Multidisciplinary Senior Design
Project Readiness Package

Project Title:	**Nicaragua Bottle Upcycling Product Design and Manufacturing**
Project Number: (assigned by MSD)	P18433
Primary Customer: (provide name, phone number, and email)	Enlace Project, https://www.enlaceproject.org/ , https://www.facebook.com/enlaceproject/ ; Kellan Morgan, kellanpmorgan@gmail.com, 585-752-0227; Henrique; Bonnie Yannie, 4 Walls, Nicaragua, bonnieyannie@gmail.com
Sponsor(s): (provide name, phone number, email, and amount of support)	RIT MSD $1000 or Autodesk $1500
Preferred Start Term:	Fall 2017
Faculty Champion: (provide name and email)	Sarah Brownell, Rob Stevens
Other Support:	Bob Bectold at HARBEC Plastics; The Construct
Project Guide: (assigned by MSD)	

Sarah Brownell

Prepared By	7/8/17 Date
Received By	Date

Project Information

*** Overview:**

Various stakeholders in the town of El Sauce, Nicaragua are interested in promoting solid waste separating and recycling to clean up the town, reduce mosquito breeding sites, and to stimulate the local economy through both recycling revenues and increased tourism. Two organizations with connections to Rochester have worked in the community for many years and will help facilitate this project: 4 Walls builds houses for families with inadequate shelter and the Enlace Project has helped support local small business and cooperative development. The goal of this MSD project is to develop an upcycled plastic product made from reclaimed plastic bottles that can be used in home construction by 4 Walls. Additionally, the team is tasked with developing the manufacturing processes and equipment needed to create such a product. This project will likely involve the opportunity for student travel to Nicaragua during fall or spring break.

Last year's MSD Team P17433 conducted research on the bottle recycling systems in place in the town of El Sauce during a spring break study abroad trip (extensive notes available) and sketched out the relationships of the stakeholders in a Mess Map (Figure 1).

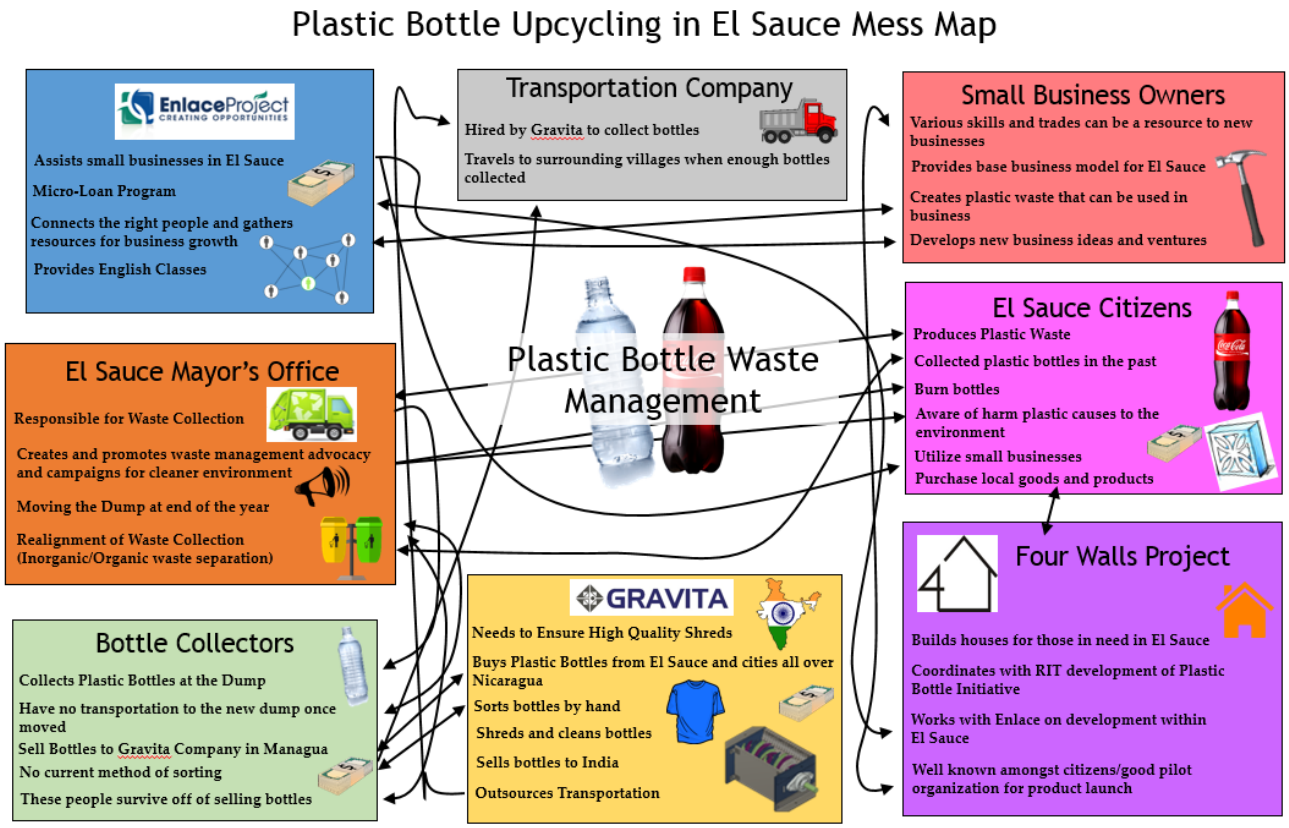
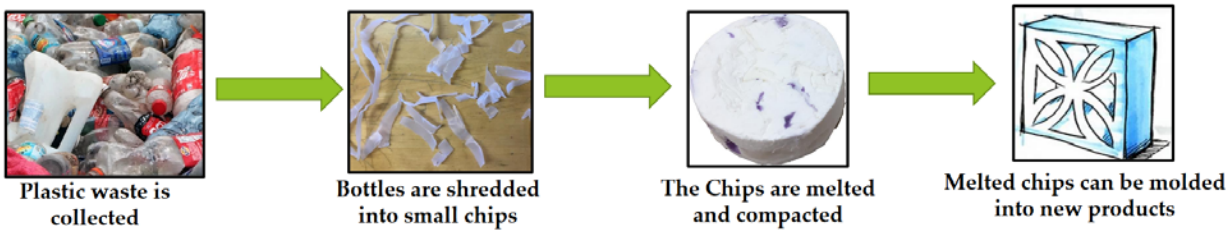


