the gaia project

realistic environmentalism

Project Guide: Sustainable Design

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Sustainable Design

A guide to delivering a waste audit, life cycle assessment and product redesign project in your classroom

The Gaia Project is a charitable organization dedicated to providing project based learning opportunities in the areas of energy, environment and sustainable engineering.

We develop projects, provide professional development, technical support and ongoing project support for teachers and students. Our projects aim to incorporate three key principles, which symbolise our focus on realistic environmentalism.

1. **Data Informed Decisions** – We want students to be able to explain why, and quantify the effect of each decision they made along the way to their final solution.
2. **Economic Assessments** – We expect students to be able to assess the cost effectiveness of their solutions, and be able to optimize their projects with limited budgets.
3. **Environmental Impact and Lifecycle Assessments** – We need students to take a holistic view to their projects. This means looking at their projects from cradle to grave, as opposed to just examining the use phase, and acknowledging that greenhouse gas reduction is not the only environmental issue at stake.

For more information, please visit www.thegaiaproject.ca

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Sustainable Design

The global market is under increasing demand for products and cost-effective processes. Design factors include cost, ease of assembly, and attractiveness to consumers. Other considerations may be safety, ease of transport, or disposal. Effective processes are highly valuable – the reduction or elimination of waste or unproductive time can positively impact not only profits, but global sustainability.

Sustainable development is often defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

The word environment does not appear in that definition and that is important. In order to be truly sustainable we need to consider our actions from a number of viewpoints – their environmental, economic and social impacts.

In order to meet an increasing demand for products while managing finite global resources, we must consider new and innovative ways to manufacture products using low impact materials and methods, to create products with minimal environmental impact throughout their useful life, and to recover and reuse those products at their end-of-life. Tracking a product throughout its life cycle – from manufacture to disposal – is known **as life cycle assessment** or **analysis**, or **cradle-to-grave** assessment and includes the processes that result in the final product.

An important part of a lifecycle assessment is examining our trends of consumption; we are currently facing a huge problem of overconsumption resulting in huge volumes of waste. Often, this is tied to the way products are designed – many products today are '**designed for the dump**'; they are not designed to be reused, and often only very few parts are designed to be recycled.

We often hear about the 3Rs of the **waste hierarchy**: reduce, reuse and recycle, but we generally hear the most about recycling. Sustainable design requires that we, as consumers, reconsider the waste hierarchy by asking ourselves questions like:

- is this an essential product/service? (reduce)
- if we do need it, do we really need to throw it out? (reuse)
- if we answered yes to the first two questions, how can recycle that product into something else that is both useful and necessary? (recycling)?

Discussing with your class

You can start off by asking students what they know about the 3Rs and challenge them to think critically about what exactly each step entails. Challenge students to think about the difference between needs and wants (luxury vs necessities), and how marketing affects how we define needs and wants.

Ask students how they would begin to critically examine their patterns of consumption – where was the t-shirt they are wearing manufactured? Where did they buy it? How did it get to that particular store? What will happen to it when they are done with it? How many t-shirts do they have? How many t-shirts do they need? Ask them to pay attention to the type of things they are throwing out every day and start to ask themselves:

- Did I need to buy/consume that?
- If yes, did I need to throw it away?
- Is there a way that this product could have been better designed so that I didn't have to throw it away?

This guide will focus on helping you to plan a two-part project to get students thinking critically about consumption and sustainability. This project does not require extensive resources and can be done on a very limited budget—mostly all you will need is internet access and a place to sort trash! It is also an easy project to modify to the readiness of your students.

Students will firstly plan a waste audit (either at school or home) and then conduct a lifecycle assessment on a product of choice. We've begun with the waste audit to get students thinking about the amount of waste that they produce and its destination; by taking a look at what kind of waste we produce in a chosen time period, we can easily start to identify areas where can effectively reduce waste.

The next part of the guide details how to conduct a lifecycle assessment; students will identify not only the environmental, but also the economic and social impacts of a product from cradle-to-grave. The driving question behind this project is: how can products and processes be more sustainably designed?

Additional Resources

Waste Hierarchy

http://en.wikipedia.org/wiki/Waste_hierarchy

Life Cycle Assessment

http://en.wikipedia.org/wiki/Life_cycle_assessment

Personal Waste Audit

There are two options for conducting a waste audit: students can examine waste at the school or at their homes. Conducting a waste audit at the school fits in nicely with developing a Sustainability Plan for the school (see Waste Audit Project Guide).

The other option is to have students document the waste they produce individually or at their homes. This type of waste audit is beneficial because it challenges the students to look directly not only at the amount of waste they are producing on a daily basis, but also the contents of that waste.

If students are auditing the amount of waste they produce individually, they can do what is called a trash carry where they carry a bag around with them for a day (or several depending on what they decide is an appropriate time frame) in which they collect all of their day's waste. This should be done on a typical day so that we can get an idea of an average inventory of waste. The downside of this type of waste audit is that we are aware of the audit and therefore may change our behaviour. Discuss the pros and cons of this type of waste audit.

Students can also conduct a waste audit by bringing in their trash from home, though a letter home requesting permission from parents/guardians will likely be required. Have the students decide which method they think would be the most effective and the assumptions that they must make for each.

