Teaching and Learning Mathematics through Hurricane

Data

During hurricane season, maps that track predicted storm paths are commonly seen on television and the Internet. The Weather Channel often receives number-one viewership ratings in regions encountering a major weather event, such as a hurricane or tornado (Kloer 2001). Mathematics teachers can tap into students' curiosity and interest about hurricanes to develop their understanding of mathematical ideas within a real-life context. In this article, we discuss observations and findings after implementing mathematics tasks based on data about hurricanes. Finding patterns and relationships, creating and interpreting graphs, and examining rates of change are just a few of the topics that can be studied. We developed these tasks as part of the Students' Transition Toward Algebra project and have used them with both middle school teachers and students.

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PATTERNS IN ATLANTIC TROPICAL STORM NAMES

What hurricane names do you remember? Wilma? Andrew? Katrina? Do you know how names of hurricanes are determined? **Table 1** lists the names of past and future Atlantic tropical storms and hurricanes, as determined by the World Meteorological Organization (WMO). What patterns do you notice in the array of names in **table 1**?

We found that discussing the patterns of tropical storm and hurricane names in **table 1** as a class provided a good introduction for lessons involving mathematical ideas related to hurricanes. The students and teachers with whom we worked observed several patterns in the names:

- "Each year, the names follow an alphabetical order."
- "Across years, names starting with the same letter alternate between girl and boy names."

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Tracking

Table 1 Names for tropical storms and hurricanes over the Atlantic-Caribbean basin

2004	2005	2006	2007	2008	2009	2010	2011
Alex	Arlene	Alberto	Andrea	Arthur	Ana	Alex	Arlene
Bonnie	Bret	Beryl	Barry	Bertha	Bill	Bonnie	Bret
Charley	Cindy	Chris	Chantal	Cristobal	Claudette	Colin	Cindy
Danielle	Dennis	Debby	Dean	Dolly	Danny	Danielle	Don
Earl	Emily	Ernesto	Erin	Edouard	Erika	Earl	Emily
Frances	Franklin	Florence	Felix	Fay	Fred	Fiona	Franklin
Gaston	Gert	Gordon	Gabrielle	Gustav	Grace	Gaston	Gert
Hermine	Harvey	Helene	Humberto	Hanna	Henri	Hermine	Harvey
Ivan	Irene	Isaac	Ingrid	Ike	Ida	Igor	Irene
Jeanne	Jose	Joyce	Jerry	Josephine	Joaquin	Julia	Jose
Karl	Katrina	Kirk	Karen	Kyle	Kate	Karl	Katia
Lisa	Lee	Leslie	Lorenzo	Laura	Larry	Lisa	Lee
Matthew	Maria	Michael	Melissa	Marco	Mindy	Matthew	Maria
Nicole	Nate	Nadine	Noel	Nana	Nicholas	Nicole	Nate
Otto	Ophelia	Oscar	Olga	Omar	Odette	Otto	Ophelia
Paula	Philippe	Patty	Pablo	Paloma	Peter	Paula	Philippe
Richard	Rita	Rafael	Rebekah	Rene	Rose	Richard	Rina
Shary	Stan	Sandy	Sebastien	Sally	Sam	Shary	Sean
Tomas	Tammy	Tony	Tanya	Teddy	Teresa	Tomas	Tammy
Virginie	Vince	Valerie	Van	Vicky	Victor	Virginie	Vince
Walter	Wilma	William	Wendy	Wilfred	Wanda	Walter	Whitney
Alpha	Alpha	Alpha	Alpha	Alpha	Alpha	Alpha	Alpha
Beta	Beta	Beta	Beta	Beta	Beta	Beta	Beta
Gamma	Gamma	Gamma	Gamma	Gamma	Gamma	Gamma	Gamma
Delta	Delta	Delta	Delta	Delta	Delta	Delta	Delta
Epsilon	Epsilon	Epsilon	Epsilon	Epsilon	Epsilon	Epsilon	Epsilon
Zeta	Zeta	Zeta	Zeta	Zeta	Zeta	Zeta	Zeta
Eta	Eta	Eta	Eta	Eta	Eta	Eta	Eta
Theta	Theta	Theta	Theta	Theta	Theta	Theta	Theta

Note: Underlined names indicate tropical storms and hurricanes that occurred that year.

