Appalachian State University
Boone, North Carolina

Plethora of Plastics: Lesson Plan

By: **Alana Baird**

Abstract

Students will engage in the mathematical modeling process by using statistics about a real world situation to build and assess linear and exponential functions to see when each model is appropriate. Students will investigate the growth of plastic creation and the rise of the resulting waste using technology and mathematics, to better understand the problem, make predictions and think about future decisions.

Alana Baird

Plethora of Plastics: Lesson Plan

Content Standards:

At the end of this lesson students should be able to:

- Distinguish between situations that can be modeled with linear functions and with exponential functions.
- Interpret the parameters in a linear or exponential function in terms of a context.
- Calculate and interpret the average rate of change of a function over a specified interval.
- Compute (using technology) and interpret the correlation coefficient of a linear fit.
- Fit a function to the data and then use the functions to solve problems in the context of the data.

Students will engage in the modeling process through choosing and using appropriate mathematics and statistics to analyze a real world situation. Students will investigate the real world problem using technology and mathematics, to better understand the problem, make predictions and think about future decisions.

a. **Launch** (10 minutes)

Students will watch a PowerPoint converted to SlideSnack (without audio) presentation the night before this lesson. Students will watch the slide show and answer the questions. Each student will bring his or her answers to class the following day. This PowerPoint will allow students to prepare for the lesson the night before through review and basic introductions. Also, students will come in with their answers ready to share with a partner. The link to the SlideSnack file is: http://share.snacktools.com/F9FEF6BA9F7/bdxj4mic

The PowerPoint will review functions previously encountered during the course, review how to create an equation to model specific problems, discuss fitting regression equations to real world data and making predictions with the model. Also, students will review how to determine which trend line to choose when presented with a graph and when only data points are given. Furthermore, the PowerPoint will review how to choose and calculate a line of best fit for linear models, and then review the skills needed to create scatter plots and add trend lines in Excel.

Lastly, the slideshow includes links to Moody's Mega Math Challenge and the "5 Gyres" website. These websites will serve as the inspiration for the mathematical modeling project, so students can peruse the website and get a sneak peak into the topic.

Teacher Considerations (Before)	Description of Learning Activities	Anticipated Student Responses	Teacher Guidance (During)
How will I engage the students' prior knowledge?	Break students into pairs. Have students discuss the	Students should be able to check most of their answers to the	When choosing the appropriate model for real life data sets

The PowerPoint slideshow should adequately review topics which relate to the current lesson. Students will be able to have a quick mini-lesson to refresh themselves on the prior knowledge, plus there are links to several websites where students can learn more about a specific idea if they feel like they need it. Also, students have to answer questions on several slides, and bring their answers to class to discuss with a partner. Students can work through the problems and then also get help from their partner if they are still struggling once they get to class. **How can I keep from giving away too much of the problem?** The links I provided to Moody's Mega Math Challenge just shows the modeling competition problem. Students might think their assignment will be that, but I just chose the links to get them thinking about plastics and recycling. When I chose	SlideSnack PowerPoint they watched the night before. Students should use this time to review what they learned, discuss their answers to the various problems posed within the PowerPoint, and ask each other for clarification about topics and questions presented in the slideshow about which they were unsure.	questions posed in the slideshow with their partner. One problem some students might have trouble with is how to determine what function will fit the data given only the table or set of points. If students are still struggling with the topic after a few minutes of discussing it with their partner they can investigate the additional link provided. Or if several groups share the same questions then the topic can be addressed with the entire class prior to starting the activity. Students also might have additional questions about Excel. Any minor queries can be addressed by the teacher to the individual. Lastly, students might have additional questions about r-squared values. Hopefully students will be excited about the problem presented on Moody's Mega Math	students should calculate the differences and ratios to identify the correct function. Ask students if they think the differences or ratios will always be exact with real-world data. Have students justify why or why not. Ask students to create a situation where the equation y = 1/4x + 25. Also, have students explain the slope as a rate of change. To address issues about r-squared values ask students if they think predictions made using the equation y = 5.5x +62 with an r-squared value of 0.79 will be a. Very accurate b. Slightly close c. Not a very good prediction

functions for the review slide in the PowerPoint I made sure to include several different types of functions, not just the ones they will need to know for this lesson. **How can I make it personal and relevant to the students?** I think the "5 Gyres" website contains a lot of cool videos and information about plastics. Students today will eventually be involved in the creation of solutions to the many global problems. Students are aware of issues, such as global warming and pollution, so showing them how to attack these types of problems will be very beneficial to them in the future. **What advantages or difficulties can I foresee?** Reviewing prior knowledge before class frees more time for the activity. Since I gathered most of the data for the students they don't even have to worry with research.		Challenge website.	

b. **Explore** (40 minutes)

