# AC 2009-979: INTRODUCTION TO SUSTAINABLE MANUFACTURING USING THE LCA FRAMEWORK FOR A BANANA SPLIT

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# Introduction to Sustainable Manufacturing Using the LCA Framework for a Banana Split


## Abstract

The current manufacturing mindset is not environmentally friendly; however, industry and academia are beginning to recognize the importance and impacts that manufacturing has on the environment. This paper presents a creative approach module to introduce first-year manufacturing engineering technology students to sustainable manufacturing using the Life-Cycle Assessment (LCA) of a banana split. Using a team-based collaborative approach, the students make the ice cream from the basic ingredients while examining the anatomy of the individual components and conducting a mini-LCA on each. This approach is both hands on and theoretical and is designed so the students begin to view the environmental impacts of manufacturing, including the acquisition of raw materials, materials manufacturing, production, use/reuse/maintain, and waste management. The student outcomes are to:

- Gain insight into the energy loss to produce a product.
- Obtain information on the Eco-indicator 99 damage type life cycle assessment.
- Explore a holistic approach to manufacturing.


## Introduction

Industry and academia alike are starting to focus their efforts in sustainable manufacturing and industrial ecology. Organizations like the National Council for Advanced Manufacturing are leading the charge to broker collaboration and educate both industry and academia.[1] Universities are developing course, curriculum and research groups that emphasize sustainable manufacturing.

Kettering University is one such organization, receiving a three year, 100k grant from NSF to create an Environmentally Conscious Design and Manufacturing collaborative course with professors from various backgrounds.[2] The professors' areas include History, Chemistry, Mechanical Engineering, Industrial Engineering and Business, which introduce students to a wide variety of material and teaching styles.

While some universities may teach sustainable manufacturing at the undergraduate level, there are institutions whose sole function is graduate studies and research on sustainable manufacturing practices and technologies. Massachusetts Institute of Technology (MIT) has an Environmental Benign research group focusing on "... environmental effects associated with manufacturing and products."[3] Under this research group, an Environmental Benign Manufacturing class has been developed and is currently being taught. In addition at MIT, a Systems Perspective on Industrial Ecology class is currently being taught to civil engineers. The class "examines quantitative techniques for life cycle analysis of the impacts of materials extraction, processing use, and recycling; and economic analysis of materials processing, products, and markets."[4]

Furthermore, the Sustainable Futures Institute at Michigan Tech is "... an education and research leader on sustainability initiatives related to water, air, and energy; industrial ecology;

environmentally conscious manufacturing; green engineering; public policy; the built environment; sustainable development that includes issues of the developing world; pre-college education for students and teachers; community outreach; and university campus eco-improvements."[5] Within this group is the Environmentally Responsible Design and Manufacturing class that emphasizes environmental issues surrounding manufacturing and design issues.

This module is an initial starting point in curriculum development throughout the Engineering Technology division and the Center for Sustainability at Central Piedmont Community College for sustainable technologies. The future hope is to create an engineering technology degree with an emphasis on sustainable manufacturing and create a sustainable technology degree focusing on manufacturing.

**Background**

This paper presents a 3 hour course module, lecture/activity, developed for a manufacturing class consisting of freshman mechanical engineering technology students. The demographics included nine male students. In addition, the class was taught at night with the average age of the student at approximately thirty. Most of the students were full time employees at a manufacturing facility working either as an operator or maintenance technician. In other words, this was not a typical class of freshmen.

Prior to the lecture/activity, the students had no or very little background in sustainable manufacturing or life-cycle assessment tools. This had its advantages and disadvantages. One advantage is that the students started with a clean slate and did not have many misconceptions. Therefore, the module created awareness of sustainable manufacturing processes and tools. On the other hand, it is difficult to have an in-depth discussion about sustainable manufacturing tools and techniques if the students do not know the lexicon.

This lecture first created awareness of sustainable development and sustainable manufacturing. Then the module focused on Life-Cycle Assessment (LCA) technique, a major sustainable manufacturing tool. According to the Environmental Protection Agency (EPA), the LCA is defined as " a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- compiling an inventory of relevant energy and material inputs and environmental releases;
- evaluating the potential environmental impacts associated with identified inputs and releases;
- interpreting the results to help you make a more informed decision."[6]

The LCA technique introduces students to a more holistic view of a process, product or service in a "cradle to grave" or “cradle to gate” assessment. The standard “cradle to grave” assessment includes 5 different stages: mining, pre-manufacturing (including transportation), manufacturing, use, and end of the life.

