



**Siemens We Can Change the World Challenge**  
**Grades 9-12**  
**Third Place National Winner – VIRGINIA**

**Team Name:** George Mason Recycling

**Location:** Manassas, VA

**School:** The Governor's School at Innovation Park

**Students:**

- Samantha Hughes
- Stacie LoVullo
- Chandler King
- Kitty Nguyen

**Teacher/Mentor:** Karen Wolfson

**Project Title:** George Mason Recycling

**Summary:** The purpose of this project is to improve existing recycling policies (specifically plastics) at George Mason University. This project aimed to improve the current situation in three aspects: 1) spatial distribution of receptacles; 2) the initiation of a punishment or reward system; and 3) the effect of monitoring on the amount of recycled goods.

## Topic Area: Land management

### Step 1: Identify and Research a Problem or Issue That Has Global Impact

- Identify a sustainability-related problem that you will address and state the negative effects of this problem. Why did you choose this topic? Describe the environment and/or people impacted by the problem. Include the population, size and other relevant data.
- Discuss any work done before the Challenge began on August 24, 2011. If others were involved in the previous work, explain their roles.
- Discuss your team's research. What publications and media review, prior observations, and/or collected data did you use to develop your problem statement?
- State your team's hypothesis. Explain how this hypothesis will help to solve the problem by changing the physical attributes of a locality, social behaviors of people in the community, local/global government policies, or any combination of the above.

During recent years, over 870,000-1.3 million tons of plastic Polyethylene Terephthalate (PET) water bottles were produced in the US in 2006, requiring the energy equivalent to 50 million barrels of oil, 76.5 % of these bottles ended up in landfills (Hopewell, Jefferson). In order to reduce the amount of materials in landfills, individuals should examine the amount of recyclable resources they would otherwise dispose and consider applying these resources to recycling programs. One common landfill item that is easily recyclable is plastic.

Plastic recycling is the method of recovering scrap or waste plastics and transforming the material into products, typically different from their original state ("Waste Online"). For example, soft drink bottles are melted down and cast into plastic chairs and tables. Usually a plastic is not recycled into the same type of plastic, and products made from recycled plastics are generally not recyclable. Approximately, 4% of oil and glass production is used as feedstock for plastics, while another 4% of non-renewable resources are used in the production of these plastics (Hopewell, Jefferson). Due to the short-lived, disposal nature of most plastic products, recycling is necessary in reducing the industry's carbon footprint. Recycling engenders reductions in oil consumption, carbon emission, and the amount of plastic waste disposal. Furthermore, combined efforts from the public, industrial, and governmental sectors are necessary in ensuring the success of recycling programs (Hopewell, Jefferson).

Waste management is the collection, transport, assortment, and disposal/recycling of waste resources to reduce their adverse effects on society and the environment ("Waste Online"). Waste management procedures differ between developed and developing nations, for urban and rural areas, and for residential, industrial, and commercial producers. Waste management for non-hazardous and institutional waste in city regions are generally the local government's responsibility; while management for non-hazardous commercial and industrial waste is usually the producer's responsibility.

Many developing countries are facing the problem of creating new disposal sites as most of the existing sites are nearly exhausted. Thus, waste managers in these countries should be flexible to allow new ideas and technologies particularly waste reduction and recycling programs in their waste management

plans. In the last 20 years, several waste management projects have been carried out in developing countries, in partnership with external support agencies ("E-waste"). Some projects were successful in producing lasting impacts on the improvement of solid waste management in developing countries. However, many projects could not support themselves or expand further when the external agencies discontinued their support ("E-waste"). This issue is common amongst developing nations as they lack the resources to sustain these projects. In developed countries resources are available to initiate proper waste management, but are often left unobserved or unregulated. Sometimes, projects are started with specific aims and expected outputs, but their scopes are not broad enough to consider other factors influencing them ("E-waste"). These projects quickly degrade, and should be re-constructed to provide long term sustainability.

