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1. Problem Formulation

1.1. Introduction

Section one introduces an objective as well as a black box model for the project. The black box model shown in Figure 1.1 demonstrates a problem going into the black box, and after a series of events occurs, the black box model throws out a solution, the solution being the effect of the project upon the children that will learn from the waste stream education kit. The waste stream education kit is an educational tool to teach children about the waste stream.

The client is SCRAP (School Community Reuse Action Project) Humboldt, up-cycling center based out of Humboldt County that implements education and affordable materials. This helps to promote their goal of environmentally sustainable behavior and creative reuse.

1.2. Objective

The objective of this project is to design a waste stream education kit that teaches children, grades 3-8, the fundamentals of the waste stream. The project will concern our local waste and where it goes.

Figure 11illustrates the initial problem, the blackbox, and the final solution.

2. Problem Analysis and the Literature Review

2.1. Introduction to the Problem Analysis

The problem analysis explains the criteria, considerations, specifications, usage and the production volume of this project. The problem analysis also analyzes the thought process, which includes analyzing the variables going in, going out, and certain constraints and solutions related to the problem.

2.1.1. Specifications

The specification is a detailed description that provides information necessary for designing an item. The final product will need to be informative to the audience, meaning that it must hold some educational value. It must also be durable because it must last awhile. The project should also be transportable by one person.

2.1.2. Considerations

The consideration is part of the design process that includes careful thought out deliberations, including weighing the pros and cons. Some considerations are who will use the kit, what the purpose is, and what the length of time the kit needs to last.

2.1.3. Criteria

The criteria are necessary factors that must be seen in the project. The constraints are a definition of each of the criteria. These constraints were defined by Team Wasted.

Criteria	**Constraints**
• Aesthetics	• The kit needs to be beautiful and pleasing to the eye by having many colors
• Costs	• Under $300

• Education Value	• Provides information
• Portability	• Must be able to be carried by one person
• Safety	• Harm free with non-toxic materials, lack of sharp edges
• Ease of Use	• A child can use
• Functionality	• Interactive
• Materials	• Needs to be durable and must be made out of 75% re-used materials

2.1.4. Usage

The amount of use may vary greatly depending on where the kit will be stationed at. It may be used in exhibits, schools, and at SCRAP Humboldt. The kit's audiences include teachers, the client, children, and anyone interested in reuse or learning to reuse. The audience may be in small numbers or a large group.

2.1.5. Production Volume

One prototype will be made and tested.

2.2. Introduction to the Literature Review

The Literature Review summarizes and interprets the information found which will support the design process. Each topic is, in some way, related to our design project.

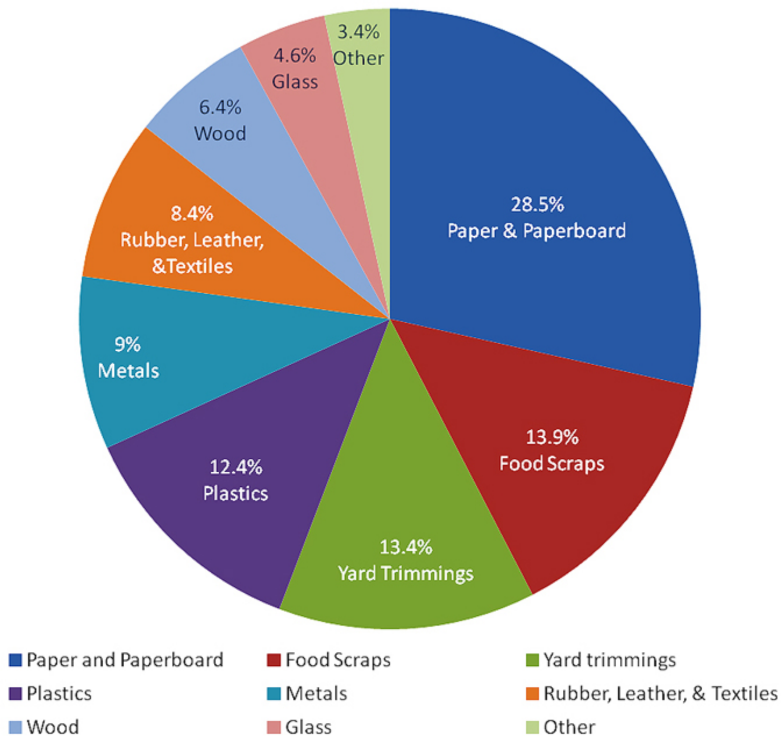
2.2.1. Brainstorm Topics

Some topics we chose to research include learning styles, education, K-8th core curriculum, waste stream, waste management, symbols, reuse, and more. We did a bubble outline format using the website buble.us and printed the diagram out.

2.3. California's Waste Stream

The California Integrated Waste Management Board (CIWMB) is in charge of California's entire waste stream. As of 2008, California had an estimated 39,722,818 tons of disposed waste stream coming from community, residential, and self-hauled waste resources (CCG, 2009). This accounts for each of the solid waste

Figure 21 shows the total municipal solid waste of the U.S. in 2010.



management companies in California. Figure 2-1 indicates that the majority of this waste came from paper and paperboard. The waste stream rates were significantly high at this point and needed to be looked into. The CIWMB set out numerous programs for lowering these rates including pushing the recycling of oil, regulating waste management facilities, and cleaning up abandoned hazardous waste sites. (USEPA, 2011).

2.3.1. Waste Diversion Goals

Often, communities will set a certain diversion goal for the local waste management system. A municipal solid waste company will set a diversion goal. Diversion goals are the amount of waste that a waste management company wishes to divert from their waste stream. The goal can be met by stressing recycling and composting, since the majority of solid waste is composed of recyclable/compostable products. In a study in Fullerton California, it was found that 75% of the waste stream is composed of paper, organics, and yard wastes (Hay, Wesner, McGee & Buell, 1993), which can all be easily composted and recycled. The California Integrated Waste Management Board set out to divert 50% of California's municipal solid waste by the year 2000 (USEPA, 2011). That means that the goal was to only have 19,861,409 tons of waste, a significant drop in the total waste stream.