The damage type of LCA used in this exercise is known as Eco-indicator 99, a method readily available and described at Pre[7]. According to Pré-Product Ecology Consultants, "The Eco-

indicator 99 is both a science based impact assessment method for LCA and a pragmatic ecodesign method. It offers a way to measure various environmental impacts, and shows a final result in a single score."[7] Although the Eco-indicator 99 score is very useful as an internal score, since it combines all the environmental impacts to a final score there are certain inherent errors and subjectivity throughout the weighting process also explained by Pré. "Traditionally in LCA the emissions and resource extractions are expressed as 10 or more different impact categories, like acidification, ozone layer depletion, ecotoxicity and resource extraction. For a panel of experts or non-experts it is very difficult to give meaningful weighting factors for such a large number and rather abstract impact categories. The problem is that panel members cannot really grasp the seriousness of these impact categories, without knowing what effects are associated with them. An additional problem is that 10 is a relative high number of items to be weighted."[7] This is the main reason why it is not widely accepted in ISO 14000 standards. However, due to its relative simplicity and availability, the Eco-indicator 99 is a useful instrument to introduce students to the LCA process as a sustainable manufacturing tool.

In addition, the students can also analyze the phases of the product, including production, use, and disposal, using a five step process. The Pré-Product Ecology Consultants outline the Eco-indicator 99 process in the design manual[6] which includes:

1. Establish a purpose for the Eco-indicator calculation.
2. Define the life cycle.
3. Quantify the material process.
4. Fill in the form.
5. Interpret the results.

This manual provides an example of LCA on a coffee maker. One of the outcomes of the example is the amount of energy used in the use phase and the amount of filters used, having the first and second largest negative environmental impact respectively. This is one of the reasons why a banana split and its components were chosen as a product to examine. The hands-on activity shows the amount of waste, just in the production phase alone, of making the ice cream. In addition, it is theorized that the way to make an impact on students is to choose an item/theme they can relate to.

## Method

A creative approach module introduced first-year mechanical/manufacturing engineering technology students to sustainable manufacturing using the Eco-indicator 99 LCA of a banana split with a part lecture and part hands-on activity. Using a team-based collaborative approach, the students make the ice cream from the basic ingredients while examining the anatomy of the individual components and conducting a mini-LCA on each.

### Pre-survey questions

The pre-survey was given to the students with the intent on gathering information on how much they knew about sustainability, sustainable development and sustainable manufacturing. This survey was used as a gage to see if the students took knowledge and understanding from the lecture. The pre-survey questions include:

- What does the natural environment have to do with manufacturing?
- In your words, what is sustainability development?

- Have you ever heard of sustainable manufacturing, and if so what is your opinion?
- Do you know any sustainable manufacturing tools/technologies available to the manufacturing community? If so, give definitions of each.

**Lecture**

This section gives an overview of the sustainable manufacturing lecture given on Dec. 10th, 2008. The lecture was approximately 1 -1.5 hours. This approach started broad by covering topics including current global challenges, the fall of civilizations and a very brief history of the industrial revolution.

Next, energy efficiency was discussed using the example that it takes 1000W generated to produce a 100-350W lightbulb[9]. Using this as a reference frame, the discussion generalized into how much energy it takes to produce an item, therefore introducing the students into embodied energy. The lecture shifted to current circumstances of population growth and diminishing resources. Furthermore, the next topic's aim was to create an awareness that the first industrial revolution mindset needs to be changed to managing natural resources resulting in the Next Industrial Revolution.[9]

After a brief discussion, the lecture focused on defining sustainability, sustainable manufacturing and LCA. The final section of the lecture focused on Eco-indicator 99 and examining what the Eco-indicator is and how it can be used. Below are brief descriptions of each topic.

What sustainability is and is NOT –The intent here was to show that sustainability is not just about the environment, but about economics and social justice or what is known as the triple bottom line. The discussion focused on how engineers will play a large role in the development of sustainable practices.

System Issues – Once sustainability was defined, the lecture broadened and defined terms outlined by Brass, including environmental engineering, pollution prevention, environmental conscious design, design for environment, life-cycle design, green engineering, industrial ecology and sustainable development. Defining the terms set a holistic picture with the intent to place manufacturing in the context of environmental and temporal concerns.[10]

Life Cycle Assessment – This part of the lecture centered on defining LCA and the holistic viewpoint of a product's life. Once defined, the lecture focused on the five categories of a life-cycle, including; mining, pre-manufacturing (including transportation), manufacturing, use and end of life. In addition, the discussion lead to the importance of measuring the items and energy it takes to create a product or undergo a process.