The procedure for a personal or at-home waste audit is similar to one conducted at the school. Students will:

- Define study area (individual, whole home, kitchen, common living area)
- Choose a time frame
- Ensure cooperation; if students are doing a 24-hour trash carry ensure that other teachers know why they are carrying around their trash! If at home, ensure

that parents/guardians are aware.

- Define sorting classes (see Waste Audit Project Guide for a list of the NB Solid Waste Commissions). You might want to encourage students to choose sorting classes that represent the destination of the contents of their trash carry in your region.
- Find a sorting area
- Weigh, sort and record waste.

Consult the Waste Audit Project Guide for a summary of how to create a waste inventory. Now that we've examined the waste that we are producing, we can start to identify some really easy ways to reduce our waste. For example, if we drink a coffee every morning from a disposable cup, we can instead bring in a reusable mug and quantify how much waste we've prevented over the course of year – it might even save us money if our coffee shop provides a discount for reusable mugs!

The Waste Audit Project Guide also contains more detailed information about implementing waste reduction strategies and calculating savings, as well as marketing these findings.

The personal waste audit leads into a product lifecycle assessment; students may start to ask themselves questions like is the amount of packaging on some of their waste necessary? Especially if it isn't recyclable in your area. If the packaging can be recycled, what will it likely be recycled into? How much extra does it cost me to have this product packaged in this manner?

You can't manage what you don't measure; while a waste audit may not be glamorous, it is the first step in managing consumption by creating an inventory of the waste each of produces.

Essential Resources

Waste Audit: The Gaia Project

http://www.thegaiaproject.ca/projects/sustainability-planning/waste

Life Cycle Assessment

We often hear about product **planned obsolescence** - products designed to be thrown out and replaced. This is an especially important concept to consider as we try to keep up with technological advancements; if products are designed to be continually tossed and replaced, we are looking at dealing with huge amounts of waste. This waste not only has environmental considerations, but also economic and social impacts, especially when we start to realize that some of our waste is shipped overseas, incinerated producing toxic emissions, or has made its way into something like the **Great Pacific Garbage Patch** [see link at end of section].

But we can't focus exclusively on a product's impact after we are done with it; we also have to look at the impact of the manufacturing process up to the time that it arrives in our hands. This is called a **cradle-to-gate** assessment, while looking at the entire product life cycle is called a life cycle, or **cradle-to-grave** assessment.

The goal of a life cycle assessment is to identity any negative impacts associated with the product, and look for ways that the product could be redesigned in a more sustainable way—sometimes called **intelligent product design**. Ideally, if we incorporate reuse or recycling, we could trace one product's life cycle into another's as a **cradle-to-cradle** assessment.

The rest of this guide will focus on conducting a product life cycle assessment.

Additional Resources

The Carbon Reduction Label

http://www.carbon-label.com/

The Carbon Trust (a UK governmental organization) provides lifecycle carbon labelling for products.

Sample Lifecycle Assessment

http://www.levistrauss.com/sustainability/product/life-cycle-jean

Third party lifecycle assessment of a pair of Levis® 501®

Lifecycle and Carbon Footprint

http://www.apple.com/ca/environment/

Apple estimates the footprint of their products throughout their lifecycle.

Materials Economy

http://www.storyofstuff.com/

The Story of Stuff; video detailing the steps of the materials economy from production to disposal.

Life Cycle Assessment Curriculum

http://www.facingthefuture.org/Curriculum/BuyUseToss/tabid/469/Default.aspx

Buy, Use, Toss Unit from Facing the Future, available for download at the link below. This unit plan has extensive resources on lifecycle assessment including links to articles and videos.

Eco-Efficiency Tools

http://www.ic.gc.ca/eic/site/ee-ee.nsf/eng/ef00036.html

Industry Canada's Eco-Efficiency Tools; this site lists a variety of web-based resources for lifecycle assessments.

Design for Environment

http://www.epa.gov/dfe/

US Environmental Protection Agency's Design for the Environment (DfE) program.

The Great Pacific Garbage Patch

http://en.wikipedia.org/wiki/Great_Pacific_Garbage_Patch

Product Disassembly

In a market without consideration for the product at its end-of-life, design often focuses primarily on ease of assembly (**Design for Assembly** – DfA). The goal is to provide as many units as possible to interested consumers, and to make the assembly process as quick and cheap as possible. Product repair or disassembly for recycling or reuse of parts may never be part of the design considerations. There is an increasing pressure for design engineers to consider many factors during the product design phase such as the economic, social and environmental consequences of their designs throughout the product life.

Before we can start to map a product's impact or redesign it, we have to know exactly what's in it, which means creating an inventory of its parts. In order to do this, we have to disassemble the product and the number and type of tools required for this process – the more tools required for disassembly, the more complex the process and the less likely the components will be reused or recycled.

During the disassembly process, identify and catalogue:

- Steps taken for disassembly
- Types and quantities of materials used
- Numbers and types of fasteners used
- Numbers and types of tools required

A product disassembly for a pair of Silver jeans is listed in Table 1.

As you conduct the disassembly, consider:

- **Fastening Complexity (L**ow, **M**edium, **H**igh): rate how difficult each component was to separate from the rest. A high fastening complexity will reduce the likelihood of re-use or recycling later and will be an important part of the life cycle assessment.