2.4. Hazardous Waste and Solid Waste

2.4.1. Composition and Characteristics of Solid Waste

Municipal Solid Waste (MSW) can be divided into two categories which include Organics/ Combustibles and Inorganics/Non-combustibles. Paper, yard waste, plastic, and "other organics" are listed under the Organic MSW's while metals, glass, batteries and "other inorganics" are listed under Inorganics. (Liu, D., Liptak, B.) Waste that is diverted from the waste stream in the form of recycling or composting is not included. Further diversion is evident when comparing the waste of residential communities and non-residential MSW with residential communities contributing more newspaper waste, yard waste, diapers, rubber, and leather. Bioavailability is also an important aspect of MSW since microorganisms can metabolize paper, yard waste and food waste while being able to partially metabolize items like disposable diapers. Waste which can be metabolized by microorganisms more easily are said to have a higher bioavailability. Toxicity is a major factor in characterizing solid waste and is classified in one of the following three categories: Toxic metals, Toxic organic compounds and Asbestos containing materials. Although most toxic wastes used to be dumped along with the rest of MSW, the process of large-scale disposal of toxic wastes in landfills has been phased out. Toxic waste has been estimated to make up about 0.5% of MSW with “bulky waste” typically containing larger amounts of concentrated toxic waste than regular MSW.

2.4.2. Implications for Solid Waste Management

Management of bulky solid waste and MSW is a big concern for a number of reasons. The waste stream produces large quantities of material, it’s unsightly, and it’s potentially polluting. Waste reduction is the best method for dealing with the problem of dealing with the waste stream issue. Waste reduction means to reduce the quantity of matter entering the solid waste management system. There is a difference between waste reduction and recycling as reduction directly reduces the amount of waste that needs disposal while recycling does not reduce the amount of material needing to be managed. There are a number of behavioral modifications that can be adopted by people to greatly reduce the amount of material in the waste stream and some of these include: increasing composting, selling products in bulk rather than individually packaged, not buying food in excess, substituting reusable containers, reusing shopping bags, using sponges and hand towels in place of paper towels, and prohibiting the distribution of unsolicited printed advertising.

2.4.3. Paper or Plastic?

1/3 of the municipal solid waste stream is household packaging. That is at least 300 pounds per person per year. 20% of municipal waste is the weight of packaging (wrappers, plastic coverings, etc.), and 40% is the volume of total municipal waste. Packaging has three main types: primary, secondary, and tertiary which is also called transport (Imhoff, D., 2005). Primary packaging is the package that holds the actual item with no other packaging between the item and the material for packaging, such as a soda can. Secondary packaging is when the item is packaged, and then packaged again, such as a package of Hershey Kisses with each chocolate kiss individually wrapped. Tertiary packaging has many forms; it is used to carry the products with the secondary and primary packaging. Some examples of tertiary packaging are strappings (the straps used to tie materials down) and the plastic milk jug crates.

Our common produce, including broccoli and oranges, travels more than 2,000 miles before arriving in the markets (Pirog, D., Van Pelt, T., Enshayan, K., Cook, E., 2001). The transportation vehicle uses fuel, which uses energy to convert the fuel to move the vehicle and have a waste product, exhaust. Food then becomes a waste, because it takes so much fuel and energy to get the food where it needs to go. A study from Stony Field Farm discovered there is more energy consumption for a small 8 ounce yogurt compared to the 32 ounce of yogurt on an ounce-per-ounce basis. If only the 32 ounce containers were sold the energy savings equivalence would be 11,250 barrel of oil saved (Imhoff, D, 2005). Food scraps, spoiled and food in general becomes a waste. In 2005, food scraps were 11.9% of the total municipal waste stream. In 2010, 13.9% of the municipal waste stream was composed of food scraps.

2.4.4. Recycling

Diversion is highly impacted by recycling, but more importantly it is impacted by the willingness of people to recycle. According to the Environmental Protection Agency (EPA), recycling is taking useable materials that we call trash, and using them to make new products. There are several steps in successful recycling, including collecting, processing, manufacturing, and purchasing the new recycled product. Once the recyclables are collected, they are taken to a processing facility where they are sorted, cleaned, and melted down in order to make a new product. Once the new product is manufactured, it can then be resold on the market, and there you have it, recycling!

Recycling is seen as a resource, it is just the same as a raw material. A recycled aluminum can is able to be processed and used as a new aluminum can in just 60 days. If left unrecycled, an aluminum can will take anywhere from 80-100 years to decompose naturally (Earthwize, 2007). Recycling emphasizes making something out of nothing, taking one man's trash and turning it into another man's treasure.

2.4.4.1. Ability to Recycle Most Waste

Most solid waste can be recycled in one way or another if enough time and money is devoted to this process. Since these are limited, waste material is distinguished in categories of most recyclable material and less recyclable material. About 75% of MSW is recyclable or compostable with the proper conditions being met.

2.4.4.2. Reduction, Separation, and Recycling

Waste reduction occurs when the design, manufacture, or use of materials leads to a reduction in waste quantity. The reuse of the products is one of the simplest ways to reduce the amount of municipal waste. Durable goods such as household appliances, clothing and similar goods can be used more than once and therefore be donated through charitable organizations or resold.

2.4.5. Composting

Composting is the same concept as recycling, however it focuses primarily on recycling organic wastes. The organic waste found in municipal solid wastes includes food wastes, and yard trimmings which constitute 32.4% of the waste stream in California. Composting is a process that involves the decomposition of organic material. There are key aspects involved in composting to create a good compost result. These include nutrient balance, temperature, oxygen flow, moisture content and particle size (USEPA, 2013). With a proper balance of all of these things, the compost can provide a good foundation for growing crops. Another benefit of composting is that it lowers the cost of store bought compost, and it contains less harsh chemicals that can get in to storm water drains and pollute the ocean.

2.5. Waste Stream Study & Waste Conversions Technology Review

2.5.1. Environmental and Economic Impacts of Landfill Disposal Reduction

Implementation of processes to reduce landfill disposal rates will reduce total greenhouse gas emission rates. Another benefit is the increased funding of local infrastructure with funds pouring into: Land & Buildings Recycling Processing Equipment, Energy Conversion Equipment, Ancillary Processing Equipment, Loaders, Lifts, Sweepers, and Trucks. In addition it directly contributes to the creation of jobs necessary for the operation of recycling processing and energy conversion process. In addition, jobs will be created as a result of the economic activity generated by the recycling and energy conversion plants, including; truck drivers to transport plant outputs, industrial service jobs to meet the operational requirements of the plant, and retail service jobs to meet the consumer needs of the new workforce.