Teacher Considerations (Before)	Description of Learning Activities	Anticipated Student Responses	Teacher Guidance (During)
How will I organize the students to explore this problem? Group students with one other person. Make sure students given Worksheet A work with others assigned A and pair students working through Worksheet B with others working through the same version. Each group will need access to one computer. If students work on two separate computers they will probably just complete the activity individually, instead of working with their partner. To make sure both students work with the technology and neither does all the work, have students switch roles half way through the activity. This way both students eventually serve as the computer operator. To further make sure both students are participating students	Students will work with a partner to complete the “Plethora of Plastics” activity sheet. The student activity sheet is attached at the end of this lesson plan. Students will utilize their graphing calculators and Excel to manipulate the data and create models. Half-way through the activity students will change roles so that each student gets the opportunity to practice with the technology. After students complete the activity sheet they will create an online poster using Glogster. Write the directions for the poster and the link to the website on the board. 1. Students will need to make a group poster that outlines what their learned about the generation and accumulation of plastics. Explain to students that they must clearly	Students used to learner-oriented classrooms should have no difficulties working through the problems. The problems build on each other and allow students to create models by following smaller simpler steps. Students should be excited about using Glogster to create online posters. Plus, this part of the activity allows them to voice their own ideas on how to make the necessary changes.	Some lower-ability level students might struggle with the content and material; therefore I have created two different worksheets for the in-class project and also for the homework problems. Students who normally struggle through difficult material or through learner-centered activities should be given Worksheet B. Worksheet B simply provides a few more suggestions and directions for lower-level students. Students who enjoy a challenge can complete Worksheet A. Worksheet A provides minimal directions and also includes several Challenge questions. Individual questions can be addressed by the teacher as he or she walks around and observes students. Specifically, what kinds of questions can

should complete their own worksheets. If a student is not operating the computer at the time he or she can simply sketch a graph of the data. **What materials will students need to encourage diverse thinking and problem-solving?** Each pair will need access to one computer with Excel, Word, and the internet available. Also, each student should use their graphing calculators when the need arises. A ruler will help students make more accurate estimations. Each student will need a copy of either Worksheet A or B. **What advantages or difficulties can I foresee?** Working with a partner will allow the students to discuss their ideas with someone else before answering the questions. Real world problems require multiple approaches and everyone's critical thinking skills.	explain (either on the poster or verbally during the presentation) their thought patterns and why they attempted the problems like they did. 2. Also, students will use the poster to voice their own ideas on how to increase plastic recycling, decrease production, and clean up the millions of tons already discarded. A link to the free edition of Glogster is located at the end of this section of the lesson plan. Students will need to create an account, if they don't have one already, and then use the application to create their online poster.		I ask: **to make them probe further into the problem if the initial question is "answered"?** How did you get that answer? Explain your thought process to me. How do you know your answer is correct? Have you justified your answer with your work and thoughts? Compare your answer to your partners. Whose argument would win in a court of law? Why? **to encourage student-to-student conversation, thinking, learning, etc.?** Don't say you can't do it, and don't just ask me because it is hard. Have you asked your partner what he or she thinks? Can you build upon your partners thinking? What can you add to the answer to make it more clear?

Group work is always challenging because you sometimes have one student who relies on the other for the answers. Making each student complete his or her own worksheet will hopefully force students to engage in the material. Also, personal views and justifications required in several questions will make students have to think for themselves.			

Glogster free student education account:

http://edu.glogster.com/register?edu_type=student

c. **Summarize** (15 minutes)

Teacher Considerations (Before)	Description of Learning Activities	Anticipated Student Responses	Teacher Guidance (During)
How can I orchestrate the discussion so the students summarize the thinking in the problem? Students must include their thought processes and justification for their methods and calculations either on their Glogster poster or during their oral presentation of their poster. Students who do not complete this component will loose points on their presentation. Also, at the end of their speech I will ask them specific questions to make them clarify their processes. **What generalizations can be made?** Students should see how although the amount of plastic generated, recycled, and discarded may increase at a linear rate each year, the total amount of plastic that has accumulated in	Students will present their group poster that outlines what their learned about the generation and accumulation of plastics. Students will explain to the class their thinking and methods for attempting the problem. Also, during their presentation students will voice their own ideas on how to increase plastic recycling, decrease production, and clean up the millions of tons already discarded. Students will then answer questions from the teacher and from fellow students about their presentation. Each group will present their posters. Then any issues which need to be further addressed will be discussed.	Students will probably be reluctant to share their thoughts and methods. During the Explore part of the lesson the teacher should try to analyze each groups' poster and give suggestions for more details where needed. Hopefully the student generated ideas to improve recycling efforts will lead into some good class discussions.	Remind students to explain their thinking! Encourage students to ask questions of each group, or discuss any topics they were intrigued by. Pose class-wide questions such as: How could we further develop this model? What other variables effect this problem? How could we account for these variables? If the class seems interested in the topic more activities could be created, especially ones that are more individual and differentiated. After students understand the basic processes for creating models for the data students could be allowed to create their own problem or model. For example, another problem is the filling of landfills with organic wastes. Students could be allowed to explore the topic and create their own problem to solve.