Eco-indicator 99 – Following this, the lecture introduced the damage type of LCA known as the Eco-indicator 99. The Eco-indicator 99 Manual for Designers refers to an eco-indicator as a "number that expresses the total environmental load of a product or process."[7] The five step process, which is outlined in the background section, was covered.

Coffee maker example – Continuing to use the designer manual, the coffee maker example was presented through the five step process. Below is a brief overview of the procedure. The coffeemaker example establishes where the coffee maker has the most environmental impact.

Next the life cycle was defined and a process tree of the components was created, ignoring water and coffee consumption. After this, the materials were quantified using a functional unit in order to fill out the form. Once the form is filled out and the indicators calculated, the process of interpreting the results begins. This example illustrates that a simple item, such as a coffee maker, can have major environmental effects. In addition, one of the outcomes of the example is the amount of energy used in the use phase and the amount of filters used having the first and second largest negative environmental impact respectively.

**Hands on Activity Description**

Continuing with the idea of consumables (filters), the design of the hands-on activity focuses on the amount of waste and embodied energy associated with creating a simple item, such as ice cream. The students actually make ice cream from items outlined in A3. While noting this is not the process that industry uses to manufacture ice cream, the example illustrates the environmental impact of a simple item. The goal of making the ice cream was to visually show the amount of packaging waste. In addition, the students were lead through a discussion that generalizes this activity to a more standard manufacturing environment. Generalizing the activity and then focusing on particular manufacturing processes, including but not limited to castings and powder metallurgy, allowed the students to connect this to the other class material.

The Eco-indicator 99 process was used as an outline to dissect the anatomy of the ice cream. The steps are outlined below. Steps 1 -3 were completed in class as part of the team based approach lead by the instructor. Step 4 was started in class and was to be completed for an individual homework assignment along with Step 5.

Step 1: Establish the purpose of the Eco-indicator calculation - The purpose is to illustrate the amount of energy and consumables accompanied in packaging used to create a bowl of ice cream.

Step 2: Define life cycle - Constraints were placed at the packaging level and on the amount of electricity used to keep the ingredients cold. Figure 1 shows part of a process tree.

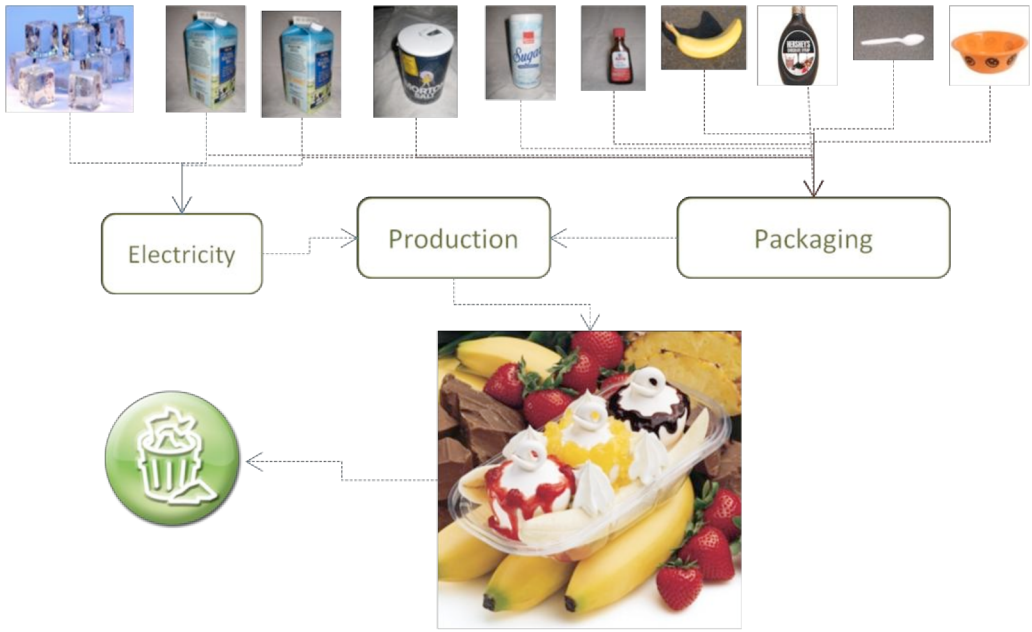


Figure 1.) Illustrates the process tree used in the hands on activity.

