnic Institute

Stephanie Smieszek
Worcester Polytechnic Institute

Follow this and additional works at: https://digitalcommons.wpi.edu/iqp-all

Repository Citation

This Unrestricted is brought to you for free and open access by the Interactive Qualifying Projects at Digital WPI. It has been accepted for inclusion in Interactive Qualifying Projects (All Years) by an authorized administrator of Digital WPI. For more information, please contact digitalwpi@wpi.edu.
Environmental Sustainability and Energy Efficiency
SMART Lessons for EduVentures Trust

By:

Julia Decker
Katherine Kowalczyk
Ryan McLaughlin
Stephanie Smieszek
An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the degrees of Bachelor of Science and Bachelor of Arts

Submitted By:
Julia Decker
Katherine Kowalczyk
Ryan McLaughlin
Stephanie Smieszek

Date:
1 May 2018

Report Submitted To:
Maria Johannes
EduVentures Trust

Project Advisors:
Associate Professor Aaron Sakulich
Associate Professor Alexander Smith

This report represents work of WPI undergraduate learners submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see http://www.wpi.edu/Academics/Projects.
ABSTRACT

We provided EduVentures Trust with three interactive SMART modules. We consulted stakeholders to determine the content of the modules and incorporated interactive elements, such as activities and games, to encourage learners. We tested the lessons at a rural school, where we observed learner engagement, received feedback, and assessed retention of the content. We made recommendations to EduVentures to improve the EduMobile Program. Our project has the potential to improve environmental education in Namibia and stimulate learner interest in environmental studies.
ACKNOWLEDGMENTS

We would like to express our deepest gratitude to everyone that has helped shape our project along the way.

We would like to thank our advisors, Dr. Aaron Sakulich and Dr. Alex Smith, and our ID2050 professor, Dr. R. Creighton Peet, for their enthusiasm and guidance throughout our project.

We would like to thank the EduVentures Trust Staff: Corris Kaapehi, Maria Johannes, Holger Vollbrecht, Sophia Nuuyuni, Tauno Nakuhaka, Hangula Werner, Josephine Moses, and Benson Muramba for their support and guidance on our project and their constructive feedback on our modules. Our project and overall experience in Namibia would not have been the same without them.

We would also like to thank the stakeholders that we interviewed: Rodney Seibeb, Abraham Hangula, Michael Mulunga, Bertchen Kohrs, Viktoria Keding, Frans Hanghome, Silas Newaka, and Reinhold Mangundu. Their expertise in, and passion for, environmental advancement in Namibia provided us with valuable information and guidance throughout the module development process.

Finally, we would like to thank the teachers and learners at the Ondjaba yo Nghalu Combined School for welcoming us into their community and participating in our project.
EXECUTIVE SUMMARY

The world’s rising energy consumption calls for a heightened awareness of sustainable practices and resource management. Many people will never make the transition to environmentally conscious behavior without first recognizing its value. Although rural villages, specifically in Namibia, do not use the majority of the energy in the country, they have an abundance of natural resources available to them. More consistent environmental education, especially in rural areas, could stimulate awareness and understanding of the use of natural resources. For these reasons, education should involve and encourage learners’ participation in sustainable practices.

Namibia is taking action to increase public knowledge about energy consumption and sustainable practices through its countrywide initiatives, including informational materials and funding for renewable energy sources. However, Namibia’s schools, especially those located in rural areas, do not sufficiently or consistently cover topics related to energy consumption and sustainability. As such, there is room to improve rural schools’ educational resources on environmental topics. EduVentures Trust, a local organization sponsored by the National Museum of Namibia, is attempting to supplement such educational efforts in Namibian classrooms. This organization uses a mobile classroom, equipped with an interactive SMART Board, to visit rural schools and provide interactive lessons on environmental education. With additional instruction, learners can be more informed and better equipped to promote and adopt the sustainable use of local resources and energy in their communities.

Our goal was to stimulate learner interest in energy and sustainability topics in order to improve the learning experience in the rural Namibian education system. To achieve this goal, we had three objectives. First, we assembled the content to include in the Resource Efficiency, Introduction Energy, and Eco-Entrepreneurship modules and developed SMART modules for EduVentures for field-testing. Next, we determined the best methods to engage learners in lessons and incorporated these methods into our modules. Lastly, we identified ways to ensure that learners understand and retain the important takeaway messages from the lessons.

Our background research and stakeholder interviews helped us determine the content to include in the modules and identify successful techniques for interactive education. We interviewed educators, representatives from environmental organizations involved in the fields of resource efficiency and sustainability studies, and the EduVentures staff, who provided us with additional module content specific to Namibia. Next, we programmed the modules using the SMART software. The EduVentures staff provided us with detailed feedback, which we used to refine the modules before field-testing. EduVentures educators taught our modules for one week at the Ondjaba yo Nghalu Combined School in the Ohangwena Region. There, we observed learner behavior and engagement in the lessons using an observation rubric. Learners also
completed an engagement survey so that we could collect more information on their perception of the lessons. Finally, we gave learners a pre- and post-assessment to determine the information they had learned from the lessons. This provided us with quantitative data that allowed us to examine learner retention statistically.

After analyzing feedback from the learners and making modifications, we provided EduVentures with final modules to use in their mobile classroom. We also provided EduVentures with information regarding the data analysis that we performed on learner engagement and retention. The engagement survey suggests that the learners found the modules interesting. Specifically, they gave the modules an average score of 4.95 out of 5 for how interesting they were. The learners also reported that they are likely to apply the content to their daily lives (average score of 4.53 out of 5). We also found that the majority of the learners exhibited positive engagement behaviors through our classroom observation. From our pre- and post-assessments, we saw a 43.3% average increase in assessment score. Based on these results, we made recommendations to EduVentures on training, educational materials, classroom interactions, and the EduMobile Program. In conclusion, our modules provided EduVentures with the tools to continue their mobile classroom project and help improve environmental education throughout Namibia.
**AUTHORSHIP**
*All members of the team edited the report*

<table>
<thead>
<tr>
<th>Section</th>
<th>Writer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Ryan McLaughlin</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>All members</td>
</tr>
<tr>
<td>Executive Summary</td>
<td>All members</td>
</tr>
<tr>
<td>Chapter 1: Introduction</td>
<td>All members</td>
</tr>
<tr>
<td>Chapter 2: Background</td>
<td></td>
</tr>
<tr>
<td>Introduction to Energy</td>
<td>Katherine Kowalczyk</td>
</tr>
<tr>
<td>Resource Efficiency</td>
<td>Stephanie Smieszek</td>
</tr>
<tr>
<td>Eco-Entrepreneurship</td>
<td>Julia Decker</td>
</tr>
<tr>
<td>Successful Teaching Tools and Strategies</td>
<td>Ryan McLaughlin</td>
</tr>
<tr>
<td>EduVentures Trust</td>
<td>Stephanie Smieszek</td>
</tr>
<tr>
<td>Summary</td>
<td>All members</td>
</tr>
<tr>
<td>Chapter 3: Methods</td>
<td></td>
</tr>
<tr>
<td>Module Programming</td>
<td>Ryan McLaughlin and Julia Decker</td>
</tr>
<tr>
<td>Engagement in Lesson Plans</td>
<td>Stephanie Smieszek</td>
</tr>
<tr>
<td>Lesson Retention</td>
<td>Katherine Kowalczyk</td>
</tr>
<tr>
<td>Summary</td>
<td>All members</td>
</tr>
<tr>
<td>Chapter 4: Results</td>
<td></td>
</tr>
<tr>
<td>Stakeholder Interviews</td>
<td>Ryan McLaughlin and Stephanie Smieszek</td>
</tr>
<tr>
<td>Module Programming</td>
<td>Katherine Kowalczyk, Julia Decker, and Stephanie Smieszek</td>
</tr>
<tr>
<td>Engagement in Lesson Plans</td>
<td>Julia Decker</td>
</tr>
<tr>
<td>Lesson Retention</td>
<td>Julia Decker</td>
</tr>
<tr>
<td>Summary</td>
<td>All members</td>
</tr>
<tr>
<td>Chapter 5: Recommendations and Conclusions</td>
<td>All members</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

ABSTRACT .................................................................................................................. iii

ACKNOWLEDGMENTS ............................................................................................... iv

EXECUTIVE SUMMARY ........................................................................................... v

AUTHORSHIP ............................................................................................................. vii

TABLE OF CONTENTS ............................................................................................... viii

LIST OF FIGURES .................................................................................................... ix

LIST OF TABLES ....................................................................................................... x

CHAPTER 1: INTRODUCTION ................................................................................... 1

CHAPTER 2: BACKGROUND .................................................................................... 3
  2.1 Introduction to Energy ....................................................................................... 3
  2.2 Resource Efficiency ......................................................................................... 5
  2.3 Eco-Entrepreneurship ..................................................................................... 8
  2.4 Successful Teaching Tools and Strategies ....................................................... 11
  2.5 EduVentures Trust ......................................................................................... 14
  2.6 Summary ........................................................................................................ 15

CHAPTER 3: METHODOLOGY ................................................................................. 16
  3.1 Objective 1: Module Development ................................................................. 16
  3.2 Objective 2: Engagement in Lesson Plans ..................................................... 18
  3.3 Objective 3: Assess Lesson Retention ............................................................. 19
  3.4 Summary ........................................................................................................ 20

