



To Be Green Or Not To Be Green? Ethical Tools for Sustainability Engineering

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Abstract

Engineers are increasingly being asked to design products and process that reduce the overall impact society has on the environment as more people realize the rising need to develop sustainable resources and to be responsible when using existing resources. In order to adequately prepare students to enter this ever increasing demand for sustainable engineering, students need to have an understanding of the technical needs of society as well as the human component in design, be it the use of local resources, the lack of surplus resources, the change in societal values, and expectation of justified answers from the public, business, and individuals.

Set within the framework of an introductory course to sustainability engineering, students from multiple engineering disciplines are introduced to the code of engineering ethics and to the application of engineering ethics to sustainability dilemma within a series of group activities. During the activities, students address the questions of “Who has to die?”, “Paper versus Plastic?”, and “How much house do I need?”, where there is not a clear conclusion to a “good” choice.

In “Who has to die?”, the changes and difficult choices stemming from the a lack of resources form the basis for discussion of changes in acceptable practices in society and how a society might decide who will have access to the resources. The students themselves represent the members of society and the class discusses some of the underlying issues that influence how a person could reach a conclusion of who survives. At the start of the “Paper versus Plastic”, students tend to be apathetic about the choice between paper and plastic bags until they are placed in competing groups. Once placed within a group that must defend a selection, students begin to increase their level of participation and their advocacy on a particular choice. At the end of this activity, students present a short message to persuade the entire class of paper or plastic. Afterwards, group discussion includes not only the technical merits of each choice but the change in levels of advocacy the class has undergone. In “How much house do I need?”, students are asked to consider their housing needs and desires and to weigh them against housing requirements of previous generations and extreme green living examples.

1.0 Introduction

Engineering has maintained a code of engineering ethics in order to maintain the integrity of the profession and the confidence that society places on its engineers. The continuation of these aspects of the engineering profession requires engineering students to be able to understand engineering ethics and to apply their understanding to both their individual everyday decisions and to their field as a whole. The need for ethics within the engineering profession is of such importance, that engineering programs seeking accreditation must be able to prove that ethics is taught.¹

This responsibility to society becomes more pronounced as our nation looks to engineering to address areas of renewable energy, sustainability, clean water, and even urban infrastructure.² However, the students within our program are not required to take a specific engineering ethics course. This places our students at a disadvantage if they are not able to consider the ethical questions that emerge from protecting the existing environment and resources, from increasing the efficiency of existing processes, and from resource allocations that are prevalent in sustainability engineering.^{3,4}

Unlike programs that have a dedicated engineering ethics courses, our program must be able to inject ethics within the context of other courses throughout their engineering education.⁵ This course shows how that approach could be applied without losing massive amounts of time within the classroom, which is one possible approach to addressing this problem.⁶ Therefore, the curriculum developed for this sustainability course is able to give students a broad overview of major ethical points while only occupying a limited timeframe within a course. This curriculum relies and builds on the students' everyday understanding of ethics and common sense approach to problem solving to circumvent the need of large amounts of reading that hinders more traditional approaches to engineering ethics education.

2.0 Background

2.1 Course Background

This course in Sustainable Engineering gives students a broad overview of the challenges and opportunities within this growing field so that they can consider careers or a higher degree in sustainability engineering. The key components to this course include Sustainability Engineering Challenges and Background, Life Cycle Assessment, Thermal Review, Eco Design, and Ethics and Consumerism. The amount of time dedicated to these components and to assessment is depicted in Figure 1.