2.5.2. General Description of MSW to Energy Conversion

THERMAL- Encompasses a variety of processes that produces heat under controlled conditions to convert solid waste into usable energy. The organic fraction of MSW is converted to energy, and the inorganic fraction is recovered as products (e.g., aggregate, metal). Thermal technologies can potentially convert all organic components of MSW into energy. Thermal processing includes such technologies as gasification, plasma gasification, and pyrolysis. BIOLOGICAL- Microorganisms are used to metabolize organic carbon based compounds through anaerobic digestion for the production of biogas or biofuel such as methane.

2.6. Children's Education

2.6.1. California's Science Education Standards (Grades 3-8)

In accordance with California state law, it is necessary that educators follow a strict set of standards in teaching grades 3-8. The standards focus on physical and life sciences for each grade, emphasizing certain scientific aspects at each grade level. Grade three focuses on the physical sciences of energy, matter, and how light works. Its life science standards centers on the concepts of survival of the fittest and adaptations. On the other end of the spectrum, grade eight focuses only on physical sciences which revolve around motion, forces, the structure of matter, Earth sciences (ex: the solar system), density and buoyancy, and basic chemistry (Bruton, Ong, 2009). Through adopting these standards, the goal is to educate children so that they can thrive as educated citizens in the twenty-first century.

3. Alternative Solutions

3.1. Introduction

In order to find the right project to fit the client's criteria, Team Wasted brainstormed six different distinct design ideas that could work as a successful waste stream education kit. This was accomplished through various sessions of structured and unstructured brainstorming. This section documents the brainstorming process that Team Wasted underwent, and it goes into detail about each of the design ideas.

3.2. Alternative Solutions

Below are the six solution ideas that team Wasted agreed would fit the client criteria:

1. Waste Stream Match Game
2. Scrolling Waste Stream Banner
3. Waste Stream Board Game
4. Waste Stream Storybook
5. Waste Stream Model City
6. Waste Stream Education Wheel

3.2.1. Waste Stream Match Game

The Waste Stream Matching Game offers children a chance to learn various facts about the waste stream through an interactive match process. The game is made of a thick piece of paper with the questions and answers written on it. As shown in figure 3-1, on the back of the paper there are strips of aluminum foil that connect from the question to its right answer. Each strip is covered with electrical tape so that no aluminum foil strip comes into contact with another strip. To make the circuit tool (required to indicate whether an answer is wrong or right), two pieces of wire will be attached to a battery and a light bulb. When the child reads the question, they will choose an answer and match them together using the circuit tool. If the child chooses the correct answer, the circuit will be completed, and the light bulb will light up.

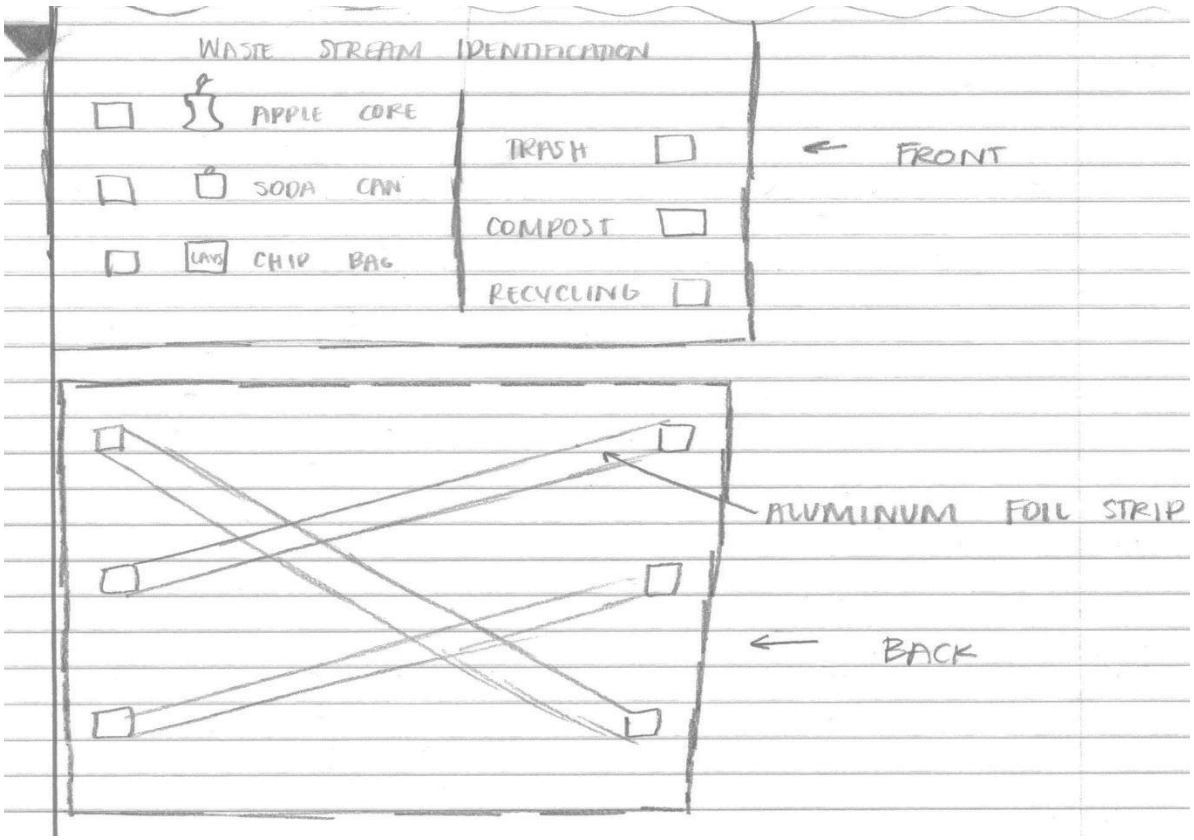


Figure 31 is a detailed drawing of the waste stream match game.

3.2.2. Scrolling Waste Stream Banner

The scrolling banner allows for a step-by-step view of the waste stream. The waste stream process will be drawn on a long sheet of paper with one side of it attached to a bamboo pole, as seen in figure 3-2. The sheet of paper will be wrapped around the pole, and the remaining side of paper will be attached to another pole. When you wind up the pole, the story will begin to unravel, and the children can see the waste stream process. This design is aimed toward children with a more visual learning process.