CHAPTER 4: Results ............................................................................................... 21
  4.1 Stakeholder Interviews ................................................................................... 21
  4.2 Module Development and Field-Testing ......................................................... 23
  4.3 Engagement in Lesson Plans ......................................................................... 31
  4.4 Lesson Retention ............................................................................................ 33
  4.5 Summary ........................................................................................................ 36

CHAPTER 5: Recommendations and Conclusion .................................................. 37
  5.1 Recommendations ......................................................................................... 37
  5.2 Conclusion ...................................................................................................... 38

REFERENCES .......................................................................................................... 39

APPENDIX A: ENGAGEMENT SURVEY ................................................................. 45

APPENDIX B: PRE- AND POST-ASSESSMENT ....................................................... 46
LIST OF FIGURES

Figure 2.1: Solar Cook Stove (left) and Parabolic Cooker (right) ........................................6
Figure 2.2: Sustainable Development Venn Diagram (Pearson, 2017, p.1) .........................10
Figure 2.3: Kolb's Experiential Learning Cycle (Kolb, 2014, p.8) .................................11
Figure 2.4: Students Using a SMART Board .................................................................13
Figure 4.1: A Lecture Slide Describing For Solar Energy Works .................................24
Figure 4.2: Renewable and Non-Renewable Energy Sorting Activity .............................24
Figure 4.3: Sorting the Advantages and Disadvantages of Renewable Energy ..........25
Figure 4.4: Renewable Energy in Different Parts of Namibia Activity ..........................25
Figure 4.5: Activity for Learners to Find Basic Definitions ............................................26
Figure 4.6: Importance of Being Resource Efficient .......................................................27
Figure 4.7: Matching Activity .........................................................................................27
Figure 4.8: Jeopardy Board and Example of a Question .............................................28
Figure 4.9: Brainstorming Eco-Entrepreneurship Definition .........................................29
Figure 4.10: Balancing Sustainable Development .........................................................29
Figure 4.11: Defining Sustainable Agriculture ...............................................................30
Figure 4.12: Sorting Different Types of Eco-Entrepreneurship .....................................30
Figure 4.13: Distribution of Pre- and Post-Assessment Unweighted Scores ..................34
Figure 4.14: Distribution of Pre- and Post-Assessment Weighted Scores .....................34
Figure 4.15: Average Test Score Per Question Weight ..................................................35
Figure 4.16: Average Test Scores Per Module .................................................................36
LIST OF TABLES

Table 3.1: Classroom Observation Rubric........................................................................19
Table 4.1: Summary of Statistics For Engagement Survey................................................32
CHAPTER 1: INTRODUCTION

Poor awareness and understanding of energy issues can be a contributing factor to a lack of support for energy conservation policies (Ministry of Mines and Energy, 2017). As a result, there is a need to improve awareness of sustainable practices, especially in the world’s education systems (Kandpal & Broman, 2014). Expanding awareness of energy issues, especially through education, can lead to a more sustainable future in areas of the world that have an abundance of renewable resources available to them.

Implementation of a resource efficiency and environmental studies program in the rural education system is key to enhancing awareness of the sustainable use of resources in Namibia. Case studies have shown that supplementing environmental lesson plans with theater plays, games, songs, and other interactive options is associated with an increase in environmentally-conscious behavior outside of the classroom (Zografakis et al, 2008). This can help create a strong foundation of learner knowledge and interest in environmental issues and play a pivotal role in strengthening the protection of Namibia’s environment.

Namibia has the highest annual potential production from the combination of solar, wind, hydro, and biomass fuels among African countries (Deichmann et al., 2011). There is great potential for rural Namibians to harness these renewable sources of energy, yet many are not aware of this potential. EduVentures Trust (2018a) is an organization dedicated to educating rural populations about renewable energy, energy usage, and sustainability by providing interactive SMART Board modules via their mobile classroom. Although EduVentures has a set of SMART modules that they use to educate rural learners, they believe that there are more lesson topics that need to be addressed.

A team of WPI students completed a set of SMART board lesson modules for EduVentures Trust in 2017 (Consedine et al., 2017). These modules covered different types of renewable energies that are available in Namibia such as solar, wind, and biomass energy. At the end of that project, EduVentures Trust still did not have a completed curriculum and wanted the additional modules of Introduction to Energy, Eco-Entrepreneurship, and Resource Efficiency. Rural schools in Namibia currently do not sufficiently cover these topics.

Our goal was to help EduVentures further stimulate learner interest in renewable and non-renewable energy, eco-entrepreneurship, and resource efficiency and to improve the experiences of learners in the rural Namibian education system. Our objectives included determining the educational content on these modules, identifying methods to assess the knowledge gained from the lessons in which the modules were used, and determining ways to effectively engage learners in lessons about sustainable energy related topics. We created three SMART modules that were tested in rural schools, where we used classroom observations, an engagement survey, and pre- and post-assessments to gauge the effectiveness of the modules.
We used this feedback to enhance the SMART modules and create a more engaging and successful education program. We provided EduVentures with finalized interactive modules as a tool to use in their mobile classroom in order to improve the learning experience in rural Namibian villages.
CHAPTER 2: BACKGROUND

In this chapter, we first discuss the topics of the SMART modules: *Introduction to Energy, Resource Efficiency, and Eco-Entrepreneurship*. EduVentures Trust wanted modules on these topics for their EduMobile Program. We then discuss successful teaching strategies, technology in the classroom, strategies for environmental education, and education in Namibia. Finally, we explain the background of EduVentures and the EduMobile project. All of the information that is presented in this chapter will be used in the creation of our modules, for both the content and teaching strategies. Since the modules will be used for rural Namibian learners in grades 8-10, the detail presented in this chapter is only to the extent appropriate for the modules.

2.1 Introduction to Energy

Our first module topic was *Introduction to Energy*, which discussed renewable and non-renewable energy. Energy is the capacity to provide work from physical or chemical resources. This can include providing electricity to homes, powering factories, and running machines such as automobiles. Energy became a large part of everyday life during the Industrial Revolution. Energy supplies, such as coal and oil, seemed to have an unlimited supply during the early twentieth century. However, by the early 21st century people began realizing how energy consumption and rising carbon dioxide levels from burning fossil fuels play a part in climate change. People also began to realize that certain non-renewable resources, which many depend on, are limited and will one day no longer exist. In response, some began looking into renewable energy options that would be sustainable and that would have less severe consequences on the environment (U.S. Energy Administration Information, 2017).

2.1.1 Non-renewable Energy

Non-renewable energies are forms of energy that cannot be replaced or take an extremely long time to be replaced (U.S. Energy Administration Information, 2017). Non-renewable energy sources, such as coal, oil, and natural gas, provide a reliable source of energy since they are not affected by weather and other external conditions. These sources of energy have a limited supply within the Earth’s crust, so over time they will be depleted with continuous use. Although non-renewable energies are widely used, there are some side effects to using them. Most non-renewable energies, such as fossil fuels, emit carbon dioxide and other gases into the air when they are burned. Carbon dioxide is a greenhouse gas that negatively affects the environment. Greenhouse gases can cause changes within the atmosphere, which have been linked to climate change.
2.1.2 Renewable Energy

Renewable energy can be generated from a natural source and can be replaced either instantly or over a short amount of time (Akella, Salini & Sharma, 2009). Renewable energies include wind, solar, hydro, and biomass energy. Biomass energy is the process of taking wood from trees or bushes and storing them underneath a water tank. When the wood is burned it boils the water to produce steam, which forces blades within a turbine to move. When the turbine moves it causes a set of coils and magnets to generate a magnetic field that can be used to produce electricity. Since renewable energy requires resources such as the wind or the sun, some areas in the world are not as suitable as others to generate and use these energies. For example, hydropower can only be used in places that have rivers or a water source that is large enough to generate power with the turbine. Renewable energies may also cause a fluctuating supply of energy. With solar energy, for example, there may not be enough energy to power everything that is connected to the solar panels if there are multiple days in a row that are cloudy. The initial costs of implementing renewable energies can be expensive because of the technology that is used to harvest the energy. Using renewable energy over a long period of time will often be cheaper. The user’s energy bill will lower because they will not have to buy as much energy from the power grid. Additionally, renewable energy use does not emit greenhouse gases like non-renewable energy use.

2.1.3 Energy in Namibia

Namibia buys over 60% of its electricity from the Southern African Power Pool (Fol, 2012). Namibia also imports some energy from Zambia and Zimbabwe. Most of the energy that is imported from neighboring countries is from coal power plants. With Namibia’s increasing use of electricity over the past decade, importing the majority of their electricity may no longer be practical due to increased expenses of meeting the demand of electricity with a growing population. Nampower, Namibia’s national provider, has discussed the idea of creating a new coal-fired power plant in order to address this issue. The use of non-renewable energy in Namibia has been contributing to climate change, as can be seen through extreme temperatures, land degradation, and flooding in northern Namibia.

