Build-A-Buoy (BABs)
Content Based, Hands-On, Education for Kindergarteners

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Introduction

Invisible integration of science into the classroom at an early age is effective in maintaining interest in formal education (Levin, et al, 2009) . In this example, buoys are used for several purposes. Red and green channel marker buoys indicate the bounds of underwater roads so ships may pass safely (Figure 1). Others locate objects that pose a threat to boaters or swimmers or otherwise mark areas where activities are prohibited. Observation is another major role for buoys. Weather stations (Figure 2) are routinely installed on buoys to record conditions. Buoys are also used to monitor water quality.

Figure 1: Channel Marker Buoy

Figure 2: NOAA Weather Bureau Buoy

In this exercise participants are tasked with building a buoy. Initial success is measured by building a structure that floats without tipping over. Progressive success is quantified by testing the amount of payload the buoy can safely support without toppling or sinking. Finally an indoor/outdoor sensor attached to the buoy turns it into an observation buoy that measures air and water temperature.

Program Delivery

The objective of Build-A-Buoy is to have participants build a floating buoy and then turn it into a data gathering system. They are provided with a myriad of PVC pipe, connectors, plastic flying discs ("Frisbee TM -like"), and plastic cable ties with which they are challenged to build a buoy. Small, portable, plastic basins (24" x 36" x 12" deep) filled with water are furnished to launch their devices.

Figure 3: Breaking World Records

The catch for getting any audience to "buy in" is in the introduction. The program starts by stating the following; "This morning I started my day, as I do every day, by going to the Guinness Book of World's Records Website and checking the record for payload in a small buoy. As of this morning that record was 15 golf balls. I'm wondering if any of you guys will be able to top that today?" The excitement in students' eyes is palpable.

The Decoy

Figure 4: The Decoy Buoy

Before students show up for the program an intentionally, poorly designed buoy model is constructed and placed to the side, or in the pool (Figure 4). During the program introduction no mention is made of this example. It is a "decoy". Students will routinely copy the model, even though it is poorly designed and will not be successful. The center of gravity is too high and, more importantly, the Disc is fastened to the frame with the convex side up. Golf balls place on top of the Disc will roll off. Clever students balance balls in the dimples caused by the holes drilled into the Disc, but because of the high center of gravity it won't hold more than three or four, far less than the "world record".

Materials

Figure 5. The Buoy Base

1½" PVC Schedule 40 pipe is used to build the buoy's base (Figure 5). This is cut into 6" Sections. The four 6" base pieces are connected using 1½" 90^{o} elbow pieces. The base is built by connecting the 6" straight pieces with the elbows creating a square buoy base. They are connected by pushing the pieces together. There is no glue involved. The fit between the pieces allows the base to be "pretty" water tight.

Figure 6, Buoy Pieces

The Buoy Superstructure is constructed using various types of ½" PVC straight pipe sections and a variety of connectors (Figure 6). Having "same length" straight pieces makes building symmetrical framework easier. The 6" length for the straight pieces is ideal. The different species of connectors (shown below) allow for innovative and strategic superstructure construction. Each of the different PVC pieces is provided to the builders in individual buckets.

The pieces required to build a buoy are:

4 - 6" 1½" PVC Pipe
4 – 1½" 90^{o} Elbows
8 - ½" 3-way connectors

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12 – 6” ½” PVC Pipe
1 – Plastic Disc (Flying Disc ™) w 8-½” holes drilled at the edge
10 – 12” Plastic Cable Ties
To make taller buoys – ½” 4-way connectors and ½” 6” PVC pieces

Figure 7, cutters and cable ties

The buoy’s superstructure and payload platform are fastened to the buoy base and frame, respectively, using plastic cable ties (Figure 7). A pair of diagonal cutters, the only tool necessary for building buoys, is used to trim the plastic cable ties and for buoy dismantling. It is helpful to have a couple of pairs of pliers around to help take the PVC pieces apart when the program has ended.

The Puzzle – Strategies for Attaching the Payload Platform.

One of the tricks to breaking the stated world’s record is to position the platform so that it can contain the golf balls without them rolling off of an edge. Another is to place it as low as possible on the buoy superstructure. The lower payload drops the buoy’s center of gravity, helps maintain stability and keeps the buoy floating in an upright position.

Figure 8, Payload Failure

If the Flying Disc is placed on the buoy with the label “up” golf balls will roll off of it, especially when floating and subject to rocking by even the smallest of waves. If the Disc is turned over, a dish is created. This will keep the golf balls from rolling out of it. Note the holes that have been drilled in the platform that are used to affix it to the superstructure with plastic cable ties. A maximum payload will be held by attaching the Flying Disc to the buoy superstructure upside down. The raised edges of the platform will keep the golf balls from rolling out.