Step 3: Quantify the material and process – In this step, the students examined how each item was produced and defined and for each packaging outlined in Step 2 were assigned an eco-indicator 99 value. In order to quantify the material and process a functional unit of 2 ice creams each week for 5 years was used. In addition, each piece of packaging had to be normalized to one bowl of ice cream.

Step 4: Fill in the form - Included in the hands-on activity is a spreadsheet modeled after the Eco-indicator 99 form. Table 1 is a duplicate given to the students at the beginning of the activity and filled out during this phase. The students fill in the material or process and the indicator/ unit taken from steps 3. The amount and unit are filled in using the functional unit and then multiplied to the indicator to be placed in the result column. The last step in the process is to total the results for each stage production, use and disposal. Line items whose characteristics involved thermodynamics or heat transfer were filled in prior to handing the document to the students due to the fact that they do not have particular knowledge of these concepts.

| | | | | | | |
|---|---|---|---|---|---|---|
| | Production (materials, treatment, transport and extra energy) | | | | | |
| | Material or process | amount | unit | indicator/unit | result | |
| | Keep cool, ICE | 71.09029737 | kWh | 37 | 2630. | |
| | Keep Cool, Cream | 1.946277909 | kWh | 37 | 72.01 | |
| | Keep Cool, Milk | 0 | kWh | 37 | 0 | |
| | ADD HERE | | | | | |
| | Total [mPt] | | | | 2702. | |
| | | | | | | |
| | | | | | | |
| | Use (Transport, energy, and possible auxiliary materials) | | | | | |
| | Process | amount | unit | indicator/unit | result | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ADD HERE | | | | | |
| | Total [mPt] | | | | 0 | |
| | | | | | | |
| | | | | | | |
| | Disposal (Disposal process for each material type) | | | | | |
| | material and type of processing | amount | unit | indicator | result | |
| | | | | | | |
| | ADD HERE | | | | | |
| | Total [mPt] | | | | 0 | |
| | | | | | | |
| | Overall total | | | | 2702. | |

Table 1.) Excel spreadsheet representing the Eco-indicator 99 form. The assignment was to fill the spreadsheet out and compare the results.

Step 5: Interpreting the results – Analyzing the results of each stage and each of their material/process, the students were to draw conclusions on the environmental impacts.

**Post survey questions**

The aim of the post survey questions was to see if the students paid attention and if the exercise met its objectives. These questions were given on the final day of class one week after the activity.

- Why does sustainability cross political, geographical and all boundaries?
- Do you know any sustainable manufacturing tools/technologies available to the manufacturing community? If so, give definitions of each.
- What is one key understanding you took from this assignment?
- What has surprised you about this lecture and assignment?
- Has this experience challenged or reinforced your thoughts? Explain.
- What would you change about the assignment? If so, how? Comments!
- Do you see the Eco-Indicator 99 tool as a valuable tool for manufacturing? Explain.
- What are some environmentally harmful chemicals in any manufacturing process, including electricity production?
- If I have a 100 W light bulb, approximate the amount of energy the power plant needs to produce?

**Results/Analysis**

The results section focuses on four key questions from the two surveys. Two results were analyzed from the pre-questionnaire focusing on awareness of sustainable manufacturing and tools associated with the practice. Then, two results were analyzed from the post questionnaire focusing on the students' knowledge of sustainable manufacturing and understanding of the material. Note all of the survey questions and answers are located in Appendix A1.

**Pre question results**

Figure 2 is a bar graph representing three groups of 11 students' answers to the question (PreQ3: Have you ever heard of sustainable manufacturing; if so, what is your opinion?). The graph shows four students have heard of sustainable manufacturing and 5 have not. However, one out of the five students who said no mentioned the importance of it.