Namibia has the potential to produce enough renewable energy for about 100 times their current energy consumption (Fol, 2012). Using renewable energy would also help to provide electricity to places in Namibia that are not connected to the power grid. Namibia has the potential to use solar, biomass, wind, and wave energy throughout the country. Solar energy is the most abundant form of renewable energy in Namibia because there is an average of 300 days a year with full sunshine. Solar energy can especially be used in the desert and in the northern part of Namibia. Biomass energy, in its conventional and unprocessed form, is the most prevalent form of renewable energy used in African countries. Most biomass energy in Namibia
comes from a form of energy called bush-to-energy. This is the practice of cutting down invasive species of bushes and trees and using them to create energy. There are some wind power plants near the southern coastline and near the Skeleton Coast, where there are strongest winds in Namibia. Namibia also has 1,570 kilometers of coastline where wave and tidal energy could be produced (Rowe, 2011).

2.2 Resource Efficiency

The next module topic we addressed was Resource Efficiency, which is using the Earth’s resources in a sustainable manner while minimizing an individual’s or society’s negative impact on the environment (European Commission, 2017). Being more resource efficient has multiple benefits that can be broken down into three subgroups: co-benefits, non-energy benefits, and ancillary benefits. Co-benefits include things such as cleaner air or increased comfort of living. Non-energy benefits include any additional benefits that are not associated with the cost of energy, such as saving money on natural gas when using solar energy instead. Ancillary benefits are any quantifiable costs saved when being energy efficient. One example is a decreased energy cost due to the use of more energy efficient technologies. It is important that the learners understand these definitions so that the drive to move towards resource efficiency is clear.

Sustainable living is a lifestyle that attempts to reduce an individual’s or society’s use of natural resources while minimizing the individual’s impact on the environment (UC Davis, 2018). Sustainable living corresponds to the sustainable development goals implemented by the United Nations (Zhu, 2016). These include affordable and green energy, sustainable cities and communities, responsible consumption and production, and climate action. These goals encourage people to adopt more sustainable practices across a wide range of areas in industry and society. Common themes of sustainable living include efficiency in the areas of energy, water, waste, and agriculture.

Energy efficiency is using or wasting less energy to provide the same services (IEA, 2018). Energy efficiency can be achieved in many different ways depending on the resources available. One way to become more energy efficient is by making one or two changes to a person’s lifestyle, such as simply turning off the lights when they are not in use or harnessing renewable energy to power homes. Over time these changes can add up to decrease the negative impacts on the world.

Using energy efficient appliances is another way to be efficient. Examples of these appliances include solar cook stoves and parabolic cookers (EIE, 2013a). Both of these efficient appliances provide the same amount of energy and use less wood than conventional methods of cooking. They provide a method of cooking that harnesses the natural energy of the sun as a substitute for burning wood or natural gas. The solar cookers and parabolic stoves
are simple to build and use in many environments. These appliances are affordable and have minimal impact on the environment.

![Figure 2.1: Solar Cook stove (left) and Parabolic Cooker (right)](image)

Another way to be more resource efficient is through water efficiency. Water efficiency involves maximizing water’s value while minimizing how much is being used (EIE, 2013b). Small changes in the amount of water used per day, such as turning off the tap or taking shorter showers, can have a large impact on the amount of water used in one year. Another way to be more efficient is by collecting rainwater (Woltersdorf et al., 2015). It decreases the amount of water taken from natural sources like groundwater wells, which take much longer to replenish. Harvesting rainwater provides an effective way to collect clean water for drinking, bathing, and cooking. In addition to being more environmentally friendly, a rainwater harvesting system also has ancillary benefits, like decreased bills. Over time, this system can save thousands of US dollars, especially in areas that receive large amounts of rainfall. Using water smarter is one major way to be more efficient with resources.

Currently there are water-shortage crises around the world, especially in more arid regions (Welch, 2018). Water shortages have become more prevalent over the past four years, which may be linked to climate change and the changes in weather patterns. The frequency of these water shortages could be minimized if water is used appropriately around the world. It is important for people to be aware of the causes and consequences of wasting water and the benefits of being water efficient.

Waste efficiency is another topic covered in the Resource Efficiency module. It is reducing, reusing, and recycling to minimize the amount of waste that is generated (USEPA, 2018). Reducing waste requires using fewer materials to complete a task. One way to reduce is by starting a compost pile. A compost pile consists of dirt and any food that can be degraded over time. Fruit peels and inedible parts of other foods are the most common foods to be
composted. Compost piles promote a small ecosystem within itself where worms and other decomposing organisms work to degrade the food, while still getting the nutrients they need to live and reproduce. Using a compost pile creates less food waste by naturally degrading food waste that would otherwise be sitting in a landfill. A compost pile is one way to be more waste efficient, however there are other ways that reducing, reusing, and recycling can be applied to someone’s daily lifestyle.

Sustainable agriculture is the final topic of resource efficiency. It is the production of food, plant, or animal products using farming techniques that protect the environment (UC Davis, 2018). The goal is to meet current agricultural needs without compromising the future ability to meet the individual’s needs. There are three main objectives: a healthy environment, economic profitability, and social and economic equity. Sustainable farming promotes soil health, minimizes water use, and lowers pollution levels on farms.

Crop rotation, the use of cover crops, reducing tilling, and planting trees for shade are some important farming techniques that fall within the principles of sustainable agriculture (Union of Concerned Scientists, 2018). When farmers rotate their crops, they create diversity in an area of the land, develop healthier soil, and attract fewer pests. Planting cover crops, such as clover, prevents erosion, replenishes the nutrients in the soil, and keeps the weeds at a minimum. This technique allows farmers to avoid using herbicides. Additionally, tilling a farm can cause soil loss. Farmers who do not use tilling or reduce the amount of tilling on their farms are helping to maintain healthy soil and reduce erosion. Finally, farmers can provide shade and shelter to protect some plants, animals, and water resources by planting trees and shrubs with their crops. By adopting some of these practices, farmers could aid in achieving the goals of sustainable agriculture.

2.2.1 Resource Efficiency in Namibia

The Namibian Ministry of Mines and Energy enacted the National Energy Policy of 2017 to guide energy usage in Namibia (Ministry of Mines and Energy, 2017). The National Energy Policy aims to “ensure the development of Namibia’s natural capital and its sustainable use for the benefit of the country’s social, economic, and environmental wellbeing.” The goals include providing cost-effective and reliable access to energy, promoting efficient energy usage, and incentivizing the discovery of new energy sources. Multiple programs have been implemented to move toward achieving the goals of the National Energy Policy. These programs include the Rural Electrification Program and the Solar Revolving Fund.

Water efficient practices are important in Namibia. Although most of Namibia has an arid climate, the northern parts have up to 24 inches of rainfall per year, making them a viable place for harvesting rainwater (Info Namibia, 2018). Currently, most homes in those regions have
water tanks to collect rainwater. Water collection systems are a better way to save water because they reduce the amount of water taken from natural sources. Based on a study done in northern Namibia, most homes in rural areas have the potential to use solely rainwater as their water source, making Namibia as a whole more water efficient (Sturm et al., 2009).

Waste efficiency in Namibia can be difficult, especially in rural villages. There is only one landfill in Namibia, which is located outside of Windhoek (Mughal, 2014). Since the country is so large, it is difficult to bring waste to the landfill. This leads to litter in villages as well as sanitation issues. Rural villages have the ability to implement different ways to be more waste efficient, such as starting a compost pile or reusing materials.

The need for sustainable agriculture is specifically high in northern regions of Namibia (UC Davis, 2018). Many of these areas have agricultural practices that provide food and water for villages, without sustainability in mind. Many villages do not rotate crops regularly, which could leave the land unusable in a few years (Shiningayamwe, 2012). Additionally, some of the villages do not have the knowledge or the financial means to implement such practices.

2.3 Eco-Entrepreneurship

In this section, we will provide the information necessary for the third module, Eco-Entrepreneurship. This describes starting a company that is focused on innovation in environmentally friendly products and services (McEwen, 2012). Entrepreneurs start these businesses to make a profit and to support a more sustainable future. Some examples of ecological businesses include waste recycling, water purification, renewable energy harvesting, and aquaponics, which are beneficial for reducing environmental degradation, improving water supply, and maintaining biodiversity.

Many eco-entrepreneurial businesses begin as small or micro-enterprises (SMEs). A micro-enterprise is a company with nine or fewer employees and a small enterprise is one with 10 to 19 employees (Ionită, 2013). SMEs are extremely important to the growth of countries with developing economies and are useful for creating jobs, sparking economic growth, and relieving poverty among vulnerable groups of society (Chiware & Dick, 2008). They have been recognized as a major source of employment and income in developing countries around the world. The National Micro and Small Enterprise Baseline Survey showed that two-thirds of all SMEs are found in rural areas and 70% of SMEs are owned by one person (Masri, 2013).

The challenges for SMEs in developing countries include limited access to money, business training, and technology (Ionită, 2013). Poor transport infrastructure and limited business management skills can also be a challenge. Additionally, growing employment in SMEs is a controversial issue all over the world (Mead & Liedholm, 1998). An increased amount of
employment comes from new enterprises starting; however, this can be offset by existing enterprises closing. This leads to a struggle between promoting new enterprises to start up and focusing on helping existing enterprises to succeed and avoid closing. Finding the correct balance relies completely on the macro-economy. If the economy is doing well, small and micro-enterprises are more likely to succeed. If the economy is at a standstill, SMEs begin to lay off employees and entrepreneurs are less likely to take the risk to begin a business. Finally, SMEs depend almost entirely on entrepreneurial skills coming from past experience and common sense (Ionită, 2013). If eco-entrepreneurs are able to overcome these challenges and start a successful enterprise, they have the ability to positively impact their community by providing jobs and helping to lead to a more sustainable future.