Figure 9, Payload Success

Figure 10, High Center of Gravity

In this position, the Flying Disc will not hold the golf ball payload efficiently. Because the dish walls are not present, the balls will roll off. They may stay put for a second, but when the buoy starts to rock, the balls will roll off. If the Flying Disc is turned over creating a “dish”, the walls will keep the balls from rolling off.

On a flat, solid, platform with the Flying Disc positioned so it acts like a dish, the buoy can hold the most payload (golf balls).

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Figure 11, Large payload, unstable Buoy

However, this does not translate to any indication how the buoy will float. If the buoy is not perfectly weighted, it will list to one side or another when placed in water. With the Disc placed on top of the structure, the center of gravity for this buoy is high. There is a high likelihood that this buoy will tip over when it is floated.

By placing the Flying Disc at the top of the superstructure the center of gravity for the buoy is at its maximum. If the Flying Disc is removed from the top and slipped to the bottom the center of gravity is lowered significantly. If the payload (golf balls) are added to the Flying Disc in this configuration, they will, again, roll off when the buoy is deployed and floated.

In one case, students agreed that the center of gravity for the buoy was significantly lowered, but they did not realize the benefits of flipping the Flying Disc over. In this case, the students were able to increase the payload capacity of the Flying Disc by strategically placing the golf balls into the dimples created by the drilled holes. When the Flying Disc is flipped to the “dish” configuration and placed on top of the buoy base the maximum payload can be held. This is accomplished because the raised edges of the Flying Disc will keep the golf balls from rolling off and the buoy’s center of gravity is lowered significantly.

Even more payload can be accommodated with additional modification of this structure. The center of gravity can be lowered by removing the buoy superstructure and placing the Flying Disc underneath the base. The original criteria did not mention a need for keeping the payload dry.

Figure 12, Large payload, stable buoy

Channel Markers vs. Observation Buoys

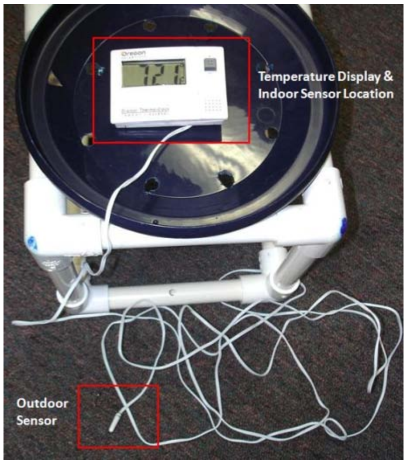

Figure 13, Observation Buoy Adaptation

A main objective of the Build-a-Buoy (BABs) program is to instill on the participants that there are different kinds of buoys. In the preamble the buoy builders are introduced to the concept of buoys that mark underwater roads or obstructions and their role in collecting environmental data.

In BABs simple indoor/outdoor thermometers are provided to the group to integrate into the buoy superstructure. The indoor temperature sensor is typically affixed to the top tier of the buoy, usually in, or on top of the Flying Disc.

In this instance, the indoor/outdoor thermometer was purchased from Oregon Scientific for about $6. It measures and displays the air temperature and the water temperature of the bin that

BABs is floated in. The indoor sensor is part of the display unit and is installed on top of the buoy, as shown. The outdoor sensor is dropped into the water. The "outdoor" temperature displayed is that of the water. Depending on the age of the student participants, a teaching strategy would be to challenge them to build a buoy that allows them to determine the difference between the air and water temperatures

Presentation Age Range

Simplistically this program uses an indoor/outdoor thermometer to show how water and air temperature differences can be measured with a buoy. It is delivered each spring to kindergarteners. The incentive of asking their help to break a world's record is too exciting for them. They don't hold back, and are so proud to be part of a class that "breaks" the record. When it is included in outdoor festivals such as Delaware's Coast Day or on the Chesapeake for a "Bay Day" it is a hit with all age groups. In some cases, by choice, this event is the only activity that some attendee's experience.

Conclusion

The Build-a-Buoy program has been delivered to audiences as young as kindergarten, to undergraduates, and high level scientists. It has been a popular attraction for all ages during "Coast Day" and other outdoor festivals. The program teaches participants that Buoys have more purpose than marking underwater roads or obstructions. They are routinely used to measure and observe things that are happening around them. Buoys are used, for example, to monitor weather in the ocean open, observe changes in water quality, and forecast the possible onset of Tsunamis. It is also a great introductory program to the student built Basic Observation Buoy (BOB) (Spence, et al, 2009).

References

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