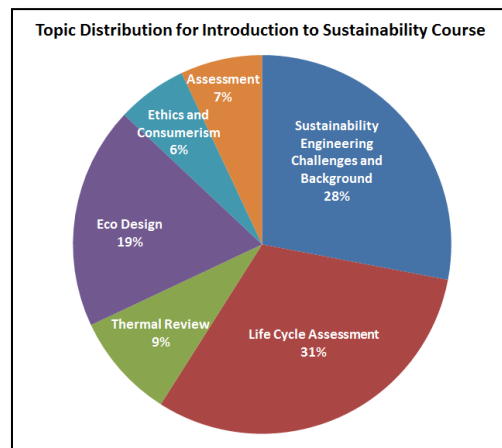


Figure 1. Distribution of topics throughout the Introduction to Sustainability

Therefore, students are first exposed to issues that are critical to Sustainable Engineering and what that would imply to society and the infrastructure that supports and maintains our current

society. The course expounds on the interconnections between natural resources, energy, supply chains, and consumer demand and our current limitations. In this way, students can connect their engineering training and skills to the challenges of creating a sustainable infrastructure for tomorrow.

During the second portion of the course, Life Cycle Assessment (LCA), students learn the theory of LCA as well as obtain some hands on experience by applying this approach to compare two similar products using Gabi software. Within the project, students define a set of system parameters to determine the boundaries of their assessment, whether it is cradle-to-grave, gate-to-gate, or gate-to grave. Students must determine a functional unit that is essential in comparing the two products and the emissions released to generate, transport, and disposal.

The third portion of the course is a review/introduction of basic thermodynamics concepts, namely the First Law of Thermodynamics, conduction, convection, and radiation. This portion of the course was included due to the lack of thermodynamics background of our Industrial Engineering students. Without some of these basic concepts, students would not be able to have a complete picture of heat losses that are necessary for their Life Cycle Assessment.

Within the fourth portion of this course, students are formed into groups and are asked to develop their own green designed system or a designed city. Students are taken through the process of ideation all the way to prototype or mock up design. They must defend their choices of green technologies or green alternatives and demonstrate that either their designed system is a better option or that their designed city is sustainable.

Within the Ethics and Ethical Consumerism portion of the course, students realize that all ethical and green options may not be obvious or simple solutions. Students are placed in the shoes of a Company, a Sustainability Engineer, and a consumer through role playing, so that they grasp the driving motivations of each. Students examine the methods of approaching an ethical dilemma, the resolution of that dilemma, and how green technologies interact with consumers and industries. This component, as depicted in Figure 2, delivers some basic knowledge about the code of engineering ethics, greenwashing, and consumerism. It also contains group activities to encourage relating ethics to commonplace aspects of life and areas in engineering.

2.2 Student Background

The class is comprised of students from the undergraduate and the graduate level students from the Civil, Mechanical, Electrical, and Industrial, Manufacturing, and Systems Engineering Departments. Even with the wide range of disciplines present in any given class, none of the students have been required to take a structured ethics course during the completion of their engineering degree plans. Under the current degree plans, students do have the option to take an ethics course, PHIL 2306 Ethics: Philosophical Perspective on Human Conduct and Values, to fulfill their Humanities Core Requirement. This means that students entering this course may have little exposure to ethics or a general background of ethics, without specifically addressing engineering or sustainability. Students invariably receive their background in engineering ethics throughout their coursework, their interaction with their professors, and through any internship or coop opportunities they may have. However, this ethical background is irregular in terms of

students' exposure and untested in terms of students' application to an ethical dilemma or ethical consideration. For this reason, the ethical component needed to include some engineering basics and tie them to sustainability.