Table 1: Components list for disassembly of a pair of Silver jeans

Component	Quantity
Front panel	1
Back panel	1
Waistband	1
Belt loops	6
Smaller inside pocket (right side)	1
Back pockets	2
Thread	1
Zipper	1
Main button (above zipper)	1
Metal rivets	6
Seam ripper	1
Label	1
Flathead screwdriver (removing rivets)	1
Pliers (removing rivets)	1

Mapping the Impact

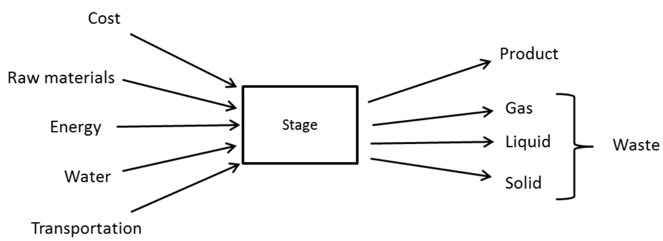
Now that the components of the product have been identified, you can start to trace the environmental, economic and social impacts of each step of the product's life cycle by creating a concept map. As students go through this process, they can start to think about possible ways to redesign the product to reduce negative impacts.

This concept map will be a stepping stone that students can revisit as they move through the life cycle assessment. Figure 1 [see end of document] maps the life cycle of a pair of jeans. Some of the steps in this map may have negative impacts like the CO_2 emissions from the transportation steps, though some may have positive impacts like providing employment to farmers or retailers. This is a starting point, and students should be encouraged to keep this map somewhere easily accessible to elaborate on it and use it as a tool to begin assessing the environmental, economic and social benefits as they examine the product's life cycle.

The next sections will go through rest of the life cycle assessment asking students to analyze the various steps that culminated in their product and to consider where the product will go after disposal. Students should record all of the information as they progress through the assessment. For some categories, the option to list the impact as low, medium or high has been provided as an option – students should be able to explain each rating. While a number of categories have been provided for students to consider, this is not meant to be a prescriptive list and other categories can be added based on interest,

Let's now look at the various steps of the life cycle of a product from obtaining the necessary raw materials, to the production and distribution stage, and then to the two stages we are most familiar with: use and disposal. There will be some common elements to each stage such as water and energy use and transportation, as seen in Figure 2.

Figure 2. Common inputs and outputs to each stage of a product's life cycle



Raw Materials

Now that we have disassembled the product and begun thinking about the various steps along the product's life cycle, we need to identify all of the raw materials in the product that are extracted, mined, farmed and processed.

For each component, students should examine:

- **Material**: what is it made of? Identify the type of plastic, metal or paper the material is composed of. Is it a toxic material? Is it a rare material? For example, the presence of a copper in a product increases the environmental impact because of its scarcity.
- **Source**: trace the source of each material you identified. Does it originate from a raw, reused or recycled material? Raw materials that have to be mined and/or refined have a higher environmental impact.
- **Social costs (L**ow, **M**edium, **H**igh): are the raw materials obtained in a way that respects workers' rights? For example, most electronics contain a mineral called coltan that is primarily mined in war-torn Congo. Workers have few rights, poorly paid and are often school-aged children – a high social cost.
- **Transportation**: do workers have to travel to the work site? Does growing the crop require machinery? Is a material only found in a remote area? What are the greenhouse gas emissions associated with each step of the production phase? What type of transportation is used: flight, boat, road, rail, or a combination thereof?

Additional Resources

Volvo's Black and Grey List

http://www.tech.volvo.com/std/docs/100-0002.pdf

Volvo Black List details high environmental cost materials that must not be present in the Volvo supply chain.

http://www.tech.volvo.com/std/docs/100-0003.pdf

Volvo Grey List details materials that should not be in their supply chain.

Canada's Toxic Substance List

http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=EE479482-1

Environment Canada's Substance List, including lists of toxic substances, and those designated for elimination.

Hazardous Substance List

http://www.nj.gov/health/eoh/rtkweb/documents/hsl_alpha.pdf

New Jersey 2010 Right to Know Hazardous Substance list.

Congo's Bloody Coltan

http://pulitzercenter.org/video/congos-bloody-coltan

Greenhouse Gas Emissions and Transportation
http://www.epa.gov/oms/climate/420r06003.pdf
Greenhouse gas emissions from the US Transportation Sector 1993 – 2003.

http://www.apple.com/environment/#transportation
Apple Environment – Transportation.

Production

Break down the various costs of manufacturing the product: processing raw materials, labour, transportation. This includes not only the direct cost but also costs to society like airborne emissions, manure, or erosion.

Students should examine:

- **Manufacturing Process (L**ow, **M**edium, **H**igh): rate how environmentally damaging the component's manufacturing process is. For example, if the manufacturing process uses a finite resource like coal or gas or a lot of physical labour, rate the component as having a high (H) impact. This category can be separated in two: environmental and social costs. Social costs account for whether the manufacturing process is socially damaging by paying workers minimally, or seeing them work in unsafe or hazardous conditions.

- **Number Produced (L**ow, **M**edium, **H**igh**):** consider the number of components that would be produced annually for this product – jeans would be manufactured in greater abundance than a high-end sports car. The abundance of a product increases its environmental impact.