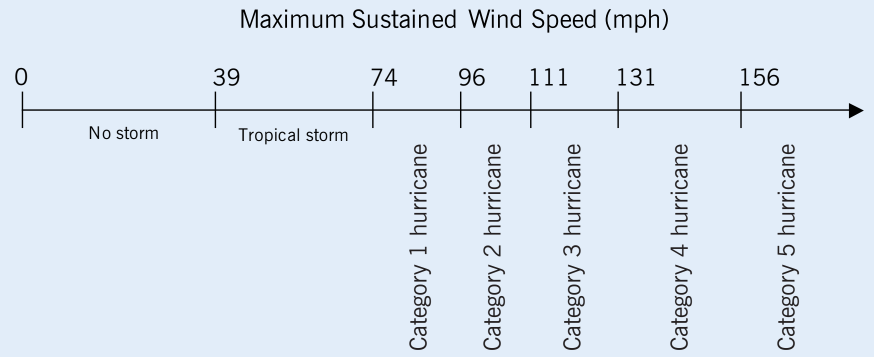
- “Each year, down each column, the names switch between girl and boy names.”
- “During the years 2004 and 2010, some of the names repeat.”

It is interesting to note that until 1979 the list contained only female names. At present, the names of tropical storms and hurricanes repeat on a 6-year cycle unless they are retired from the list. A name is retired when the storm it represents causes severe damage. The havoc wreaked by Katrina in 2005, for example, caused its name to be retired.

Atlantic tropical storms are named in alphabetical order, beginning with A, for the first storm of each year. When a rainstorm originating over tropical waters reaches sustained wind speeds between 39 and 73 mph, it is assigned a name from the list. If it strengthens to sustained wind speeds of over 74 mph, it becomes a hurricane under the same name. Hurricanes are classified into five wind-speed categories based on the Saffir-Simpson Hurricane Scale (see **fig. 1**). The WMO coordinates tropical storm and hurricane information, including regional lists of names, across different ocean basins all around the world. The lists of names follow different patterns and rules depending on the region of the Earth where the storms originate. Typically, storm names are taken from the culture of the people who live in the region of the storms. To infuse a cultural perspective into the storm-name activity, students can explore and compare patterns across different regional lists of names for tropical storms and hurricanes (known as typhoons or cyclones in some world regions). More information on tropical storms, including the rules for regional names, can be found at the WMO Web site (www.wmo.ch/index-en.html) (WMO 2006) or the National Oceanic and Atmospheric Administration (NOAA) Web site (www.nhc.noaa.gov/aboutnames.shtml) (NOAA 2006).

In addition to finding patterns in the lists of tropical storm names, students can be challenged to use mathematical reasoning to determine the characteristics of selected future storm names. For example, using the names in **table 1**, we ask students to project for the year 2052 whether the name for the 13th Atlantic tropical storm will be female or male. Students may answer that the name will be male, because the 13th storm of each year begins with an M and that male M names occur on even-numbered years, whereas female M names occur on odd-numbered years. Another more challenging question is to ask the students to determine the name of the 21st storm for the year 2080, if the current name has not been retired. Hurricane Walter might be an initial guess, because it is the 21st name in 2010. On closer inspection, students realize that the list of storm names for years ending in zero is not always the same. The lists repeat on a 6-year cycle, beginning with year 2010 and recursively adding 6 years. Students can use elements of modular arithmetic to confirm that the list of storm names for 2080 is not the same as that for 2010 (see **table 2**). One approach is to use **table 2** and observe that the list for year 2080 falls 2 years before 2082 (or 4 years after 2076). Thus, the list of names will be the same as the list 2 years before 2010 (or 4 years after 2004), that is, year 2008. Applying another approach, 2080 – 2010 = 70 years. Dividing 70 years by the 6-year cycles results in 11 cycles, with a remainder of

Fig. 1 The Saffir-Simpson hurricane scale



Hurricane Category	Typical Damage
1	Minor coastal flooding, signs damaged
2	Some roof damage, mobile homes damaged, downed trees
3	Large trees down, mobile homes destroyed, coastal flooding
4	Major roof damage, inland flooding, major beach erosion
5	Some buildings destroyed, major flooding, large-scale evacuation

Table 2 Years with same list of storm names as year 2010

2004	2010	2016	2022	2028
2034	2040	2046	2052	2058
2064	2070	2076	2082	

4 years. The 4-year remainder indicates that the list of names for 2080 is the same as the list of names 4 years after 2010, or 2014. Using **table 1**, this list of names is the same as the list 4 years after 2004, year 2008. Therefore, the actual projected name for the 21st storm of 2080 will be Wilfred.