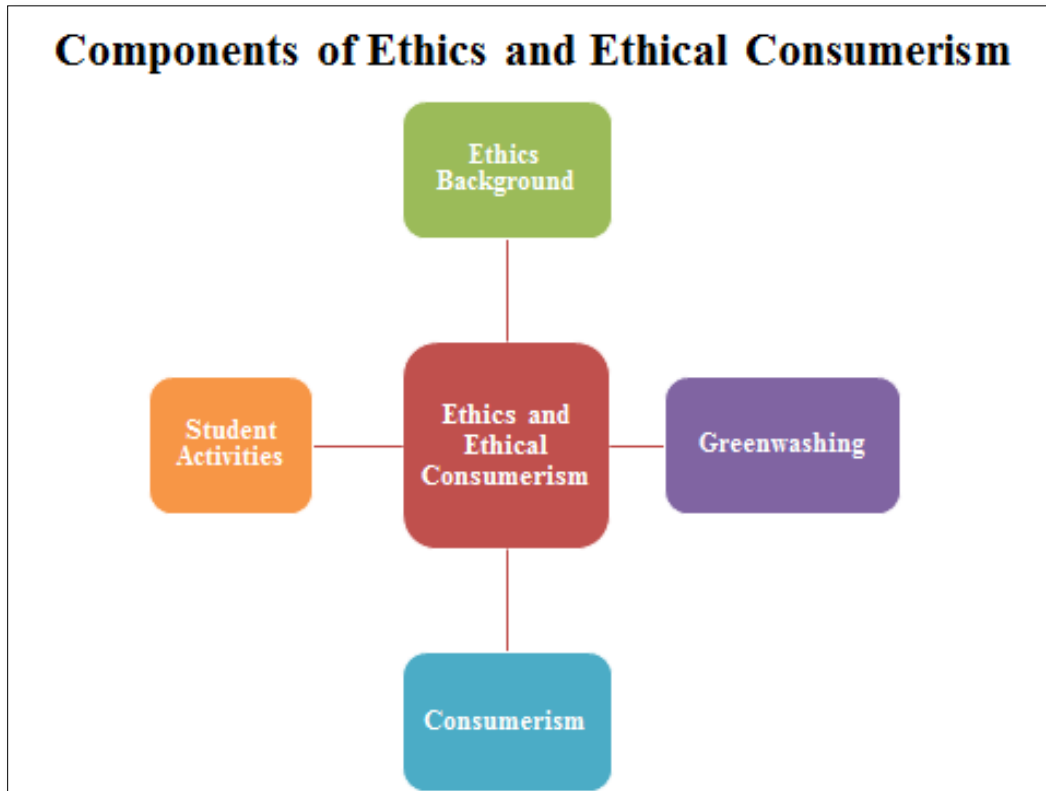


Figure 2. Components of Ethics and Ethical Consumerism.

3.0 Key Ethical Concepts

Due to the limited timeframe, the use of ethical codes and reliance on case studies would not allow students to face specific ethical questions. However, it is crucial that students begin to consider ethical issues and their impact on practicing engineering, namely,

- What methods could be used to resolve an ethical dilemma or to reach a decision?
- What ethical codes do we have and what codes do we really follow?
- What constitutes a “need” for the individual?
- What ethical issues are facing our global, national, and local economies?
- How does your relationship with the product affect the perception and attitudes towards a product or process?

For this reason, students have an overview of the code of ethics from the National Society of Professional Engineers (NSPE).

Likewise, this timeframe does not allow an in depth look at the philosophers that have shaped ethics as we know it today. For this reason, it is important to compress their philosophies into methods for application. Students review the concepts of Cost-Benefit Analysis, Duty Ethics,

Moral Absolutes, Utilitarianism, and Virtue Ethics as possible guides to resolving an ethical dilemma. This background in ethics and dilemma resolution serves several purposes, namely 1) fulfilling ABET objectives, 2) guiding students to see problems, beyond the merely technical, as having human and environmental considerations, and 3) equipping students with tools to address all design considerations.

4.0 Components of Ethics and Consumerism

4.1 Student Activity #1: Hansel and Gretel – Who is Going to Die?

In order to introduce the concept of decision-making and to examine the ethical codes students adhere to, we have students participate in a scenario activity named, “Who is Going to Die?” In this activity, one of the students plays the role of the Parent, while the other students play the role of the Children. The Parent has a bag of candy that represents all the resources this family has. The Parent is tasked to decide which of the Children will receive enough candy to survive and who will not.