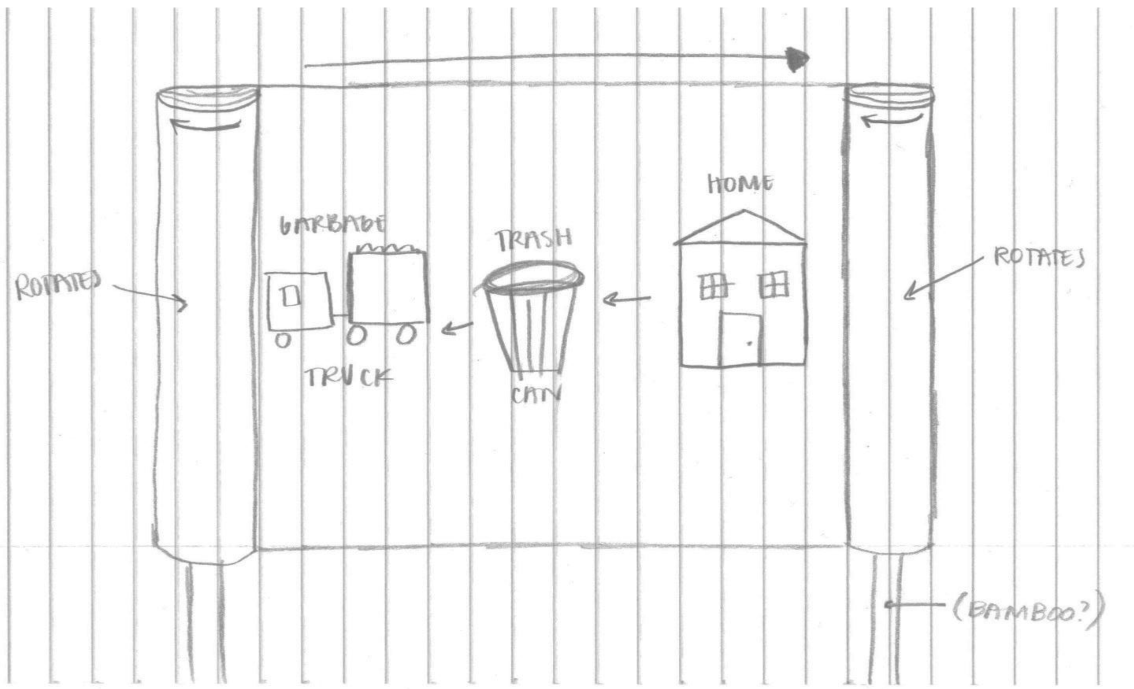


Figure 32: Drawing of the scrolling waste stream banner.

3.2.3. Waste Stream Board Game

The object of this idea is for the children to be interactive with a multiplayer game. The game board will be modeled after Monopoly complete with game pieces, and a board that models the pathway of the waste, as seen in figure 3-3. The game board is easy to transport by one person.

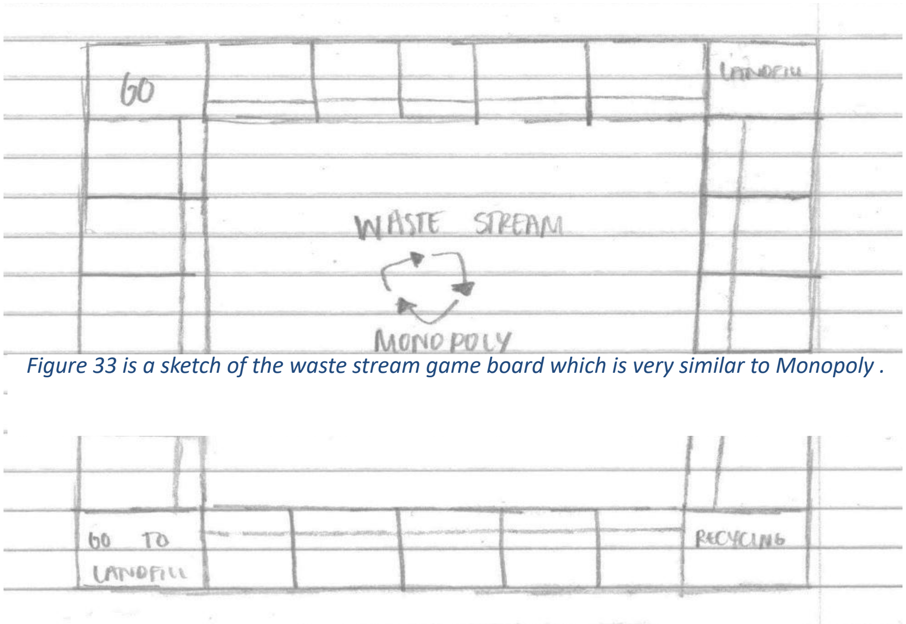


Figure 33 is a sketch of the waste stream game board which is very similar to Monopoly .

3.2.4. Waste Stream Storybook

The waste stream storybook is a book that shows the waste stream process from the home to the dump and or recycling or reuse center. The information is interactive through pop-up pictures and is engaging with fun facts, as seen in figure 3-4. The storybook allows a few children to participate in the learning experience. The storybook is easy to transport by one person.