Distribution

After production, the product is now ready for sale. How does the product reach its consumer? Does it travel to a distribution center? Is it sold at the local market, easy-to-access stores or in big-box stores away from residential centres?

Students should examine:

- **Size: Weight/Volume (L**ow, **M**edium, **H**igh): how big and heavy is the product? Can it be easily transported? Shipping balloons full of air would require a lot more space and cost than if they were shipped deflated. For example, Apple reported that decreasing the packaging of MacBooks by 53% allowed them to ship 80% more boxes in each airline shipping container.

- **Transportation:** how far did the raw materials have to travel before entering the production phase? From production to retailers?

Use Phase

Product consumption is directly tied to its marketing – is it considered an essential product? How and why do we use it? Are there direct environmental impacts (like CO_2 emissions from driving) from using the product?

Students should examine:

- **Use Time (L**ow, **M**edium, **H**igh): identify a typical length of use time for a product. For a pair of jeans, this could be anywhere from a year to many years. A disposable cup however, is used once and then disposed. How many do we consume? A low use time would increase the product's environmental impact —if we consume one disposable cup every day, that means in a year we use 365 and over the course of 5 years, that quickly adds up to 1825 disposable cups.

- **Water consumption**: is water consumption tied to the product use? For example, how many litres of water are consumed each time a pair of jeans is washed? Assuming they're your favourite pair of jeans, you wash them once a week, your washer used ~ 100 litres of water on the shortest cycle and you wore the jeans for one year, this would mean you would use 5,300 L of water in a year—this number could be adjusted because you would be washing other clothes in that cycle alongside the jeans.

- **Energy use:** How much energy is associated with product use? How much CO2 emissions are tied to that energy consumption? Assuming your washer use 1.75 KWh per cycle and you used it for the jeans once a week in a year, this would translate to 91 kWh/year or roughly $9 at the current utility prices.

Disposal, or End of Life (EOL)

Identify where the product (or components therein) will likely end up in your region – does your Solid Waste Commission recycle the plastic in the packaging? Do most people throw away the product or recycle it, or keep it for a really long time?

Students should examine:

- **Destination**: at the product's end-of-life, is this component destined to be waste, recycled or reused? Rivets could be potentially be reused in another pair of jeans, or jeans could be down-cycled to become insulation. It's important to determine their likely destination in your area—can this product be recycled or reused by your local Solid Waste Commission? If a component is made from a type 3 plastic but your area only recycles type 2, 5 and 7 plastics, then it would either have to be shipped elsewhere to be recycled or reused, otherwise end up in the landfill.

- **Reason for Disposal:** what triggered the product's end of life? Was it a product malfunction and is cheaper to replace it than to repair? Was it because the product, like a pair of jeans, wore out and were filled with holes?

Depending on the type of product, students could do a survey asking other students, peers or community members what they do with this type of product at its end of life.

Product Redesign

Now that you have conducted a life cycle assessment, you want to start thinking about how the product can be redesigned to minimize any negative – environmental, social and economic – impacts. We can begin asking some questions about both the functionality and environmental impact of each product component.

- Are there parts of the design that could be changed to make it easier to disassemble, such as only one type of fastener, or requiring the use of only one type of tool?

- Could fewer materials be used in the manufacturing process?
- Could the parts be reused on a subsequent model or in a different product?

Some product components may be essential to the functionality of the product and redesign might hinder product performance—a product that sits on a shelf without a consumer has a negative environmental impact. The following are some questions to consider in determining whether the part is essential in its current form:

- Does the part need to be from a specific material for functional reasons? This could be one of many functional reasons such as the primary product function, safety, storage, e.t.c.
- Does the part need to be the shape it is for functional reasons?
- Does the part need to be the fastened the way it is for functional reasons?
- Does the part have a different functional lifetime than other parts? That is, will one part have a much longer lifetime than the rest of the parts?
- Is the part required for assembly or disassembly?

Students should rate each components to determine whether it is essential in its current form:

- **Essential for Product Functionality (L**ow, **M**edium, **H**igh)**:** if the product cannot function without this component in its present form, rate it as high (H). Do you think the product could function without this component? For example, a computer could not function without a CPU, but it would function perfectly fine without a Case.

In proposing a product redesign, we should focus on the areas that will have the greatest positive impact – we cannot really alter those components that are essential in their current form for product functionality.

Identifying Improvements

Everything is easier with a visual. **Fishbone diagrams** are visualizations of cause-and-effect relationships. These diagrams can be used to trace the many inputs affecting an output – this output could be a product such as laptops purchased by the school board or a process like an inefficient school bussing system. A fishbone diagram, seen in Figure 3 [see end of document] can be used to discover limiting factors, thus allowing maximization of time by focusing on the areas that will have the most profound effect.

To make a fishbone diagram:

- Set the problem to be studied as the 'head of the fish' (*Effect* in Figure 3); for example, this might be Low Recycling Rate.
- Label each 'bone of the fish' as a major category (*Cause* in Figure 3); for Low Recycling Rates, these might be Technology, Education, Proximity, Cost.
- Identify factors within each category that may be affecting the overall problem (secondary and tertiary).
- Continue to do this for each factor, generating sub-factors along each of the major branches
- Repeat this until the point is reached

where the question 'why is this happening?' can no longer be answered.

