

Polystyrene Versus Down to Earth

New Mexico

Supercomputing Challenge

Final Report

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Down to Earth School

Team 38

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1. Executive Summary:

We decided on a project involving the use of polystyrene (brand name Styrofoam) in restaurants. Restaurants generate more garbage daily than most other businesses. An average restaurant produces 100,000 lbs of trash per year. Many restaurants in our town use disposable products for take-out and in-store dining. Some of these restaurants use polystyrene which is an un-biodegradable substance that is produced from oil, a non-renewable resource. Some of these restaurants also use paper which, although it also uses vulnerable natural resources, comes from a renewable source, is biodegradable, and can be recycled easily in our region. Since polystyrene is not biodegradable, it will stay on Earth forever. It is a large creator of waste, not only in itself, but in production.

By developing an agent-based NetLogo model, we hoped to show that the environmental "cost" outweighs the monetary one. Even though the cost of polystyrene is comparably lower than the cost of paper, polystyrene is a creator of waste that effects the environment in negative ways.

We decided to base our project on two restaurants in our town which use both products. We developed a model that finds a balance between monetary benefits and environmental impact. In the future we hope that this model can be a basis from which our town can derive an environmentally friendly approach to the products they choose to use.

We gathered data from our selected businesses, Un Mundo Cafe and Tacos Las Palma, and used this information to create an observer restaurant. This is tested against our two controls: one using all paper, one using all polystyrene. Each of these two businesses' (observer) products uses acts as our independent variable.

We gathered information on how much paper or polystyrene is used in our two businesses and how much waste they are creating, inserted it into our model and found out how much money is being spent/earned vs. the environmental impact. This is what we found out:

In our model with our two independent restaurants and two controls it is possible to make the most money only if a restaurant caters to the environmentally friendly population and thus gets the most business. This large amount of customers, however, results in a high environmental impact. In our computational model a slight balance was found between money and environmental impact in our community but only if two out of the three businesses use primarily paper.

2. Question:

How do quantitative changes in products (i.e. polystyrene and paper) affect the restaurant business and in relative decline or incline impact the environment?

3. Hypothesis:

We hypothesize that the success of the businesses, is affected by their use of paper or polystyrene. We believe that as we modify our independent variables, the amount of either product used, we can determine the success of the restaurants based on their environmental impact and amount of money they earn. We think that the more polystyrene a business uses the higher their environmental impact will be thus lowering their environmental score. We hypothesize that we can find a good balance between monetary benefits and environmental impact by using more paper than polystyrene.

4. Research:

A. Products

In the U.S, we generate 3.2 million tons of disposable packaging from quick-serve food. One percent of this was recycled. We have increased our use of disposable products by gigantic amounts, and used enormous amounts of energy to transport it. Fifteen billion dollars in packaged foods is sold in America. This includes more than one-hundred thirteen billion cups. All this trash threatens marine life with its threat of ingestion and entanglement.¹ Some of these products include paper and polystyrene (brand name Styrofoam).

Styrofoam is made by a process is called polymerization. These are the steps to make polystyrene:

- Styrofoam starts in little beads of hydrocarbon.
- Heat the beads until the agents start to boil.
- The beads soften and expand into 40x their original size.^{2,2.5}

Polystyrene is made from oil. Ray McIntyre invented Styrofoam around the time of World War II with the Dow Chemical Company³. Polystyrene is made in foam factories such as Merryweather Foam Inc. in Anthony, NM. Smoke from Styrofoam factories carries; carbon monoxide, carbon dioxide, oxides of nitrogen, and water vapor.⁴

Styrofoam® cups cost \$25 for 1000 and paper cups cost anywhere from 50 to 80 dollars for 1000. Plastic cups cost \$11 for 1000⁵. Polystyrene takes 1,000,000 or more years to decompose⁶. It takes about 2-4 weeks for a paper cup to decompose⁷. The fundamental element of polystyrene is Styrene which is made from

petroleum (oil). Styrene is used in the making of boats, tubs, resins, and plastics. It is classified as a possible carcinogen (cause of cancer) by the EPA and the International Agency for the Research of Cancer (IARC).⁸ Styrofoam is made of only 5% polystyrene and the rest is air. If it is dissolved into a biodegradable substance it can be used as permanent glue. Styrofoam is very low cost and light weight. Its durability makes it hard to recycle⁹

When paper is made it releases carbon into the air. It leads to emission of carbon compounds, nitrogen, and sulfur. Wood wastes are burned for fuel, but more than 95 per cent of the pulping chemicals are recovered for re-use.

