Daylight, Latitude, and Traditional Japanese Clocks

Grade Levels

This activity is intended for grades 6 - 12.

Objectives and Topics

In this lesson, students will be introduced to the wadokei, a traditional Japanese clock, and think about how it compares to our current timekeeping system. Traditional Japanese timekeeping methods divided the day into 6 even "hours," and the night into another 6 even "hours." Unlike our hours, which are of constant length, the day and night "hours" of the wadokei change in length depending on the time of year and the latitude. At the end of this activity, each student will choose a city (see the worksheet below, or feel free to include cities and their latitudes of your choosing) and create summer and winter wadokei for the city.

Materials and Resources

Before beginning the activity with your students, you may want to include a short introduction with background information of the wadokei. One good resource for this background information can be found at:

$$http://en.wikipedia.org/wiki/Japanese\_clock$$

Otherwise the only materials required for this activity are:

- A copy of the worksheet below for each student
- An overhead or projector, along with a computer, to display the chart used to answer #2 on the worksheet, which can be found online at:

$$http://upload.wikimedia.org/wikipedia/commons/e/e1/Hours\_of\_daylight\_vs\_latitude\_vs\_day\_of\_year\_cmglee.svg$$

- A printout of this chart, attached to the worksheet given to each student

Outline

As mentioned in the previous section, you may wish to include some background of the wadokei (many wadokei

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are particularly ornate and beautiful, so including pictures can be a hook for some students). Either way, before beginning the activity, it is STRONGLY recommended that you go over a couple of questions of the worksheet with an example city and its latitude, particularly because the chart used to answer #2 on the worksheet can be confusing to use without example.

In our case, we used Honolulu, with a latitude of 21° N, as our example city and latitude since it helped students answer the second Reflection question at the end of the worksheet. We then referred to the chart used for #2, explaining that the left side of the chart is where the students will find the latitude for their city, and the top of the chart is where the students can locate mid March, mid June, mid September, and mid December. We then referred to the numbered curves within the chart, explaining that if we fell anywhere on a particular numbered curve, there is the same amount of daylight as what is numbered. Furthermore, if we fell in an area between two numbered curves, there is the same amount of daylight in the area as what is between the two numbers of the labeled curves (for example, if we fall the space between the 10 hour and 12 hour curve, we will read it as there being 11 hours of daylight).

We then proceeeded to show them how to use the chart to answer #2 for Honolulu, starting at the 21°N mark on the left of the chart and moving along this mark to the right, stopping at mid March, mid June, mid September, and mid December, reading that Honolulu has 13 hours, 13 hours, 13 hours, and 11 hours of daylight, respectively. We then simply read through the rest of the instructions of the remaining questions together with the students, stopping to write down our precalculated answers for #3b and #3d (roughly 46% and 54%, respectively) before arriving at #4c. When showing our students #4c for Honolulu, we referred back to our answers for #3b and #3d, explaining that we would be estimating blocking off 46% of the winter wadokei (you can tell them to think of it as creating a pie chart), and then proceeding to break each of the two "halves" into 6 equal pieces to complete the winter wadokei (similar steps can be followed to show them how to create the summer wadokei).

After going over the worksheet with them with an example city and its latitude, divide your students into groups of 3-4, and instruct them to each choose a city different from the other members of their group. This will allow interesting examples of student work to refer to during the reflection discussion. After allowing your students time to complete the worksheet, you can choose a couple of students to come up and present their work. Since you will be leading a discussion on the reflection questions with the entire class, it is recommended that you choose students with interesting cities to come up and present (for example, one student who chose Alert, Canada whose two wadokei will each only have six segments and one student who chose a city in the southern hemisphere, whose winter wadokei will be mostly daylight and summer wadokei will be mostly night time). In discussing #5b with your class, you can ask your students to explain why there are differences amongst their wadokei and the presenters' wadokei (lead them towards thinking about the significance of a city's latitude, as well as its location in the northern or souther hemisphere). For #5c, you can point out that our faster-paced lifestyle is one reason why we no longer use wadokei. Furthermore, a pro of the traditional Japanese time-keeping system might be easily seen if one compares the wadokei to the students' daily school schedule; their school day is broken up only into a few peices, just as daytime is on a wadokei.

Name_____ Class_____ Date_____

Daylight, Latitude, and Traditional Japanese Clocks

1. Choose a city from the list on the back page.
    a. What's your city's name?_____
    b. What is its latitude?_____
2. Use the chart to estimate the hours of daylight your city in:
    - Mid March_____
    - Mid June_____
    - Mid September_____
    - Mid December_____
3.
    a. Compare the hours of daylight in winter to a full 24-hour day.

    ➢ $\frac{(\quad)hrs\ \ of\ daylight}{(24)hrs\ total} = \_\_\_\_\_$

    b. What percentage of a whole day is the fraction in part a.?

    ➢ _____%

    c. Compare the hours of daylight in summer to a full 24-hour day.