2.3.1 Green Economy and Sustainable Development

Eco-entrepreneurship is one way to promote sustainable practices. With growing concerns about climate change and other environmental issues, it is important that people prioritize such practices. Sustainable development has been an international goal since the UN Conference on Environment and Development in 1992 (Zhu, 2016). The conference called upon governments to implement policies that would lead the world to a more sustainable future. The three main pillars of focus in sustainable development (Fig 2.2, overleaf) are economic, environmental, and social (Nhamo, 2011). The economic pillar focuses on economic growth, while maintaining a healthy balance with our ecosystem and a sufficient standard of living for everyone. The environmental pillar places importance on the limited and responsible use of natural resources for economic growth. The social pillar acknowledges the need to address social inequality, injustice, and poverty. All three pillars must be considered to achieve sustainable development.
In order to act upon international cooperation with sustainable development, the government of the United Kingdom first proposed the concept of “green economy” (Nhamo, 2011). This concept generally refers to the attempt to balance the economic, social, and environmental justice in order to make sustainable decisions that have positive impacts on the future (Brand, 2012). Green economy is focused mainly on the transition to a low carbon economy. It addresses climate change and biodiversity loss while aiming to create new jobs (Nhamo, 2011). Making people aware of these concepts will increase the likelihood that they keep them in mind during their everyday lives. It is important that we teach the learners about these goals so that they can acknowledge the potential they have to be a part of reaching them. Becoming eco-entrepreneurs could help to expand the participation in environmental policies and goals.

### 2.3.2 Eco-Entrepreneurship in Namibia

Many people in Namibia have limited access to funding, business training, and technology (Travel News Namibia, 2015). There are four main types of entrepreneurial businesses that will be covered in our module. These were chosen specifically because they can be started successfully with limited resources. First, by using sustainable agriculture, farmers can make the same amount of money from their crops while spending less to produce them. By using hydroponics or aquaponics, farmers could grow and sell crops even in areas that do not have
healthy soil. Hydroponics is the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil. Aquaponics is the production of waste from farmed fish or other aquatic animals to supply the nutrients for plants to be grown hydroponically. Finally, waste recycling can be used to convert waste materials into other useful products to be sold for a profit. Taking advantage of these four options would help the Namibian people, not only to get jobs, but also to avoid the future effects of climate change and other environmental issues.

2.4 Successful Teaching Tools and Strategies

The approaches and strategies that teachers use to educate learners can be as important as the information they intend to communicate. One of the largest challenges in teaching any subject is ensuring that students are engaged with the material so they can learn and retain knowledge (Weimer, 2013). It may be more difficult for conventional classes, especially lectures, to provide a creative learning environment for students. Certainly, this does not mean that conventional learning fails to facilitate an exciting and engaging atmosphere for learners. However, learner-based education can give students an alternative and unique hands-on approach for their learning.

Teachers use many techniques to engage students. David Kolb (2014), an educational theorist, is credited with creating an approach for learner-based education. Kolb’s Experiential Learning Theory (ELT) emphasizes the learner’s active participation in lessons to further aid in absorption of material. Kolb describes the experiential learning environment as one where “the learner is directly in touch with the realities being studied. It is contrasted with the learner who only reads about, hears about, talks about, or writes about these realities but never comes into contact with them as part of the learning process” (p.7). Unlike other teaching techniques, experiential learning is modeled in the form of a cycle (Fig. 2.3).

Figure 2.3: Kolb's Experiential Learning Cycle (Kolb, 2014, p.8)
Kolb’s (2014) cycle begins with the individual encountering a new experience. He or she then observes and reflects on the experience. Conceptualization of new ideas or modifications of existing concepts stem from a reflection on what the student learns. Finally, the student applies his or her experience, knowledge, and new ideas to the world around him or her for testing.

The ELT is especially effective when applied to environmental education. John Dewey, one of the foundational scholars of the ELT, emphasized that experiential learning in nature promoted greater respect for the natural world within learners (Saylan & Blumstein, 2011). Dewey believed that learners develop a greater appreciation for and awareness of nature and the environment around them if they experience such phenomena first-hand. Relatable and learner-specific experiential lesson plans that cover local environmental topics should provoke a sense of personal and communal responsibility within learners as shown in studies around the world.

Zografakis, Menegaki, & Tsagarakis (2008) studied an ELT program on effective energy education in Greece. The energy education program in this example was targeted towards students, teachers, and parents. It was important to target parents in order to ensure that the concepts taught in school were then reinforced at home. The program used interactive ways to convey the knowledge to the students, including the use of theater plays, songs, and games, among other strategies. The students and parents completed energy surveys to provide information on energy behaviors at home. This showed that students and parents were more conscientious and knowledgeable regarding the information presented during the interactive lessons.

2.4.1 Classroom Technology Implementation

Technology is revolutionizing the way educators teach and how children learn. However, the impact of educational technology is critically dependent upon the role it fills in the classroom (Lowerison, 2006). The presence or use of computer technology does not guarantee a benefit to learning. Computer technology is often used passively as an extension of the blackboard or for practice exercises that do not stimulate active learning (Lee & Boyle, 2003). This highlights the difference between learning from the technology rather than with it, where the technology becomes only a delivery system. The potential for enhancing education using technology is high, so long as the technology is appropriately incorporated into classrooms to complement both the educator and the course material.

One technology-integrated device used in classrooms around the world is the SMART Board (Nichols, 2015). A SMART Board is an interactive whiteboard developed by SMART technologies that combines both the material provided by a computer projector and the accessibility of a standard whiteboard. It features a large touch-screen display and software
designed to create interactive lesson plans and games (Fig. 2.4). The SMART Board delivers a wide variety of media, such as photos, illustrations, maps, graphs, games, and videos, providing educators flexibility with designing lesson plans. These types of media can be embedded into a SMART presentation and do not require an Internet source, which would be especially useful in areas with little to no Internet access.

![Figure 2.4: Students using a SMART Board](image)

The use of SMART Boards could positively affect students' academic achievement, especially for science topics (Aktas & Aydin, 2016). Research indicates that students see SMART lessons as more exciting and engaging than conventional lessons and media (Lee & Boyle, 2003). This is likely attributed to the inclusion of visual media and interactive modules. Given the features of SMART technology, SMART boards can greatly enhance the material learned in the classroom, especially on topics in environmental education.

2.4.2 Environmental Strategies

The first environmental education conference was held in 1977, which began a worldwide discussion on this topic (Athman & Monroe, 2001). Out of this conference came the Tbilisi Declaration, which established five different objectives in environmental education: awareness, knowledge, attitudes, skills, and participation. Each one of these objectives is important to improve environmental education and preserve the environment in which we live.

Teaching students about the environment and the energy around them has been shown to be more effective if students are learning within their own environment (Athman & Monroe, 2001). This is more likely to make them passionate about that topic and help them to understand the impact it has on their daily life. Teaching about the environment from multiple sources and in different ways can also help to stimulate students’ interest about the environment.
To assess the effectiveness of an environmental educational program, feedback from the students and teachers should be collected during the program (Athman & Monroe, 2001). Environmental education should spark student interest so they become empowered to want to make a difference in their environment. After an effective environmental education program, a student should have the “skills to help prevent and address environmental issues… with a sense of personal and civic responsibility” (p. 40).

2.4.3 Current Education, Curriculum, and Practices in Namibia

In 1990 the National Institute for Educational Development (NIED) worked with the Namibian Ministry of Education to reform the basic educational system (Ministry of Education, Arts and Culture, 2018). More than 80% of children ages 6 to 16 are enrolled in school, which is much higher than most African countries. The NIED is working to provide material for schools, training manuals for teachers, and are designing a school curriculum nationwide for both primary and secondary school, so that all curricula across the country are consistent.

Theoretically all schools within Namibia follow the same structure of education, so education across Namibia should be relatively the same (Consedine et al., 2017). In reality, there is a gap in information and experiences between learners who attend urban schools and those who attend rural schools, especially on energy topics. High performing teachers are more likely to move to and work at urban schools, which leaves rural schools with less experienced teachers and staff. The funding that goes into rural schools cannot always go straight towards new technologies and innovative ways to teach children. A lot of money that goes to rural schools is used to fix the physical state of the school. They also do not always have access to the Internet and other technologies that are readily available in urban schools because many rural schools are not connected to the power grid. Given many different factors, rural schools’ education quality can be less technologically advanced than urban schools.

2.5 EduVentures Trust

EduVentures Trust (2018b) is a non-profit organization located in Namibia and Germany. The mission of EduVentures Trust (2018a) is to “…actively provide environmental experiences for mainly disadvantaged Namibian youth whilst simultaneously contributing to the continued expansion of Namibian scientific knowledge and deepening the collective understanding of its natural and cultural heritage, all of which are crucial to the conservation & sustainable use of Namibia’s environment” (About Us, paragraph 1).