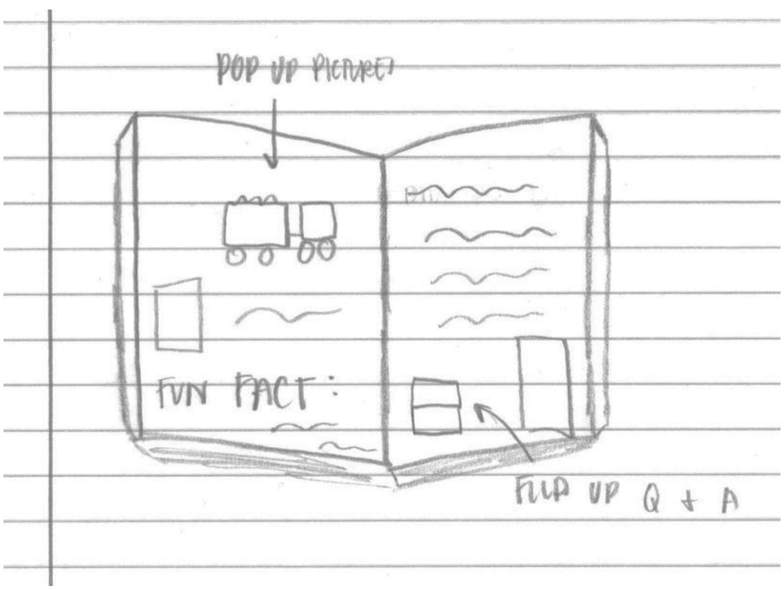
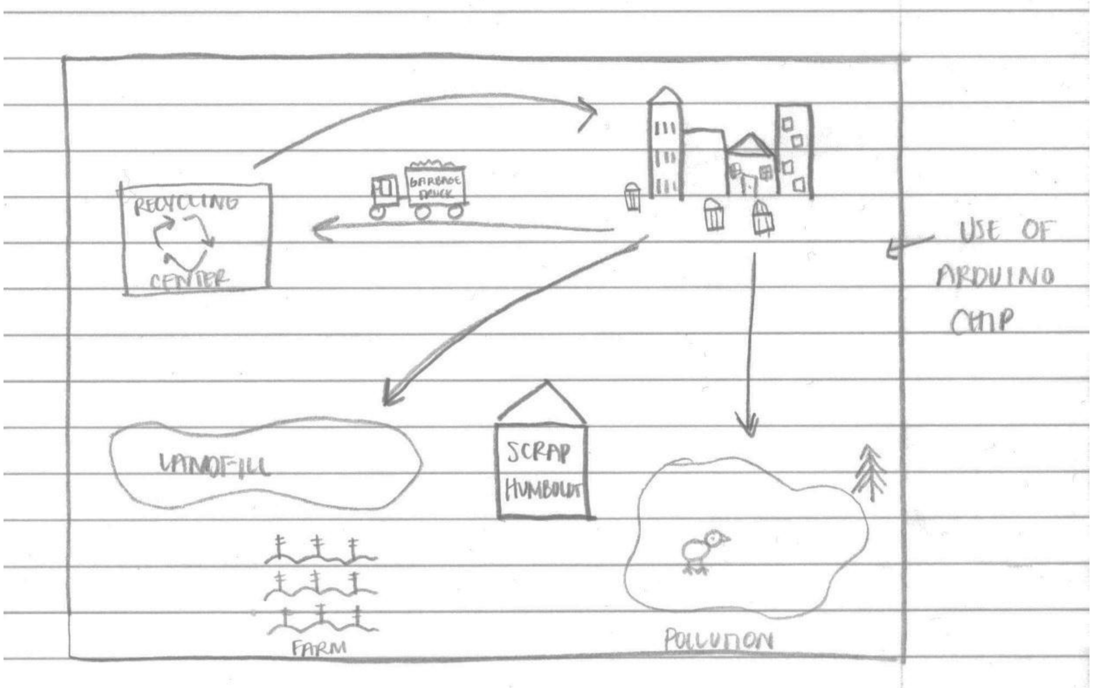


Figure 34 is a drawing of the waste stream story book. As you can see, there are plenty of pictures and interactive elements.

3.2.5. Waste Stream Model City

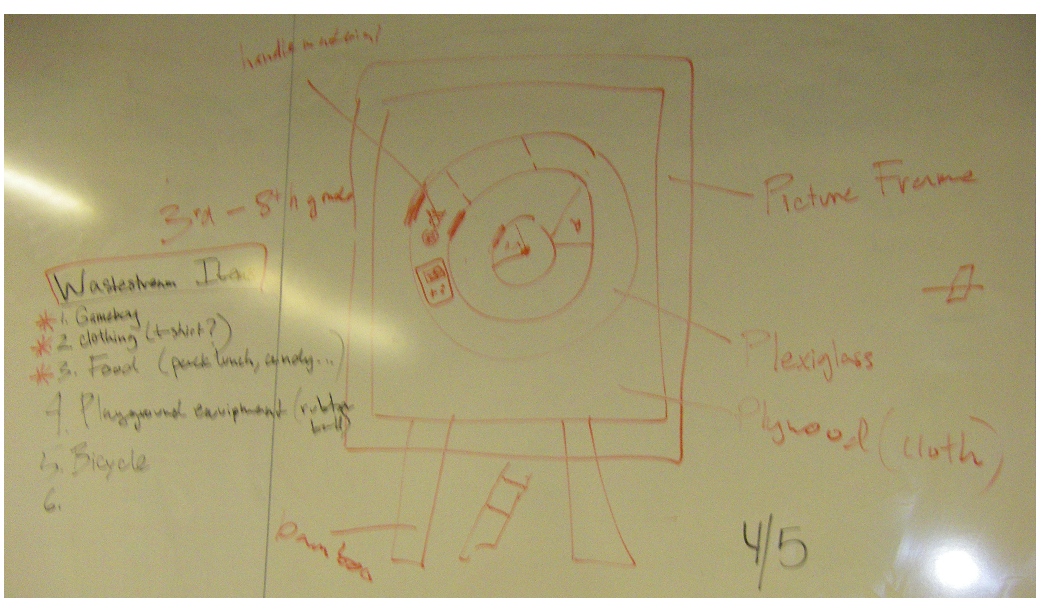
The waste stream model city is a miniature city that traces where the garbage goes after throwing it away. It has arrows that show the different pathways that waste can take, as seen in figure 3-5. The model city uses an Arduino chip for lighting up the waste pathway, sounds and buttons. The model city not only allows many children to observe, but also enables many children to interact with the model via buttons hooked up to the Arduino chip.

Figure 35 is a sketch of the waste stream model city. Arrows indicate where the waste is traveling.



3.2.6. Waste Stream Education Wheel

The waste stream education wheel is an interactive board with three separate wheels on it. Each wheel is spun



separate from the other wheels. A cutout on each wheel provides a viewing window for what is underneath the wheel. Underneath each wheel, there is a life cycle analysis of an item that a child sees everyday, as seen in figure 3-6. This design enables kinesthetic and visual types of learning.

4. Decision Phase

4.1. Introduction

The decision section is dedicated to the decision making process. In order to make a decision, the alternative solutions from Section 3 are evaluated. The overall solution is identified by using the Delphi Matrix. The Delphi Matrix compares each solution to the criteria from Section 2.