This is how paper is made:

- Debark the trees with a spinning knife.
- Then the trees are cut into small pieces or chips. A large rotating knife cuts the logs into chips.
- Soak the wood chips in sodium hydroxide and sodium. Bleach it to remove the lignin (a substance found in the plants cell wall.) This makes a strong dark brown pulp. Formaldehyde is added to copy paper.
- The pulp is then rinsed and diluted with water. Then it is dispensed through a continuously moving belt of wire. The water is then drained away .The cellulose is then trapped on the wire.
- Add a little more pulp to form the paper web. The newly formed sheet of paper is put on a cloth belt, the rollers squeezing out the extra water.

Bleach can cause many problems including respiratory problems, burned skin, and damage to the nervous system. Sodium hydroxide (used in paper production) is also called lye. It has no odor and can be a solid or a liquid. It quickly absorbs carbon dioxide and water from air.

Formaldehyde, a colorless, pungent-smelling gas, can cause cancer in animals and may cause cancer in humans. As one can see, the chemicals used in paper can be very harmful.^{10, 11, 12}

B. Survey:

We collected information on people's preferences and tendencies so we could use this information to create our model's turtles with actual product preferences. The following graphs show the results of a survey we administrated in our community.

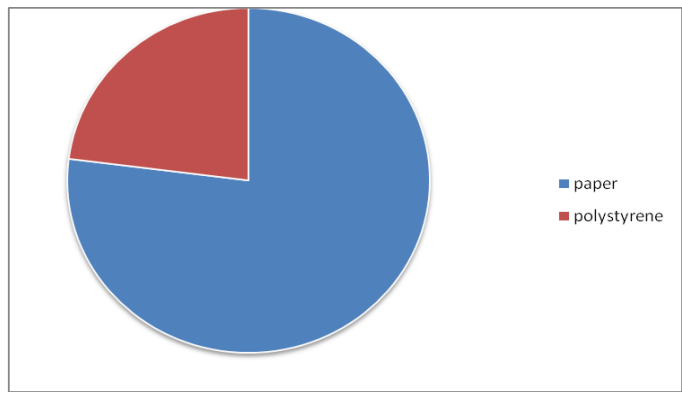


Figure 1: shows preference of paper or polystyrene.

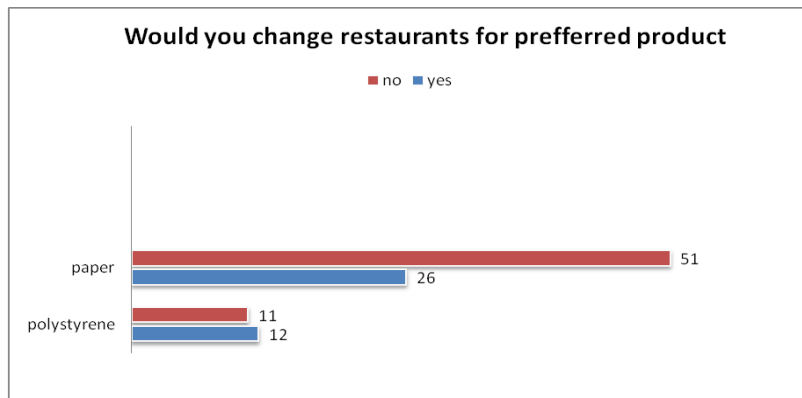


Figure 2: The people in the survey who said “yes” are created as the “environmental” turtles in our model. These agents are strongly opinionated enough to go to a restaurant because of its product use. Those who feel strongly about polystyrene are “poly” turtles.

