Lesson Plan by Adam Pyle

Lesson: Box-and-Whisker Plots

Length: 2 periods (140 minutes)

Age/Grade Intended: 8th Grade Mathematics

 Academic Standard(s):

Standard 5 Measurement
Students convert between units of measure and use rates and scale factors to solve problems. They compute the perimeter, area, and volume of geometric objects. They investigate how perimeter, area, and volume are affected by changes of scale.

Indicator(s):
8.5.1 Convert common measurements for length, area, volume, weight, capacity, and time to equivalent measurements within the same system.

Standard 6 Data Analysis and Probability
Students collect, organize, represent, and interpret relationships in data sets that have one or more variables. They determine probabilities and use them to make predictions about events.

Indicator(s):
8.6.4 Analyze, interpret, and display single- and two-variable data in appropriate bar, line, and circle graphs; stem-and-leaf plots; and box-and-whisker plots and explain which types of displays are appropriate for various data sets.

Performance Objectives:
Given a tape measure, the students will convert a measurement they have found in feet to an equivalent measurement in inches with 100% accuracy.

Given a data set, the eighth-grade students will construct three box-and-whisker plots 2 out of 3 times correctly.

Given a data set, the students will write a one or two sentence explanation describing why a box-and-whisker plot is appropriate for the data set with 100% accuracy.

Assessment:
For a general feeling about the whole class, the teacher will get much information from the questioning used during the lesson. The questions are written to both allow students to explore their own knowledge and check their understanding of the components and structures of a box-and-whisker plot. To assess students on an individual level, the teacher will circulate during the journaling and homework time; many problems can be taken care of during this phase. The construction of a box-and-whisker plot involves exact numerical values and a certain structure. The teacher can create a checklist to look for specific parts that the students must include for the box-and-whisker plot to make any sense. Finally, there were not many homework problems assigned so the teacher is able to do an extensive feedback with respect to the assignment. To
check for understanding of the conversion from feet to inches, the teacher will get a good feel when the students form the line. At this stage unreasonable answers should surface.

Advanced Preparation by the Teacher:
The teacher should gather or create many supplies for this lesson. Enough paper (for the planes) and index cards will be needed for each student. Tape measures will be needed for every four or five students. The teacher also needs to create the various necklaces and signs ahead of time. For the physical construction of a box-and-whisker plot, the teacher will need to prepare appropriate size construction paper and cash register tapes. Finally, the teacher will need to make sure the gymnasium is available and reserve it in advance. The tape on the floor should also be set in place prior to the start of class.

Procedure:
Introduction/Motivation:
After asking the students if they have any questions about histograms and frequency tables, draw the face of an animal that is well-known for its whiskers; a cat would work nicely. Pay attention to the manner in which it is drawn; the mouth should be quite box-like, and the whiskers should extend significantly out to the sides.

This is clearly a rather rough sketch. Tell the students that today the class will be looking at another way to represent data; this is known as the box-and-whisker plot. Ask the students:
- Based on the drawing, what do you think the box-and-whisker plot will look like?

(Analysis)
After taking a few suggestions or allowing students to draw their ideas at the board, tell the students to notice that the “box” is in the center and pinned between the “whiskers”. Explain that the goal of today’s lesson is to move from our cat to an actual box-and-whisker plot.

Step-by-Step Plan:
1. Tell the students that we need to collect some data before we can build the box-and-whisker plot. The data will be collected in the gymnasium. Before going to that location, distribute a piece of paper and an index card to each student. They should bring these materials to the gym.
2. Once the class has reached the gymnasium, explain the following procedures to the students:
   a. Line up in groups of four (or five if necessary) at the pieces of tape that have been placed on the gym floor. (At this time give the second student in each line a tape measure.)
b. Draw a line down the center of one side of the index card; label one side Measurement #1 and the other side Measurement #2.

c. Fold the piece of paper into an airplane; use whatever design you want.

d. The first person in each line should toss their airplane; the second person in line will hold one end of the tape measure while the thrower takes the other end to his or her plane. Under Measurement #1, he or she should record the distance in feet. When he or she has done this, he or she should go to the end of the line and convert the distance to inches. The second person in line is now the first, the third is now the second, etc.

e. This pattern will continue until everyone has made two tosses.