4.2. Criteria

The criteria are defined to help find the best alternative solution for the client's vision as follows:

Figure 36 shows a detailed drawing of the waste stream education wheel. It includes elements of up-cycled materials.

Photo Credit: Jeanne Fashauer

- Cost: The total materials costs are less than $300.
- Aesthetics: Professional and unique appearance.
- Education Value: Provides information on the waste stream for K-8 students.
- Portability: The item is able to be carried by one person
- Safety: The project is harm free. No sharp items.
- Ease of Use: A child can use the project.
- Functionality: Is interactive and has more than one purpose.
- Materials: Is durable, toxic-free and is made of at least 75% reusable materials.

4.3. Alternative Solutions

The alternative solution is evaluated to determine the overall best possible solution for the project. As described in Section 3, the six different solutions are:

1. Model Waste Stream City
2. Scrolling Waste Stream Banner
3. Waste Stream Story Book
4. Waste Stream Match Game
5. Waste Stream Game Board
6. Waste Stream Education Wheel

4.4. Decision Process

The decision process includes using a Delphi Matrix shown in Table 4-1. A Delphi Matrix shows each alternative solution and ranks each solution against the criteria on a 0-50 scale. A rank of 50 means alternative solution matches the criteria fully while 0 means there are no criteria factors involved. The criteria are ranked on a 1-10 scale with 0 being least important and 10 being very important. The overall score for each solution is calculated by multiplying the criteria weight with the rank (0-50) of the solution and then adding each of the scores for each criterion. The alternative solution with the total highest value is considered the more qualified solution.

Criteria	Weight	Model City		Scrolling Banner		Story Book		Match Game		Board Game		Education Wheel	
		Score	xWeight	Score	xWeight	Score	xWeight	Score	xWeight	Score	xWeight	Score	xWeight
Cost	4	25	100	40	160	45	180	40	160	45	180	49	196
Aesthetics	7	45	315	36	252	40	280	36	252	39	273	45	315
Educational Value	10	40	400	38	380	35	350	42	420	17	170	44	440
Portability	8	30	240	48	384	49	392	40	320	40	320	49	392
Safety	9	44	396	47	423	47	423	22	198	38	342	48	432
Ease of Use	6	40	240	42	252	48	288	43	258	28	168	45	270
Functionality	9	38	342	26	234	28	252	35	315	33	297	33	297
Materials	5	27	135	35	175	34	170	41	205	39	195	39	195
Average Total		2168		2260		2335		2128		1945		2537	

Table 41 is the Delphi Matrix. The waste stream education wheel scored the highest overall.

4.5. Final Decision

The final decision is to construct a waste stream education wheel. This was determined through the help of the Delphi Matrix, as well as the client's feedback on the alternative solutions. This solution best fits the given criteria and will fulfill the client's requests as well as our overall objective.

5. Specification of Solution

5.1. Introduction

The specification section describes the structure of the design chosen in Section 4. It gives a detailed breakdown of the waste stream kit and includes a cost analysis as well as instructions for assembly.

5.2. Solution Description

The waste stream education kit is an interactive learning tool that educates children about the life cycle of certain objects they see every day. It consists of three wheels, with knobs on them, which can be spun to reveal a life cycle diagram of an item that a child sees everyday, as seen in figure 5-1. This gives the child the opportunity to see what happens to their waste after they discard it. It is interactive and aesthetically pleasing, so it can educate visual and tactile type learners.

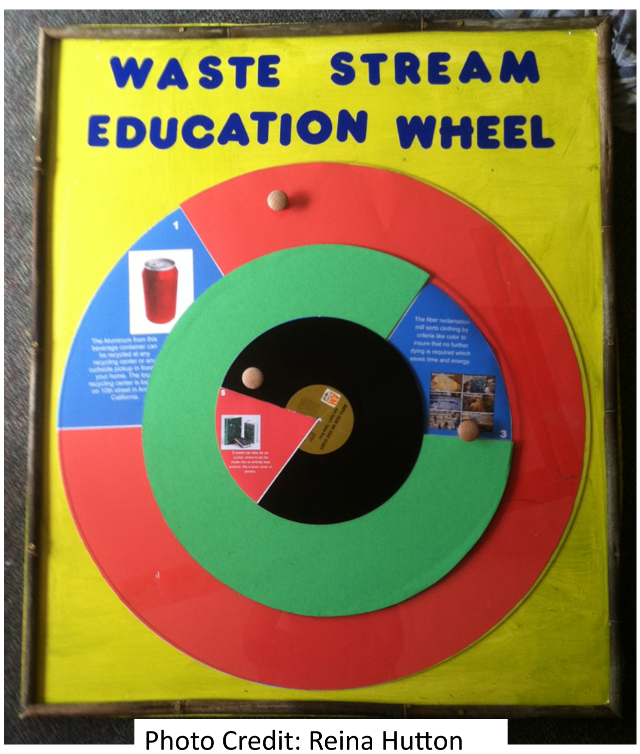


Photo Credit: Reina Hutton

Figure 51 is the final design of the waste stream education wheel.

5.2.1. The Wheels

Two of the wheels are made of plexiglass and the third wheel (the smallest wheel) is an up-cycled record. All three wheels spin about a single screw in the center of the three wheels. The biggest wheel has a diameter of 28 Inches, the middle wheel has a diameter of 20 inches, and the record has a diameter of 12 inches. Each wheel has an up-cycled knob screwed into it. The wheels are blacked out so that the cycle underneath remains hidden until they are revealed in the viewing window. Each wheel gives a life cycle analysis of items a child sees every day. These items include an aluminum can, a t-shirt and a gaming device. The cycles underneath the wheels were designed using Microsoft Publisher, Figure 5-2 is a preview of the wheel showing the life cycle of a gaming device.