landfills over the years can only be modeled with an exponential function. **What advantages or difficulties can I foresee?** Students will have to keep their presentations of their posters short so we don't run out of time. However, more importantly students will have to fully explain their thinking. More time might need to be spent on this lesson. This lesson is very broad and many more activities could be generated from this topic. If students seem very interested it might be fun to expand this into a unit.			

d. Assessment of Student Learning
   Students will complete the "Plastics Piling Up: Pointless Panic?!?" homework worksheet. Assign students either Worksheet A or B based on their understanding. Students who need less guidance should complete Worksheet A.

   i. What questions are appropriate for my students to do after the investigation?

      This worksheet will present a different situation and have students focus on choosing the best model using data points, difference, and ratios.

   ii. What are the goals of the homework/classwork assignment?

      Students will focus more on how to choose a good model, instead of allowing Excel to show them which is the best model. Since students have now worked with real-life models that are not always "pretty" this will give them a chance to do more of the mathematics behind the models instead of focusing on the results. Plus, this worksheet introduces new variables into the overall topic and could be used to further explore the problem.

iii. How will students be supported in completing the assignment? Do I provide information and support for students and parents?

Students can still access the PowerPoint on SlideSnack to help guide them through the process of choosing models when only given data. The homework will be discussed as a class during the following class period.

Plethora of Plastics

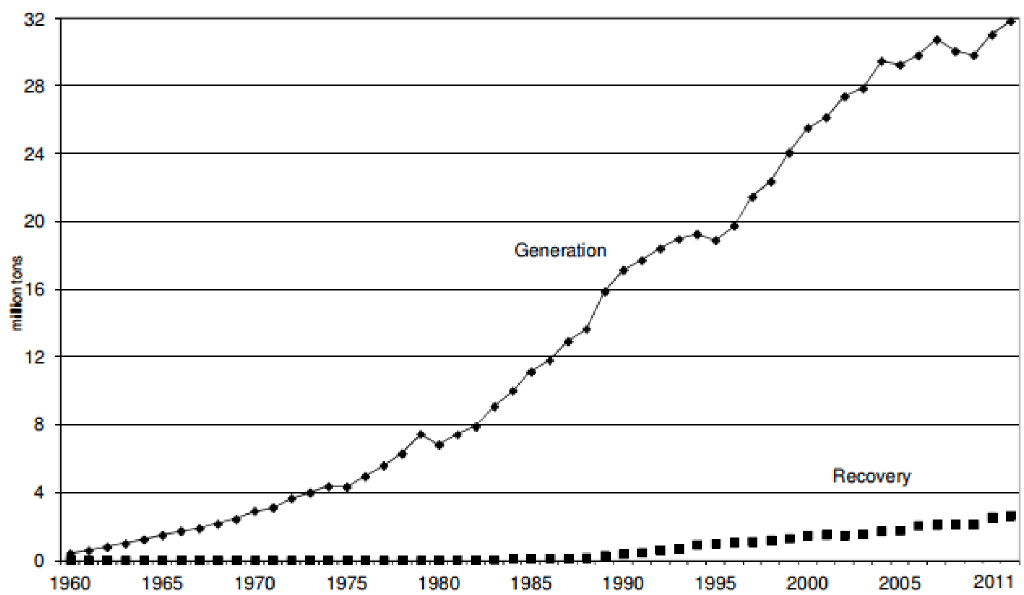
Plastics are a rapidly growing segment of MSW. While plastics are found in all major MSW categories, the containers and packaging category (bags, sacks, and wraps, other packaging, PET bottles, jars and HDPE natural bottles, and other containers) has the most plastic tonnage at 13.9 million tons in 2011 (Figure 8 and Table 7).

Generation. Plastics made up an estimated 390,000 tons of MSW generation in 1960. The quantity has increased relatively steadily to 31.8 million tons in 2011 (Figure 9). As a percentage of MSW generation, plastics were less than one percent in 1960, increasing to 12.7 percent in 2011.

Recovery for Recycling. While overall recovery of plastics for recycling is relatively small – 2.7 million tons, or 8.3 percent of plastics generation in 2011 (Table 7) – recovery of some plastic containers is more significant.

Discards After Recovery. Discards of plastics in MSW after recovery were 29.2 million tons, or 17.9 percent of total MSW discards in 2011 (Table 3).

