Voyager & Ozobot: A STEM Team to Determine the Dimensions of a Cardboard Box

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Ozobot "Evo" (ozobot.com) is a tiny one-inch diameter robot that can be quickly programmed using a Google Blockly dialect known as OzoBlockly (ozoblockly.com). PocketLab Voyager could well be the world's smallest science laboratory. Combining the ability to program Ozobot to rotate precisely as desired with Voyager's ability to sense the resulting motion through its collection of sensors, the possibility of a seemingly endless variety of STEM projects becomes a reality.

The purpose of this STEM project is to determine the length and width, and to some extent the shape, of a cardboard box using Voyager's range finder. Voyager is mounted to the top of Ozobot Evo using a thick, double-sided removable tape. This "STEM team" is then placed in the center of a cardboard box, with the front of Evo and Voyager parallel to one side of the box, as shown in Figure 1. A typical box that is likely available in most schools would be an empty box that held ten reams of copy paper. But any cardboard box whose length and width are not smaller than about 20 cm would work just fine. This size limitation is a result of the minimum distance of about 10 cm detectable by Voyager's range finder. A small piece of smooth cardboard is placed on the bottom of the box, as the corrugated cardboard may cause some erratic movement of Ozobot.

Figure 1

Ozobot Evo is programmed with the simple OzoBlockly program shown in Figure 2. Evo's top light is set to red, and then a 15 second pause gives the student time to place the "STEM team" in the center of the box. The top light then turns green, giving the student a three second time interval in which to start data collection with the PocketLab app. Evo then rotates 90º a total of four times, with a 2-second pause after each rotation. After each rotation, the "STEM team" faces the next side of the cardboard box in sequence.

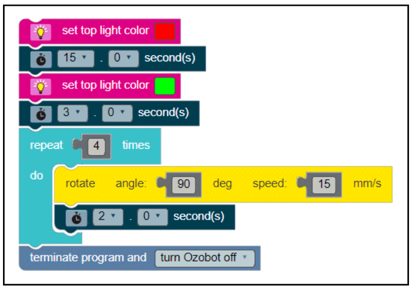

Figure 2

Figure 3 shows the "STEM team" in the box just before beginning the experiment. Also included with this lesson is a video combined with a graph of range finder distance (in meters) to the walls of the box as a function of time while Evo rotates. Viewing this video gives a real feel for what is happening during data collection.

Figure 3

By carefully analyzing the graph either on the data collection device (see Figure 4) or by importing the *csv* file created by the PocketLab app into Excel and making a graph (see Figure 5), the length and width of the box can be easily determined.

Figure 4

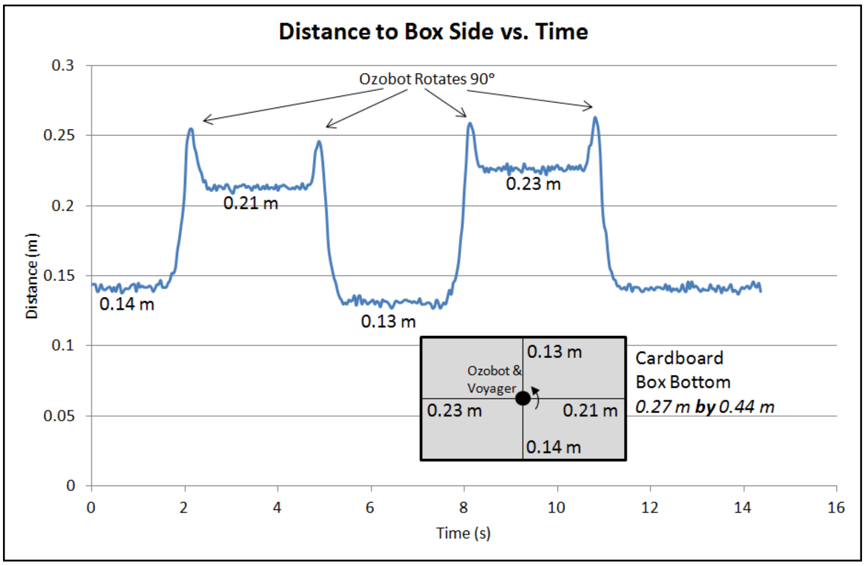

Figure 5

Figure 5 shows that during the first two seconds, the average range finder distance was 0.14 m. After Evo rotated 90° and was facing the next side of the box, the reading was 0.21 m. In a similar manner, the third and fourth sides of the box provided readings of 0.13 and 0.23 meters. Since Evo may not have been in the exact center of the box, it is reasonable to assume that the actual length and width of the box are 0.21 + 0.23 = 0.44 m and 0.14 + 0.13 = 0.27 m, respectively. (These results, by the way, are within about a centimeter of the actual size of a 10-ream box of paper.)