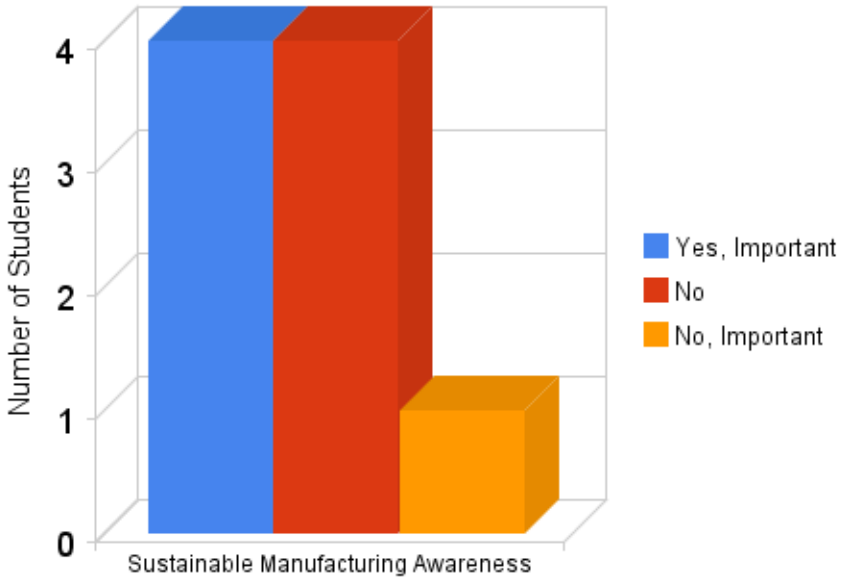


Figure 2.) Shows the grouping of student answers to PreQ3: Have you ever heard of sustainable manufacturing; if so, what is your opinion?

Figure 3 is a bar graph representing the partitioning of 11 students' answers to the following question (PreQ4: Do you know any sustainable manufacturing tools/technologies available to the manufacturing community? If so, give definitions of each.) The graph shows 5 students said no and 6 of them tried to answer it.

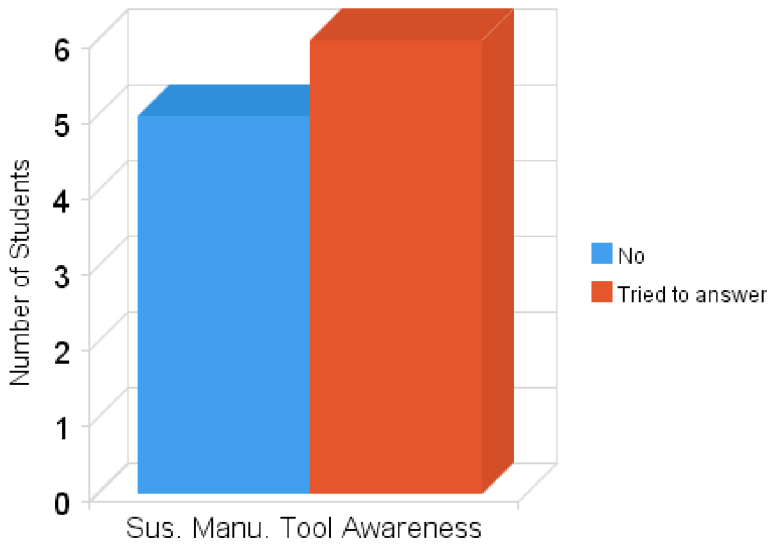


Figure 3.) Shows the grouping of student answers to PreQ4: Do you know any sustainable manufacturing tools/technologies available to the manufacturing community? If so, give definitions of each.

According to the answers in PreQ3, 4 students acknowledge sustainable manufacturing. However, 6 students mentioned the use of alternative energy as a tool used in sustainable manufacturing, which plays only a small part of sustainable manufacturing.

**Post question**

One of the post questions focused on the knowledge the students took away from the activity. The student answers are below and a grouping of the answers are represented in Figure 4:

- "That the earth does not have a indefinite amount of fossel fuels, water, lumber and other materials that are used on a daily bases and what we need to do to either ensure we replace/recycle what we use or find alternative resources."
- "Everything means something on some level or another."
- "To look critcally at manufacturing processes because manufacturing can have large impacts on the environment."
- "The most efficient process will be one that creates the lower amount of waste and use of energy."
- "well we are not taking responsibility for ou useage of our resources.in fact i have made a comic book that has an alien culture that did use it's planete's resources up.now they have come to earth to take ours.but the twist is they have mutated us."

The data shows two out of five students mentioned resource management, one student was more general and mentioned manufacturing and the impact on the environment, one student mentioned replace/recycling due to the limited resources, one student mentioned efficiency in a process and one student was vague. Note the data shows six answers; one of the student's answers counted twice.