Figure 9. Plastics generation and recovery, 1960 to 2011



United States Environmental Protection Agency. (May 2013). *Municipal solid waste in the United States: 2011 facts and figures*. (Office of Solid Waste Publication No. EPA530-R-13-001). Washington, DC: U.S. Government Printing Office. Retrieved from http://www.epa.gov/epawaste/nonhaz/municipal/pubs/MSWcharacterization_fnl_060713_2_rpt.pdf.

Alana Baird

Worksheet A Name: ____________________________

1. Complete the table below. Data listed in the 1995 to 2011 Fact Sheets is given, however, you must estimate the values for years between 1960 and 1995 using Figure 9 above and fill in the appropriate cells.

   *Remember Weight Discarded = Weight Generated – Weight Recovered (through Recycling)

YEAR	**MILLIONS OF TONS OF PLASTIC DISCARDED**
1960	
1965	
1970	
1975	
1980	
1985	
1990	
1995	18.90
1996	18.00
1997	18.70
1998	20.40
1999	22.80
2000	23.40
2001	24.00
2003	25.31
2005	27.25
2006	27.46
2007	28.61
2008	27.93
2009	27.71
2010	28.49
2011	29.19

2. Graph the data above using Excel and insert the graph below. Describe the data and any trends you notice.

3. Using Excel add a linear trend line. Display the equation and the r-squared value on the graph and write the equation and the coefficient of determination below. Is the equation a good fit? How do you know?

Alana Baird

4. Interpret the slope of the linear regression equation created by Excel as a rate of change.

5. Interpret the y intercept. Does this make sense in this model?

6. Using the linear regression equation to predict how many millions of tons of plastic will be discarded in

   2015:

   2025:

7. Read back through the Generation section and study the graph of plastic generation from 1960 to 2011. Calculate the average rate of increase from 1960 to 2011. How many tons per year are created?

   Do you think plastic production will continue at this rate? Why?

8. Look back at the Recovery information and the graph. Why do you think only 8.3% of plastics created are recycled?

9. Calculate the average rate of increase in Recovery. How many tons per year are recycled?

   Do you think the rate of Recovery will continue to increase, start to decrease or plateau? If you think Recycling rates will continue to increase how do you think the rate of increase will change?

10. CHALLENGE: How many more tons per year must be recycled to make the amount of tons Discarded start to decrease?

Alana Baird

11. Re-enter your data from above and then calculate the total amount of plastics Discarded into landfills at the end of each year.

    *Remember to calculate Total Dumped at End of 1965 = Total Dumped at End of 1960 + Millions of Tons of Plastic Discarded in 1965

YEAR	**MILLIONS OF TONS OF PLASTIC DISCARDED**	**TOTAL DUMPED AT END OF YEAR**
1960		
1965		
1970		
1975		
1980		
1985		
1990		
1995	18.90	
1996	18.00	
1997	18.70	
1998	20.40	
1999	22.80	
2000	23.40	
2001	24.00	
2003	25.31	
2005	27.25	
2006	27.46	
2007	28.61	
2008	27.93	
2009	27.71	
2010	28.49	
2011	29.19	

12. Using Excel create a scatter plot of the Total Dumped at End of Year with respect to time. What does the graph look like? What type of model will represent the data best?

13. Add the regression model you think will best fit the data. Write the equation and the r-squared value below. Is it a good fit? How do you know?

14. Using the equation make a prediction of how much plastic will be in landfills (and the ocean gyres) by

    2015:

    2025:

    2050:

15. Do you think recycling alone will solve this problem? What are some of the challenges in recycling plastic that might hinder the United States from recycling all plastic?

16. What else do you think should be done to combat this problem? What are your ideas to curb generation, increase recycling, and begin cleaning up?

Alana Baird

Worksheet B Name: ________________________

1. Complete the table below. Data listed in the 1995 to 2011 Fact Sheets is given, however, you must estimate the values for years between 1960 and 1995 using Figure 9 above and fill in the appropriate cells.

   *Remember Weight Discarded = Weight Generated – Weight Recovered (through Recycling)

YEAR	MILLIONS OF TONS OF PLASTIC DISCARDED
1960	
1965	
1970	
1975	
1980	
1985	
1990	
1995	18.90
1996	18.00
1997	18.70
1998	20.40
1999	22.80
2000	23.40
2001	24.00
2003	25.31
2005	27.25
2006	27.46
2007	28.61
2008	27.93
2009	27.71
2010	28.49
2011	29.19

2. Create a scatter plot of the data above using Excel and insert the graph below. Describe the data and any trends you notice.

3. Using Excel add a linear trend line. Display the equation and the r-squared value on the graph and write the equation and the coefficient of determination below. Is the equation a good fit? How do you know?

Alana Baird

4. Interpret the slope of the linear regression equation created by Excel as a rate of change.

5. Interpret the y intercept. Does this make sense in this model?

6. Using the linear regression equation to predict how many millions of tons of plastic will be discarded in

   2015:

   2025:

7. Read back through the Generation section and study the graph of plastic generation from 1960 to 2011. Using the points (1960, ____) and (2011, 29.19) calculate the average rate of increase from 1960 to 2011. How many tons per year are created?

