Environmental Activities for the Classroom: Product Life-Cycle Analysis

Objective: To have students become aware that the products they buy have an impact on the environment beyond that of disposal of the packaging or other wastes generated from use.

Grade Level: 7-12

Class Time Estimate: 2 or more hours

Materials needed: shoes, paper, pencil

Background

Dissecting a consumer product into all the various processes that contribute to its production and disposal can help us better understand how our consumer habits affect the environment. Consumption of products drives an array of extraction, manufacturing, processing, transportation and disposal operations. An analysis of these operations, called life-cycle or cradle-to-grave analysis, documents the inputs (water, energy, raw materials) and outputs (products and wastes), for these various steps.

Life-cycle analysis (LCA) has most often been used to compare two or more products, such as plastic vs. glass vs. aluminum beverage containers, for their environmental impact. This type of analysis can point out strengths and weaknesses in the production and disposal/recycling steps.

While LCA can be used as comparative tool, comparing energy usage between plastic, glass and aluminum beverage containers, for example, it does not provide a way to rank the importance of the factors examined. For example, what should be ranked higher in importance in maintaining a healthy environment: energy usage, air quality, water quality, solid waste? How do we compare the environmental impact of 1 pound of toxic heavy metal sludge to 1 gallon of water use or consumption of 1 btu of energy? In addition, there are economic, employment and social issues tied into this web.

For example, this analytical technique has been adopted by some manufacturers who hire private research firms to conduct LCAs for their products. This has raised great concern in scientific and environmental circles. With a growing environmental consciousness on the part of consumers, marketing a product as “environmentally-friendly” can mean money in the bank for manufacturers. As an example, three LCAs have been conducted on cloth vs. disposable diapers by separate firms hired by different groups. Each analysis came out with different results and each group marketed their products using the numbers from the studies they backed.

To help alleviate concerns over the trend to use LCA as a marketing tool, the Society of Environmental Toxicology and Chemistry (SETAC) has established guidelines for conducting LCAs by both governmental and private agencies, as well as developed a code of ethics. This group suggests that an LCA should include three basic parts as described below: inventory, impact, and improvement.

Inventory

This includes making decisions on the depth of the study. In diapers, for example, you would want to include: manufacturing, packaging, distribution, use, and disposal. One step more detail would include extraction or production of the raw materials to produce the separate ingredients of plastic, paper, cotton, etc. Conceivably, you could spin off into even further subdivision such as cotton production and chemicals, energy, and equipment required for this. Thus, a need exists to determine the boundaries of the LCA.

Within these boundaries, you need to decide what you will and will not gather data on in your environmental assessments. For example, do you include erosion, loss of habitat and biodiversity, groundwater contamination, generation of global warming gases, etc.?

With your list of what you will include, and what you won't, a mass balance determination is performed. Basically, a mass balance equation is: Inputs = Outputs. Inputs include both renewable and nonrenewable raw materials, energy, water, etc. Outputs include product, any by-products, air, water, and ground pollution, and solid waste. This mass balance is done for every stage of the product life-cycle from extraction of raw materials to disposal/recycling.

Impact

This portion of a LCA is to determine the relative destructiveness of the pollutants. Here the question of making decisions on ranking occurs. For example, is a pound of benzene in the air, a pound of herbicide in the water, or loss of habitat for a threatened species the most important? As of now, no agreed upon method to do this type of ranking has been determined.

Improvement

By having all the data pieces gathered in the inventory and impact steps before them, analysts will have improved opportunities to find methods to prevent or reduce pollution from occurring. Without this analysis, reductions in one aspect may result in increased pollution in other aspects of production.

Classroom Activity

This is an activity using hypothetical leather tennis shoes as the product under study. Students will work through a simple life-cycle analysis of a tennis shoe and discuss the issues involved. Because of the complexity of life-cycle analysis, the concept of this activity is to introduce students to thinking beyond the final product bought at the store and disposed of later on. It is to encourage their understanding of the many processes that can be involved in manufacturing a product and the effects of these processes on the environment. This activity can be expanded as much as you desire.

1. Introduce the concept that all production processes generate some type of waste. Ask everyone to wear a pair of tennis shoes to class the following day. Provide a couple of old tennis shoes for those students who may not have them, or forget to wear them.

2. Have each student take off a shoe and put it on the desk in front of them. The student should make an attempt to draw their shoe. Have them examine it closely and list all the different types of materials (to their best guess) that the shoe is made of a label these parts on their drawing. You may want to do the same process on the chalkboard for a tennis shoe of your own to aid in later discussion. This list will probably include such items as leather, nylon, canvas, plastic, rubber, cotton, etc.

3. Add to the list the packaging materials the show came in from the store (this could include cardboard shoe boxes, tissue paper, plastic bags, paper bags, etc.).

4. Start a discussion by asking the students where their shoe came from. While the obvious answer will be 'the store,' expand their understanding to include the various components they just listed. For example, the leather came from a factory that processes and cuts leather which is then delivered to the shoe manufacturer. Further back to the raw materials, the leather comes from cattle via a slaughterhouse and tanning factory. You may want to develop a type of flow chart similar to that in Fig. 1 for several of the components of the shoe to get across the idea that all the various parts are a result of a number of manufacturing processes.