    ➢ $\frac{(\quad)hrs\ \ of\ daylight}{(24)hrs\ total} = \_\_\_\_\_$

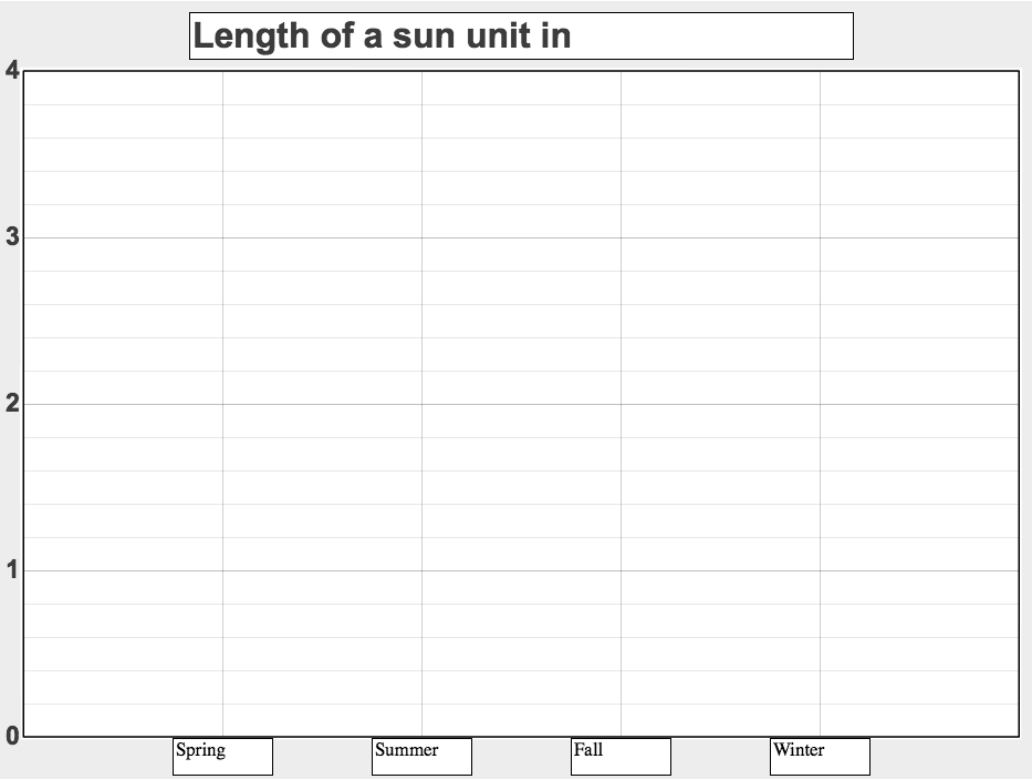
    d. What percentage of a whole day is the fraction listed in part c.?

    ➢ _____%

4. Traditional Japanese timekeeping methods divided the day into 6 even “hours” which we will call sun units for this assignment. Similarly they divided the night time into 6 even “hours” that we will call moon units. Unlike normal hours which are of constant length, sun and moon units change in length depending on the time of year, and the latitude. In terms of functions, we say that sun units are a function of time and latitude.
    a. To find the length of a sun unit in your city, take the total daylight you listed above (2-b), and divide each value by 6.

        - Mid March_____
        - Mid June_____
        - Mid September_____
        - Mid December_____

    b. Plot the values in part a. on the graph below



c. Using the percentages you found for winter and summer in problem 3., create two clocks that show 6 sun units and 6 moon units. You can take a look at the graphs on the next page for an example.

Winter

Summer

5. Reflection Time!
   a. What do all of these data mean in terms of total daylight in the city you chose?
      - _____

        _____

        _____

   b. How does the sunlight in your city compare to the sunlight here in Hawaii? What does it mean for people who work outdoors there/here?
      - _____

        _____

        _____

c. What is the purpose of measuring time in sun and moon units? Why do we not use this system anymore? Compare the pros and cons of the constant hour system we use now, and those of the traditional Japanese timekeeping system.

- _____
  _____
  _____
  _____
  _____
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83°N	Alert	Canada	
61°N	Anchorage	Alaska, US	
56°N	Edinburgh	Scotland	
55°N	Moscow	Russia	
53°N	Dublin	Ireland	
52°N	Amsterdam	Netherlands	
51°N	London	England	
50°N	Prague	Czech Republic	
49°N	Paris	France	
48°N	Vienna	Austria	
42°N	Rome	Italy	
41°N	Barcelona	Spain	
41°N	Istanbul	Turkey	
40°N	New York City	New York, US	
38°N	Seoul	South Korea	
36°N	Tehran	Iran	
35°N	Tokyo	Japan	
34°N	Los Angeles	California, US	
33°N	Baghdad	Iraq	
32°N	Marrakech	Morocco	
25°N	Dubai	U.A.E.	
23°N	Havana	Cuba	
22°N	Hong Kong	P.R. of China	
21°N	Mecca	Saudi Arabia	
19°N	Mexico City	Mexico	
17°N	Timbuktu	Mali	
15°N	Saipan	Northern Mariana Islands	
14°N	Manila	Philippines	
13°N	Bangkok	Thailand	
11°N	Caracas	Venezuela	
9°N	Panama City	Panama	
12°S	Lima	Peru	
14°S	Pago Pago	American Samoa	
23°S	Rio de Janeiro	Brazil	
26°S	Johannesburg	South Africa	
27°S	Hanga Roa	Easter Island (Rapa Nui)	
33°S	Santiago	Chile	
34°S	Sydney	Australia	
35°S	Buenos Aires	Argentina	
35°S	Montevideo	Uraguay	
37°S	Auckland	New Zealand	
55°S	Ushuaia	Argentina	