EduVentures uses its Ombombo truck, a mobile classroom equipped with a SMART Board, to host interactive classroom lessons around Namibia for their EduMobile Program
These lessons focus on the topics of biodiversity and energy. The EduMobile Program lasts for one week. On Monday and Tuesday, EduVentures teaches two lessons to the learners each day. On Wednesday, EduVentures and the learners walk around the local village to talk about sustainable practices and how to implement them in their community. EduVentures also introduces an environmental project and gives the learners an opportunity to work on that project. On Thursday, EduVentures teaches learners how to start and maintain an environmental club at their school. Finally on Friday, the learners present their projects to their classmates, teachers, parents, and the EduVentures staff.

The main sponsor of the EduMobile Program is the Hanns Seidel Foundation (HSF). The HSF (2018) promotes democracy, service, and development through political education. They have educational centers around the world and scholarships to enrich learners’ studies. The HSF sponsors EduVentures Trust and is specifically funding the EduMobile Program, as it is part of their Promoting Renewable Energies in Namibia (PREN) Project. The PREN Project is active from 2017 to 2019 and targets schools and Small-Micro Enterprises (Amutenya, 2017). Since the EduMobile Program is part of the PREN project, HSF must approve the content within the SMART modules before they are presented to learners and educators.

### 2.6 Summary

Environmental education varies greatly among Namibian communities, which creates a need for more consistent education throughout the country. Namibia has the opportunity to create enough energy for its citizens through renewable sources such as wind, solar, wave, and biomass energy. Switching to renewable energy sources would reduce the amount of non-renewable energy that Namibia imports from South Africa. A combination of government policies and education programs has been successful in promoting resource efficiency in other areas of the world, which can be successfully applied in Namibia. A technique used to provide education on these topics is through experiential learning and interactive classroom technology, which can help learners become more engaged with lessons. Teaching learners about resource efficiency, the local availability of renewable resources, and their roles in becoming eco-entrepreneurs can help minimize the insufficiencies in environmental education. We have developed methods to provide EduVentures with a complete set of effective modules for their EduMobile Program.
CHAPTER 3: METHODOLOGY

Our goal was to stimulate learner interest in energy topics to improve education in rural Namibia. To achieve this goal, we provided EduVentures Trust with three complete SMART modules on Resource Efficiency, Introduction to Energy, and Eco-Entrepreneurship for their EduMobile Program. To create and test the effectiveness of these modules, we had the following objectives:

- Objective 1: Develop three SMART modules for EduVentures Trust for field-testing.
- Objective 2: Determine the best ways to engage learners.
- Objective 3: Identify ways to ensure that learners retain important takeaway messages from lessons.

In this chapter, we explain the methods that we used to achieve each objective.

3.1 Objective 1: Module Development

We developed three interactive SMART lessons to improve education in Namibia and provide EduVentures with more tools for their EduMobile Program. Before we made the modules, we obtained content by doing background research and talking to local stakeholders in the three fields. The modules were intended to be broad enough to educate learners about the world’s ecological, environmental, and energy-related issues, yet specific enough to encourage learners to improve the conditions in their communities.

3.1.1 Content Assembly

We gathered background research on the module topics suggested to us by EduVentures Trust. This research helped us to better understand practices involving energy and sustainability around the world. To obtain information specific to Namibia, we held interviews with local stakeholders to supplement our background research. We used our general research for basic definitions and understanding of the topics, while our interviews provided us with specific information pertaining to Namibia.

The EduVentures staff has worked extensively with Namibian schools and with the SMART software. They were able to provide us with information that was of great use to us in the module development process. We had a group interview with the EduVentures staff where we inquired about activities and teaching techniques that have consistently been used by the educators, as well as the content relevant to our modules. The EduVentures staff also provided information regarding past successes and failures in learner engagement. Much of the
information that we obtained from the EduVentures staff was based on their past experiences and is not published in journals or on the Internet. Based on what we learned from the variety of stakeholders that we interviewed, we determined important points to include in our modules.

We interviewed local educators to assess how environmental, entrepreneurial, and energy-related subjects are taught in Namibian classrooms. We needed to learn how such topics are presented to learners and to understand how well educators believe their learners retain the information. We interviewed Abraham Hangula, the Namibia Energy Efficiency Programme (NEEP) Project Energy Efficiency Specialist at NUST, Silas Newaka, an employee at the Namibia Business Innovation Institute (NBII) at NUST, and Michael Mulunga, an employee at the National Youth Council of Namibia. All interviews included questions on which aspects of the topics should be the areas of primary focus, how to keep learners interested in the topics, and common challenges faced while teaching these topics.

Since it can be difficult to identify specific regional information through research, especially newer topics, we interviewed four representatives from local organizations to obtain content for the modules. We interviewed Rodney Seibeb, the Promoting Renewable Energies in Namibia (PREN) Project Coordinator at the Hanns Seidel Foundation, Bertchen Kohrs, the Chairperson of Earthlife Namibia, Frans Hanghome, an employee in the renewable energy department at the Ministry of Mines and Energy, and Viktoria Keding, the co-founder of Namib Desert Environmental Education Trust. The questions focused on gaining a better understanding of the state of energy usage in Namibia, how to spark interest in entrepreneurship, and which energy practices are harmful to Namibia’s environment.

3.1.2 Module Creation and Field-Testing

We created an outline of the modules, which we then used to develop interactive lessons using the SMART notebook application. Along with the modules, we created a module handbook, which included a more detailed outline for what educators should discuss on each slide. Finally, we worked closely with the EduVentures staff and the Hanns Seidel Foundation to refine the modules and get approval for field-testing, which helped us determine how engaging they were and the amount of information the learners retained.

On April 16, 2018 we attended a workshop at EduVentures’ Waterberg Learning Center to teach the educators how to use the SMART software. At the workshop we presented on the basic features of the SMART software. We also created and provided instructional handbooks on using SMART software to the educators, which they could use at their centers. We showed the educators the Resource Efficiency module to demonstrate what a complete SMART module would look like.
A week later, we delivered and tested our modules as part of the EduMobile Program at the Ondjaba yo Nghalu Combined School in the Ohangwena region. We visited the community for one week to make classroom observations, gave the learners an engagement survey, and had the learners complete a pre- and post-assessment. We used the data to formulate recommendations for editing the modules and improving the EduMobile Program. We used our results from this analysis and recommendations from the EduVentures staff to create finalized modules for EduVentures to give to educators around the country.

3.2 Objective 2: Engagement in Lesson Plans

We analyzed learner engagement in the modules using a survey and classroom observation. These two methods provided us with the quantitative and qualitative data necessary to assess engagement in the lessons.

3.2.1 Survey for Level of Engagement

As mentioned in Section 3.1, learners at the Ondjaba yo Nghalu Combined School completed the engagement survey at the conclusion of the EduMobile Program. The survey had learners rate their perception of the lessons on a scale of one to five, including questions about how fun and interactive the lessons were (Appendix A). The survey also contained open-ended questions where learners could give more specific feedback on the aspects of the lessons that they did or did not enjoy. The data made it possible for us to complete quantitative and qualitative analyses of how the learners rated their engagement. To analyze our quantitative data, we calculated the mean and standard deviations of learner ratings of engagement for each question. Our qualitative analysis compiled common feedback from learners to recognize strengths and weaknesses of the modules. The survey permitted learners to anonymously give recommendations for ways to make the lessons more interesting and engaging. Knowing that everyone interprets values on a scale differently, it was difficult for us to standardize the data. Despite these drawbacks, it was still a useful way to learn something about the level of learner engagement in the lessons.

3.2.2 Observation of Classroom Participation

We also determined the engagement of learners using a classroom observation rubric. Since this form of data collection can be subjective, we looked for certain patterns during our observations, as shown in Table 3.1 (overleaf). We spoke with EduVentures Staff members to determine common patterns of engagement among learners and categorized them into positive and negative indicators. The rubric helped us compare engagement over the course of the lesson by analyzing ten-minute segments, allowing us to determine the sections of the lessons that
needed improvement and those that were engaging. We used the percentage of learners demonstrating high or low levels of engagement to determine if the lessons were engaging.

Table 3.1: Classroom Observation Rubric

<table>
<thead>
<tr>
<th>Observation</th>
<th>Number of Learners to Exhibit the Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>0 - 10 minutes</td>
</tr>
<tr>
<td>Positive Observations</td>
<td></td>
</tr>
<tr>
<td>Taking notes</td>
<td></td>
</tr>
<tr>
<td>Looking at the board and teacher</td>
<td></td>
</tr>
<tr>
<td>Raising their hand</td>
<td></td>
</tr>
<tr>
<td>Participating in group discussion</td>
<td></td>
</tr>
<tr>
<td>Negative Observations</td>
<td></td>
</tr>
<tr>
<td>Engaging in side conversations/other activities</td>
<td></td>
</tr>
<tr>
<td>Nodding off/sleeping</td>
<td></td>
</tr>
<tr>
<td>Demonstrated confusion</td>
<td></td>
</tr>
<tr>
<td>Comments for any other behaviors:</td>
<td></td>
</tr>
</tbody>
</table>

3.3 Objective 3: Assess Lesson Retention

To assess lesson retention, we created a test of the information covered in the modules (Appendix B). The learners completed the test on the first and final day of the program. We used the pre-assessment to gain an understanding of the learners’ baseline knowledge on the module topics. The assessment had open-ended questions with three different weights. These weights were assigned to each question so that questions requiring more critical thinking were worth more than those requiring learners to define terms. The simpler questions, such as basic definitions, received a weight of two points. Medium difficulty questions, where students had to explain concepts, were given a weight of three points. The toughest questions that required students to apply the knowledge received a weight of five points. The assessment had five questions from each module to assess learning on all topics. Having multiple levels of questions allowed us to obtain a wide range of data to analyze what learners gained from the modules.