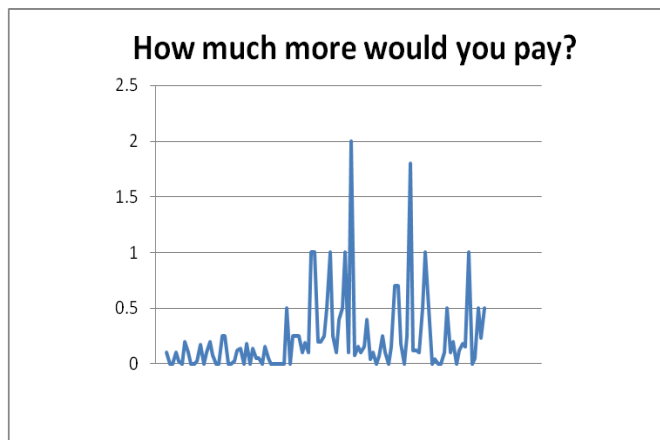


Figure 3: shows how much more people would pay.

C. Restaurants info

The two businesses we will be using in our computational model are Cafe Un Mundo and Tacos Las Palma. Cafe Un Mundo is a community business that uses 80% paper 20% polystyrene and is located in Silver City. Cafe Un Mundo told us that they prefer using paper and environmental friendly products but that they have

to keep a steady balance between being to costly and being good to the earth. Tacos Las Palma is a Taco cart located along Highway 180. They use primarily 50% polystyrene/20% paper but they are trying to have a smaller carbon footprint.

D. Influence

We decided that we wanted to add the element of influence to our model. Researcher Solomon Asch worked with "the magic number three". After his experiments, Asch concludes that when the majority consists of just one or two individuals, there is very little conformity. The addition of a third majority member dramatically increases conformity, but increases *beyond* three did not result in increasing amounts of conformity.¹³ A person is more likely to be convinced by three people. We used this idea of majority influence, which occurs when people conform to certain beliefs and behaviors in order to be accepted by others, for our aspect of influence for our model.

5. Model:

We used Net Logo 4.1.3 to create our agent-based model. We developed a program where restaurants are scored based on the money they make and the environmental impact they have. Our model has three restaurants: paper, the restaurant that uses 100% paper; polystyrene, the restaurant that uses 100% polystyrene; and observer, the restaurant that the observer gets to control . Our third restaurant(observer) tests against our two controls (paper and polystyrene). The Observer restaurant acts as each of the two restaurants we chose to model (Tacos La Palma and Un Mundo). We also created three breeds of people: Environmentals, Polys, and Neutrals based on the results from our survey. The Environmentals (someone who prefers paper) only go into restaurants that use more than 60% paper products. This includes the all paper restaurant and under some circumstances, the observer restaurant(if the slider for this is set higher than 60% percent paper used). The Polys (meaning the actual status of someone who favors polystyrene) only dine at a restaurant that uses less that 60% of paper, thus using more polystyrene. The Neutrals enter any restaurant that they come within a certain radius of. Upon entering a restaurant, a "person" causes the money score of the businesses to increase. The money score also goes down, depending on whether this restaurant uses paper or polystyrene because of the cost of the product. They are triggering a theoretical usage of a product. Also, the environmental score goes down depending on what product this restaurant uses. If a restaurant uses 50% paper and 50% polystyrene, an agent will technically use .5 of a paper product and .5 of a polystyrene product. What we are really stimulating though, is a business where approximately 50% of the people who go in use paper and 50% use Styrofoam.

Money score formula:

$$y = os + 1 - Pc(pp) - Poc(pop)$$

y=money score

pp=paper percentage

Pc=paper cost

pop= polystyrene percentage

Poc=polystyrene

From each of our businesses, a set amount was deducted ,an environmental score, for what product they use based on toxicity, source, production, and ability to biodegrade/recycle. The following formula and table was used to show this:

Environmental formula(every time a person enters):

$$y = os + pq(-8) + poq(-14)$$

y=environmental score,

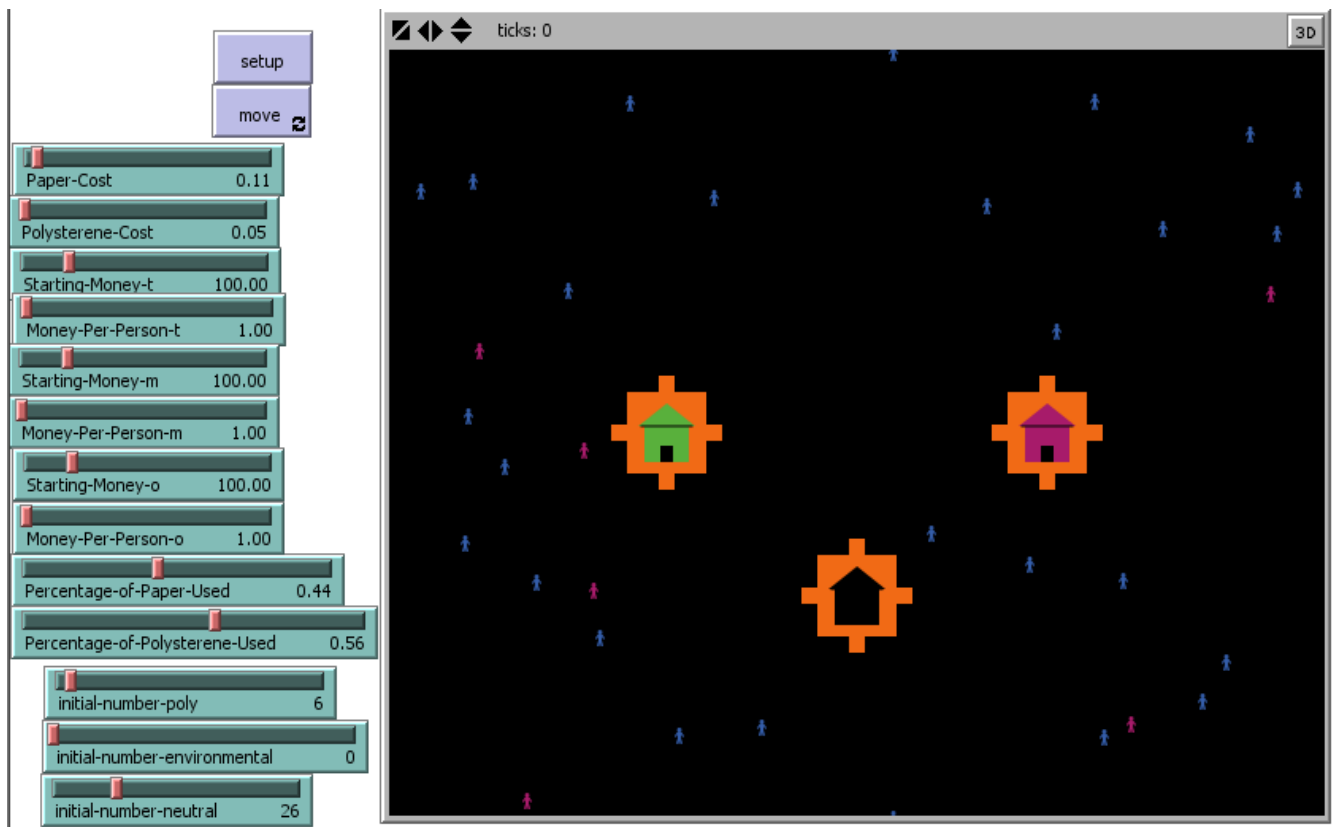
os= original score,

pq=paper quantity,

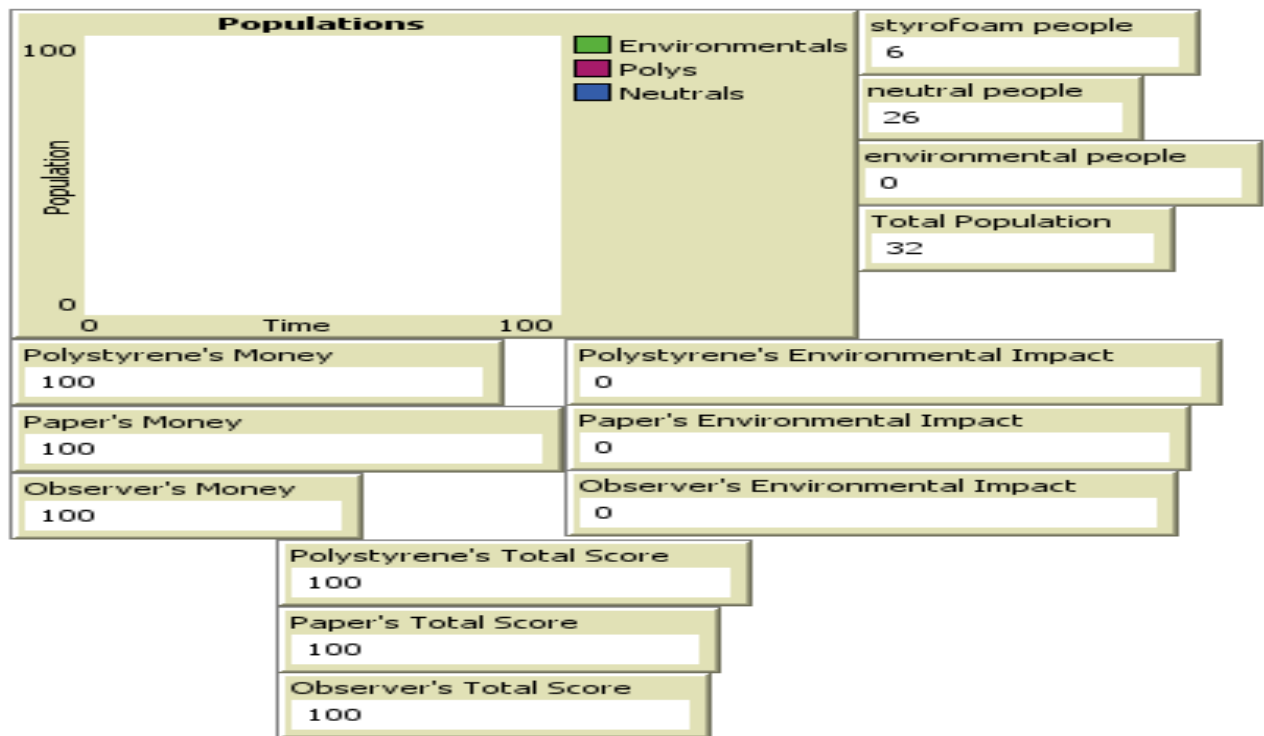
poq=polystyrene quantity

	Paper:	Points:	Polystyrene:	Points:
1.Toxicity:	<ul style="list-style-type: none"> Chlorine makes dioxins. It releases 40-50,000gal. Of H2O , Organic compounds from paper can clog waterways 	<ul style="list-style-type: none"> -2 	Styrene is classified as a possible carcinogen by EPA	<ul style="list-style-type: none"> -2
2.Source:	<ul style="list-style-type: none"> Comes from Trees -renewable resources/factory byproducts 	<ul style="list-style-type: none"> -2 	non-renewable-oil	<ul style="list-style-type: none"> -3
3.Production:	<ul style="list-style-type: none"> Byproducts- Water,Bleach,Formaldehyde 	<ul style="list-style-type: none"> -3 	5 th largest creator of hazardous waste. 57 chemical byproducts released. The process of making polystyrene pollutes the air and creates large amounts of liquid/solid waste. (29)	<ul style="list-style-type: none"> -4
4. Biodegrade:	<ul style="list-style-type: none"> 1-5 months, easily recyclable 	<ul style="list-style-type: none"> -1 	<ul style="list-style-type: none"> Never, possible but not many outlets, close loop 	<ul style="list-style-type: none"> -4

Also, neutral agents are able to be influenced by either Polys or Environmentals to turn to either an Environmental or a Poly respectively. The neutrals, upon coming in radius of one of these other agents, turn a different shade but retain their identity. If it comes in radius a second time it turns another shade. If the neutral comes in radius a third time it is changed into that breed. This is set in accordance to Solomon Asch's idea.



Figures 4 and 5: Screenshots of model.