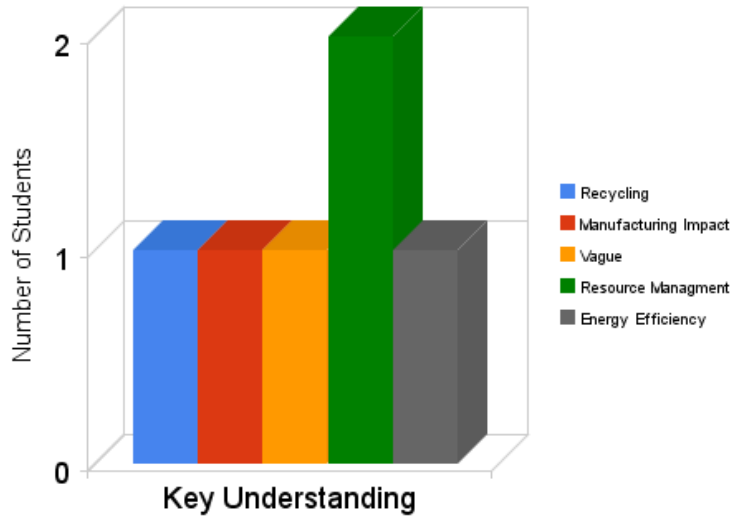


Figure 4.) Shows the grouping of student answers to PostQ3: What is one key understanding you took from this assignment?

In the lecture, energy efficiency was discussed, and the approach showed the amount of energy loss from the power plant to the pumps in a factory. The energy loss was approximately 90%. For example, the power plant needs to produce 1000W of power for a 100W pump. In addition, the lecture noted about approximately 65% loss from the power plant to a house light bulb. The question was asked "If I have a 100 W light bulb, approximate the amount of energy the power plant needs to produce?" The results from this show that after hearing the lecture, no student got the correct answer. Three of the students got it incorrect and 2 students did not answer.

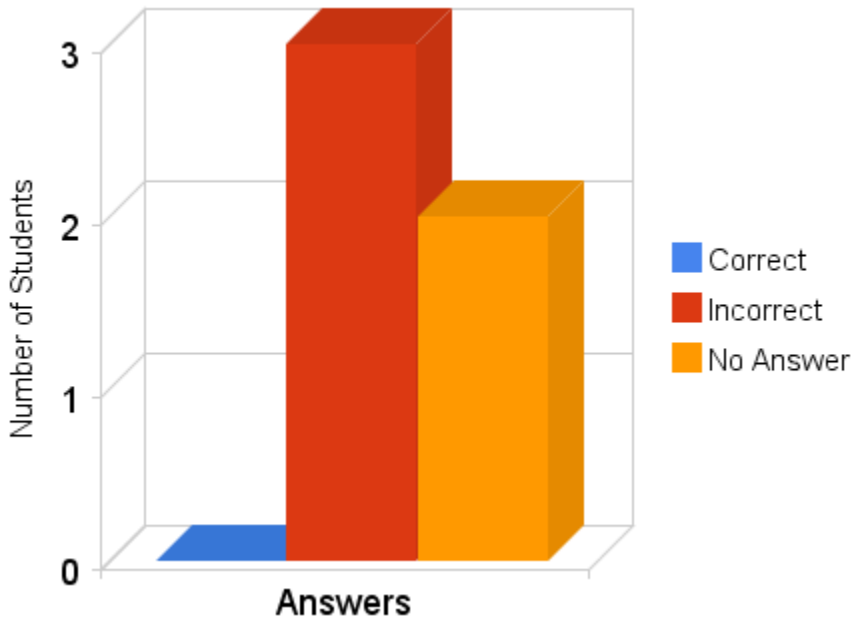


Figure 5.) Shows the grouping of student answers to PostQ9: If I have a 100 W light bulb, approximate the amount of energy the power plant needs to produce?

**Assessment (Conclusions)**

Overall, the activity was a success; it met the general objectives and introduced the students to sustainable manufacturing and the Eco-indicator 99 LCA method. The data presented in the Pre-question Results Section showed the students did not have a firm grasp of sustainable manufacturing and the tools/techniques associated with the subject.

First, I want to point out how the students were amazed at the amount of consumables (ie. filters) used in the coffee maker example and how it rated second to electricity as the most negative impact on the environment.

Second, from these results we can conclude the students, at least in the short term, gained knowledge and possibly a paradigm shift in their thinking process. This can be concluded from the data in Figure 4 that shows the grouping of student answers to "PostQ3: What is one key understanding you took from this assignment?*"* The students acknowledged certain understandings of the topic, including resource management, importance of energy efficiency, recycling and the environmental impact from manufacturing.

Third, the results to the question "If I have a 100 W light bulb, approximate the amount of energy the power plant needs to produce?*"* were interesting. The fact that no one in the class had the correct answer allows me to take a step back and make improvements in the next draft of the lecture/activity.