At this stage typically has the Parent asking for advice from the instructor, namely

- *How are they to decide who lives?*
- *Why would anyone do this?*

The answer to “Why would anyone do this?”, is based climate change and hunger, two topics that are still relevant today, especially in sustainability. The root to the fairy tale of Hansel and Gretel lies in the Little Ice Age of Europe during the Middle Ages. Plague and excessive rain and cold lead to food shortages and families sometimes made difficult decisions to ensure the survival of at least part of the family. The endurance of this fairy tale through the centuries indicates that this was not an isolated incident within the Middle Ages. In this scenario, the father must decide between his survival and his wife’s survival over that of his children. This question introduces the concept of accepted societal norms both in the past and in the present and how that might influence decisions.

These questions and historical facts open discussions about how individuals are valued by our society and other societies, our perspective based on our proximity to a problem, the influence of delayed benefits, and impacted of limited resources. This activity is quite simple to undertake, it opens discussions about methods for resolving an ethical dilemma and can be linked to modern day issues such as the resource allocation, distribution of resources in everyday operations to disaster areas, optimization, and even supply chain management.

Given the quick delivery of this activity and the dearth amount of information given to the students, students realize this decision process could be quite complicated and that society and industry need a well thought out answer. Through discussion about the decision making process in this activity, students examine the task of resolving an ethical dilemma and how they might justify their decisions to others. It is within this context that we discuss Utilitarianism, Cost Benefit, Virtue, Duty, and Rights Approaches to decision making. As with many semester long courses, the introduction of these approaches forms the foundation of a student defending their

decision to both themselves and to others. For this reason, this activity is given prior to any of the other ethics activities designed for this course.

Additionally, this activity allows the students to consider their own set of ethics and motivators to being ethical. Since the Little Ice Age is a historical fact, we can look to the past for concrete evidence on how lack of resources changed and shaped a society. It comes as a surprise to many students that the tale of “Hansel and Gretel”, where two young children are left to die by their wicked step-mother and that mirrors our activity, stems from this culture and this time period. Since this has been a popular tale told through the centuries, society must have been aware that such measures were in fact being taken to increase the likelihood of survival of the few. This discussion can include the development and modifications of an ethical code, their own personal code, and the Engineers Code of Ethics

4.2 Student Activity #2: How Much House Do I Need?

Like most people, students know we need air, water, food, and shelter to survive, but most have not considered when a want becomes a need within a society. Nor have they considered what the impact of meeting inflated views of needs means for our natural resources, our infrastructure, and our ability to create a sustainable society. In this activity, named, “What Type of House do You Want”, students are placed in the shoes of a typical consumer. As a class, students are asked to name the features they desire in the home of their dreams and how many people will live in that home. The list of features can become quite long and somewhat atypical as students consider their options. It is interesting to note that each group usually has a bathroom for each bedroom and at least one guest bathroom. It is also important to note that the number of people living in this dream house has never exceeded two people and two pets.

Students are then asked to consider housing options stemming from green technology, design for smaller urban spaces, and even art, such as the ones in Figure 3, and how these existing options could influence or alter their list of desired features. Most students, like most consumers, are unwilling to greatly change their level of personal comfort or perceive investment. This activity illustrates to the students that even with innovative solutions, consumers may agree with the overall concept of being but may not take action to apply it to their own situation.

Reviewing the options in sustainable housing leads to a discussion about meeting basic housing needs and meeting housing desires. Examples of basic housing can be seen in relatively inexpensive housing designs that have been generated for victims of natural disasters or for impoverished communities. These designs are laid out such that a typical family has the “necessary” components of a home. The comparison between the two houses makes a clear distinction between a need and a want. Most students recognize that the house that they want far exceeds their basic needs and contributes sharply to their overall carbon footprint.