6. Results

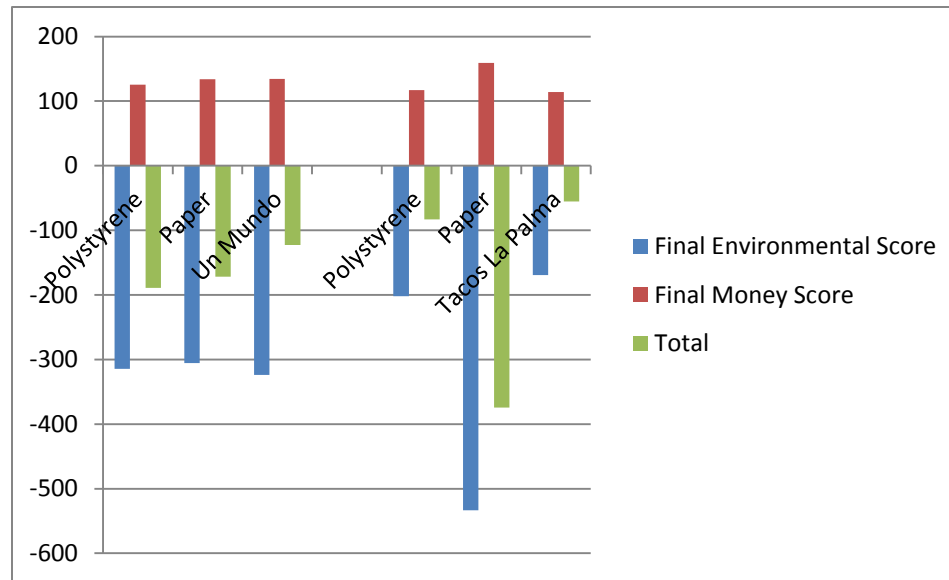


Figure 6: Final Results

In our first trial we ran the observer restaurant as Un Mundo. We discovered that Un Mundo got only a slightly lower environmental score but a higher total score. Its money score was about equal to that of the other restaurants. It may appear as though the polystyrene restaurant should have got a lower environmental score than that of the paper restaurant, but this equality in scores is mainly because there are more Environmentals in our model than Polys so the polystyrene restaurant gets less people and thus has fewer points taken away from its environmental score.

In our second trial, our data shows that Paper got a much lower environmental score and a much lower total score. They did however get the highest money score. All this can be explained by the fact that no Environmentals went in any of the other two restaurants, and the paper restaurant got all the environmental agents dining at their restaurant. Because they had the most people, the paper restaurant got the lowest environmental score even though they used the best product. In the first trial the environmental scores were around the same because the polystyrene restaurant had less people and the environmentals were split between the paper restaurant and Un Mundo.

7. Conclusion:

We believe it is indeed possible to achieve a balance between monetary benefits and environmental impact but perhaps it is only really feasible for the long-term if tax breaks were given to “green” restaurants or if more people were persuaded to go “green”. We found a slight balance when two businesses used paper but the balance was between the restaurants themselves and not necessarily good for the environment. The restaurant that uses all paper in our model had the lowest environmental score

because the most people went to that restaurant. This is true to life. Any thing in excess is bad for the environment. Using any disposable product does make for a sizable carbon footprint regardless.

We conclude that we did not find a good balance using our two town restaurants in our model, but we do believe there might have been some glitches in our program. For instance, we are not sure if the relativity between our money deduction for product use and our money addition for customer endorsement was real to life. We also think that our model would work better on a larger scale, with four or five restaurants. We want to be able to change and alter the amount of different people and the emphasis put on money in our model to see if we get different outcomes. These are things we can continue to work on into the proceeding months and into the future

8. Significant Original Achievement

We were able to bring to the attention of the restaurants how the products they use can affect the environment, and how they can change them. By conducting the survey, we got out into our community and found out that a lot of people do care. We helped to stir peoples emotions and made them aware that they so have a choice. We think that by doing this project we will make people more aware about the devastating effects of polystyrene. With this project, we made one small step towards preserving our Earth.

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Cafe Un Mundo; Silver City NM, Manny Martinez

Tacos La Palma; Silver City NM, Chip Philips

10. Acknowledgements

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An enormous thanks to the Super Computing Challenge for their support.