One of the best ways to improve recycling in the United States is to begin at the state level and filter down to the community and home level. The more accountability taken at lower levels in the recycling chain, the better the state and national outcome will be. One of the most efficient methods to stimulate interest in recycling drink bottles is to create bottle deposit regulations, but individual states have different policies (EPA). For example, Oregon has a bottle deposit system where an individual will receive five cents back for each bottle you take to a deposit facility (EPA). These recycling centers for Oregon are located in several easily accessible places, such as grocery stores.

In 2009, the city of Milwaukee instituted a Pay As You Throw recycling system that punishes citizens based on the amount of waste they produce (Nowak, Seth). As a way to promote recycling, the PAYT system charges a flat rate for waste sent to the landfill, however recycling is free. As a result of this new system, recycling has increased 16-17% in PAYT communities and 6.5 million tons of Municipal Solid Waste, household garbage sent to the landfill/incinerator; is now being recycled ultimately extending landfill life as well as reducing transportation and tipping fees (the cost of unloading waste at a landfill). Milwaukee has observed a 20-35% increase in weight going through their recycling centers and an overall 16-17% decrease in weight of waste being produced from PAYT communities (Nowak, Seth). This shows that while reward systems have some influence over the improvement of a situation, punishment is much more effective at stimulating public participation.

Virginia has addressed the need of waste management programs within individual counties. According to § 10.1-1411 of the Code of Virginia, the Virginia Waste Management Board requires each region, city, county, or town to develop a "comprehensive" and "integrated" waste management program that includes source reduction, reuse, recycling, resource recovery (waste to energy), incineration, and land-filling ("Solid Waste Planning and Recycling Regulations"). Each waste planning unit must have a minimum 25% recycling rate, or a minimum of 15% recycling rate if the population density is less than 100 persons per mile-squared or a high unemployment rate. In order to stimulate interest, there is a credit system in place that rewards specific waste management procedures. These procedures include: credits per ton of recycled residual waste, per ton of reused solid waste, and for implementing a source reduction system ("Solid Waste Planning and Recycling Regulations").

Locally, Prince William County has instituted a very effective waste management plan that has been deemed one of the best in the state of Virginia. The Prince William County waste management plan

requires recycling facilities to be made available to all private and public corporations/businesses ("Solid Waste"). Despite population growth within recent years, Prince William County has continued to increase its amount of recycling. This growth is due to the county's policy of public awareness ("Solid Waste"). Prince William County raises awareness through: the County's Web page, fliers and brochures, campaigns, outreach groups such as L.E.E.P. (Local Environmental Education Partners), newspaper advertisements, direct mailings and inserts in the County's newsletter, advertisements on local television channels, special events, award programs, contests, and a partner with the County schools for recycling education. Through these efforts, Prince William County has shown that while reward/punishment systems may be effective, public awareness is also key to the success of any new policy.

The purpose of this project is to improve existing recycling policies (specifically plastics) at George Mason University. If a reward/punishment system is implemented with optimal spacial distribution of recycling receptacles, then George Mason University will observe an increase in the amount of materials recycled. By introducing a reward/punishment procedure, individuals will be more likely to put forth the effort to recycle materials they would otherwise place with trash. This will increase the amount of goods recycled. By observing the current arrangement of waste and recycling receptacles, one should observe the relation between receptacle placement and amount of recycled material. Once this relationship is established, the optimal placement of these containers will be easy to determine.

#### **Citations:**

EPA. Environmental Protection Agency. Web. 21 Feb. 2012.

<<http://www.epa.gov/wastes/conserve/rrr/rogo/documents/moscone.pdf>>.

"E-waste: Crude recycling methods used in developing countries contaminate air, water and soil, researchers say." Science Daily: News & Articles in Science, Health, Environment & Technology. Web. 22 Feb. 2012. <<http://www.sciencedaily.com/releases/2010/03/100322073534.htm>>.

Hopewell, Jefferson. "Plastics recycling: challenges and opportunities." Philosophical Transactions of the Royal Society B: Biological Sciences. 364.1526 2115-2126. Web. 21 Feb. 2012.

Nowak, Seth, Kevin Luecke, Gail Krumenauer, and Hall Catherine. "City of Milwaukee; Impacts of Pay As You Throw Municipal Solid Waste Collection." (2009). Board of Regents of the University of Wisconsin System, Spring 2009. Print. 21 Feb. 2012.

