Modeling Real-World Weather Data

Summary

This lesson has students use real-world data to create a mathematical model for weather data and recognize that the data can be modeled using either a sine or cosine function. Students will use the model to make a prediction about a missing piece of data.

Main Core Tie

Secondary Mathematics III

Strand: FUNCTIONS - Trigonometric Functions (F.TF) Standard F.TF.5

Group Size

Small Groups

Materials

Handouts / Guide Sheets:

- Guide sheet: Weather: Modeling Real Data (pdf)
- City Temperature Data (pdf)
- Teacher Information for Sunspots: Modeling Real Data (pdf)
- Guide sheet: Sunspots - Modeling Real Data, Part 2 (pdf)

Working materials (on a side table):

Large graph paper or sheets of bulletin board papers
markers
yard sticks
rulers
string
tape
textbook

Student Prior Knowledge

Students should understand amplitude, period, and phase shifts.

Instructional Procedures

Activating Background Knowledge:
This lesson should be used after students have learned how to graph sine and cosine functions. Students should already understand amplitude, period, phase shifts, and be able to plot data on an x-y graph.
Anticipating Student Response: It is anticipated that students will graph the temperature data on graph paper or on graphing calculators, and then create an equation (mathematical model) of the data based on the period and amplitude of the temperatures over a year time period. Fifteen months are provided so that the periodic nature of the data will be apparent. Students may choose either a sine or cosine function for their function.
Students may attempt to use Sine regression on the calculator. This should not be allowed, as it reduces the cognitive level desired for developing the model. Although few Pre-Calculus students know how to use the regression feature on the calculator, watch carefully. If a student is observed attempting to use Sine regression, talk to the student individually and tell them that regression isn't allowed for this activity.

Misconceptions and errors:

Students may be puzzled about the term "mathematical model". Clarify this use of language within the launch activity.

Students may think that the period is the entire 15 months, rather than 12 months.

Students may not recognize that the function can be either sine or cosine.

If students make their temperature prediction based on the graph only, remind them that they are required to create a mathematical model (equation) to check their prediction.

Launch:

Introduction to the lesson: *"The National Weather Reporting Center had a computer crash in April (or whatever month chosen) and lost all of their data for that month because, of course, they didn't have their data backed-up. They need your help in writing a model can predict the average temperature for the missing month. They are providing us with 14 other months of data to use to create our model."*
"Equations used to model real world information are called mathematical models. For example, engineers use computer mathematical models to design, test, and build rockets, irrigation systems, cars, fireworks…you name it. Your group will be creating a mathematical model (equation) to predict the missing month for your assigned city."

This introduction should help students who are tempted to guess or estimate the missing data point. This should also develop the hook that will engage the student's interest.

Note: on the Salt Lake City temperatures that there is a little glitch or dent in May between the model and the actual data. This has been noted by meteorologists as a significant deviation from the trend, and they attribute it to the Lake Effect from the Great Salt Lake moderating spring temperatures.

Day 1:

5 min. Give introduction to the lesson. Group students, mixing their ability levels. Provide students with the City Temperature Data (pdf) and the Guide sheet: Weather: Modeling Real Data (pdf)

The weather data contains month and temperature info for 4 cities over a 15 month time period. Provide each group the data for one city. Don't let groups know that some groups have duplicate data. Instructors will need to white out the month that students will predict. We deleted April. (The data is the highest daily temperature for each city, averaged for the month.)

20 min. Monitor student work asking leading questions such as: Did you look in your textbook and notes? Do you see a pattern? (Watch for students that may know how to use the regression feature on the calculator and let them know that it is not allowed for this assignment.) Remind students to fill out all areas of the worksheet. If students are spending too much time talking about irrelevant information, ask them why they think this is an important piece of information, and then they should figure out that the discussion point is not important.

10 min. Tell students that additional groups are working on the same set of data. Have two smaller groups join together to compare findings, reconcile differences, and discuss how they developed their model, what they know and why they know it. Instruct students not to change anything on their worksheet but to turn it over and put their changes on the back. They should not modify their first results. *While they are finishing up, display the expectations for the student presentations and tell groups to make sure everyone has a role (see below).*

Presentations: 3-5 minutes per group. The first group to present will be guinea pigs. The instructor should provide lots of prompts for the first group so that the other groups will see the level of detail that is expected.

