Title: Math is Malleable?

Author: Durrell Jones
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Subject: Mathematics
Level: 9-12
Standards: Modeling/Multiple Representation

4. Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships.
construct tables, charts, and graphs to display and analyze real-world data.
• use multiple representations (simulations, manipulative materials, pictures, and diagrams) as tools to explain the operation of everyday procedures.
• use variables such as height, weight, and hand size to predict changes over time.
• use physical materials, pictures, and diagrams to explain mathematical ideas and processes and to demonstrate geometric concepts.

Schedule: 45 - 50 mins

Objectives:

Use the language of mathematics to describe the rate at which the material changes over time using the concept of slope (particularly the description of the y-intercept in relationship to the x-intercept) and model a chemical behavior both in table form and graphically.

Students will:

- Bake a plastic material, record the changes in certain characteristics (in table and graphical form), and use this information to relate the concept of slope
- Identify slope as rate of change
- Calculate slopes of certain parts of curves given two sets of points graphed

Vocabulary:

- Slope
- Positive
- Negative
- Constant
- Undefined

Materials:

For Each Pair:

- Lesson Handout (s)
- "Shrinky Dinks" Sheet (s)
- Vernier Scale (s) ***Or some other thickness measuring device***)
- Ruler (s)
- Calculator (s)
- Stopwatch (s)
- Compass (s)
- Scissors
- Markers

Safety:

Do not bake the "Shrinky Dinks" Sheets in Microwave.
Do not remove "Shrinky Dinks" Sheets after baking without proper hand covering.

Science Content for the Teacher:

Polymers are essentially long chains of molecules that have formed by a chemical reaction of some sort. What is most interesting about polymers is that the use, or way in which a polymer, is created, can be found in many of the items that we possibly take for granted today. From what we wear to what we drive in and on, the research on polymers play a vital role in determining the types of materials that are used in items such as the rubber for tires and shoes, or the nylon in clothing. Understanding how this material behaves and under what conditions can mean the difference between something working efficiently or causing society to dread its creation. One way to begin a great discussion of how polymers behave is to use a form of a polymeric material called a "Shrinky Dink" Sheet. By applying the appropriate amount of heat (transition temperature), we can see how this plastic shrinks, bends, or buckles.

For more information, check out http://www.shrinkydinks.com/ to find out the best ways to use the material. To give students a chemical refresher of the make-up of a polymer, check out http://www.pslc.ws/mactest/kidsmac/. The latter website provides a sufficient understanding of a polymer and gives examples of where materials with polymeric properties exist in our current world.

Preparation:

1. Make copies of the Supplemental Sheet for students to use with their activity.

2. Students should have some idea of what polymers are beforehand to help facilitate the discussion piece. If not, use the website (http://www.pslc.ws/mactest/kidsmac/) to provide a quick resource for them.

3. Divide the class into groups of 4, assigning roles to each person.
   a. Timer: 1 student
   b. Designer/Cutter: Each student designs his or her own material.
   c. Oven Handler: 1 student
   d. Recorder: Each student records data from his or her own design.

4. Distribute a Supplemental Sheet to every student and inform them that each student will complete his or her own sheet while working in groups of 4.

Classroom Procedure:

Engage (Time: 5 – 10 mins):

Discuss what a polymer is and how it behaves. Illicit questions from students to see whether they've used the concept in other classes. If students have heard of the concept before, see if they can name as many places in their real world where one can find some sort of polymeric material. If students are unfamiliar, use the websites mentioned in "Science Content" to help with the discussion. There is actually a virtual activity included in one of the websites to give students a good idea of polymers. Do not spend too much time on the topic, though, because the goal should really be about the discovery process of how one can model certain chemical behaves in table form and graphically.

Explore (Time: 20 – 30 mins)

Let students know that this is an opportunity to review their geometric and designing skills and apply them in creating something of their own. Encourage students to use the language of slope (x-intercept or y-intercept) when they are graphing their results. Discuss how the students will be graded during this activity. Ask students within groups to each pick a different design so that the results can be slightly different. This will allow for greater discussion between the students.

Explain (Time: Varies)

Have students discuss what they did and did not like about the activity and why. Review with students what you will expect them to do for homework and what the next class period will entail. Have each student complete their own worksheet for homework. This is where the students extend the ideas from lesson. During the next class period, discuss some big ideas that came out of the lesson. Ask students to begin a conversation about what essentially happened during the heating of the material. How did the area change? Volume change? Thickness Change? with respect to time. Are there ways that these outcomes could have been different? For instance, what would have happened if the temperature were decreased or increased. Ensure that the idea of slope as rate of change is verbalized and written down by the students by the end of the lab.

Expand (Time: Varies)

Have students lead a discussion about other instances where they can apply this notion of slope (or rate of change) to ideas that frequently occur in their real world.