Figure 1: Stakeholder Mess Map for Bottle Upcycling in El Sauce

The team also developed an initial concept for a building block (figure 2) designed to increase ventilation and make a home feel cooler through a venturi effet. The block is intended to be used as a non-structural component in house construction for room dividers, decoration above doors, and to fill in the "culata" – the empty triangular space between the walls of a house and the peak of the roof. Based on interviews in El Sauce with residents of homes constructed by 4 Walls, in addition to the aesthetic value of decorative blocks, the homeowners were interested in using the blocks to provide added security, ie. to keep people from breaking into the home through the culata. They also liked the idea of using the blocks to allow light and airflow into the home while keeping out rain. Room dividers are often made of flimsy cardboard, paperboard, or curtains, so any improvements there would also appreciated--as long as the cost is low.



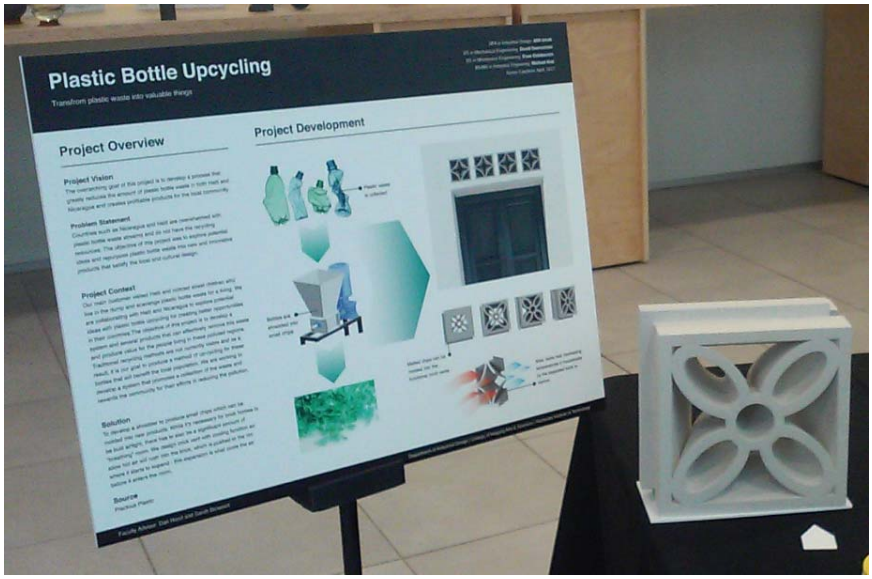


Figure 2: Building Block Concept

Team P17433 designed and built one of the tools required in the system to create the block, a shredder to turn the bottles into chips (figure 3). However, due to delays in manufacturing the shredder blades because the RIT waterjet was down for repairs for many weeks last spring, the

team was not able to adequately trouble shoot the design. The first task of this new MSD team will be to get the shredder working and making chips. Last year's team suggested a few ideas for improving the shredder that the team can explore:

- add spacers at each the end of the blade assembly next to the bearings in order to hold the blades tightly in place in the housing
- grind down the blades and spacers to a precise and consistent thickness
- use a slightly larger hex rod or recut the blades to fit the rod more securely
- attach the shredder securely to a stand for operation
- add a hopper for safety
- possibly add a motor (if hand cranking is still difficult—the team should do a theoretical calculation to see if hand cranking is feasible)

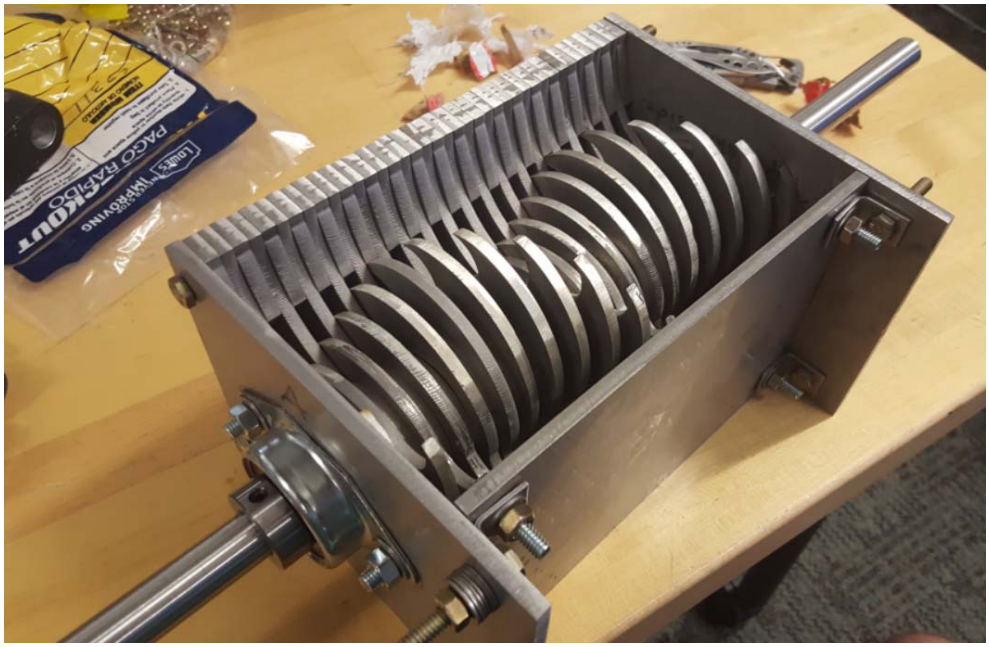


Figure 3: The bottle shredder

The team is also responsible for designing the rest of the manufacturing process following the shredder and for determining what product will be made from the chips. The manufacturing process needs to be simple and inexpensive enough for a small business to start making products on a small scale in El Sauce to see if there is customer demand. Ideally, the process should be flexible enough to allow changes to the product design or additional products to be made. The initial product should be a construction item that is useful to 4 Walls but also marketable beyond the 4 Walls project and the town of El Sauce. However, the customers are also open to other product ideas from the team.

In summary, this new MSD team is tasked with the following:

1) get the shredder working to make chips
2) continue to develop and refine product ideas that can be made from the chips
3) create a method and tools for turning bottle chips into new products including a construction product

Resources:

- MSD Team P17433's website is available here: http://edge.rit.edu/edge/P17433/public/Home
- A Design Project Leadership course team explored the idea of upcycling plastic bottles during spring 2016. Their work can be found here: http://edge/edge/R16401/public/Home
- "Precious Plastic," https://preciousplastic.com/en/
- Enlace Project, https://www.enlaceproject.org/, https://www.facebook.com/enlaceproject/
- 4 Walls, http://www.4wallsproject.org/

*** Preliminary Customer Requirements (CR):**

Product General
Made from recycled bottles
Used in home construction
Manufactured in El Sauce

Construction Block Product
Modular
Connecting
Adaptable to various uses (internal walls, culata, doors, windows)
Provides privacy
Provides security (baseball bat test)
Allows airflow
Allows light to pass
Keeps out rain
Discourages animial life from living in it or entering home
Aesthetically pleasing

Manufacturing Process
Melts PET and HDPE chips to form objects
Interchangable molds up to 12"x12" (negotiable depending on size of product chosen)
Scaled for operation as a home or small business
Uses human or grid power (120V AC)
Safe
Must not tip over when bumped into by an average person
Protect user from to sharps, hot surfaces and pinch points

Ergonomic operation
Machine SHOULD NOT work when disconnect device is engaged

* **Preliminary Engineering Requirements (ER)**:

Engineering Requirement
At least 25 % increased profit on current recycle value for new product.
Overall processing rate of 60 bottles/hr
Bottle must be shredded by machine within 5 seconds of entry to shredder
Accepts up to ¼" square chips from P17433 grinder
Footprint of grinding and molding system equipment < 10ft sq
Size of molds accepted: Up to 12"x12"
Reaches temperature to melt PET or HDPE (needs research)
Holds temperature +/- x? °F
Mold pressure (needs research)
Max temperature reached at any plastic exposed spot < 500°F (for PET) where plastic will burn.
Holds x lbs of chips pre molding
Meets all specified Human Factor Specs and Ergonomic considerations (OSHA)
Harmful fume concentrations (ppm, research acceptable levels for plastic forming, melting does not generate harmful fumes, avoiding burning)
Number of pinch points, exposed sharps, and exposed hot surfaces = 0
Percent of materials that are Corrosion/Rust Resistant or easily replaced > 95% by weight and cost
Force to tip over is higher than a person bumping into it
Machine SHOULD NOT work when disconnect device is engaged (ER depends on chosen design)
Max weight for component or sub assembly: 50lb
Each sub assembly must be no larger than 2'x2'x2'
Input power 120V AC or power that can be applied by a human
Construction block shape, thickness, and size (tbd—3" x 6" x 6"?)
Block weight (tbd--1-2 lb)
Minimize number of bottle used per area covered by block < lb/sq ft
Tolerance on construction block dimensions (+/- 3%)
Percent of blocks that fit together > 90%
Visibility through block < 2 ft
Sunlight transmission of block (% tbd)
Rain entering home through block = 0 mL
Resists impact from baseball bat when connected to house structure, resists impact of x psi
Keeps out rodents (research max hole sizes for mice)
Surface roughness of x

* **Constraints:**

Made from recycled bottles
Used in home construction

Run as a small business
Low start up costs
Project budget of $900 (if MSD) to $1500 (if Autodesk)

[*] Project Deliverables:
Minimum requirements:

- All design documents (e.g., concepts, analysis, detailed drawings/schematics, BOM, test results)
- working prototype
- technical paper
- poster
- All teams finishing during the spring term are expected to participate in ImagineRIT

Additional required deliverables:

- 3 minute video

[†] Budget Information:
$ 200 Estimated cost of the compression machine from Precious Plastics with junk yard parts
$ 250 Repairs to grinder, hopper, stand
$ 250 grinder motor
$ 200 prototyping materials, 3D printed prototypes,
$ 100 mold

TOTAL $ 1000 minimum

[*] Intellectual Property:
NA

Project Resources

† **Required Resources (besides student staffing):**
Describe the resources necessary for successful project completion. When the resource is secured, the responsible person should initial and date to acknowledge that they have agreed to provide this support. We assume that all teams with ME/ISE students will have access to the ME Machine Shop and all teams with EE students will have access to the EE Senior Design Lab, so it is not necessary to list these. Limit this list to specialized expertise, space, equipment, and materials.

Faculty list individuals and their area of expertise (people who can provide specialized knowledge unique to your project, e.g., faculty you will need to consult for more than a basic technical question during office hours)	**Initial/ date**
Environment (e.g., a specific lab with specialized equipment/facilities, space for very large or oily/greasy projects, space for projects that generate airborne debris or hazardous gases, specific electrical requirements such as 3-phase power)	**Initial/ date**
Use of the Construct tools for experimentation, ventilation during plastic melting	
Equipment (specific computing, test, measurement, or construction equipment that the team will need to borrow, e.g., CMM, SEM,)	**Initial/ date**
Bending test equipment, outdoor testing for rain	
Materials (materials that will be consumed during the course of the project, e.g., test samples from customer, specialized raw material for construction, chemicals that must be purchased and stored)	**Initial/ date**
Many plastic bottles	
Other	**Initial/ date**
Bob Bectold, HARBEC plastics	

† **Anticipated Staffing By Discipline:**
Indicate the requested staffing for each discipline, along with a brief explanation of the associated activities. "Other" includes students from any department on campus besides those explicitly listed. For example, we have done projects with students from Industrial Design, Business, Software Engineering, Civil Engineering Technology, and Information Technology. **If you have recruited students to work on this project (including student-initiated projects), include their names here.**

Dept.	# Req.	Expected Activities
BME		
CE		
EE		

ISE	1-2	Safety, ergonomics, materials science, materials processing, manufacturing process design, mold design, DFM, engineering economy, test procedures: MFg Process Development for shredding plastic.
ME	3-4	3D CAD, machining, stress analysis, machine design, heat transfer, fluids, mold design, DFM, fluid dynamics, CFD modelling or FEA (maybe?)
Other	1	Industrial Designer—design the construction block product