IMPLEMENTING THE HURRICANE TRACKING TASK

The "Hurricane Tracking" task involves graphing, exploring, and examining the paths of hurricanes from a mathematical perspective. (See **activity sheet 1**, "Hurricane Tracking.") To discuss the position of hurricanes traveling through regions around the Earth, it is important for students to understand latitude and longitude. To clarify students' understanding of these terms, we use a world globe and a map containing scales of both longitude and latitude and encourage students to share their understanding of these ideas during class discussion.

Background on Latitude and Longitude

Globes of the Earth contain a coordinate grid that covers the sphere. Latitude and longitude on a globe use axes similar to the horizontal axis, x, and vertical axis, y, of the Cartesian plane. On the globe, the equator may be thought of as the horizontal axis and the prime meridian as the vertical axis. The equator is the 0 degree latitudinal line drawn around the Earth. Degrees north or south of 0 are represented by circles parallel to the equator along the surface of the globe. These circles provide latitudinal positions on the surface of the Earth. The prime meridian is the 0 degree longitudinal line passing through Greenwich, England. Degrees east or west of 0 are represented by lines of longitude passing through the north and south poles. The lines of longitude to the east of the prime meridian are marked in degrees east; those to the west of the prime meridian are marked in degrees west.

Cooperative Learning for Hurricane Tracking

For the "Hurricane Tracking" task, we placed students in pairs and designed the task to draw purposefully on key elements of effective cooperative learning experiences, as discussed by Johnson, Johnson, and Holubec (1994). One central element is "positive interdependence," requiring that groups have a clear task and group goal. In this task, pairs of students work jointly on graphing the paths of two hurricanes on one map and jointly complete the questions. We found that it was important to instruct the pairs on how we expected them to work cooperatively. It did not suffice to tell them just to work together with their partner. When the task was first implemented, students were not given instructions on ways to work cooperatively, and many pairs did not cooperate at a satisfactory level. We then agreed to implement the cooperative-learning structure as outlined in **figure 2**. Students were instructed on ways to work in pairs, such as sharing ideas and materials and taking turns recording responses to promote learning by both students. This scenario fostered a second element of effective cooperative learning, which is "face-to-face promotive interaction" (Johnson, Johnson, and Holubec 1994). The students were also told that both partners were responsible for agreeing on and understanding task responses because during a class discussion, students would be randomly selected by the teacher to explain their thinking and responses to the questions. This arrangement promoted "individual accountability," a third element of effective cooperative learning (Johnson, Johnson, and Holubec 1994). As might be expected, the cooperation among the pairs improved greatly after students received instructions and expectations for working together.

Graphing through Hurricane Tracking

Activity sheet 1 contains a table of positions for the two hurricane paths. Before beginning, we found it important for students to read and discuss as a class what represented a day in the path of a hurricane. For example, position 0 to position 1 represents the track of the hurricane on day 1; position 1 to position 2 represents day 2; and so forth. After the students completed **activity sheet 1**, we found

Fig. 2 Model for pair cooperation during the “Hurricane Tracking” activity

Create a positive interdependence with a group goal. Pairs complete the “Hurricane Tracking” activity sheet.

Describe both the group promotive interaction and the individual/group accountability.
Pairs should be expected to—

1. use the tracking map and have one member call the positions of hurricane 1 and another member graph the position. Then, reverse the roles for hurricane 2.
2. take turns recording the answers to questions on the activity sheet.

Carry out the group promotive interaction and the individual/group accountability and pair cooperation. Students follow the teacher’s description of how to interact with a partner. The teacher monitors and reminds students about how best to interact.

Assess individual/group accountability through pair-to-class discussion. While discussing pair work as a class, the teacher—

1. asks a question from the activity sheet, then randomly draws a group number out of a bag and rolls a die (i.e., odd or even) to select one pair member to respond for the group.
2. opens up questions and initial pair responses for class discussion so other groups can share their approaches and responses.
3. then repeats task 1.

it valuable to call on students randomly, as described in **figure 2**, to present solutions found by the pair as part of the class discussion.