We used assigned numbers to anonymously keep track of learners and their pre- and post-assessments. This helped us determine if there were any areas in our modules that were not clear to the learners based on minimal improvement in their understanding of each subject. We used the percentage of learners whose knowledge increased in each area as a quantitative measure of how well the learners retained the information in the modules. To analyze our data, we
determined the average score on the pre- and post-assessment as a class. Questions on how the learner would apply the information were weighted more heavily than simple definitions based on a predetermined point system.

3.4 Summary

Our background research and interviews with stakeholders helped us identify the most important information for our modules. We organized the content into interactive SMART Board modules for delivery in rural Namibian villages. Next, we assessed learner participation in the lessons using an engagement survey and classroom observations. The engagement survey gave learners an opportunity to express their opinions on how interactive the modules were. Classroom observation assisted us in quantifying the level of learner engagement using a participation rubric. Finally, we assessed lesson retention using pre- and post-assessments. We accomplished our objectives, designed to help us reach our goal of improving sustainability education in rural Namibia, and provided EduVentures Trust with modules for use in their mobile classroom.
CHAPTER 4: Results

Our first objective was to create and test preliminary modules. We used the information from our stakeholder interviews to create a detailed outline of our modules. We then programmed three SMART modules and consulted with the EduVentures staff for module refinement and approval. Finally, we tested the modules at the Ondjaba yo Nghalu Combined School as part of the weeklong EduMobile Program for learners. Our second objective was to promote learner engagement with the lessons. We analyzed qualitative and quantitative data from our engagement survey and found that the majority of the learners were interested in our modules and the EduMobile Program. Through our classroom observations, we saw that learners were participating and interested in the modules. Our third objective was to optimize learner retention of the material. We calculated that there was an increase in the learners’ scores from the pre-assessment to the post-assessment.

4.1 Stakeholder Interviews

To achieve objective one, we interviewed stakeholders to collect information specific to Namibia. By using this method, we were able to determine teaching practices, the current state of energy in Namibia, and the major topics to include in the modules.

4.1.1 EduVentures Staff Interviews

Through our staff interviews with EduVentures we learned the topics they wanted covered in the modules and details on their structure. One of the most important takeaways we received from these interviews was understanding the language we should use in the modules. Since English is typically not the first language of learners in Namibia, all of the EduVentures staff advised us to avoid using advanced English in our modules. They also advised us to keep in mind that learners might not understand some of the visual media we reference in the modules, which may result in miscommunication due to technological or cultural barriers. Another key takeaway was the balance of lecture material and interactive activities within the modules. EduVentures expressed that they preferred to have many activities and interactive elements to maintain learner engagement with the modules. The staff noted that there is an increase in participation if each module’s concluding activity was exciting and competitive.

4.1.2 Educator Interviews

Through our interviews with three educators, we learned about how rural villages use energy and the potential for entrepreneurs throughout Namibia. Abraham Hangula of the
Namibian Energy Institute at Namibia University of Science and Technology (NUST) spoke to us about rural communities and how they use energy. He emphasized that while awareness of more efficient energy usage is important, it is certainly not enough. He believed that demonstrating the monetary value of efficient energy usage is critical to leaving an impact upon the learners. Silas Newaka of the Namibian Business Innovation Institute stressed the need and opportunity for innovation, collaboration of ideas, and entrepreneurship in rural communities. Many rural communities live without basic amenities, such as electricity and water sources. Such conditions show great potential for innovative eco-entrepreneurs to market technology within these communities. Michael Mulunga of the National Youth Council of Namibia advised that we demonstrate to the learners that farming, attending university, and/or moving to urban areas is not the only path to success. He suggested we showcase stories of successful eco-entrepreneurs and enterprises that have come from rural communities and strayed away from the particular career path that learners are pressured to follow. Michael also suggested that we include simulation activities, which he has found to be successful in inspiring learners to think as entrepreneurs. Overall, all three educators agreed that rural areas of northern Namibia have untapped potential, especially in the area of eco-entrepreneurship.

4.1.3 Organization Representative Interviews

We interviewed four representatives from local organizations to learn specific information for our modules. We learned more about the goals of the PREN project, current energy usage in Namibia, and the available solar funding programs. Rodney Seibeb of the Hanns Seidel Foundation gave us more information on what topics to include in our modules. As the director of the PREN Project, Rodney gave us insight into the different technologies that rural villages currently have. He suggested that we integrate innovation throughout all of our lessons. He wanted the modules to spark innovative thinking in the learners and to empower them to make changes in their own lives, which is one of the goals of the PREN Project. Bertchen Kohrs, the Chairperson of Earthlife Namibia, stressed the importance of switching from non-renewable to renewable energy. She gave examples of ways to be more efficient in rural villages, especially with the resources people have available to them. Bertchen also provided us with educational materials to bring with us to the Ondjaba yo Nghalu Combined School. Frans Hanghome of the Ministry of Mines and Energy provided us with more information on the current programs that are in place in Namibia to promote renewable energies. He stressed that the programs are developed but many citizens are not aware of them. A simple solution would be to better advertise the programs, especially in rural areas. He expressed that promoting the programs would assist Namibia in moving towards a more efficient state. Viktoria Keding, the co-founder of NaDEET, addressed information regarding energy efficiency. Since her company works to promote sustainable practices, she was able to give us tips on how to show learners that they are capable of starting their own companies using some of the efficient practices and habits they
learn in the classroom. In agreement with Abraham Hangula, she also mentioned that framing efficiency in terms of saving money is the best way to teach learners about these topics.

4.2 Module Development and Field-Testing

We developed our modules using the information we gained from our stakeholder interviews. Our modules followed the same general structure and features of the previous modules that EduVentures had. We incorporated many engaging elements into each module to maximize opportunities for learners to interact with the modules.

During the educator workshop we presented on how to use the SMART Software. We showed the educators the basic features and activities that they could include in a module. To demonstrate how these features can come together to make a complete module, we showed the educators our Resource Efficiency module. In this workshop we were able to train the educators so they had the tools to edit EduVentures’ SMART lessons to make them more specific to the educators’ regions. Although we did not receive any results on our modules from this workshop, we assisted EduVentures in increasing knowledge of the SMART software among environmental educators in Namibia. The following sections break down how each SMART module was composed and tested at the Ondjaba yo Ngalhu Combined School through the EduMobile Program.

4.2.1 Introduction to Energy

On the first day of the EduMobile Program, we tested the Introduction to Energy module. The Introduction to Energy module was 25 slides long and took approximately two hours to teach. Of the 25 slides, seven of them had smaller activities that allowed the students to come up to and interact with the SMART Board. This lesson started by defining energy. The opening slide allowed students to come up to the board and take different parts of the definition and put them together into a sentence. The educator described the difference between renewable and non-renewable energy, and which sources of energy are renewable and non-renewable. We then explained how the different renewable energies, such as solar, wind, wave and biomass, can be harvested and used to produce electricity (Fig. 4.1, overleaf).
We paired renewable and non-renewable energy sources with corresponding pictures and introduced an interactive activity to sort the energies into the two different categories (Fig. 4.2).

We provided learners with information on the advantages and disadvantages of renewable and non-renewable energy. For non-renewable energy we discussed that for many energy users it is convenient to use non-renewable energy because it provides a consistent source of energy and has been used for over a century now. Although using non-renewable energies may be convenient, they emit greenhouse gases, which can lead to climate change. Next, the learners played a sorting game where they came up to the board and put the examples in the
middle of the board into either the green box if it was an advantage or the red box if it was a disadvantage of renewable energy (Fig. 4.3).

![Advantages and Disadvantages Of Renewable Energy](image)

**Figure 4.3: Sorting the Advantages and Disadvantages of Renewable Energy**

We also taught the learners about Namibia’s current energy status and the potential for renewable energy throughout the entire country. The learners were taught what renewable energy was most beneficial in different areas in Namibia. Once the learners knew which renewable energy sources were best in certain areas, they had the chance to come up to the board and place where different renewable energies would be most appropriate on a map of Namibia (Fig. 4.4).

![Namibia's Renewable Energy Potential](image)

**Figure 4.4: Renewable Energy in Different Parts of Namibia Activity**

After this activity, the class had a discussion about what renewable energies are best for Namibia as a country and what is best for their own village. Lastly, we presented how switching
from non-renewable to renewable energy can be beneficial to the learner’s community and discussed what the learners could do in their own life. This is presented in a matching game where the students come up and match a picture to a definition. The backgrounds of the matching pair are the same color so that the educator can instantly know if the learner received a match. Before the learners completed their final activity they did a fill in the blank exercise that had eight questions reviewing the information that they had learned. In the concluding activity the learners were able to apply what they learned during the lesson to determine ways to use renewable energy in their community. The learners were split into three groups and were presented with three scenarios. They discussed with their group what advice they would give a fellow Namibian based off of environmental, economic, and social factors.