On the whole, the activity was a success because the students became aware of sustainable manufacturing practices, energy loss and waste in the manufacturing process. Although it is a small amount of data, it is a good starting point to refine the lecture and activity.

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## Appendix

### A1: Pre Questionnaire and Answers

PreQ1: What does the natural environment have to do with manufacturing?

- It depends on the process. Some processes require "clean rooms" or the process may be contaminated by outside debris. You wouldn't want to work metal in an area with ocean water in the air. Unless there was some sort of air-filters, the metals could rust quicker.
- Most manufacturing is not environment friendly. With the global warming issues that are becoming more apparent these days it would be a good idea to start considering the natural environment when using manufacturing.
- In manufactoring we convert raw unusable material into usable. So using the natural material is a vitle part in manufactoring. Using wood from forest to make lumber to build structures, or using molten rock to make usable metal products.
- The natural environment is made up of the materials that we make products that we manufacture.
- It can control where you may or may not build a facility. You would want to be careful not to dump waste products from your process into the environment.
- The raw materials used in maufacturing come from the natural environment and the use of these materials can have drastic impacts on the natural environment. Also, the byproducts of maufacturing such and pollution can have dramatic effects on the environment.
- It's can supports but yet hinders the process with todays mind set. Adds expense to todays processes, but eventually it won't (my believes).
- well the natural environment has wind, heat , radiation earthquakes, and things like hurricanes. when we build or /engineer something, it has to be able to withstand these and other variables.
- how does manufacturing effect the overall enviorment, usage of raw materials, emissions/ discharges and what you ar manufacturing and it's effect on the enviorment.

PreQ2: In your words what is sustainability development?

- What can be done to endow longer life into the product and/or process.
- Sustainability sounds like the ability to keep a constant production of development.
- Sustainable develpoment would be a process that will virtually never run out of resources such as wood or water. Oil would not be consider as a sustainable development due to the lack of crude oil
- Makeing something enviromently safe, to go green.
- Finding processes that have a low impact on the natural environment.
- Development of processes that can be repeated many times over with little to zero impact on the environment.
- Little negative impact on the surroundings as possible, for the long hail. a closed loop process in manufacturing. now wasted materials.
- i think this is where we build something that we can maintain ourselves, or will not be exhausted by our efforts ; wind power devices solar energy panels, etc.

- where manufacturing/production of things and the enviorment is not effected and sustains it's current status.

PreQ3: Have you ever heard of sustainable manufacturing, if so what is your opinion?

- No. I have not.
- Nope
- No, is it a manufacturing process that uses natural resources? If so would a hydro dame be concidered a sustainable manufacture to creat electricty?
- Yes, I think it is very inportant.
- No
- Yes. i believe that we must pursue sustainable maufacturing in order to protect the environment
- Yes, needs to be incorporated into todays manufacturing, for the generations to come.
- yes, but haven't been exposed to info about it. i think it is a wonderful and necessary path. we have just now waken up.
- No, but if it is what I believe it good have a effect on items manufactured concerned about possible over regulation and cost.

PreQ4: Do you know any sustainable manufacturing tools/technologies available to the manufacturing community? If so, give definitions of each.

- I'm not sure I've even heard the term. My first couple of answers were guesses.
- Nope
- No, due to the previous question I'm not familiar with sustainable manufacturing
- To use one heat sourse for manufacturing and to heat the building. To reuse the heating sourse
- No
- An example of sustainable maufacturing technologies would be solar power as it is a renewable resource and creates little to no impact on the enironment.
- corn based plastics, I think is one. Something about soy in everything basically.
- solar panels of coarse, panels to conveert light
- wind turbines using the wind to produce electricity
- herbology advancements new foods that will survive.
- No, best guess would be auto manufacturer making of Hybrids

**A2: Post Questionnaire and Answers**

PostQ1: Why does sustainability cross political, geographical and all boundaries?

- Earths natural resources are needed for all manufacturing. Different countries/geographical areas have different resources needed.
- Because it affects us all. We all need to be aware of what we do to the enviroment. We're way past the point of taking our resources forgranted.
- Because it affects everyone that lives on this planet with no exceptions.
- Because how we manufacture products affects everyone. The smaller the effect on the environment a process has the better off we all are. We all will either benefit from using less energy and producing less waste, or suffer from excessive energy consumption and large amounts of production waste byproducts.
- because it is global. it is a planet problem.use up your resources and don't replace 'em, and you 'll have to find something else.