Lastly, we want to thank Down to Earth School and our supportive parents for making all this possible.

11. Appendix

A. Code

```
globals
[ environmental-count           ;;globals for the plot, populations counts for all the breeds of
people
  poly-count
  neutral-count
  environmentalpaper           ;;variables for the math formulas
  environmentalpolystyrene
  environmentalo
  moneym
  moneyt
  moneyo]

breed [environmental a-environmental]
environmental-own [target]
breed [neutral a-neutral]
neutral-own [target]
breed [poly a-poly]           ;;these are our breeds and what they own
poly-own [target]
breed [paper a-paper]
breed [polystyrene a-polystyrene]
breed [restaurants restaurant]

to setup
  clear-all                   ;; this clears everything
  set-default-shape paper "house"
  set-default-shape polystyrene "house"
  set-default-shape environmental "person"       ;;these set the shape of each breed
  set-default-shape poly "person"
  set-default-shape neutral "person"
  set-default-shape restaurants "house"

  create-paper 1               ;; this creates one of the paper breeds
```

```

[
  setxy -12 0
  set size 4
  set color green ;; this sets papers traits
  set moneym Starting-Money-m
  set environmentalpaper 0
  ask patches in-radius 3 [
    set pcolor orange]]

create-polystyrene 1 ;; this creates polystyrene restaurant
[
  setxy 12 0
  set size 4 ;;this set polystyrenes characteristics
  set color magenta
  set moneyt Starting-Money-t
  set environmentalpolystyrene 0
  ask patches in-radius 3 [ ;; this creates a radius circle around the restaurant
    set pcolor orange]]

create-restaurants 1 ;;create the observers restaurant - environmental/polystyrene
based on
[
  setxy 0 -10
  set size 4

  if Percentage-of-Paper-Used >= .60 ;;the percentage of the products they use
  [ set color white
    set breed paper
    set moneyo Starting-Money-o ;; this is the observer restaurant and its characteristics
  being set
    set environmentalo 0
  ]
  if Percentage-of-Paper-Used < .60 ;;the percentage of the products they use
  [set color black
    set breed polystyrene

```

```
set moneyo Starting-Money-o
set environmentalo 0]
ask patches in-radius 3 [
  set pcolor orange]
]
```

```
create-environmental initial-number-environmental[ ;;this is a slider
  setxy random-xcor random-ycor
  set target one-of paper ;;these are characteristics
  set color green]
```

```
create-neutral initial-number-neutral[ ;; this is another slider
  setxy random-xcor random-ycor
  set color blue] ;;these are characteristics being set
```

```
create-poly initial-number-poly [ ;;this is another slider that sets how many polys to create
  setxy random-xcor random-ycor
  set target one-of polystyrene ;;these are setting characteristics
  set color magenta]
end
```

```
to move
  setup-plot
  plot-counts ;; people move to targets and they dine
```

```
ask environmental [ ;; this makes environmental people move and changes other variables
  rt random 5
  lt random 5
  fd 1

  if distance target < 3
    [move-to target]
```

```

if distance target = 0
[
  ifelse target = a-paper 0                               ;;environmental people eat at one of the paper
restaurants
  [
    set moneym moneym + Money-Per-Person-m - (Paper-Cost * 1) - (Polysterene-Cost * 0)
    set environmentalpaper environmentalpaper - 8
  ]
  [
    set moneyo moneyo + Money-Per-Person-m - (Paper-Cost * Percentage-of-Paper-Used) -
(Polysterene-Cost * Percentage-of-Polysterene-Used)
    set environmentalo environmentalo + (Percentage-of-Paper-Used * -8) + (Percentage-of-
Polysterene-Used * -14)
  ]
die]]

```

```

ask poly [                                               ;; this makes poly people dine at the polystyrene restaurants and change
the variables
  rt random 5
  lt random 5
  fd 1
  if distance target < 3
  [move-to target]
  if distance target = 0
  [
    ifelse target = a-polystyrene 1
    [
      set moneyt moneyt + Money-Per-Person-t - (Paper-Cost * 0) - (Polysterene-Cost * 1)
      set environmentalpolystyrene environmentalpolystyrene - 14
    ]
    [
      set moneyo moneyo + Money-Per-Person-o - (Paper-Cost * Percentage-of-Paper-Used) -
(Polysterene-Cost * Percentage-of-Polysterene-Used)
      set environmentalo environmentalo + (Percentage-of-Paper-Used * -8) + (Percentage-of-
Polysterene-Used * -14)
    ]
  ]