- Analyze the diagram looking for areas that appear on multiple bones, which signify that they are likely to be a significant cause of the overall problem. Also look for easy to change factors with solutions that could be implemented quickly.
- Create a priority list of factors that must be looked at in solving the overall problem.

In Figure 3, the fishbone diagram identified that the main cause of low recycling rates was due to lack of education among consumers, government officials and producers.

Additional Resources

Fishbone Diagrams

http://en.wikipedia.org/wiki/Ishikawa_diagram

Process Redesign

We can think of a process as the act of doing something; so this could include the steps required to manufacture a product, the steps involved in making a meal, or in disposing of waste. Often, a small change in a process or behaviour can have profound impacts.

For example, small changes at a school or classroom level may be able to significantly increase the amount of recycling. Let's say there is a small wing of 4 classrooms in a school. No garbage cans, only recycling bins, were located within each classroom and one garbage can was available in the hall for the 4 classrooms. This could be compared to a similar wing where the reverse situation was found: garbage cans in each classroom with one recycling bin in the hall. It is likely that recycling will be more common in the first situation because it is easier to recycle.

In industry, the use of RFID (Radio Frequency Identification) tags are becoming more common to help improve processes. They enable companies to improve inventory record keeping - how much of each product is in-stock, and exactly where it is in the distribution chain. Companies such as Wal-Mart have been able to implement these in their supply chain and reduce wasted inventory by 2%. This may not sound like much, but for a company the size of Wal-Mart, it represents roughly $8 billion a year.

Re-designing processes is all about making something easier, or more attractive to do for the person doing it. A viral video sensation explored this idea of increasing a desirable behaviour by making it more fun than the alternative – you can find it at **thefuntheory.com**. This idea could be applied in an innovative way to increase school-level recycling or reducing the amount of waste in a cafeteria every lunch hour.

Steps of the Process

The first step in process re-design is identifying all the steps required to complete the task under the current system.

For example, the process for recycling a beverage container may include the steps shown in Table 2.

Table 2. Steps to recycle beverage container.

Steps
Drink beverage
Decide to recycle container
Walk 250 m to nearest recycling location
Deposit container

Assessing Steps

Each of these steps then needs to be analyzed for several factors:

- **Resources required**: Identify the resources required to perform the step. For example, if a step involved driving a car from point A to point B, the resources required would be a car and gas.
- **Source of resources**: Identify the source of any resources required. Is it something already available to the user, or does it have to be purchased each time?
- **By-Products**: Identify any by-products produced by the step. Again, if a step involves driving a car, the by-products would include carbon dioxide emissions, air pollution, and noise.
- **By-Product Destination**: Identify the destination for each by-product. Where do the by-products end up? Are they recycled, or emitted to atmosphere?
- **Environmental Impact (L**ow**, M**edium**, or H**igh**):** Using the previous factors, assess the environmental impact of each step as either low, medium, or high. This will be quite subjective.
- **Memorability (L**ow**, M**edium**, or H**igh**):** Rate the step according to how easy it is to remember to perform.
- **Complexity (L**ow**, M**edium**, or H**igh**):** Rate the complexity of the step.
- **Enjoyability (L**ow**, M**edium**, or H**igh**):** Rate the level of enjoyment that the user will receive from performing the step
- **Likelihood of Performing (L**ow**, M**edium**, or H**igh**):** Based on the previous three categories, rate the likelihood that the step will be performed. Steps that are easy to remember, easy and enjoyable are much more likely to happen than those that aren't.

These will all be entered into Table 3 [see end of document]. This table allows us to quickly identify any problems with an existing process. The questions we need to ask are:

- Are there currently any unnecessary steps in the process?
- Can we make any adjustments to the step to maximize the likelihood of performing?
- Can we make any adjustments to the step to minimize the environmental impact?

In the example in Table 3 [see end of document], the key steps we really need to address are:

- Remembering to recycle the product – how can we make this easier for people to remember? This might be signage, advertising, peer marketing, e.t.c.
- Walking 250m to nearest recycling container – how can we make this seem like less of an inconvenience? This might be by placing recycling containers in more locations, so that they are closer.

There may have to be a compromise between environmental impact and likelihood of performing. We may be able to increase the likelihood of performing by allowing people to drive, but this increased the environmental impact.

Process redesign will be important when students begin thinking either about reducing waste at the school or at home by making it easier to reduce, reuse or recycle.

Setting Targets

Behavioural changes like encouraging students to bring reusable mugs to school are generally free to implement, however, people need to be convinced to make that choice repeatedly for it to have an effect. In order to do that, we need to make the task:

- as easy as possible;
- as enjoyable as possible; and,
- seem important to people.

In Germany, **Design for Environment** (**DfE**) is incorporated into the **German Packaging Ordinance**, which regulates the way products are packaged and sold in the country; companies are legally responsible for the costs of disposal of packaging after a product is used. This encourages companies to find ways to minimize the amount of packaging and ensure that the materials used are capable of being reused or recycled.

The **Waste Electrical and Electronic Equipment (WEEE)** is a European initiative that sets mandantory collection, recovery and recycling targets for all types of electronics.