"Solid Waste Management Plan." Prince William County Government. Web. 21 Feb. 2012.

<<http://www.pwcgov.org/government/dept/publicworks/trash/Pages/Solid-Waste-Management-Plan.aspx>>.

Virginia. Virginia Department of Environmental Quality. Solid Waste Planning and Recycling Regulations. 2001. Web. 21 Feb. 2012 <<http://leg1.state.va.us/cgi-bin/legp504.exe?000 cod 10.1-1411>>.

"Waste Online." Waste Online. Web. 21 Feb. 2012. <[www.wasteonline.org.uk/](http://www.wasteonline.org.uk/)>.

## Step 2: Plan and Design Your Project

- What is your team's action plan? Include experimental design, project steps (including communication and tracking plans), timeline for completion, necessary resources, and proposed method.
- Specify how each member of the team will contribute. Define the role of your mentor in your project plan. Identify any other individuals who will help with your project and define their roles (including teachers, parents, classmates, and community, business and organizational leaders).
- What variables did you select to measure the potential solution's impact on the issue or problem?
- Describe your team's data collection processes, including what data you plan to collect.

### Materials:

- GMU Bullrun Hall level 1 floor plan
- Trash Receptacles
- Recycling Receptacles
- Subjects: Classmates and family

### Variables:

Independent: Placement of trash and recycling receptacles, presence of a reward or punishment system, and the awareness of the student body.

Dependent: Amount of recycling.

Control: Equal placement of trash and recycling receptacles, no punishment or reward system, and an unawareness of the student body.

### Spatial Distribution:

1) Week One: Normal receptacle placement

a. Placement of Trash and Recycling receptacles

i. Should be equally accessible

b. Conduct waste and recycling audit daily

c. At the end of the week calculate percent by weight of recycling in correct bin out of total possible recycling

2) Week Two: same as Week 1, with Recycling bins less accessible

- 3) Week Three: same as Week 1, with Trash bins less accessible
- 4) Compile data into one table and graph results by percent of weight of recycling in correct bin out of total possible recycling
- 5) Analyze results and conclude

#### Reward/Punishment System:

- 1) Week One: Control
  - a. No reward or punishment system in place
  - b. Conduct recycling audit daily
  - c. At the end of the week calculate percent by weight of recycling in correct container out of total possible recycling
- 2) Week Two: same as week 1 with a reward system in place
- 3) Week Three: same as week 1 with a punishment system in place
- 4) Week Four: same as week 1 with a reward and punishment system in place
- 5) Compile data into one table and graph results by percent of weight of recycling in correct bin out of total possible recycling
- 6) Analyze results and conclude

#### Awareness

- 1) Week One: Control
  - a. Monitor a select group of student's recycling habits
  - b. Conduct recycling audit daily
- 2) Week Two: Aware
  - a. Continue as Week 1, but make the student's aware their recycling habits are being observed
- 3) Compile data into one table and graph results by amount of correct recycling out of total possible recycling
- 4) Analyze results and conclude

## Participation:

- Stacie and Chandler conducted research and implemented experimental procedure on rewards/punishment programs.
- Samantha and Kitty conducted research and implemented experimental procedure on spatial distribution of recycling and waste receptacles.
- Mrs. Wolfson provided constructive criticism and class for experimental subjects.

## Citations

N/A

## Step 3: Analyze and Provide Results

- Describe all qualitative and quantitative data collected by your team, including charts, tables, graphs, written notes, sketches, photographs, or video.
- Explain any key results derived from the data above.
  - What happened as a result of your proposed solution?
- Describe your plan's progress.
  - What did your team's experimental plan reveal?
  - Did your hypothesis impact the problem it identified? If yes, how?
  - How did you modify the plan over time as the project evolved?