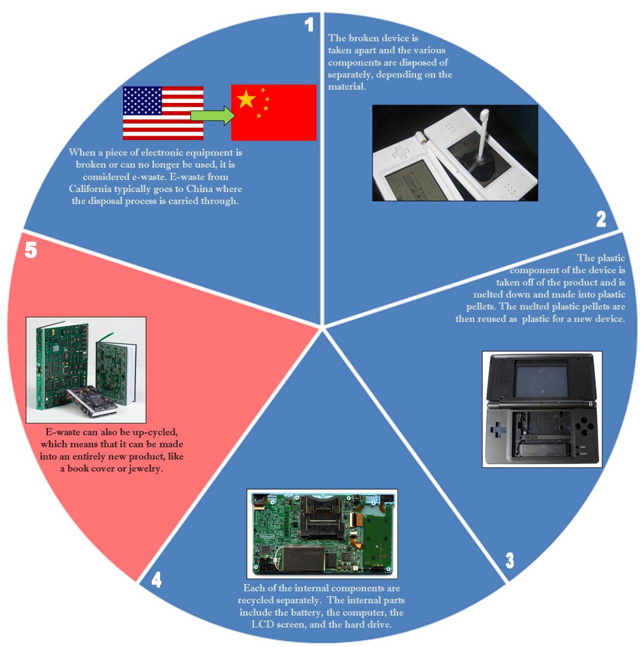


Figure 52 shows the life cycle analysis of a gaming device.

5.2.2. The Stand

The entire structure rests upon a stand that can fold. This is what makes the product portable, so that it can be set up in different places with ease.

5.3. Cost Analysis

The cost analysis covers the cost of materials, and the cost of designing the project.

5.3.1. Cost of Materials

This project allowed for a budget of only $300. Of that money, only $95.31 was spent, as seen in Table 5-1. A majority of the materials was donated or up-cycled, otherwise this project would have cost $293.31. This means that this project had a total savings of $198.00.

Material	Quantity	Retail Cost ($)		Team Costs ($)
		Each	Total	
1qt Natural Paint Eggshell Base green	1	22.02	22.02	22.02
Alphabet Letters (package)	1	10.00	10.00	0.00
Bamboo	8	2.00	16.00	0.00
Brush 4 PC Set	1	8.99	8.99	8.99
Bulls eye zero quarts	1	12.34	12.34	12.34
Door nobs	1	10.00	10.00	0.00
Duck Tape	1	5.99	5.99	5.99
Paint with tray set	1	5.99	5.99	5.99
Paintbrush .5”	1	0.99	0.99	0.99
Plexiglas 32x44x.100”	1	32.99	32.99	32.99
Plywood	1	32.00	32.00	0.00
Vinyl record disk	1	10.00	10.00	0.00
Printing	1	120.00	120.00	0.00
Colored paper	6	1.00	6.00	6.00
Total			293.31	95.31

Table 51 shows the materials costs in designing the project.

5.3.2. Cost of Design

The cost of design is the total amount of time the group spent on the project. In total, 188 hours were spent on building this project. As seen in Figure 5-1, most of our time was spent on Section 5 and Section two.

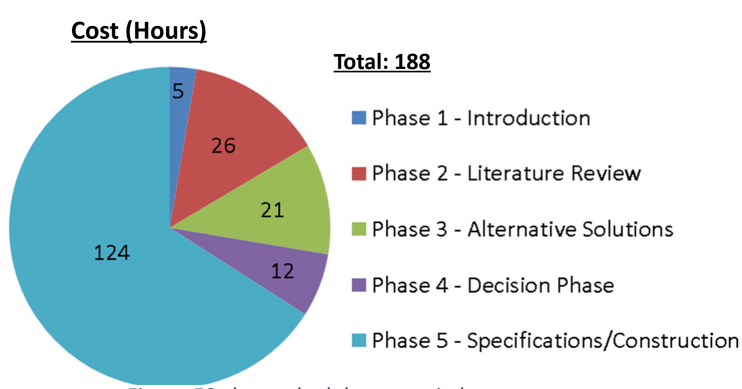


Figure 53 shows the labor costs in hours.

6. Appendices

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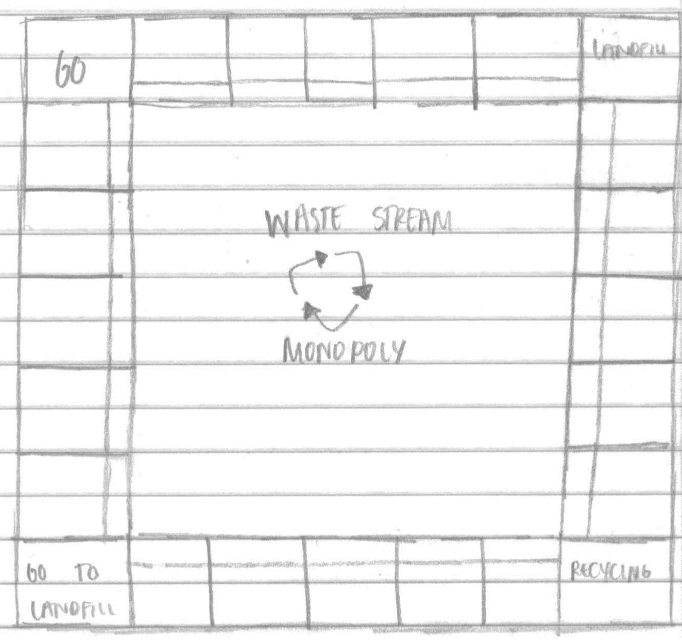
6.2. Brainstorming Notes