Our middle-grades students’ graphs of the paths of the two hurricanes given are represented in **figure 3**. The students illustrated the direction of the hurricanes by using arrow marks (as used to define vectors) or numbering the points plotted for the paths with the corresponding position numbers. Graphing the hurricane paths allowed our students to apply concepts related to coordinate graphing in a concrete, tangible, and context-based coordinate plane. It also gave students an opportunity to clarify their understanding of graphing on the Cartesian coordinate plane by contrasting it to aspects of

Fig. 3 Examples of students’ tracking the paths of two hurricanes

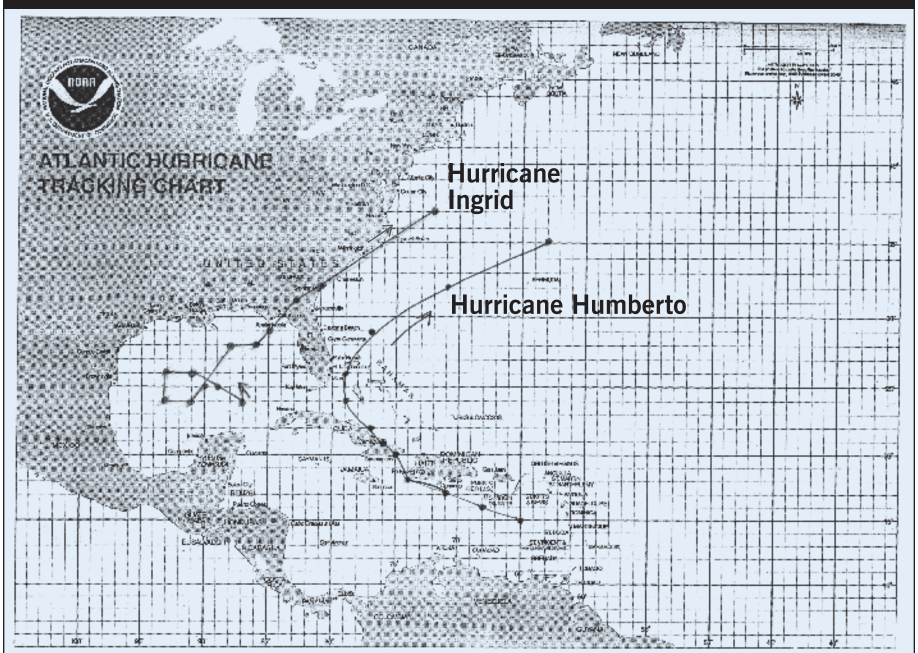
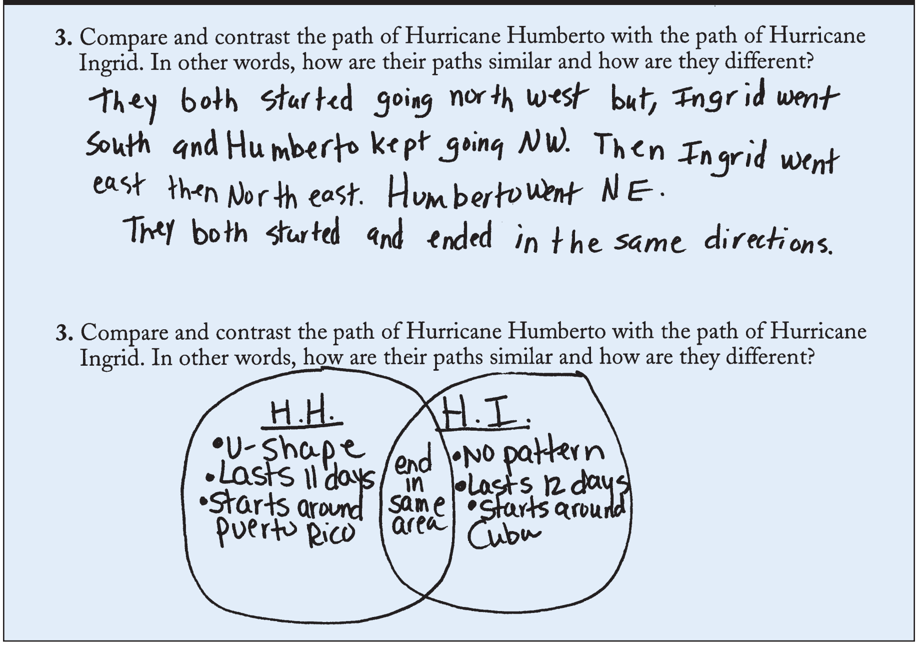


Fig. 4 Two pairs compare their hurricane paths.



graphing on a map using longitude and latitude. It helped them understand the usefulness of coordinate planes in a real-world context. The use of such a context can help to facilitate students' abstraction of the general concept of coordinate graphs (Bell and Janvier 1981). Our students recognized that much about graphing on the (x, y) Cartesian coordinate plane is based on conventions that support mathematical communication.