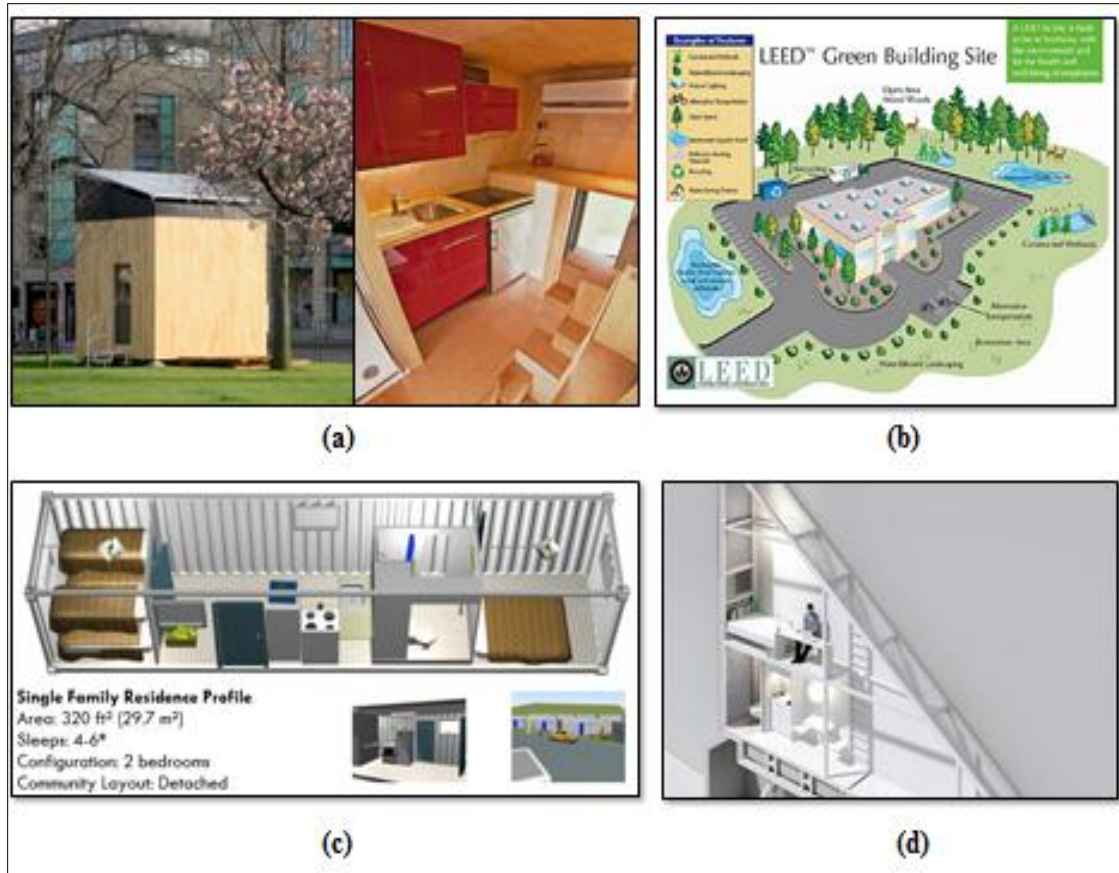


Figure 3. Housing and building options presented to students that could reduce their personal carbon footprint. (a) Exterior and interior of the Cube Project, a carbon neutral 3m x 3m x 3m home designed by the University of Hertfordshire, (b) LEED Building site with sample features, (c) PFNC Design for an \$8,000 home using shipping containers for low income families in Mexico, and (d) Thinnest house in the world designed by Polish architect J. Szczensy

Students are then asked to consider the typical home designed in the 1950's, such as the one in Figure 4. During this time, home designs have one bathroom for the use of the entire family. When this is placed in contrast to the number of bedrooms and baths in their Dream Home, students are asked, "Why do they need so many bathrooms?" given that people today are not different physically from those in the 1950's. Students quickly realize that the needs of the individual have not changed much in the past centuries and that many of today's needs are in fact wants. The increase in the demand for amenities has fueled renovation of existing structures, innovative design solutions, finding new and sustainable materials, and increasing the available energy to power it all in order to maintain consumer wants while attempting to reduce the economic impact on the consumer and maintain the environment.