European **End of Life Vehicle Directives** require car manufacturers to take possession of any car they sell at the end of its life and recycle a significant portion of it (more than 95% after 2012). Since manufacturers have to do this, they have started to look at ways to make their cars easier to disassemble, recycle, and even reuse parts by reducing the number of materials, avoiding toxic substances, and simplifying the manufacturing process.

Making a technological change in the way a product is manufactured, or making producers responsible for disposal at a product's end of life, probably won't be possible. Students could look at various ways of pressuring a company to manufacture a more sustainable product through letter writing, or by rating the sustainability of the various products they examined to encourage others to consume the most responsible product. This could be done through a school-wide awareness campaign using word-of-mouth, social media and technology, where a survey is administered both before and after to assess its success.

Setting targets should be an area where the students have a chance to be innovative and can take a variety of forms. Setting your targets appropriately is always difficult, but you should keep these pointers in mind.

- Targets should be measurable.
- Targets should always be achievable, but challenging to reach.
- There should be times when you don't meet your targets (hopefully you are close).
- Targets can be adjusted as you go through the process and begin to realize what is appropriate.

For instance, if students drink coffee or tea (or even water) and are currently using disposable cups or bottles, they could start bringing reusable mugs to eliminate their consumption of cups. They can then look at implementing this type of strategy at the school by setting a target like reducing the number of disposable cups used at the school by 20% this school year by working with cafeteria staff to ask students whether they have their refillable cups.

Additional Resources

The Fun Theory

http://www.thefuntheory.com/

This project is a great way to demonstrate how you can change behaviour for the better by making the task fun. Obviously, the expense involved in some of these projects is probably too great, but the idea is sound (particularly the stair case piano)

EU End of Life Vehicles Directive

http://ec.europa.eu/environment/waste/elv_index.htm

Summary of German Packaging Ordinance
http://www.cleanproduction.org/library/EPR_dvd/DualesSystemDeutsch_REVISEDoverview.pdf

Waste Electrical and Electronic Equipment (WEEE)
http://en.wikipedia.org/wiki/Waste_Electrical_and_Electronic_Equipment_Directive

Calculating Savings, Costs and Benefits

Calculating savings made from any of the proposed changes is an essential step. Before we actually implement any changes, people are going to want to see that the change is one worth making. We want to direct our resources to where they are going to be most useful—having conducted a cause-effect analysis will help.

Savings don't always have to be financial (although those will usually get the most attention). We can also calculate any environmental benefits (such as tonnes of CO_2 avoided, or tonnes of material diverted from landfill) as well as any social benefits (the new behaviour is more fun!).

One of the key elements here is going to be the cost benefit / analysis. This allows any decision maker to see the costs and benefits of any proposed change. Where the benefit can be seen in financial terms, we can also calculate how long it will take to pay back the initial investment.

Say for example we invest $10 on a reusable water bottle, but save $1 each day because we are no longer buying a bottle of water at school. A very simple cost benefit analysis tells us that it will only take 10 school days (or 2 weeks) to pay back the initial investment.

Reduced CO_2 emissions, means lower mitigation costs for climate change (maybe our flood defences won't have to be quite as high). We can usually assign a cost to society for each tonne of CO_2 emitted (although finding the right price is usually difficult).

Essential Resources

Calculating Savings: The Gaia Project
http://www.thegaiaproject.ca/sites/default/files/teacher-resources/additional-resources/calculating-savings.pdf

Marketing Your Findings

Implementing the recommended improvements is the next step. The availability of disposable cutlery or plates at the school may not be in your control, but encouraging students to bring their own containers and providing either a place to wash or store them might be.

Implementing behavioural changes are usually a case of effective marketing. How do you convince people to make a change their way of life? There are a variety of ways to do this.

Quantifying the impact is often useful. Instead of just pointing out that someone's consumer choices are having negative impacts, actually inform people of the size of their impact – and not just from one perspective. Driving a car for example has an environmental impact, but also costs people money.

Making people aware of the impact of their decision might be enough. For certain behaviours, people aren't even aware that they are causing a negative impact, and just pointing it out can cause a change. Reminding someone to throw their used paper in the paper recycling rather than the garbage might be enough—though this can be time-consuming.

Pointing out the negative impact isn't enough for most situations though. Everyone knows that cars pollute, but that doesn't stop many people from driving around in their cars by themselves. You will probably have to take additional measures.

Social marketing can be effective. People behave in certain ways simply because everyone else does it. Peer pressure can result in a positive change; you are less likely to use disposable cups if all of your friends bring reusable drink containers to school. This could be part of an awareness campaign on the life cycle assessment research encouraging peers to consume the most sustainable products because it's the most popular and fun option.

Incentives can be another useful tool to cause people to make a change; however, it is unlikely that the incentive can stay in place forever, so people need to see a reason to continue once they have made a change.

All of the changes need to be as easy and as enjoyable as possible for people to respond positively. No matter how often you tell someone what the effect of their choice is, they are unlikely to recycle a bottle if they have to walk twice as far to do it versus throwing it in the garbage. They are unlikely to use a reusable mug if it is awkward and inconvenient.

It's hard to imagine recycling as an enjoyable thing to do, but just making it as easy as or easier than throwing something in the garbage, coupled with the right information can make all the difference. Or consider putting a basketball net over the recycling container!