After graphing the hurricane paths, students discussed characteristics of the curves they plotted, describing similarities and differences observed, in response to question 3 on **activity sheet 1** (see **fig. 4**). Several pairs used a Venn-diagram writing strategy that they learned in their language arts classes to compare and contrast the paths. Our students recognized and discussed important attributes of the hurricane paths. They used language to organize and strengthen their mathematical thinking and communicate it coherently and clearly to others, important elements of learning as suggested in *Principles and Standards for School Mathematics* (NCTM 2000).

Rates of Change in Hurricane Tracking

Our students also examined various mathematical features of the hurricane paths more closely, including changes in longitude and latitude that are analogous with changes in x- and y-values on a Cartesian coordinate plane. Although hurricanes can affect large areas along their paths, for the purposes of this lesson, our students examined the paths traveled by the center of the storm, as shown on prediction models in national weather reports. The class discussion exposed different approaches used by students for analyzing changes in the paths. Some students tended to focus more on the table of values (an analytic approach) and others on the graphs of the paths (a visual approach).

For instance, when discussing which days Hurricane Ingrid had no changes in latitude (question 6 on **activity sheet 1**), students using an analytic approach examined the table of values for Ingrid's path (see **activity sheet 1**), explaining that they "looked for positions where the degrees north remained the same from one to the next." These included day 3, when the position of Hurricane Ingrid remained at 26° N from position 2 to 3; day 5, when it stayed at 24° N from position 4 to 5; and day 8, when it did not move from 28° N from position 7 to 8. Other students used a visual approach to find where the graph showed no change in latitude, explaining that "horizontal segments indicate a constant degree north" or "0° change up or down." By comparing analytical with graphical approaches, students recognized that a 0° change in latitude on the table corresponded to a horizontal line on the graph and vice versa. Similarly, in response to which days Humberto had no change in latitude (question 7 on **activity sheet 1**), some students used the table of values and others used the graph to explain that "there were none." Some students demonstrated an analytic tendency using the table of values and remarked, "The degrees north are always changing." Others demonstrated a visual tendency, explaining that "the latitude is always changing as the path curves northward" and "there were no horizontal segments." Questions 6 and 7 provided experiences with latitude that supported students' development of the notion of zero slope on the (x, y) plane (e.g., graphs of horizontal lines). The concept of change (or no change) along one dimension (i.e., latitude) is important in many contexts and is revisited throughout a variety of mathematics classes (e.g., algebra, calculus, differential equations).

In addition, students examined and compared the hurricane paths for extents traveled on different days, lengths of distances traveled, and rates of change (e.g., velocity). For example, question 8 on **activity sheet 1** asked students to compare which hurricane traveled the farthest over the first two days, Humberto or Ingrid. Again, they used various approaches. One pair that compared the change in latitude and longitude using the table of values responded, “Humberto, because it traveled 2° N, 6° W, and Ingrid traveled only 2° N, 4° W.” A different pair who referred to the graph of the paths explained, “Humberto. It traveled farther west, more boxes. But they traveled the same north.” Some pairs used both representations (see **fig. 5**). Such questions helped our students make connections between distances observed through tables of values and distances observed through graphs. Other questions engaged our students in analyses of the graphs of the hurricane paths to approximate distances traveled and speed of travel. **Figure 6** shows a student’s responses to questions about the day with the farthest distance traveled and an approximation for that distance, questions 10(a) and (b), respectively. When determining distances traveled, as in 10(b), our students typically compared the length of the map scale with the length of the path. For 10(b), they recognized that one unit on the map scale is 500 miles, but the desired part of Humberto’s path is 1/5 longer than the scale. Thus, the distance of the path for the desired day (day 11) was about 600 miles.

Fig. 5 One pair’s use of both graph and table in response to question 8

8. Which hurricane traveled the farthest over the first two days: Humberto or Ingrid? Explain. Humberto, you can tell becouse the distance on the map and you can also tell you can subtract the latitude from both hurricanes and you can subtract the longitude and so which ones have the biggest difference.

Fig. 6 A student’s response to question 10(a) and (b)

10. (a) Which single day did Humberto travel the farthest? Justify your answer.

The last day because the dots are farthest apart.

(b) How many miles did Humberto travel on that day? Justify your answer. (Hint: Use the scale on the map.)

I measured the scale and then I measured the path. I cane up with 600 miles.