The beauty of this investigation is that it brings out the importance of graphs in providing information of interest, in this case the dimensions of the box. Also, in this "maker" world that we live in today, it shows that innovation can be achieved by combining different technologies. Finally, as shown in the "Student Activities" section that follows, a number of math and geometry concepts can also be investigated.

Student Activities

The following are a number of suggestions for related activities for students. You can have your lab groups do any combination of activities shown here, as well as related activities of your own design!

1. Provide your lab groups with a variety of different size cardboard boxes and have them collect data for determining the ***length and width*** in meters of each by the method discussed here.
2. Have the students use their graphs from activity 1 to determine the length of the ***diagonals*** of the box. The students will need to think carefully here about what the Voyager range finder is reading while it is being rotated by Evo from one side to the next side of the box.
3. Does the length of the diagonal agree reasonably well with predictions based upon the ***Pythagorean Theorem***?
4. What is the ***area*** of the bottom of the box in m^2? What does this convert to in cm^2?

5. Have the students use the Voyager/Ozobot "STEM team" to measure the height (depth) of the box in meters. What does this convert to in cm?
6. What is the volume of the box in m^3? What does this convert to in cm^3?
7. Give the students a box that is too small, i.e., smaller than the range properly detectable by Voyager's range finder. What do they find?
8. If you have access to a room that is less than 4 meters in length by 4 meters in width, have the lab group determine its length and width using the Voyager/Ozobot "STEM team" and its associated graph. Compare to the "actual" dimensions using a meter stick.
9. What happens when the Voyager/Ozobot "STEM team" is used to determine the length and width of a typical classroom? What appears to be the longest distance measurable by Voyager's range finder?
10. Ask the students to predict what the graph would look like if they were to place the Voyager/Ozobot "STEM team" in the center of a ***round box***. Then have them perform this investigation using an actual round box. From the graph for the round box, ask the students to determine the radius and then calculate the diameter and circumference.

    Alternatively, show the students a graph that you have constructed using a round box, and ask them if they can determine the ***shape of the box from its graph***.

    You can probably find a round Paper Mache box, like the one shown in Figure 6, at local hobby shops such as Michaels, for less than $5.

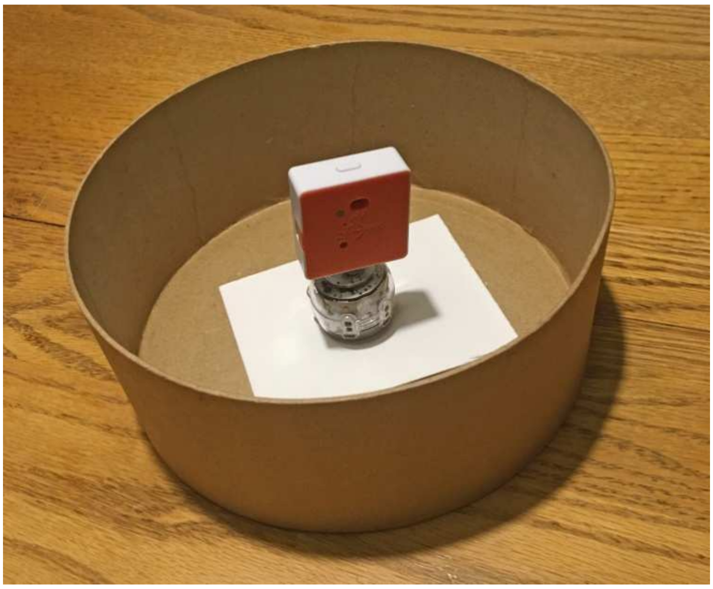

Figure 6