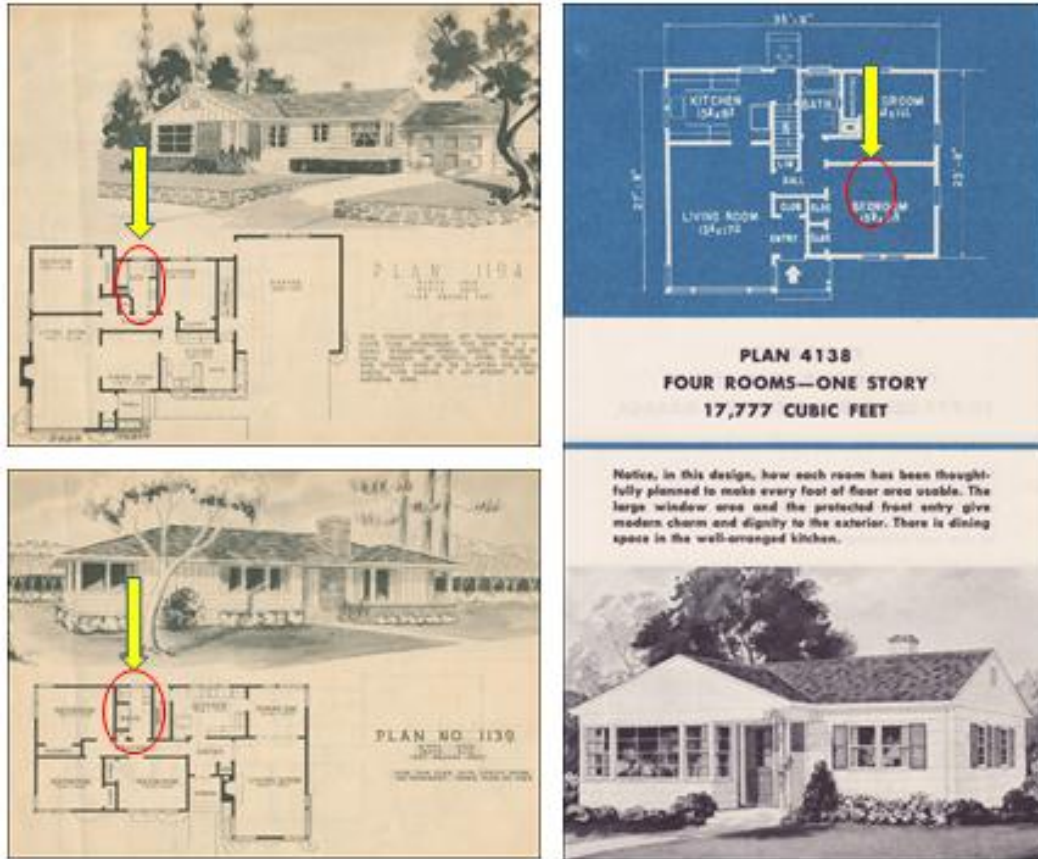


Figure 4. Layouts from three typical 1950's homes that show the inclusion of only one bathroom.

4.3 Student Activity #3: Paper vs. Plastic

In this activity, “Paper versus Plastic”, students must fill the roles of the impartial observer, part of the company, and as a consumer. As impartial observers, students are asked “What’s better, paper or plastic?”. Since students have already performed the life cycle assessment of both paper and plastic, they are all aware of the advantages and disadvantages of both products. Within this role, students are typically dispassionate about the outcome of the discussion. Next, the students are placed in the role of a company that produces and hence supports a particular product. Within their groups, students must create an advertisement that supports the selection of their product. Once placed within these teams, students become competitive; they focus only on positive attributes of their product, create negative images of the other product, participate in deception, create false labels, and rely on catchy jingles. While students can present a wide variety of creative advertisements, what really shocks students is the amount of time required for them to become adamant supporters of their product when only an hour before they really did not care one way or another. This activity leads to the discussion of company mindsets and peoples reaction to any type of opposition and/or change. Since this type of behavior can easily be seen within manufacturing, engineering, and industrial firms, students must be prepared to encounter and manage this type of reaction.