Graphing on the Tracking Map versus the Cartesian Plane

Finally, students also compared graphing on the hurricane-tracking map with graphing on a Cartesian coordinate plane with its related conventions (i.e., quadrants and points) (see questions 12(a) and (b) on **activity sheet 1**). Students made connections between mapping positions on the Earth’s grid to graphing on a coordinate plane, recognizing that the hurricane-tracking map represented the region of the Earth’s grid that was analogous to quadrant II of the Cartesian plane. Some students who had forgotten the quadrant numbering system referred to the textbook. The students equated the degree north measures on the prime meridian with the positive values on the y-axis and the degree west measures on the equator with the negative values of the x-axis. They found that hurricane positions such as 15° N, 65° W would be represented by (–65, 15) on the (x, y) plane.

Expanding Our Ways of Thinking about Mathematical Approaches

When we implemented the hurricane-tracking task with middle-grades teachers, an important discussion arose related to possible “mathematical” approaches. When discussing question 8 on **activity sheet 1**, one teacher proudly announced, “I did this one the *mathematical way*.” We were not immediately certain what she meant by “mathematical.” This teacher explained that she and her partner had subtracted the values on the table. The distance that Humberto traveled corresponded to a 2° change in longitude and a 6° change in latitude, whereas the distance that Ingrid traveled corresponded to a 2° degree change in longitude and a 4° degree change in latitude. Thus, Humberto had traveled farther. We agreed that this method of measurement was certainly mathematical; others felt, however, that their solutions were also mathematical.

Another teacher announced that she had measured the distances on the map with a ruler and that Humberto’s path was longer than Ingrid’s. Someone else added that they compared the distances using the scale printed on the map. Another teacher thought using the distance formula was a better solution method. This discussion helped everyone recognize that all these solutions were mathematical and provided the same answer to question 8 that “Humberto traveled farthest over the first two days.” In this context, each approach for comparing distances traveled by each hurricane provided estimates of amounts traveled, whether in degrees, centimeters on a ruler, or miles based on the map scale. Within this context and others, each approach brings its own merits and drawbacks. For example, the distance formula is an important tool for determining length in a plane; however, in the context of the path of a hurricane, it loses precision because of mapping the curved surface of the Earth to the flat surface of the map, where direction is preserved but distance is not. Thus, all distances that we calculate with this data (even exact distances computed from the coordinates) are imprecise estimations.

The teachers recognized that it was valuable to discuss different mathematical approaches as well as the merits and drawbacks of each in context. We all have our own initial approaches or strategies for solving a problem in a mathematical way, based on our understanding of the mathematics involved. It is rarely the only way and does not always align with our students' level of understanding. In our mathematics classrooms, we teach all these mathematical ideas (i.e., measurement, estimation, distance formula, and so on). NCTM (2000) calls for students to be able to use and discriminate among the merits of different methods or strategies, given particular contexts. A class discussion with students sharing different ideas for solving these problems can help broaden their minds to alternate solutions and support their learning to discriminate among different methods. It can provide insight for the teacher into what ways the students are processing the mathematics and how they tend to approach a problem.

Our students recognized that much about graphing on the (x, y) Cartesian coordinate plane is based on conventions that support mathematical communication

CONCLUDING REMARKS

This article presents ideas related to students' learning of mathematics and teachers thinking about teaching mathematics within a hurricane context. As the middle school students in this project engaged in these hurricane-related tasks, they applied mathematical ideas in a context that piqued their curiosity and engaged them in making connections, communicating mathematically, and using representations in ways proposed by NCTM (2000). These tasks helped them enhance their understanding of various algebra-related concepts, particularly constructing and interpreting graphs and analyzing patterns, through connections with science and geography.

For the teachers with whom we worked, these hurricane-related tasks provided a context for them to expand their thinking about the use of multiple approaches and representations for solving mathematics problems. These tasks also encouraged their thinking about pedagogical strategies for effectively engaging their students in cooperative learning. The student-teachers also developed knowledge about hurricanes that they could bring to their mathematics class. For other hurricane-related information, access "Mathematics That Will Rock You Like a Hurricane" (Moore and Schwarz 2003) in *ON-Math*, NCTM's electronic journal.