PostQ2: Do you know any sustainable manufacturing tools/technologies available to the manufacturing community? If so, give definitions of each.

- I do all manufacturing facilities try to cut down on waste and cost of materials. The only thing that comes to mind is possibly the atomotive industry converting fro gas to electrical engines or Hybrids ythe combination of booth.
- Recycling helps. It reuses some of our resources.
- The use of corn for fuel energy.
- DID NOT ANSWER
- well i know solar panels will replenish our energy needs with nimimun depreciation.

PostQ3: What is one key understanding you took from this assignment?

- That the earth does not have a indefinite amount of fossel fuels, water, lumber and other materials that are used on a daily bases and what we need to do to either ensure we replace/recycle what we use or find alternative resources.
- Everything means something on some level or another.
- To look critcally at manufacturing processes because manufacturing can have large impacts on the environment.
- The most efficient process will be one that creates the lower amount of waste and use of energy.
- well we are not taking responsibility for ou useage of our resources.in fact i have made a comic book that has an alien culture that did use it's planete's resources up.now they have come to earth to take ours.but the twist is they have mutated us.

PostQ4: What has surprised you about this lecture and assignment?

- Eye opening, food for thought, and how wasteful we are as humans. Take a lot of things for granted and we all need to be educated on this particular subject.
- Not surprised so much as overwhelmed. It makes you feel like you can't do anything

without messing something up.
- How many resources are needed in maufacturing and how much goes to waste.
- I didn't realize how much enregy is used to produce simple products like coffe makers.
- i did not realize how much waste we ceate just to have simple things.

PostQ5: Has this experience challenged or reinforced your thoughts? Explain!

- Yes,definetly challenged, just the awareness as mention in above sections. No way am I a enviormentalist and I would never do anything to damage the enviorment but we do have to look at earths resources and what we can do to conserve these resources but continue our standard of living.
- Reinforced. We as a society have painted ourselves into an impossible corner. What can one person do to change our path. I've heard all of the cliche's. Honestly. I can do all that I can, but it doesn't feel like much.
- It has reinforced my thoughts because I have always believed that manufacturing can be extremely wastefuly and harmful to the environment.
- It has challenged my thoughts on manufacturing. I used to believe the fastes way was the more efficient way. Now I see that the lowest energy use and recyclable materials are better for total cost.
- i am now aware about sustainability, and i am very interested in making a difference.

PostQ6: Would you change about the Assignment? If so, how? Comments!

- Nothing, I believe alot of us were just not aware consciencly.This lecture helped bring this to the forefront of my mind.
- I would figure out why the spread sheet will not open.
- I wish it didn't feel like doom and gloom. I don't want to be ignorant of my actions, but I wish there was a more positive spin available.
- I would not change anything about the assignment.
- i would start it sooner in the course than later.

PostQ7: Do you see the Eco-Indicator 99 tool a valuable tool for manufacturing? Explain.

- Yes, definetly give them indicators in areas need for improvement, alternative resources, and reduction of waste in specific areas.
- I believe the persuit of money will always drive the masses. We're eco-freindly only when it's convinient. Therefore, no. I don't see it being widely used.
- Yes. I think it is a helpful guideline but everyone must take resonsibility and I think that is the hardest part.
- It is a valuable tool. You can use it to compare materials for environmental impact and choose materials that don't create as much energy use or waste.
- yes it's a reference that has commonalities that different people can use to disciver variables that are the same between them.

PostQ8: What are some environmentally harmful chemicals in any manufacturing process discussed, including electricity production?

- Carbon dioxide I believe was the largest we talked about also I believe cyanide and arsenic was mention in the production of plastics. Elictric production we discussed how much energy is needed and storage and possibly hazards of damaged and disposal of electric storage units
- Freon is the main one I know.
- Radioactive waste is one of the most harmful and dangerous byproducts of manufacturing.
- Carbon Dioxide
- oils.plastics, and spent nucleur waste,

PostQ9: If I have a 100 W light bulb, approximate the amount of energy the power plant needs to produce?

- I know you mention didn't write down(?)
- How?
- DID NOT ANSWER
- ?
- DID NOT ANSWER

**A3: Inventory of a banana split**

- Ice cream
    - bags
    - 2 lbf of ice
    - 1 1/2 lbf of salt
    - 1 cup of cream
    - 1/2 cup of whole milk
    - 1/3 cup of sugar
    - 1/4 tspn of vanilla
- fork/spoon
- spoon
- napkin
- bananas
- Pineapples
- nuts
- whipped cream
- cherries