4.2.2 Resource Efficiency

During the morning of the second day of the EduMobile Program we tested the Resource Efficiency module. It consisted of 46 slides with 25 slides on content and the remaining slides were for Jeopardy!, the final activity. Eight of the content slides included interactive activities. The lesson took approximately two hours to teach. We began this module with a small activity where the learners could move a magnifying glass to reveal the definitions (Fig. 4.5).

![Activity for Learners to Find Basic Definitions](image)

*Figure 4.5: Activity for Learners to Find Basic Definitions*

We conveyed the importance of resource efficiency by showing learners the ways that not being efficient can affect them and the world. The educator clicked on the photos to reveal what each one represents (Fig. 4.6, overleaf).
Students then had a chance to brainstorm ways they could be efficient in their own village. To reinforce the concept, there was a matching game where students had the chance to match photos to descriptions (Fig. 4.7).

After, we addressed resource efficiency in relation to natural resource management, including energy, water, waste, and sustainable agriculture. We provided students with the definition of each efficiency as well as different ways they can be more efficient in each of the major areas. Each type of efficiency had a different activity, including dragging photos, drawing lines, or writing descriptions of ways to be efficient. We then explained the different benefits of
being efficient and included an activity where students could sort them into the proper categories. There were larger activities where learners could calculate the amount of money they would save if various resource-efficient practices were adopted in their homes. We showed learners the disadvantages of using inefficient resources and practices by highlighting the potential money wasted by such habits and their impacts on the environment. Then, we defined living sustainably and explained the advantages, which includes ways that they will benefit as individuals as well as how their community can benefit from being more efficient. After learning about the benefits, the students could come up to the board and sort concepts into living unsustainably and living sustainably. The module concluded with a group *Jeopardy!* game that gave the learners a chance to use the knowledge they learned during the lesson (Fig. 4.8).

![Figure 4.8: Jeopardy Board and Example of a Question](image.png)

**4.2.3 Eco-Entrepreneurship**

We were also scheduled to test the *Eco-Entrepreneurship* module on the second day of the EduMobile Program. We were unable to present this module on the SMART Board due to a malfunction with the solar power system of the mobile classroom. Although the SMART Board was not working, the educator was able to teach the lesson using the information from the module’s handbook.

We designed this module to inspire learners to think like entrepreneurs and to encourage eco-friendly business practices. This module was 24 slides long with six interactive activities. We first gave the learners an introduction to entrepreneurship by providing them with its definition. We then allowed them to brainstorm what eco-entrepreneurship may mean after learning what the word entrepreneurship meant. Learners would have come to the SMART Board to write in their thoughts (Fig 4.9, overleaf). After the brainstorming, we defined the correct meaning of eco-entrepreneurship and explained what the concept entails.
The module went on to demonstrate why eco-entrepreneurship is useful by highlighting the importance of sustainable development and green economy. There would have been a small activity demonstrating that all three pillars of sustainable development must be considered and balanced for it to be successful. When one pillar is removed, the village will fall (Fig. 4.10). This is one example where we had to use simpler English. The EduVentures staff recommended that we use “legs” of sustainable development instead of “pillars” so that the students would better understand it.

Next, we explained what a small and micro-enterprise (SME) is and the challenges that may be faced when starting one. The learners were then given an opportunity to think of ways that they could overcome the challenges and become successful business owners. After coming up with ideas on their own, we presented four examples of eco-entrepreneurship business options, including sustainable agriculture, hydroponics, aquaponics, and waste recycling. For
sustainable agriculture, students would have been asked to come to the board and create the sentence to define the term (Fig. 4.11).

![Figure 4.11: Defining Sustainable Agriculture](image)

Next, in the module, the learners would have been able to sort pictures to match the types of eco-entreprises had the SMART Board been working (Fig. 4.12).

![Figure 4.12: Sorting Different Types of Eco-Entrepreneurship](image)

The lesson finished with an activity where learners split off into groups and came up with a solution to a problem in their community. The students developed a business pitch and presented it in front of their peers and the educator. This activity could be completed without the use of the SMART Board.
4.3 Engagement in Lesson Plans

We observed and analyzed learner engagement with the SMART lessons. It was our goal to make the SMART modules as interactive as possible. To do this, we embedded interactive media throughout the modules and programmed one large group activity to conclude each module. This technique was used to keep learners engaged throughout the entire lesson. Our engagement survey and classroom observations provided us with qualitative and quantitative data that helped us gauge learner interaction with the SMART lessons.

4.3.1 Engagement Survey

We gave an anonymous engagement survey to each learner at the end of the weeklong program. We calculated the average for each question on the survey to assess the modules on various criteria such as learners’ willingness to participate, learners’ interest in the lessons, and aspects that learners did or did not enjoy. We summarized the written feedback from the open-ended questions to assist us in our recommendations to EduVentures.

On the first question, the learners claimed that they were willing to participate in the lesson with an average score of 4.47 out of 5. Learners who are more shy or nervous may have been less likely to participate in the lessons, which could have resulted in lower scores on this question.

Learners ranked that they had fun during the lessons with an average score of 4.37 out of 5. Since the SMART Board was not working for the last module, there were no interactive elements for the learners to participate in. This could have caused the learners to not have as much fun with this lesson, affecting their overall view of the modules.

The average score for how focused the learners were during the lessons was a 4.21 out of 5. The learners who ranked this question lower may have had a tough time with the length of the lessons. Each lesson lasted multiple hours, which may be longer than they are used to sitting in a classroom. Also, the new environment and technology could have been distracting.

Learners also found the lesson content to be very interesting. They ranked this question at an average of 4.95 out of 5, which is the highest average rating of all the questions. This showed that our modules presented new, relevant, and intriguing information to the learners.

Finally, learners believed they were likely to apply the information they learned to their everyday lives with a average score of 4.53 out of 5. This feedback was particularly encouraging because it showed that learners were willing to utilize the skills and knowledge they gained from the program at home and in their community. Some learners may have ranked this question
lower due to the fact that their energy consumption and environmental impacts are minimal because their village is not on the power grid. Therefore, they may have a harder time seeing and understanding the value in changing their habits. A summary of statistics for the survey can be seen in Table 4.1.

<table>
<thead>
<tr>
<th>Question</th>
<th>Average (Out of 5)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you find the content of the lessons interesting?</td>
<td>4.95</td>
<td>0.229</td>
</tr>
<tr>
<td>How focused were you during the lesson?</td>
<td>4.37</td>
<td>1.21</td>
</tr>
<tr>
<td>How willing were you to participate in the lesson discussion?</td>
<td>4.47</td>
<td>0.697</td>
</tr>
<tr>
<td>Did you have fun?</td>
<td>4.21</td>
<td>1.32</td>
</tr>
<tr>
<td>How likely are you to apply what you learned to your everyday life?</td>
<td>4.53</td>
<td>1.17</td>
</tr>
</tbody>
</table>

We used the learners’ qualitative feedback to complement the quantitative data we received. Overall, most of the learners stated that they thoroughly enjoyed using the SMART Board and playing the educational games. The learners either expressed no issues or mentioned that they were not satisfied with the Eco-Entrepreneurship lesson. This is likely because the module could not be shown, leaving the learners wanting the fun and interactive aspects of the previous two lessons. Finally, the only area for improvement, according to the survey, was to fix the solar panels, which provide power for the SMART Board. The qualitative feedback supported the quantitative feedback, demonstrating that the learners genuinely enjoyed learning and interacting with the SMART Board.

### 4.3.2 Classroom Observation

Through a classroom observation rubric, we assessed how engaged learners were with each of the SMART lessons. We associated changes in learner behavior with the material and activities they were shown at a particular time and counted the number of learners that exhibited each behavior for each lesson. We used the number of students to determine the overall percentage of learners that exhibited positive and negative engagement behaviors for each time segment. Lastly, we determined the overall level of interaction the learners had with the lessons. Since the SMART Board was not working during the Eco-Entrepreneurship lesson, the data
collected through classroom observation did not reflect student interaction with the module. Therefore, we only analyzed the observation data that we collected from the Introduction to Energy and Resource Efficiency modules to determine the quality of our modules.

Through classroom observations, we recognized that very few learners exhibited the negative behaviors that we were looking for, such as falling asleep, engaging in side conversation, and expressing confusion. We noticed that about 10% of the class engaged in side conversations, mostly to share notes with their classmates if they missed information. We also observed that all students were looking at the board almost 100% of the time. This showed that they were engaged in the information being presented and their surroundings did not distract them. The Introduction to Energy module was the most engaging because it had more involved activities included in the slides. Learners participated in group discussion twice as much as during the Resource Efficiency lesson. Learners took the most notes during the Resource Efficiency module. An average of 98% of students were taking notes throughout this module compared to 40% during the Introduction to Energy lesson. The activities, such as matching games and Jeopardy!, made the students more excited and engaged than any other portion of the modules. Since an outside observer can only perceive body language to a certain extent, we placed more importance on learners’ feedback to analyze engagement.

4.4 Lesson Retention

To achieve objective three, we analyzed how learners retained the material from the SMART lessons. The learners completed a duplicate set of assessments of the material covered in the modules. Learners completed the pre-assessment on the first day of the program before any lessons were taught and the post-assessment on the final day of the program after the completion of all lessons. We used this information to assess the change between learner knowledge of the material before and after the lessons. To examine the performance of the class, we first looked at the distribution of unweighted and weighted scores. Then we calculated the average unweighted scores, the average weighted scores, the average scores in each weighted category, and the average scores for each module for both assessments.