```



```
]
die]]
```

```
ask neutral      ;;send neutrals to the dine-neutral procedure
```

```
[
  rt random 5
  lt random 5
  fd 1
  dine-neutral
```

```
;;Influence
```

```
  if breed = neutral and color = blue and any? other turtles-here in-radius 3 with [breed =
environmental] ;;environmentals influence neutrals
```

```
  [set color red
```

```
    rt 180
```

```
    fd 6]
```

```
  if breed = neutral and color = red and any? other turtles-here with [breed = environmental]
```

```
  [set color white
```

```
    rt 180
```

```
    fd 5]
```

```
  if breed = neutral and color = white and any? other turtles-here with [breed = environmental]
```

```
  [set color green
```

```
    set breed environmental
```

```
    set target one-of paper]
```

```
  if breed = neutral and color = blue and any? other turtles-here in-radius 3 with [breed =
poly]      ;;polys influence neutrals
```

```
  [set color orange
```

```
    rt 180
```

```
    fd 6]
```

```
  if breed = neutral and color = orange and any? other turtles-here with [breed = poly]
```

```
  [set color yellow
```

```
    rt 180
```

```
    fd 5]
```

```

if breed = neutral and color = yellow and any? other turtles-here with [breed = poly]
[set color magenta
  set breed poly
  set target one-of polystyrene]
]

if count environmental + count poly + count neutral = 0 ;;when all people are gone go to dayOver
[
  dayOver
  stop
]
end

to dine-neutral ;; makes neutrals dine at any restaurant and change environmental impact and the
money they have made
  if breed = neutral and any? other turtles-here in-radius 3 with [breed = paper and color = green]
  [ set moneym moneym + Money-Per-Person-m - (Paper-Cost * 1) - (Polysterene-Cost * 0)
    set environmentalpaper environmentalpaper - 8
    die ]
  if breed = neutral and any? other turtles-here in-radius 3 with [breed = polystyrene and color =
magenta]

  [ set moneyt moneyt + Money-Per-Person-t - (Paper-Cost * 0) - (Polysterene-Cost * 1)
    set environmentalpolystyrene environmentalpolystyrene - 8
    die ]

  if breed = neutral and any? other turtles-here in-radius 3 with [breed = paper and color = white]

  [ set moneyo moneyo + Money-Per-Person-o - (Paper-Cost * Percentage-of-Paper-Used) -
(Polysterene-Cost * Percentage-of-Polysterene-Used)
    set environmentalo environmentalo + (Percentage-of-Paper-Used * -8) + (Percentage-of-
Polysterene-Used * -14)
    die ]
  if breed = neutral and any? other turtles-here in-radius 3 with [breed = polystyrene and color = black]

```

```
[ set moneyo moneyo + Money-Per-Person-o - (Paper-Cost * Percentage-of-Paper-Used) -  
(Polysterene-Cost * Percentage-of-Polysterene-Used)
```

```
  set environmentalo environmentalo + (Percentage-of-Paper-Used * -8) + (Percentage-of-  
Polysterene-Used * -14)
```

```
    die]
```

```
end
```

```
to dayOver ;;ends program
```

```
  tick-advance 1
```

```
end
```

```
to plot-counts ;;graph it!
```

```
  set-current-plot "Populations"
```

```
  set environmental-count count turtles with [ breed = environmental ]
```

```
  set-current-plot-pen "Environmentals"
```

```
  plot environmental-count
```

```
  set poly-count count turtles with [ breed = poly ]
```

```
  set-current-plot-pen "Polys"
```

```
  plot poly-count
```

```
  set neutral-count count turtles with [ breed = neutral ]
```

```
  set-current-plot-pen "Neutrals"
```

```
  plot neutral-count
```

```
end
```

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