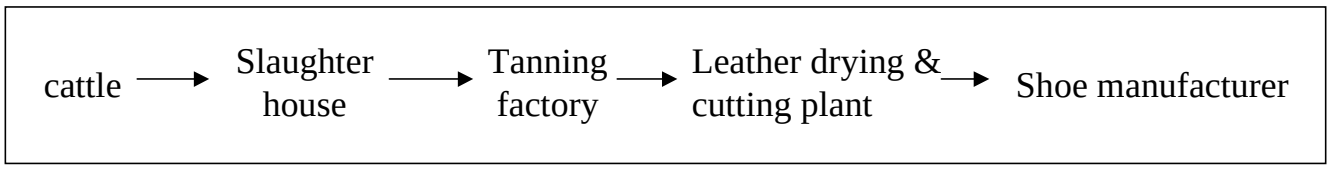

Figure 1: Simple Flow Chart for Leather Shoe Parts

5. Examine one of the manufacturing processes in depth and develop a chart such as the one illustrated in Fig. 2 which uses leather production as an example. Introduce the concept that his process requires energy, water, and raw materials and produces a product (which goes on to the next step for further manufacturing) and air, water, or land pollution as well as solid waste. Discuss that for each part that goes into the final product, a similar chart could be developed.

6. Discuss the impact this process has on the environment, the fact that all of the shoe parts have some impact on the environment, and that everything we buy as consumers comes with an environmental price tag.

7. Introduce the term life-cycle analysis/cradle-to-grave analysis. Explain to the students that they have just done a simplified version of a life-cycle analysis. Draw Table 1 on the board. Discuss which tennis shoe, A (leather) or B (synthetic) is better for the environment (there is no correct answer). Is it possible to weight one aspect (air, water, land pollution or solid waste) as being more important than another? How? Why? Who makes these decisions in our society?

8. Have students discuss ideas on how to decrease the impact of consumerism on the environment.

Extensions

Have students do research on what "environmentally friendly" means in terms of marketing of products in the U.S. Extend this to other countries that have labelling procedures to alert the consumer to the product's environmental qualities (Germany - Blue Angel; Canada - Environmental Choice; Japan - Ecomark; Australia - Green Spot).

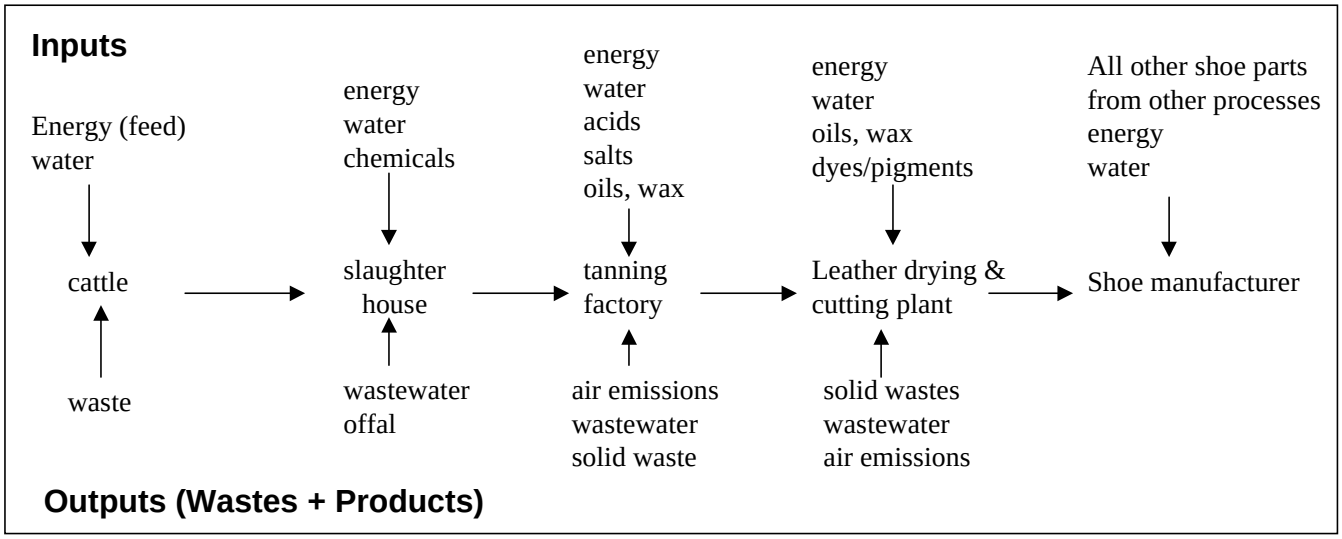

Figure 2: Inputs and Waste Outputs from leather components of a tennis shoe.

Product	Energy Use	Raw Material Consumption	Water Use	Air Pollution	Water Pollution	Hazardous & Solid Waste
Shoe A (e.g. leather)	1 Btu	limited supply some renewable	2 gal.	4 lbs.	2 lbs. organic chemicals	2 lbs. haz. sludge
Shoe B (e.g. synthetic)	2 Btu	large supply non-renewable	4 gal.	1 lb.	8 lbs. inert inorganic chemicals	1 lb haz. sludge 3 lbs. non-haz. solid waste

Table 1: Hypothetical example of life-cycle environmental impacts of shoes A (leather) and B (synthetic) per 100 pairs of shoes produced.