The distribution of student grades on the pre- and post-assessment for unweighted scores shows the improvement of each student (Fig. 4.13, overleaf). There was a more even distribution of grades on the post-assessment when compared to the pre-assessment. On the pre-assessment, the highest score was 26.7% and the highest score on the post assessment was 100%. This tells us that most students had an increase in their score.
Figure 4.13: Distribution of Pre- and Post-Assessment Unweighted Scores

The distribution of student grades on the pre- and post-assessment for weighted scores shows the improvement of the class (Fig. 4.14). On the pre-assessment, the highest score was 22.2% and the highest score on the post assessment was 100%. This tells us that most students had an increase in their score based on a more even distribution of post-assessment scores.

Figure 4.14: Distribution of Pre- and Post-Assessment Weighted Scores
The class’ average unweighted score was 9.12% for the pre-assessment and 50.5% for the post-assessment. This showed a 41.4% increase in unweighted scores. The class’ average weighted score was 8.77% for the pre-assessment and 52.1% for the post-assessment. This showed a 43.3% increase in weighted scores. The learner with the greatest improvement demonstrated a 82.2% increase, whereas the learner with the lowest improvement scored a 0% on both assessments. Eight out of the 19 learners had an increase of over 50% in their weighted score. The larger improvement in weighted scores when compared to the increase in unweighted scores shows that students were able to better apply the information to their lives after the modules were taught. The difference in improvement from pre- to post-assessment could be due to varying levels of interest in the subject and proficiency in English.

The data we collected showed that the lessons effectively communicated the information to the learners. Not only were the learners receptive to the content, but they also demonstrated their ability to apply what they learned (Fig. 4.15). We used a two-tailed, paired t-test to determine significance in score increase. There was a statistically significant increase in the scores by weight, with a p-value of 0.022.

![Figure 4.15: Average Test Scores per Question Weight](image)

The most significant improvement between the two assessments was found in the Eco-Entrepreneurship module; however, the Introduction to Energy module had the highest overall score for both the pre- and post-assessment. The learners most likely picked up on the eco-entrepreneurship information easily due to the fact that it is a subject they are familiar with, as entrepreneurship is part of their school’s curriculum starting in eighth grade. We used a two-tailed, paired t-test to determine if the increase in scores was significant. Figure 4.16 (overleaf)
shows that there was a statistically significant increase in weighted scores per module, with a p-value of 0.016. Modules 1, 2, and 3 on the graph below refer to Introduction to Energy, Resource Efficiency, and Eco-Entrepreneurship, respectively.

![Average Test Scores per Module](image)

**Figure 4.16: Average Test Scores per Module**

### 4.5 Summary

The data that we collected demonstrated that we achieved all of our objectives. The stakeholder interviews provided us with the information to supplement our own research, which we used to develop our modules. The engagement survey gave us the opportunity to understand what learners thought about the lessons. To further gain information, we used the classroom observation to determine our perceptions of learner engagement with the lessons. The pre- and post-assessments showed us that the learners were able to retain the information that was taught in the modules throughout the week. We found a statistically significant increase in the assessment score and a high level of positive engagement with the lessons. Through stakeholder interviews, module programming, engagement surveys, classroom observations, and a retention assessment, we collected enough data to provide EduVentures with recommendations on how to improve the program in the future.
CHAPTER 5: Recommendations and Conclusion

At the conclusion of our project, we formulated recommendations for EduVentures to improve their EduMobile Program. We made these recommendations based on the data collected from our field-testing at the Ondjaba yo Nghalu Combined School in northern Namibia.

5.1 Recommendations

We made recommendations on training, educational materials, classroom interactions, and the EduMobile Programs. These recommendations for EduVentures will aid in making environmental education more thorough and consistent throughout Namibia.

Following the EduVentures workshop, we recommend that EduVentures hosts at least two workshops per year to enhance educator training. These workshops should cover important energy topics and how to use the SMART software. This will allow the educators to return to their centers where they can share the updated material with local teachers. At the workshops, educators should receive additional materials with detailed instructions on the module content and teaching techniques. These training materials would assist in making the rural education system more uniform and would provide EduVentures with the infrastructure to increase the outreach of the EduMobile Program.

Since EduVentures visits many different schools around Namibia, it is important that they update the material in the modules for each school. First, it would be helpful if the educators and teachers could translate the modules into the native language of the village they are visiting. When delivering the lesson, the educator often had to switch between English and Oshiwambo so that the learners could fully understand the information. If educators are trained on the SMART software, they will have the ability to translate the modules so learners can be taught in their native languages. This will allow teachers to better communicate information to the learners without fear of losing details due to language barriers. The information in the modules should also be updated frequently since educational material and technology change so rapidly. This will help with teaching the newest information to the learners, including what is most relevant to their lives. In order for environmental education in Namibia to progress, information must be continuously updated, which will allow learners to become and remain interested in current energy topics.

Through our classroom observations, we noticed that students were very reserved, especially at the beginning of a lesson. We recommend that EduVentures starts each lesson with an interactive game to make the learners more comfortable in the new environment. Each lesson could start with a fun game that would recap the last lesson they covered. We also recommend
that the weeklong program start with an activity, such as the walk they typically do on Wednesday. This would give the learners an opportunity to get to know the educators so that they are not as nervous to participate during the lessons. These recommendations would allow for a more interactive atmosphere than in a conventional classroom, ensuring that the students are engaged and having fun while they are learning.

Based on our time in the field, we recommend that there be a different course of action in the instance that the Ombombo truck is not functioning properly. On our trip, the solar panels on the truck were not correctly connected, so there was no power to work the SMART Board. Technical difficulties can be experienced at any point, especially given the road conditions and the distance to the nearest mechanic. Since EduVentures has many other projects they are also working on, it may be difficult for them to take the time to focus on scheduling activities for the school visits. WPI and EduVentures have developed a strong working relationship; therefore this could be an opportunity for another Interactive Qualifying Project. This project could include updating and editing all the current modules, developing an agenda for the weeklong program, and determining a backup plan for when the SMART Board is not working. For example, a backup plan could have lectures that don’t involve the SMART Board, activities that do not need electricity, or outdoor games that are related to environmental topics. This would help to ensure that the EduMobile Program reaches its full potential and achieves everything it is meant to.

5.2 Conclusion

We have recognized the need to improve education, especially on energy consumption and sustainability practices, in Namibia. Through our partnership with EduVentures Trust we created three interactive SMART modules for their EduMobile Program. The SMART modules conveyed the important information to the learners, which was shown by a significant increase in test scores from the beginning to the conclusion of the program. We received feedback from learners on how interactive and engaging they thought the lessons were so that we could make changes that will further enhance the modules.

The SMART lessons and the EduMobile Program play a valuable role in the PREN initiative to encourage environmentally conscious lifestyles and promote technologies that facilitate such behavior. Knowing this, our project improved education in Namibia by bringing environmental education to rural learners that otherwise would not learn about it in their classrooms. Our project stimulated learner interest in mitigating environmental issues in their communities. This is important to help protect Namibia, and the world, from the future effects of climate change and other environmental issues. Our project helped to improve environmental awareness in Namibia and will lead the country to a more sustainable future. Mobile classrooms, like the EduVentures’ Ombombo truck, have the potential to bring education and new technologies to even the most rural areas of Africa and the world.
REFERENCES


doi:10.1016/j.renene.2008.05.002


doi:10.1177/026666907087694

(Undergraduate Interactive Qualifying Project No. E-Project 050517-040423).


APPENDIX A: ENGAGEMENT SURVEY
Please answer each question on a scale of 1-5 (1 being not at all and 5 being very)

Did you find the content of the lessons interesting?
1  2  3  4  5

How focused were you during the lesson?
1  2  3  4  5

How willing were you to participate in the lesson discussion?
1  2  3  4  5

Did you have fun?
1  2  3  4  5

How likely are you to apply what you learned to your everyday life?
1  2  3  4  5

What portions of the lesson did you enjoy?
________________________________________________________________________
________________________________________________________________________

What portions of the lesson did you not enjoy?
________________________________________________________________________
________________________________________________________________________

What portions of the lesson do you think could be improved?
________________________________________________________________________
APPENDIX B: PRE- AND POST-ASSESSMENT

Identification Number: ____

**Introduction to Energy Sources**
1. Define energy and list the two major categories of energy. (2)
2. Describe the difference between renewable energy and non-renewable energy. (3)
3. Describe one example of renewable energy and explain how it works. (3)
4. List two reasons why non-renewable energy can be bad. (2)
5. What are some of the renewable resources you could use in your life? How would you use them? (5)

**Energy Efficiency**
1. Define resource efficiency. (2)
2. Name the four types of resource efficiency. (2)
3. Explain the importance of resource efficiency. (3)
4. Describe the advantages of living sustainably. (3)
5. What are some of the ways you and your family could live more efficiently in your home? (5)

**Eco-Entrepreneurship**
1. Define entrepreneurship and eco-entrepreneurship. (2)
2. Name the three pillars of sustainable living. (2)
3. Explain two challenges faced by eco-entrepreneurs and describe how one could overcome such challenges. (3)
4. Explain the importance of eco-entrepreneurship. (3)
5. Describe an idea you have of for an eco-friendly business you would start in your community. (5)