SOLUTIONS

1. See the map in **figure 3**.
2. Answers will vary. Humberto directly affects Haiti and Cuba. Many other countries are near the path and might be affected, including Puerto Rico, the Dominican Republic, Jamaica, the Bahamas, and the United States. Ingrid makes landfall in the United States, but weather effects could be felt in Mexico. Ingrid moves northwest, turns to the south and makes a loop, and then continues moving to the northeast. Humberto moves northwest, turns north, and then travels to the northeast. Students have used the terms *looping*, *u-shaped*, *wandering*, *straight*, and so on to describe the shapes.
3. Answers will vary. (See **fig. 4**.)
4. Latitude 1° between position 2 and position 3 (17° N to 18° N). Students may determine this using the graph, the table, or both.
5. On day 12 (the 24-hour period between position 11 and 12), there is a 5° change, from 32° N to 37° N.
6. On days 3, 5, and 8. Once again, this may be seen on the map as a horizontal line or in the table as no change in degrees north between two positions.
7. Humberto's latitude changes every day. All differences in degrees north in the table are greater than zero, and there are no horizontal lines for the daily path on the map.
8. Humberto. (See **fig. 5**.)
9. Ingrid traveled farther on day 2 than on day 3. Explanations could include direct measurement; the map grid ($2 + 1 > 2 + 0$); or a notion related to the lengths of the legs of triangles or the Pythagorean theorem.
10. (a) Day 11. (See **fig. 6**.)
(b) Any answer will be an estimate. (See **fig. 6**.) Another solution could be

$$\frac{500 \text{ miles}}{20 \text{ mm}} = \frac{x \text{ miles}}{26 \text{ mm}},$$

where the map scale measures 20 mm and the path length is 26 mm, giving an approximate length for x of 650 miles.
11. (a) Ingrid traveled the farthest on day 12. Solutions may vary, as in the

solution to 10(b). One solution follows: If the length of Ingrid's path on day 12 is 32 mm and the scale measures 20 mm (the students' measured lengths vary, depending on the scale and size of the map), then

$$\frac{500 \text{ miles}}{20 \text{ mm}} = \frac{x \text{ miles}}{32 \text{ mm}},$$

so x (the number of miles in that part of the path) is approximately 800 miles.
(b) If Ingrid traveled 800 miles in 24 hours, then dividing 800 by 24 gives an average speed of approximately 33 miles per hour during day 12.

12. (a) Quadrant II.
(b) Continuing the analogy in (a), 15° N, 65° W corresponds to (–65, 15) in standard (x, y) Cartesian plane notation.

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activity sheet 1

Name ______________________________

Hurricane Tracking

The following table tells the location of the centers of two hurricanes: Humberto and Ingrid. The positions mark the location of the hurricanes at midnight (when one day ends and another begins). Position 0 and position 1 mark the start and end of day 1. Then position 1 and position 2 mark the start and end of day 2, and so forth. Can you tell what position numbers define day 6?

Position No.	Hurricane Humberto	Hurricane Ingrid
0	15° N, 65° W	24° N, 87° W
1	16° N, 68° W	25° N, 89° W
2	17° N, 71° W	26° N, 91° W
3	18° N, 74° W	26° N, 93° W
4	20° N, 75° W	24° N, 93° W
5	21° N, 76° W	24° N, 91° W
6	22° N, 77° W	25° N, 90° W
7	24° N, 79° W	28° N, 88° W
8	26° N, 79° W	28° N, 86° W
9	29° N, 77° W	29° N, 85° W
10	32° N, 71° W	31° N, 83° W
11	35° N, 63° W	32° N, 81° W
12		37° N, 72° W

1. Plot the position points on the hurricane tracking map for both hurricanes. You may want to use different colors for different hurricanes. *Important: Be sure to indicate the direction each hurricane is traveling.*

2. What countries do these two hurricanes affect? What do you observe about the direction they travel and the shape of their paths?

3. Compare and contrast the path of Hurricane Humberto with the path of Hurricane Ingrid. In other words, how are their paths similar and how are they different?

4. How many degrees latitude did Humberto change between position 2 and position 3? Explain.

5. On which day(s) did Ingrid have the largest change in longitude? Explain.

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6. Which day(s) did Ingrid have no change in latitude? Explain.

7. Which day(s) did Humberto have no change in latitude? Explain.

8. Which hurricane traveled the farthest over the first two days: Humberto or Ingrid? Explain.

9. Decide which day Ingrid traveled farther: day 2 or day 3. How do you know that this length is longer than the other? Justify your answer.

10. (a) Which single day did Humberto travel the farthest? Justify your answer.

(b) How many miles did Humberto travel on that day? Justify your answer. (Hint: Use the scale on the map.)

11. (a) Which hurricane traveled the farthest in one day? Which day was it? How far did it travel? Explain your reasoning.

(b) What was the average speed of that hurricane in miles per hour on that day? Explain your solution.