At the end of this activity, students are asked to play the role of an average consumer and select a product based only on the advertisements produced in class. Given this task, students can see how society might come to their sustainability decisions based on current advertisements and media.

4.4 Green Washing and Engineering

Sustainability goes beyond creating a green option for the market; it must be able to sell the green option. Within this section of the course, we provide a brief overview of Green Marketing, the advertising and marketing of green products and services. Part of the general increase of Green Marketing also includes Green Washing, the deceptive use of marketing to promote the perception of an organization or of specific products. Students are exposed to how companies can green wash through omission, irrelevance, and even false or misleading labels. Companies can even rely on the ignorance of the general public's awareness of valid labels. This possibility is proven to the students, a set of consumers with education, when they judge the labels in Figure 5. Students are also challenged to rank common products based on their labels. Typically, students rank products with green colored labels higher than others. These exercises reinforce the



Figure 5. Sustainable Products have given rise to both reliable and fake labels to influence consumer decisions. Students are asked to judge the validity of these labels.

4.5 Ethical Issues facing global, national, and local economics

As students are considering their wants and their needs, it is important to highlight the ethical issues that impact the supply of products required to meet our needs and our desires. Due to the global nature of our current economy, it is possible to hide these ethical issues by having the interested parties separated by distance and language. The areas of concern that students should be aware of are still ethical issues around the world and even here in the US include,

- Slave labor
- Child Labor

- Animal Exploitation
- Ethical Banking
- Fair Trade

Most students do not condone slavery, child labor, or animal exploitation, but fail to realize how these practices might indeed be part of the processes used to generate their next purchase. Few of the students are aware of the methods corporations find to circumvent these issues publicly but who profit from these methods directly or indirectly. At this point, the reality of distance and how it affects their ethical choices can become apparent to students.

Contrasting the power and money of corporations, the ability of the individual to build a business, maintain a business, or increase their earning ability can be greatly hindered by the inability to obtain a relatively small loan or the inability to sell their products efficiently. This introduces the need for ethical banking practices for the public both here in the US and around the world and the need for Fair Trade practices.

5.0 Evaluation

Students were evaluated both quantitative and qualitatively. Students were assessed for their knowledge of the code of engineering ethics, of methods of greenwashing, and sustainability topics using quizzes. The green city designs were also evaluated to determine if there were sufficient resources to meet population need and the resources were allocated equally among the proposed population and the proposed environment. Students were evaluated qualitatively during the in class activities. During Paper vs. Plastic, students were assessed on their initial position, their final position, and their contribution to the follow up discussion as they realized how much their opinions and intensity had changed within the space of a class. Similarly, student discussion was assessed after Hansel and Gretel and Ethical Issues, since both of these topics exposed students to some harsh realities and can lead to a broad range of topics. In “How Much House Do I Need?” and Green Washing, students discussed their own views as consumers and how difficult consumer views and habits are to change.

6.0 Conclusions

This curricula provides a structured format to efficiently introduce major ethical concepts to engineering students within the framework of a sustainability course to both fill in the gaps in our current engineering degree plan. This curricula is able to expose students to methods for resolving ethical dilemmas, understanding their own ethical code, understanding the professional code used by their discipline, ethical issues facing economies, and how relationships can attitudes toward products. By providing students with these tools, students become better equipped to answer both general engineering dilemmas and sustainability engineering dilemmas. The ability to package these major concepts in such a way that they can be delivered within a timeframe of 1-3 classes of 1.5 hours, allows the instructor to adjust the activities to their specific needs and time constraints, to insert this topic at almost any point of the semester, and to use the role playing nature of these activities to engage students in discussion. These topics also allow for students to question, consider, and discuss society’s norms, society’s needs, and society’s expectations of engineering solutions and technology. The ability to think beyond the

technological design is crucial to developing engineers that are also leaders and promoters of sustainable policy.

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