3. Before the students are turned loose, ask the following questions:

   a. How many inches are in one foot? (Knowledge)

   b. To convert our measurement from feet to inches, we are going to use a conversion factor. What is that factor, and what does it actually equal? (Comprehension)

   c. Suppose I had four feet of fabric. How many inches of fabric do I have? (Application)

4. After the airplane tosses have been complete, return to the classroom. Tell all the students to come to the front of the room and arrange themselves from least to greatest distance (using their best toss).

5. Tell the students that we are going to create a human box-and-whisker plot. To do this we need to find five different values. The first value is the median. Ask the students the following questions:

   a. What is the median of a data set? (Knowledge)

   b. If the data set has an odd number of values, how do we find the median? What about a data set with an even number of values? (Comprehension)

   c. Find the median of this data set (our airplane tosses). (Application)

6. Give the student (or students) who has the median value a necklace with three pizza pictures: a large, a medium, and a small. The medium will be highlighted in some way.

7. Explain that the data has now been split into two halves, an upper half and a lower half. Tell the students the next two numbers we need to find are called the quartiles. There is an upper quartile and a lower quartile. Ask the students:

   a. Where do you think these quartiles might fall in relationship to the median? (Analysis)

   b. What is a quarter written as a fraction? (Comprehension)

   c. How are one-fourth and one-half related? (Comprehension)

   d. Now where do you think these quartiles might fall in relationship to the median? (Analysis)

8. Lead students to understand that the lower quartile is the median of the lower half, and the upper quartile is the median of the upper half. Have the students identify who those individuals in our line are (using the airplane distances). Let the students who is the lower quartile wear a necklace with the lower half of a picture of a quarter (blown up, printed, and laminated). Let the student who is the upper quartile wear necklace with the upper half of the quarter picture.

9. Explain that we are now ready to form the box part of the box-and-whisker plot. The box runs from the lower quartile to the upper quartile; give the students paper (a decent size
of construction paper) that runs from the student lower quartile to the student upper quartile. Emphasize that our median always lies within this box.

10. Finally explain that there are two more data entries needed to create our whiskers. Ask students, “What data values might we use to get a complete picture of the data spread? (Analysis) Tell students that we need to include the least data value (the lower extreme) and the greatest data value (the upper extreme). Give the student lower extreme a necklace with the word “extreme” written in small letters. Give the student upper extreme a necklace with the word “extreme” written in large letters. Extend cash register tape from the student lower quartile to the student lower extreme and from the student upper quartile to the student upper extreme. These are our whiskers.

11. Have the students who are not wearing anything sit down. Explain that this is what the box-and-whisker plot looks like, and these are the data values we need to construct it. Then have all the students return to their seats.

12. Do an example with students to check for understanding.
   a. Suppose we have the following data set: 15, 37, 45, 62, 14, 12, 17, 10, and 11. These are the ages of people who attended a birthday party. What five values do we need to find? (Knowledge)
   b. How do we find the median? Upper quartile? Lower quartile? (Comprehension)
   c. Find these three values. (Application)
   d. Identify the lower extreme and the upper extreme. (Comprehension)
   e. Construct the box-and-whisker plot for this data set. (Application)

13. Use the example to discuss interpreting a box-and-whisker plot. Ask:
   a. How many data values lie between the lower quartile and the median? Upper quartile and the median? Upper quartile and the upper extreme? (Comprehension)
   b. What percentage is that of the total number of values in the data set? (Comprehension)

14. Explain that the box-and-whisker plot has four distinct sections: the two whiskers and the two sections of the box. Each section has about the same number of data values (that is, about 25% of the data values).