   Do you think plastic production will continue at this rate? Why?

8. Look back at the Recovery information and the graph. Why do you think only 8.3% of plastics created are recycled?

9. Using the points (1960, 0) and (2011, 2.7) calculate the average rate of increase in Recovery. How many tons per year are recycled?

   Do you think the rate of Recovery will continue to increase, start to decrease or plateau? If you think Recycling rates will continue to increase how do you think the rate of increase will change?

10. BONUS: How many more tons per year must be recycled to make the amount of tons Discarded start to decrease?

11. Re-enter your data from above and then calculate the total amount of plastics Discarded into landfills at the end of each year.

    *Remember to calculate Total Dumped at End of 1965 = Total Dumped at End of 1960 + Millions of Tons of Plastic Discarded in 1965

YEAR	MILLIONS OF TONS OF PLASTIC DISCARDED	TOTAL DUMPED AT END OF YEAR
1960		
1965		
1970		
1975		
1980		
1985		
1990		
1995	18.90	
1996	18.00	
1997	18.70	
1998	20.40	
1999	22.80	
2000	23.40	
2001	24.00	
2003	25.31	
2005	27.25	
2006	27.46	
2007	28.61	
2008	27.93	
2009	27.71	
2010	28.49	
2011	29.19	

12. Using Excel create a scatter plot of the Total Dumped at End of Year with respect to time. What does the graph look like? What type of model will represent the data best?

13. Add an exponential regression model to the data. Write the equation and the r-squared value below. Is it a good fit? How do you know?

14. Using the equation make a prediction of how much plastic will be in landfills (and the ocean gyres) by

    2015:

    2025:

    2050:

15. Do you think recycling alone will solve this problem? What are some of the challenges in recycling plastic that might hinder the United States from recycling all plastic?

16. What else do you think should be done to combat this problem? What are your ideas to curb generation, increase recycling, and begin cleaning up?

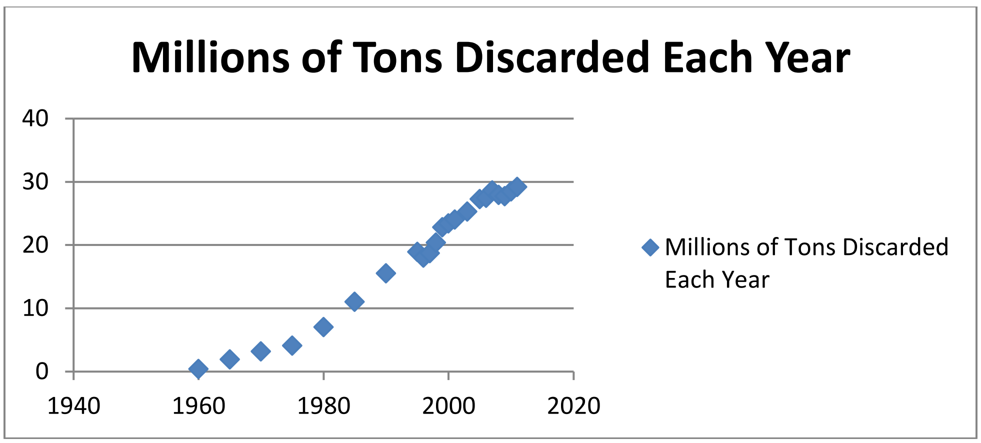
Alana Baird

Answer Key: Worksheets A & B

1. Estimations may vary; should be close to

Year	Millions of Tons Discarded
1960	0.39
1965	1.9
1970	3.2
1975	4.1
1980	7
1985	11
1990	15.5