The purpose of this project is to improve existing recycling policies (specifically plastics) at George Mason University. On a global scale, the observations from this project can be applied to universities across the globe and increase awareness about recycling. This project aimed to improve the current situation in three aspects. The first element we examined was the special distribution of the trash and recycling receptacles and whether this had an effect on the amount of recycling on campus. When the recycling bins were placed away from the main hall, there were 43 pieces of trash and 39 pieces of recyclable materials inside the recycling bins. When the recycling and the trash bins were on the main hall, there were 20 pieces of trash and 87 pieces of recyclable materials inside the recycling bins. When the trash bins were placed away from the main hall, there were 2 pieces of trash and 89 pieces of recyclable materials inside the recycling bins. As the recycling bins became more conveniently located, and the trash receptacles were placed further away from the main hallways, the amount of recycling improved while the amount of garbage in recycling containers decreased. This was interesting, as we

originally hypothesized that the optimal amount of recycling and minimal amount of trash would occur with an equal placement of trash and recycling receptacles.

The second element we examined was the effect of a punishment or reward system on the efficiency of recycling. We hypothesized that if a reward and punishment system were initiated, then the amount of recycling would increase. We first observed the experiment group, with permission, without a system in place; and repeated this with a reward system, punishment system, and a reward and punishment system. The control group recycled only 2 out of the 5 opportunities they were presented with. With a reward system, the group recycled 4 out of the 5 opportunities they were presented with. With a punishment system, the group did not recycle at all; and with both systems the group recycled 3 out of the 5 opportunities they were presented with. The best way to maximize the amount of recycling on campus is to initiate a reward system. With a larger sample size, we could more accurately determine the system that has the largest impact on recycling.

The third element that we briefly examined was the effect of awareness on recycling. We hypothesized that if a student was aware that their actions concerning recycling were monitored, then they would be more likely to recycle. We first examined the student population at the Governor's School at Innovation Park, and its recycling status. We then made the student body aware that we were monitoring their recycling activities and further examined the recycling habits of the student. On the days that the students were unaware of the monitoring, only 23 out of 75 bottles were recycled. On the days they were aware of the monitoring, 31 out of 50 bottles were recycled. It was determined that once the students were aware that their recycling actions were monitored, they became more inclined to recycle.

This plan revealed that spatial distribution of recycling and trash bins can optimize recycling output only if the recycling is more conveniently located than the trash bins. It was also revealed that by implementing a reward system and increasing public awareness, a community can successfully increase recycling activity from its participants. Our hypothesis did impact the issue of campus recycling as it addresses how to improve on campus recycling activity. As the project progressed, several aspects changed such as the location of receptacles due to the traffic flow in Bullrun Hall. Originally, the receptacles were to be placed in the back corner of the atrium to be away from the main hall. However, we soon realized that this was where students congregated between classes, so we changed our "inconvenient" location to a different hall. This project should be carried out on a larger scale before initiating any large changes to the George Mason University campuses; however, it does provide sufficient information to carry out changes on the Prince William Campus.

#### **Citations:**

N/A

#### Step 4: State Your Conclusion

- State your solution and describe what makes it unique.
- Explain your conclusion based on your data.
  - Is your solution effective?
  - What made the plan work?
  - What challenges occurred along the way?
  - How did your team overcome those challenges?
  - What would you do differently if given the opportunity?
- How could your solution have global implications?

In order to successfully improve recycling on the George Mason University campus, the recycling receptacles must be more convenient than the trash receptacles, a reward system must be established, and students should be aware that their recycling habits are monitored. This solution is effective, because it has proven to increase recycling on a small scale; and when placed together, will increase recycling on campus drastically. This plan works because it considers both the environmentalist aspect and the psychological aspect. While some people may respond well to the current program, which targets the type who are willing to go the extra “mile” for recycling; this solution targets those who may be more likely to recycle if it is easier and more beneficial to do so. By making recycling convenient and stimulating, it will attract more people to participate.

Some challenges to accomplishing this project include: sufficient rewards and punishments to fit the task, permission to examine and move various trash and recycling receptacles within the Bullrun Hall, and student participation for the monitoring part of the project. It was difficult to assign a reward and punishment that was equivalent to recycling. By applying the project on a smaller scale, it was easier to determine an adequate assignment for acts against or for punishment. On a National scale, the reward for recycling could be free recycling services. Whereas a punishment could follow a pay-as-you-throw community, where citizens pay for each bag of garbage they create. It was easy to receive permission to examine and move the recycling receptacles, but the garbage management was less open to allowing our teams to move the trash receptacles. We managed to compromise by only moving the trash receptacles on the same floor and within eye-sight of its original location. Student participation was relatively difficult to receive, because most students are not open to allowing others record their general activities. By explaining our project and its goals, more students were open to our investigations. If given another opportunity, we would monitor George Mason as a whole, instead of a minute amount of students. By having a larger selection, our data would more accurately portray the habits of the student body.