Measuring Success

As we have said before, you can't manage what you don't measure. And that is still important. Even though you may have already implemented your changes, it is still important to track their performance and see if they are falling below, meeting or exceeding expectations.

This is usually as simple as following the initial measurement process conducted in the audit. You'll be able to track improvements over the years very easily this way and see if your estimates match up with the actual realized improvement.

If they do match – great. You can pat yourself on the back for a job well done and look for more improvements.

If they don't, then it is time to look at why. It is likely due to an assumption you had to make. *Are people behaving as expected? Are as many people taking part as anticipated?*

Looking at how things actually happened compared to your assumptions can assist you in determining whether you could improve the way you estimate, measure and make assumptions in the future.

Glossary

Cradle-to-Cradle
Refers to the concept of reusing or recycling a product at the end of its natural lifecycle. Rather than simply disposing of the product, it becomes part of a new product.

Cradle-to-Grave
Refers to the entire life of a product from conception (cradle) to disposal (grave).

Cradle-to-Gate
Refers to the entire life of a product prior to it coming into possession of the user. This would include raw material extraction, manufacturing, transportation and distribution.

Design for Assembly
Designing to minimize the effort/cost required to assemble. We can have Design for X, where X can be any aspect of the design process including, cost, safety, functionality, etc.

Design for Environment
Product designed in such a way to reduce negative environmental impacts.

Fishbone Diagram
A tool used to identify the root causes of a problem as the first step towards finding a solution.

Intelligent Product Design
Product designed in sustainable manner to reduce any negative impacts associated with stages in its life cycle.

Life Cycle Assessment
Analysing a product or process throughout its entire life from an environment / cost / social perspective. In this case we are looking at it from a sustainability perspective. The full life-cycle refers to raw material extraction, manufacturing, transportation and distribution, use and disposal

Waste Hierarchy
The classification of waste reduction strategies according to their usefulness: 1. reduce, 2. reuse, 3. recycle.

Figure 1: Mapping the impact of a pair of jeans.