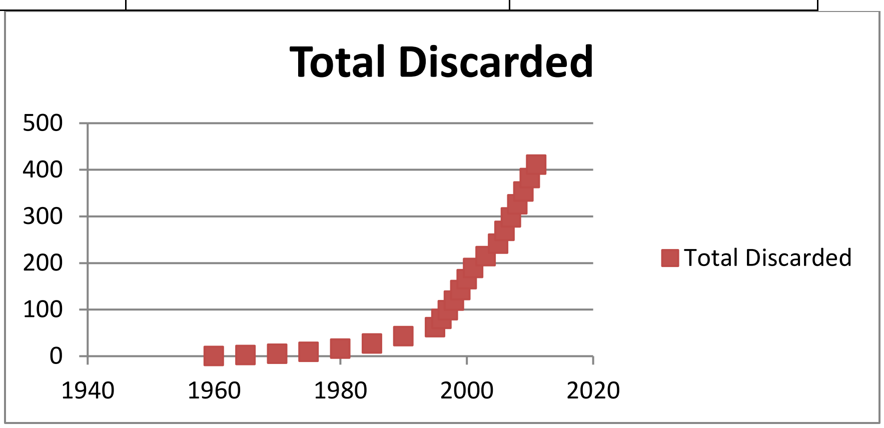
2. Fairly linear; positive slope



3. y = 0.636x - 1249.6
   R^2 = 0.9748
   Good fit; coefficient of determination close to 1
4. Slope = 0.636; 636,000 tons of plastic are discarded each year
5. Y intercept: – 1249.6 means at year zero there were negative amounts of plastic; doesn't make sense in the context of the problem
6. Predictions
   a. 2015 31.94 million tons of plastic
   b. 2025 38.3 million tons of plastic
7. Generated = $\frac{31.8-0.39}{2011-1960} = \frac{31.41}{51} \approx 0.6159$; 615,882 tons/year generated
8. Answers will vary
9. Recovered = $\frac{2.7-0.0}{2011-1960} = \frac{2.7}{51} \approx 0.0529$; 52941.2 tons/year recycled
10. If Generated rate stays at 615,882 tons/year then people must recycle at least 562,942 more tons per year to make the trend decline.

Alana Baird

Year	Millions of Tons Discarded	Total Discarded
1960	0.39	0.39
1965	1.9	2.29
1970	3.2	5.49
1975	4.1	9.59
1980	7	16.59
1985	11	27.59
1990	15.5	43.09
1995	18.9	61.99
1996	18	79.99
1997	18.7	98.69
1998	20.4	119.09
1999	22.8	141.89
2000	23.4	165.29
2001	24	189.29
2003	25.31	214.6
2005	27.25	241.85
2006	27.46	269.31
2007	28.61	297.92
2008	27.93	325.85
2009	27.71	353.56
2010	28.49	382.05
2011	29.19	411.24

12. 

13. $y = 2E\text{-}103e^{0.1208x}$ $R^2 = 0.9753$ Good fit

14. Predictions
   a. 2015 1031.62 million tons of plastic
   b. 2025 3452.6 million tons of plastic
   c. 2050 70,748.2 million tons of plastic

15. Answer will vary

16. Answers will vary

Alana Baird

Plastics Piling Up: Pointless Panic?!?

In class we investigated how plastic generation is increasing and the total amounts of plastic in our landfills and the ocean gyres is growing exponentially. Recycling rates are insubstantial, and as new plastic waste is added each year the total amount of plastic garbage is growing very quickly.

Who cares? Bury the plastic in the landfill and make new plastic goods!

Wait…let's examine how plastic deteriorates. Most waste products, once buried in the landfill, undergo the process of biodegrading as microorganisms begin to break down the organic materials which make-up the product. However, plastics, which are man-made polymers, are not ingestible by microorganisms, therefore, plastics do not decompose. Instead plastics are broken down by the process of photo degradation. Sunlight causes plastics to become brittle, and eventually shatter into smaller and smaller pieces.

Some news sources say it will take 500 years for plastic products to "decompose" in the landfills. On the other hand, if it has simply split into smaller pieces and has not actually become part of the carbon cycle has it really disintegrated or is it still there?

Lapidos, J. (2007). Will my plastic bag still be here in 2507? *Slate*. Retrieved from http://www.slate.com/articles/news_and_politics/explainer/2007/06/will_my_plastic_bag_still_be_here_in_2507.html.

Andrady studied plastic samples exposed to the air and samples exposed to marine conditions to study the deterioration rates. For example, he tested a sample of Polyethylene, which is representative of the plastic rings around soda six-packs and also of plastic bags. He calculated the tensile strength and the ultimate extension on each sample over the course of one year. Andrady states ultimate extension "is considered a more appropriate parameter than tensile strength for measuring physical degrada-tion since it reflects the brittleness and consequent tendency of the plastic to fragment."

Andrady, A. *Environmental degradation of plastics under land and marine exposure conditions*. Retrieved from http://5gyres.org/media/Environmental_Degradation%20of%20Plastics_by_Andrady.pdf

Alana Baird

Worksheet A   Name: ______________________

1. Calculate the differences and ratios to determine what type of regression equation should be fitted to the data.

Data on Sample of Plastic Strapping Tape (Exposed in Air)

Months	**Ultimate Extension Mean**	**Difference in Values of Dependent Variable**	**Difference of Differences**	**Ratio of Values of the Dependent Variable**
0	82			
2	70			
4	43			
6	19			
8	12			
10	10			
12	8			

Is the data linear? Why or why not?

Is the data quadratic? Why or why not?

Is the data exponential? Why or why not?

2. Now, create a scatter plot using Excel, and insert the graph below. Does the graph justify your conclusion from #1? Add a trendline and write the equation and the coefficient of determination below.

CHALLENGE: How many months before the ultimate extension mean will reach zero?
To reach 0.5?