Based on these results, it is worth pursuing the possibility of reconfiguring the waste receptacles on campus, but a larger sample size would be necessary before changing on a larger scale. Globally, this project could impact developing communities as they design and develop waste management facilities and raise awareness to their citizens. This project benefits universities across the globe, as it was specifically designed to improve campus participation in recycling. Even high schools and other places of business can model their recycling policies to incorporate our findings and improve their recycling figures.

## Citations

N/A

## Step 5: Share

- How did your team spread the word?
  - Provide details and examples of how your team has reached others to communicate your findings and motivate them to get involved. Include documentation of a communication strategy and audience response.
  - What tools/resources did your team use to extend your project's impact? (e.g. creating a website, a social networking page, and/or a marketing tool that includes a description of the project.)
- Explain in detail how other communities (domestic and/or global) might benefit from the team's conclusions.
  - What unique challenges does someone replicating your project have to keep in mind?
  - How can you overcome the challenges that there are to implementing your solution on a global scale?

In order to spread the word about our project, our team gave presentations to students and staff at George Mason University. We plan on attending a recycling convention held at the university and presenting our findings to the waste management at George Mason. We regularly encouraged students and staff at the Governor's School to recycle and informed the student body about correct recycling techniques. The audiences were very receptive to our message, and seemed to put forth the effort to recycle more. Our experiment concerning the effects of awareness on recycling shows this trend. After the students became aware of our efforts, they became more likely to recycle.

Our team also created a George Mason University Recycling page on Facebook in order to increase awareness of recycling and its benefits as well the consequences of not doing so. Facebook is a widely used social media, and was therefore ideal in trying to reach as many people as possible. The page updates regularly with facts and statistics about the waste we produce, what of that waste can be recycled, and how we can cut down on our waste production entirely. We also made a George Mason University Recycling webpage, to inform the public of our operations and about the proper methods of recycling.

While the purpose of this project was to improve the recycling policies at George Mason University, the results of this experiment can be applied to any university interested in improving their recycling programs. The spatial distribution portion of this project can be applied to theme parks, museums, and other businesses who are seeking a way to improve their recycling figures while spending little money. The reward system can be applied on any scale, ranging from households to nations. While the specific rewards will differ as the range of the system increases, smaller personal rewards for families and larger monetary rewards for nations, the same principles still apply. Some challenges to applying this project on a global scale would be: funds to implement the reward system, funds to monitor the public, and raising interest in big businesses about the importance of spatial distribution. Funds to implement the reward system would be a challenge, because not many governments would see this as a high priority. In order to change this, public interest groups could be created to raise awareness and potentially raise funds for this purpose. Monitoring public recycling is not feasible on a global scale, simply because the cost outweighs the benefits; this portion of the project is best applicable on a smaller scale such as a university or small community, where it is easier to monitor participants. Raising interest in the spatial distribution aspect of this project could potentially become a challenge, because there is very little literature on the subject. The best way to overcome this challenge would be to carry out this project in several other locations to demonstrate its effectiveness.

#### **Citations:**

N/A

#### **Step 6: Attachments**

- You may include attachments to provide more information.
  - You may choose to upload one PDF containing materials to support your application.
    - <http://player.discoveryeducation.com/index.cfm?guidAssetId=9B56DD52-9B5D-3698-4F6B-2B1EDC78B5E0&productCode=DEMS>
  - Additionally, you may include the link to one YouTube video that is two minutes or less.
    - N/A

- Please briefly describe the information in your attachments

Our pdf includes: data tables showing our research, graphs displaying our research, screen shots of both our facebook page and our website we created to further spread our project's impact and inform the public about recycling, and photos of our team conducting trash and recycling audits.