15. Use the example to check for understanding about interpreting.
   a. About how many people at the party were under the age of 41? (Comprehension)
      (*Note: Be sure to ask students how they got this answer; they could simply have counted the appropriate values without interpreting the actual plot.)

16. Finish the lesson with a discussion of the interquartile range. Ask the students:
   a. You know how to find the range for a set of data. How do you think you can find the interquartile range? (Analysis)
   b. Explain that the interquartile range is the difference of the upper quartile and the lower quartile.

**Closure:**
The lesson will end with a chance for the students to reflect in their math journals. They should be guided by the following questions:

- Consider the parts of the box-and-whisker plot. What are the advantages of box-and-whisker plots? Disadvantages? (Analysis)
- Do you think our airplane toss data was best represented by a stem-and-leaf plot or a box-and-whisker plot? Why did you choose what you chose? (Evaluation)
After finishing the reflections, the students can spend the remainder of their time on the night’s assignment.

**Gardner’s Theory of Multiple Intelligences:**
*Intrapersonal:* Reflecting on the box-and-whisker plots and how they are useful in the math journals
*Verbal-Linguistic:* Writing the personal responses to the lesson in the math journals, responding to questions
*Bodily-Kinesthetic:* Students actually becoming the box-and-whisker plot when they stood at the front of the room
*Visual-Spatial:* Seeing the gradual creation of a box-and-whisker plot, measuring distances and getting a sense for what something like 2 feet (and therefore 24 inches) looks like, using the cat picture and the necklaces to attach meaning to the parts of the box-and-whisker plots
*Logical-Mathematical:* Calculating the median of various data sets, constructing and interpreting the box-and-whisker plot
*Interpersonal:* Using teamwork to measure the distances

**Adaptations/Enrichment:**
For students with ADHD – The paper airplane activity is a good way for them to release some energy that may build up while simply sitting at a desk. Unfortunately it also has the potential to get out of hand. I think the line process mentioned in the lesson is actually a modification for this kind of student. It gives them some active to do (throwing the plane and measuring the distance to its landing spot), but also provides a much-needed break as well (going to the back of the line and converting the distance to a different form). This time to calm down could do wonders for the student’s behavior and participation in the lesson.

For students with LD – The checklist that I would use to assess the students’ construction of box-and-whisker plots could be provided to these students (possibly in a less detailed format). I will also make several visits to these students during the homework time and make sure that the process of constructing and interpreting box-and-whisker plots is going smoothly. I can also pose questions to these students during the questioning segments of the lesson; I may choose questions on the level of knowledge and comprehension in an effort to boost students’ confidence in their understanding of the material. Positive attitudes can do wonders for achievement rates.

For gifted and talented students – The experience of these students can be enriched by posing questions that come from higher levels of Bloom’s taxonomy. For instance, these students can be given more opportunities to compare and contrast the different data representations at which the class has looked. These students can be challenged by looking at the effects of possible outliers on the data set. For instance, a data set that has a mean of 13 may also contain the data value 120. Gifted and talented students can begin to explore the relevance of this particular data value when one wants to describe the data set as a whole.

**Self-Reflection:**
These questions will guide my self-reflection to be completed after teaching the lesson:
• This lesson shows the potential for many behavioral issues. For example, having the students throwing paper airplanes and arranging themselves from shortest to longest throw could be potentially hazard to proper management of the class. What can be done to avoid any problems?
• The goal of the various necklaces is to create a visual image that students can mentally reference as they utilize box-and-whisker plots. Are students making the connections or do they simply find them silly?
• The textbook recommends just one day for box-and-whisker plots. This lesson can clearly not be taught in just one period. Am I placing too much importance on this form of data representation?

References:
Adapted from


http://www.learnnc.org/lessons/NikkiHoneycutt5232002643