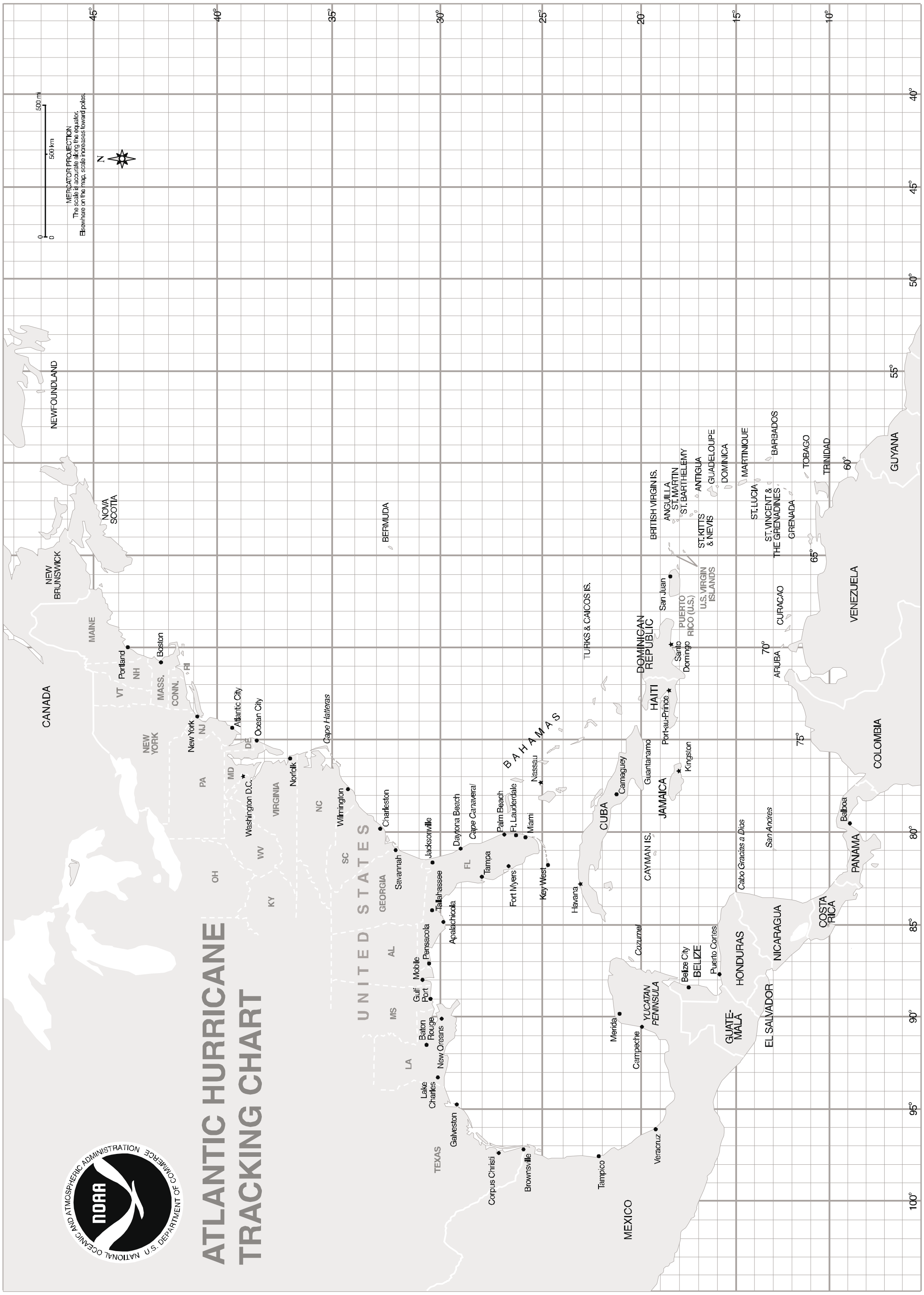
12. Latitude and longitude on a flat map divide the surface of the Earth into a plane that is similar to the Cartesian coordinate plane with its four quadrants.

(a) In what quadrant on the Cartesian coordinate plane would the region in which you plotted the hurricanes belong? Explain your reasoning.

(b) How would the positions for the hurricanes given with respect to north and west (i.e., 15° N, 65° W) be written in point notation (x, y) to graph on a Cartesian plane? Explain your reasoning, and provide examples.

Name ______________________________

Hurricane Tracking Map



Map courtesy of www.nhc.noaa.gov