3. Calculate the differences and ratios to determine what type of regression equation should be fitted to the data.

Data on Sample of Plastic Strapping Tape (Exposed in Seawater)

Alana Baird

Months	**Ultimate Extension Mean**	**Difference in Values of Dependent Variable**	**Difference of Differences**	**Ratio of Values of the Dependent Variable**
0	89			
4	91			
6	82			
8	79			
10	63			
12	61			

Is the data linear? Why or why not?

Is the data quadratic? Why or why not?

Is the data exponential? Why or why not?

4. Now, create a scatter plot using Excel, and insert the graph below. Does the graph justify your conclusion from #3? Add a trendline and write the equation and the coefficient of determination below.

5. What do the graphs tell us about the longevity of plastic products? With regards to the amount of plastics in landfills why should scientists be concerned about plastic decomposition time?

6. Andrady notes samples in the marine environment do not undergo “heat buildup” therefore they decompose more slowly. However, they do break down into smaller pieces. What other problems could be modeled and evaluated mathematically that relate to this topic?

7. How does this information relate to food chains? Could we model the event and use it to make an estimate? Explain.

Alana Baird

Worksheet B Name: ______________________

1. Calculate the differences and ratios to determine what type of regression equation should be fitted to the data.

Data on Sample of Plastic Strapping Tape (Exposed in Air)

Months	**Ultimate Extension Mean**	**Difference in Values of Dependent Variable**	**Difference of Differences**	**Ratio of Values of the Dependent Variable**
0	82	70 – 82 = - 12	-27 – (-12) =	70/82 =
2	70	43 – 70 = - 27		
4	43			
6	19			
8	12			
10	10			
12	8			

Is the data linear? Why or why not?

Is the data quadratic? Why or why not?

Is the data exponential? Why or why not?

2. Now, create a scatter plot using Excel, and insert the graph below. Does the graph justify your conclusion from #1? Add an exponential trendline and write the equation and the coefficient of determination below.

3. Calculate the differences and ratios to determine what type of regression equation should be fitted to the data.

Data on Sample of Plastic Strapping Tape (Exposed in Seawater)

Months	**Ultimate Extension Mean**	**Difference in Values of Dependent Variable**	**Difference of Differences**	**Ratio of Values of the Dependent Variable**
0	89			
4	91			
6	82			
8	79			
10	63			
12	61			

Is the data linear? Why or why not?

Is the data quadratic? Why or why not?

Is the data exponential? Why or why not?

4. Now, create a scatter plot using Excel, and insert the graph below. Does the graph justify your conclusion from #3? Add a trendline and write the equation and the coefficient of determination below.

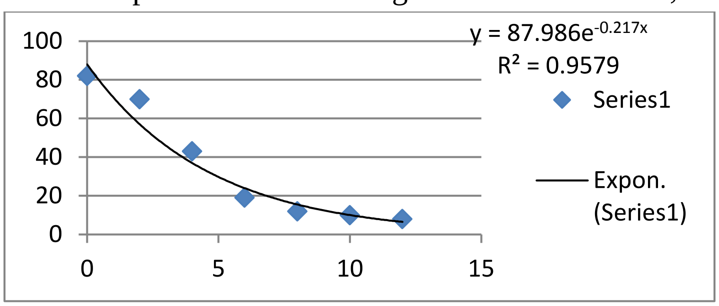
5. What do the graphs tell us about the longevity of plastic products? With regards to the amount of plastics in landfills why should scientists be concerned about plastic decomposition time?

6. Andrady notes samples in the marine environment do not undergo “heat buildup” therefore they decompose more slowly. However, they do break down into smaller pieces. What other problems could be modeled and evaluated mathematically that relate to this topic?

7. How does this information relate to food chains? Could we model the event and use it to make an estimate? Explain.

8. **Answer Key Worksheets A & B:**

months	ult. ext.	diff	diff of diff	ratio
0	82	-12	-15	0.853659
2	70	-27	3	0.614286
4	43	-24	17	0.44186
6	19	-7	5	0.631579
8	12	-2	0	0.833333
10	10	-2	-6	0.8
12	8	-8	8	0

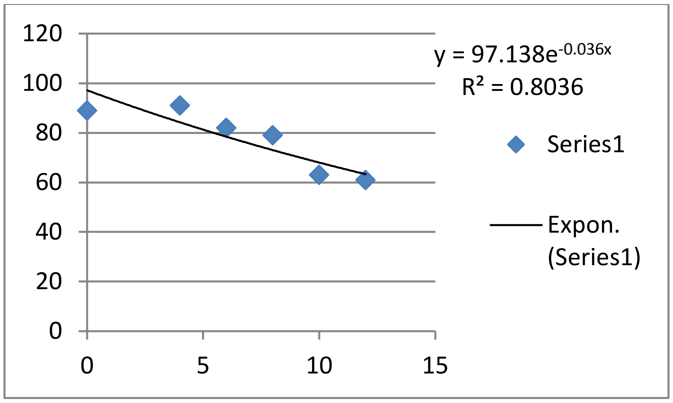
1. Chart
   a. Linear- no; difference not constant
   b. Quadratic- no; difference of differences not constant
   c. Exponential- best fitting model from choices; ratio close to the same for each
2. 