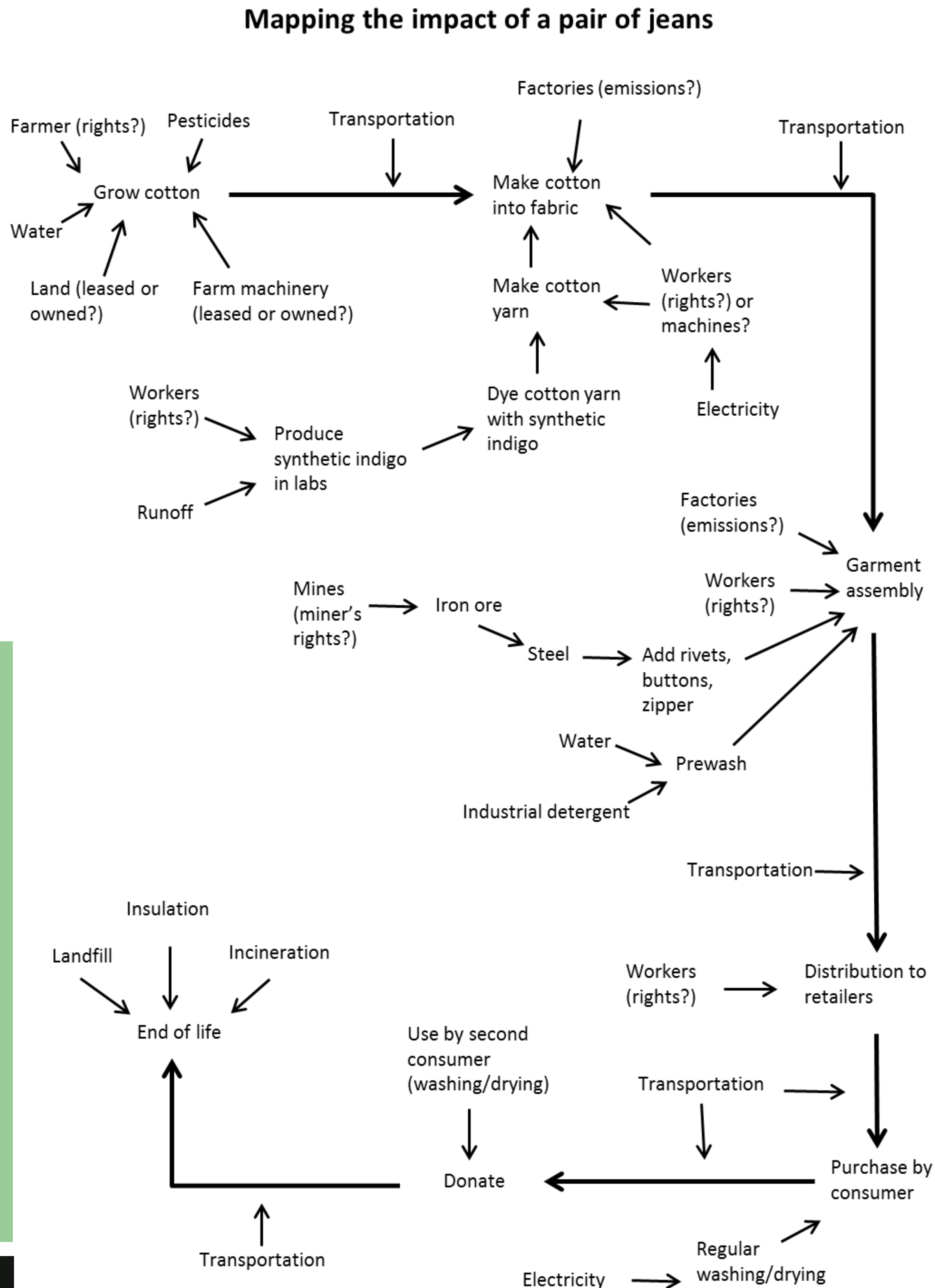


Figure 3: Fishbone Diagram for Low Recycling Rates

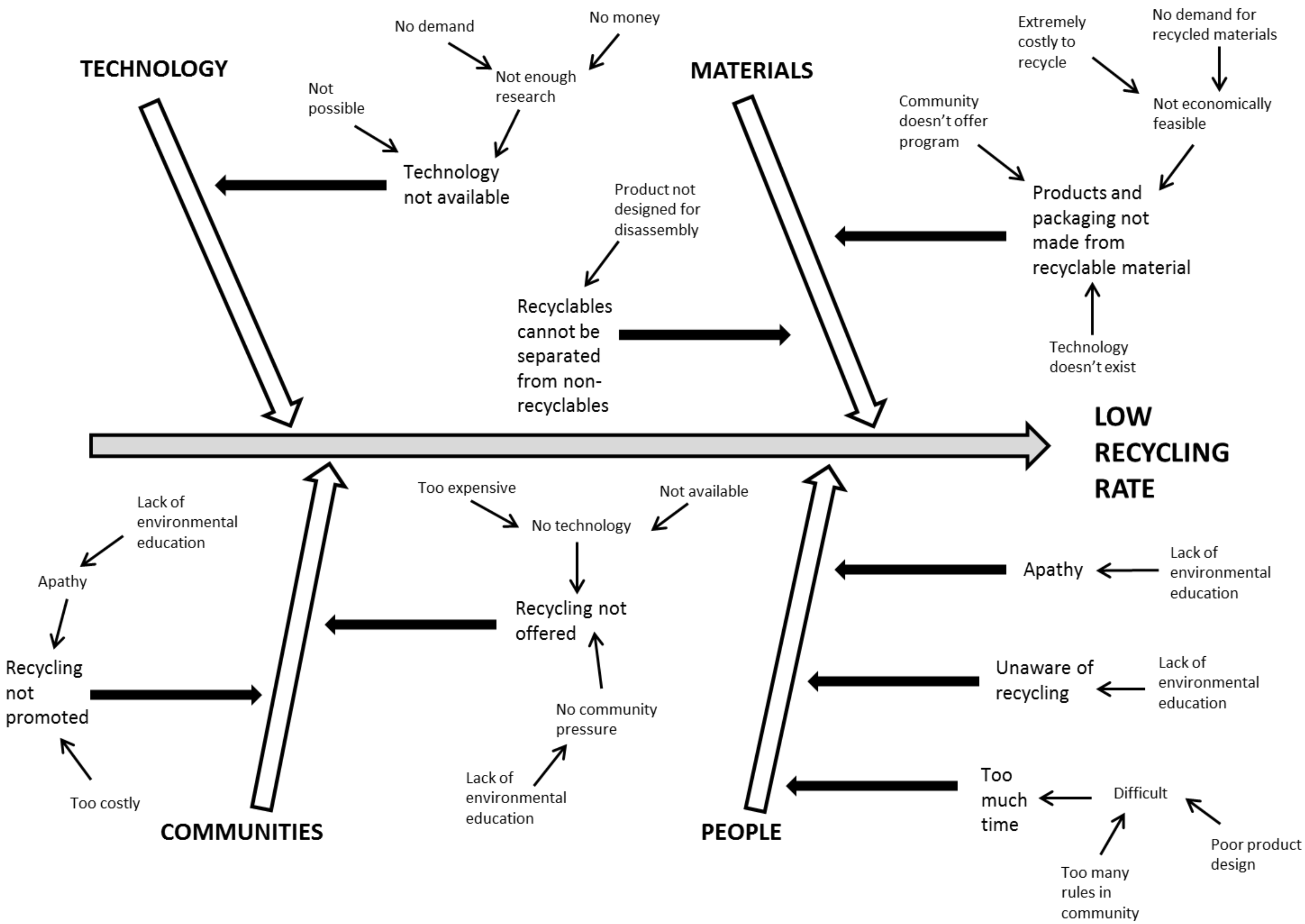


Table 3. Evaluating a process for environmental impact and likelihood of participation

Step	Re-sources Required	Source	By-Products	Destina-tion	Environmental Impact			Memorabil-ity			Complexity			Enjoyability			Likelihood of Perform-ing			Essential for Process Success			Notes
					L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	
Drink beverage	Beverage	Pur-chase	Contain-er	Dependent on this		X				X	X					X			X			X	
Decide to recycle con-tainer					X			X			X			X				X				X	
Walk 250m to nearest recycling location					X					X		X		X			X					X	
Deposit container	Recycling container	Existing – Plastic			X					X	X				X				X			X	