Assessment:

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

	Engage	Explore	Explain	Expland/Synthesis
1	Shows leadership in the leading discussion and offers creative ideas reflecting a good understanding of possible places where the mathematics can be modeled.	Completes all work accurately labeling all the tables and graphs, and providing units where necessary. Works very well with all group members.	Provides an in-depth explanation of graphs and tables making good use of vocabulary terms. Fills out worksheet clearly.	Shows leadership in the leading discussion and offers creative ideas reflecting a good understanding of possible places where the slope, or rate of change, can be realized.
2	Participates in the leading discussion and shows an understanding of the possible places where the mathematics can be modeled.	Completes some of the work accurately labeling some of the tables and graphs, and providing some units where necessary. Works somewhat well with all group members.	Provides clear explanations of graphs and tables. Completes worksheet and questions clearly.	Participates in discussion and shows an understanding of the possible places where the slope, or rate of change, can be realized.
3	Contributes to the leading discussion, but shows little understanding of the possible places where the mathematics can be modeled.	Works cooperatively with other group members labeling few of the tables and graphs, and providing few units where necessary. Makes mistakes with the procedure.	Provides limited explanations of graphs and tables. Fills out some of worksheet and questions following lab.	Contributes to discussion, but shows little understanding of the possible places where the slope, or rate of change, can be realized.
4	Does not participate in the leading discussion. Shows no understanding of the possible places where the mathematics can be modeled.	Has trouble working with other group members. Does not label any tables or graphs and provide units where necessary. Does little to complete the procedure.	Is not clear in explanations of graphs and tables. Does not fill out worksheet or answer any questions following lab.	Does not participate in the discussion. Shows no understanding of the possible places where the slope, or rate of change, can be realized.

Extension Activities:

- Questions following the activity help to facilitate discussions for students during the activity and for the day following the activity.
- Have students offer suggestions about other activities they feel could enrich their understanding of slope as it applies to rate of change

Supplemental Information:

- See Formulas Table

Safety:

- Students are working with ovens. Ensure that they have received the proper training necessary for handling all the materials associated with the use of the oven, including proper hand-ware and the operating the oven itself. Adult supervision is recommended at all times.

Acknowledgments:

- “Shrinky Dinks” Website: http://www.shrinkydinks.com/
- Useful Polymer Information Website: http://www.pslc.ws/mactest/kidsmac/.

Malleable Math Activity: Supplement Sheet

Directions:

1. Follow the steps to complete the activity.
2. Then answer the questions that follow.
3. Ensure that you label your tables and graphs with the appropriate units.

Steps:

1. Decide on shape to use for your experiment using one of the shapes below in the "Formulas" table.
    a. You are also able to use a combination of the shapes. For instance, a rectangular shape with a triangular shape above it may make an interesting looking house figure. It is probably best to measure and draw your figure on a separate sheet of paper first and then transfer this design onto your "Shrinky Dinks" Sheet.

    NOTE: The formulas you choose will vary depending on the figure you decide to cut out of your "Shrinky Dink" Sheet. I encourage you to use a compass if you would like to construct a circle or semicircle. If you are making a more elaborate figure, ensure that you get the measurements before heating. Be creative. Here are the following shapes from which you can choose:

2. Trace that shape onto "Shrinky Dinks" Sheet. Color your design any way you would like.
3. Use scissors to cut shape out.
4. Record measurements on tables provided. This means you will also have to use your venier scale to get the thickness and then do a measurement to include for your thickness table, and to be able to calculate your volume.
5. Pre- heat oven to 325°F (163°C).
6. Place "Shrinky Dinks" Sheet on aluminum foil or baking sheet (color side up) to be placed in oven. (Ensure you have your
7. Using appropriate hand covering, place sheet in oven.
8. Start timer.
9. After 30 Seconds, remove "Shrinky Dinks" sheet from oven.
10. Wait about 1 minute for sheet to cool. Measure and record results in table.
11. Repeat steps 7 – 10 Until your "Shrinky Dinks" sheet no longer shrinks.
12. Afterwards, complete the questions that accompany. Record your results using the tables and graphs below.

Formulas:	
▪ Rectangular: Area: $A = L \times W$ Surface Area: $SA = 2(L \times W) + 2(W \times H) + 2(L \times H)$ Volume: $V = (Area\ of\ Base) \times Height$	
▪ Trapezoidal: Area: $\frac{(Base1 + Base2) \times Height}{2}$	
▪ Circular: Area: $A = \pi r^2$	
▪ Triangular: Area: $\frac{Base \times Height}{2}$	
▪ Combination: Your own combination using the aforementioned figures.	

Table 1

Graph 1

Time	Area

Table 2

Graph 2

Time	Volume

Table 3	Graph 3

Time	Thickness

<u>Questions</u>:

1. What is the equation for calculating the slope, m, of a line given ordered pairs (x_1, y_1) and (x_2, y_2)?

2. What is the general shape of the curve in each situation? What is the general behavior or your curve?
   a. (Graph 1)

   ____

   b. (Graph 2)

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   c. (Graph 3)

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3. Describe how the characteristic of the material changed over time in each situation?
    a. (Table 1, Graph 1)

    b. (Table 2, Graph 2)

    c. (Table 3, Graph 3)

4. What difference(s) and or similarities between the area, volume, and thickness graphs do you notice?
    a. (Table 1, Graph 1)

    b. (Table 2, Graph 2)

    c. (Table 3, Graph 3)

5. Describe the thermal behavior of the material in each situation. Use Question #4 to help you.
    a. (Table 1, Graph 1)

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    b. (Table 2, Graph 2)

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    c. (Table 3, Graph 3)

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6. Using the concepts of area, thickness, and volume describe the overall rate of change of the material over the time interval.

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