   Good fit- looks like exp. Decay

   CHALLENGE: (Worksheet A)
   a. Zero: Never
   b. 0.5: 23.8 months or approximately 24 months

months	ult. ext.	diff	diff of diff	ratio
0	89	2	-11	1.022472
4	91	-9	6	0.901099
6	82	-3	-13	0.963415
8	79	-16	14	0.797468
10	63	-2	-59	0.968254
12	61	-61	61	0

3. Chart
   a. Linear- no; difference not constant
   b. Quadratic- no; difference of differences not constant
   c. Exponential- best fitting model from choices; ratio close to the same for each

4. 

   Not as good of a fit as #2. Less data points. The data is definitely decreasing, and it is not linear and it is not quadratic. Exponential is the best fitting model from the choices.
5. Answers will vary
6. Answers will vary
7. Bioaccumulations; toxins; could model with DDT in tropic levels model.

Guessing game

Activity

Read out different types of rubbish and get students to guess how long they can survive in the ocean. This can be done as a class activity (students can shout out answers and you can tell them higher or lower) or as a team activity (students can be put into teams and write their answers down, then check together as a class at the end).

At the end of the game, talk to the students about how the plastic doesn't go away, it just breaks down into smaller and smaller pieces. Even though this plastic is degraded, it still exists as tiny pieces. Plastic doesn't completely go away. You can also talk to them about the problems that plastic causes once it's in the ocean.

Item	Ocean degrade
Apple core	2 months
Aluminum can	200 years
Tin can	50 years
Cardboard box	2 months
Plastic Bag	20 years
Styrofoam	50 years
Nylon fabric	40 years
Plastic bottle	450 years

Rationale:

I chose this modeling problem because when Dr. Bauldry showed it to our class the first time I was intrigued. The problem is astronomical, and the extensions are limitless. Plus, this problem is current and needs to be addressed. I briefly discussed this problem with one of my classes, and showed them the video and they were interested as well. I didn't have my class complete an activity, so I thought it might be nice to have an activity ready if I ever got the chance to discuss this problem again with a new class.

I chose to create a PowerPoint and then tried to convert it to a SlideSnack because I am doing my Product of Learning on how flipped classrooms affect math anxiety, so I will be creating a lot of videos and SlideSnacks in the future. I had not created a SlideSnack before, so I thought I would be good to practice, however I could not get any audio recorded to my slides, therefore it is simply a PowerPoint presentation. In the future, when I master the audio recording part, I know that the addition of audio will complement the slides in the PowerPoint and will really be beneficial to students. I really like having students review prior knowledge and presenting mini-lessons outside of class time. Having students watch these videos at home allows more time in the classroom to complete activities like this one.

I chose to have students use Excel instead of relying solely on their calculators to create scatter plots and regression models of all of the data. I think students mainly interact with their calculators, so the introduction to new technology offers them a new way to work with mathematics, making them more adaptable. Plus, I like how easy it is to create display data and graphs in Excel.

I provided the web pages and data sets the students would need to complete the problem because the EPA documents are long and can be very confusing. I did not want the students to spend a bunch of time in class trying to find the right information, because then they would run out of time to actually complete the activity. Students need time in class to play with the technology and the problem, to discuss their results with their peers and their teachers, and time spent researching will only cut into this time. If I were to do further extensions of this project, such as letting a student choose a new problem to model, then I would have the student complete their own research, but for homework.

Alana Baird

I chose to differentiate for lower-ability level students because I often have these types of students in my developmental classes. Also, it was one of my goals for this class. I practiced creating an assignment, and then modifying it to better serve lower ability groups. For example, I incorporated more steps and hints into the original activity, but was still able to have students complete the same tasks as their peers.

I choose to have students present a Glogster poster- a Glog- instead of a presentation using any other technology or simply an oral presentation because it is a cool technology which most students probably have never seen. Additionally, I had students create a poster and then give an oral presentation as well because I hoped their explanation of their thinking would be more profound if they could use two different mediums to describe their methods and thoughts. Lastly, I had students create a poster because part of the assignment asked students to be creative and come up with ideas to improve the current waste production situation. I think posters and collages are very creative, so maybe the medium will help students get in touch with their inner creativity. Modeling problems take a lot of creativity to solve, so my hope is students' general creativity will positively influence their mathematics problems and help them create innovative and resourceful solutions.