Different students should be assigned the following roles:

Write the model on the board and be the scribe.

Present <u>how</u> the group found the amplitude.

Present <u>how</u> the group calculated the period and phase shift.
Present answers from the guide sheet.
Present group dynamics: How did joining groups affect what they thought? Did they change their model? If so, why? How did their group choose whether to use sine or cosine?
Present the predicted value: What was their predicted value for the missing month? How did they get that value?

***Answers should be explicit such as *"We used the number 4 for April, put 4 into the equation for x, then solved the equation and found the temperature was ______ "*

Everyone should answer questions from the rest of the class.

After the guinea-pig group has presented, allow the other groups a few additional minutes to polish their presentations if needed.

Day 2: Continue presentations as needed and Wrap-Up.

Wrap Up: Give students the actual temperatures for the missing month. Ask the following discussion questions:

- How close were the predictions to the actual temperature?
- Why do we call the function (equation) we developed a "model"? Link student's ideas to other models they may be familiar with such as the simple model of estimating height based on arm span, or more complex models from art, computer science, architecture, and engineering. For example, at ATK engineers build computer models to predict outcomes, like how will the inner layers of a rocket nozzle burn away during a launch. Then they test their models to see if it fits the actual data.
- Find the <u>prediction error</u> for your model. How well did you do? (The difference between their prediction and the actual temperature.)
- What is an acceptable level of error? Is 1° Fahrenheit acceptable error? Can you tell the difference between 40° and 41°? (Note: any measurement that is sufficiently large enough to increase an AVERAGE temperature by 1 degree is significant! That's what melts polar ice-caps.)

Display:
All four data graphs and regression models. Then show all four graphs on the same window. Talk about setting the scale and starting point the same. Maybe show students how to use the graphing utility and the regression feature to find the model. (Note: This is difficult and time consuming on TI-89's unless calculators have the special Stats Apps, which is available on newer calculators.)

Homework for Day 2 or Class Activity on Day 3:
Provide students with the follow-up activity: Guide sheet: Sunspots - Modeling Real Data, Part 2 (pdf).

Maintaining the level of cognitive demand:
It is important for instructors to resist the urge to "help". If you have visitors in your room, warn them that they must only observe and not assist the students in any way, other than suggesting they use their available resources.

Do not tell the students that the data fit into a sine or cosine model. The instructor only presents the situation and the rest is up to the students. Starting with groups of size 3 (later joined into size 6) ensures that all members of the group will have something to do and can all take ownership in the task.

Strategies for Diverse Learners

The diversity of learner abilities will be dealt with by carefully selecting groups, making sure that each group has a mix of ability levels.

If a group is floundering or not sure where to start, the instructor will ask questions to guide students in the direction they need to go without telling them what they need to do, such as: "Have you used

your textbook as a resource?"
During the group presentation, require that several students present the data and findings, not just one.
Mid-way through the lesson, small groups will be put together to form larger groups, allowing students to discuss their thinking, verify their equations, and reconcile the differences in mathematical models. This protocol allows for struggling students to be helped by their peers.

Extensions

This type of activity could be extended to other types of real data that model different functions like logarithmic, exponential, etc.
Resources for data sets:

- Pearson Data Sets
- Algebra LAB
- Logarithmic Regression Model Example

Activities where students collect their own data:

- Algebra LAB

Assessment Plan

Walk about and observe graphs and models. Listen for appropriate language in during group work, in presentations, and wrap-up discussion. For example: period, amplitude, shift, sine and cosine.
Collect and evaluate "Weather: Modeling Real Data" and "Sunspots: Modeling Real Data Part 2".

Bibliography

Temperatures data came from:
http://www.worldclimate.com/
Sunspot data came from:
http://serc.carleton.edu/files/introgeo/teachingwdata/examples/GreenwichSSNvstime.txt
and http://solarscience.msfc.nasa.gov/predict.shtml
The data has been averaged per month in a given year.

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