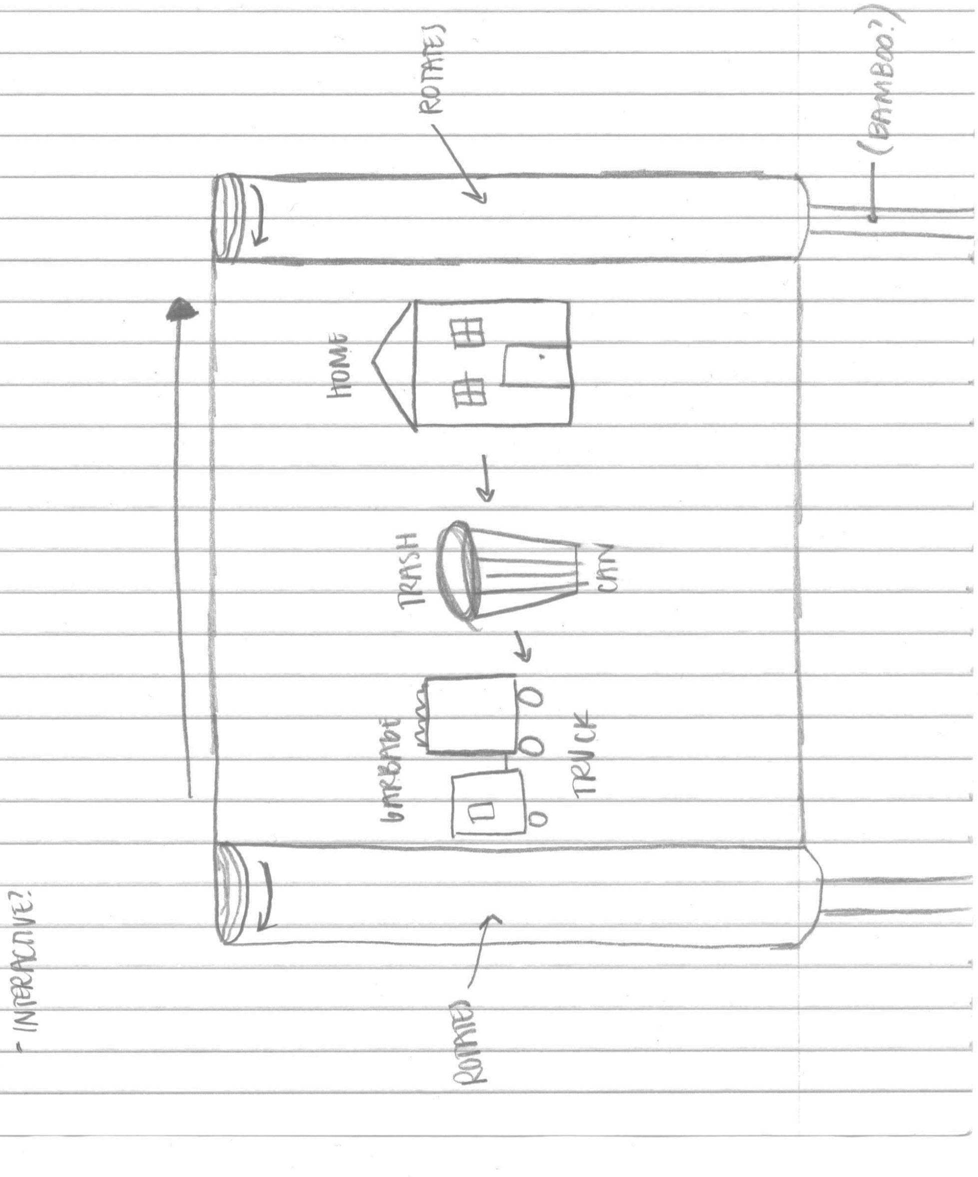
BRAINSTORM: GAMEBOARD 3/6

- WASTE STREAM
- ROTATING
- LIGHTS
- PIECES
- MUSIC
- SAFARI
- ~~CHICKLETS~~
- CARDS
- CANDY LAND
- MONOPOLY
- DIE
- MOUSETRAP
- SORRY
- HUNGRY HUNGRY HIPPOS
- OPERATION
- PUZZLE
- PRETTY PICTURE



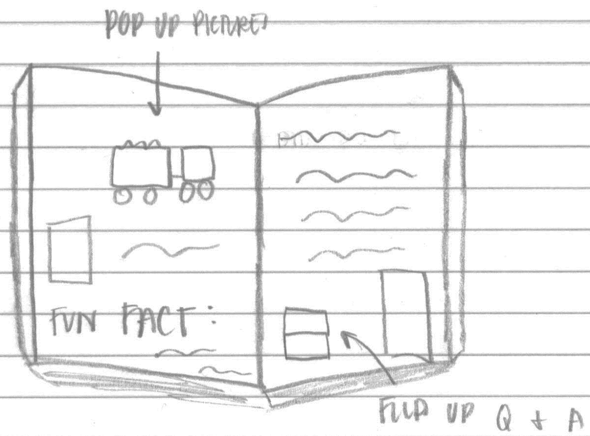
SCROLLING BANNER

- AS YOU ROTATE THE BANNER, THE PICTURES CHANGE AND IT SHOWS THE FLOW OF WASTE.



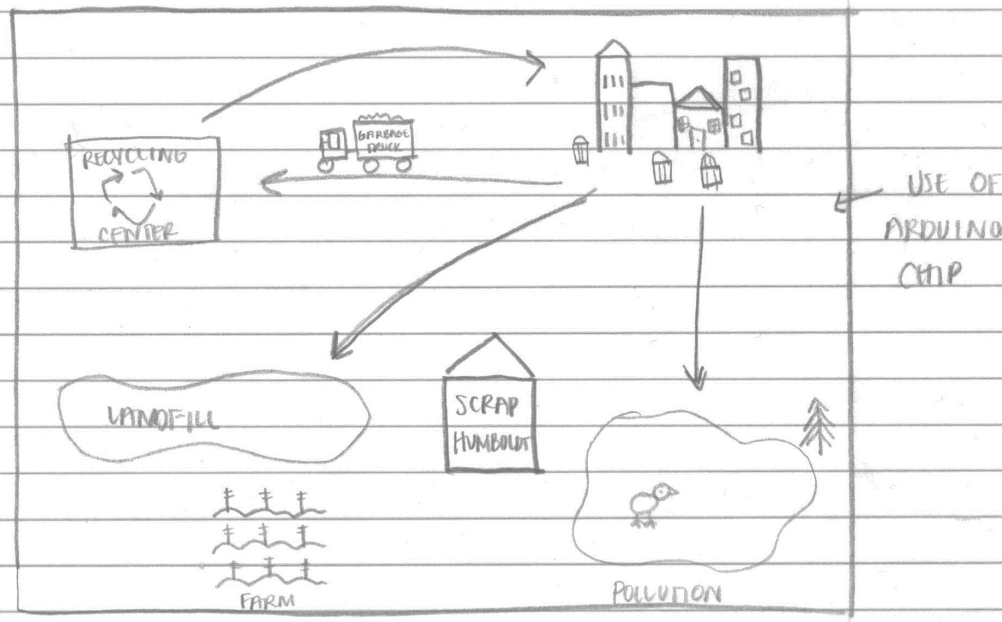
WASTESTREAM
STORYBOOK 3/6

- POP UP PICTURES - FUN FACT
- INTERACTIVE PAGES



MODEL CITY

A REPLICA CITY THAT IS INTERACTIVE THAT SHOWS WHERE GARBAGE GOES.



- GARBAGE
- RECYCLING
- DIVERSION
- REUSE
- REPURPOSE
- DISPOSAL

- LAND USE