TEACHING SCIENCE BY OCEAN INQUIRY
Buoyancy

Part II: Assessments

The following activities present different ways by which a student's knowledge of a concept can be assessed and how misconceptions can be revealed. We use the concept of buoyancy as an example.

Assessment I: Interactive Quiz

Step 1: Take the quiz individually and turn in your answer sheet.

Step 2: Take the quiz again but this time with your group members. Discuss each question within the group, agree on the correct answer and use a scratch paper to discover if the answer is correct (a star is revealed if the answer is correct).

Assessment II: Debate (Rock in a Boat)

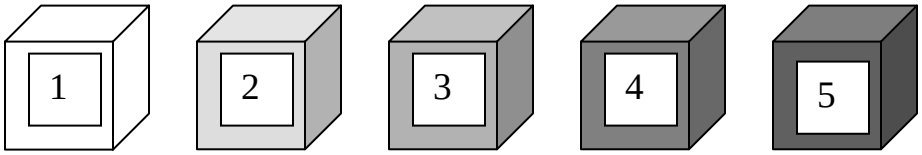
Class Problem:

"You have a large rock on a boat that is floating in a pond. If you throw the rock into the water and it sinks, will the water level of the pond rise, drop, or remain the same?"

When you do it with your students give them a few minutes to think about the problem, then communicate their prediction by a vote. Students are then grouped according to their "vote". Each group has to come up with an argument that supports their prediction (or discover in the process that their prediction needs to be revised) and present it to the entire class. After each group has presented its argument, a demonstration is presented in class. (*Materials: A plastic boat, a weight or large rock, a container with water, lab tape to mark water level.*)

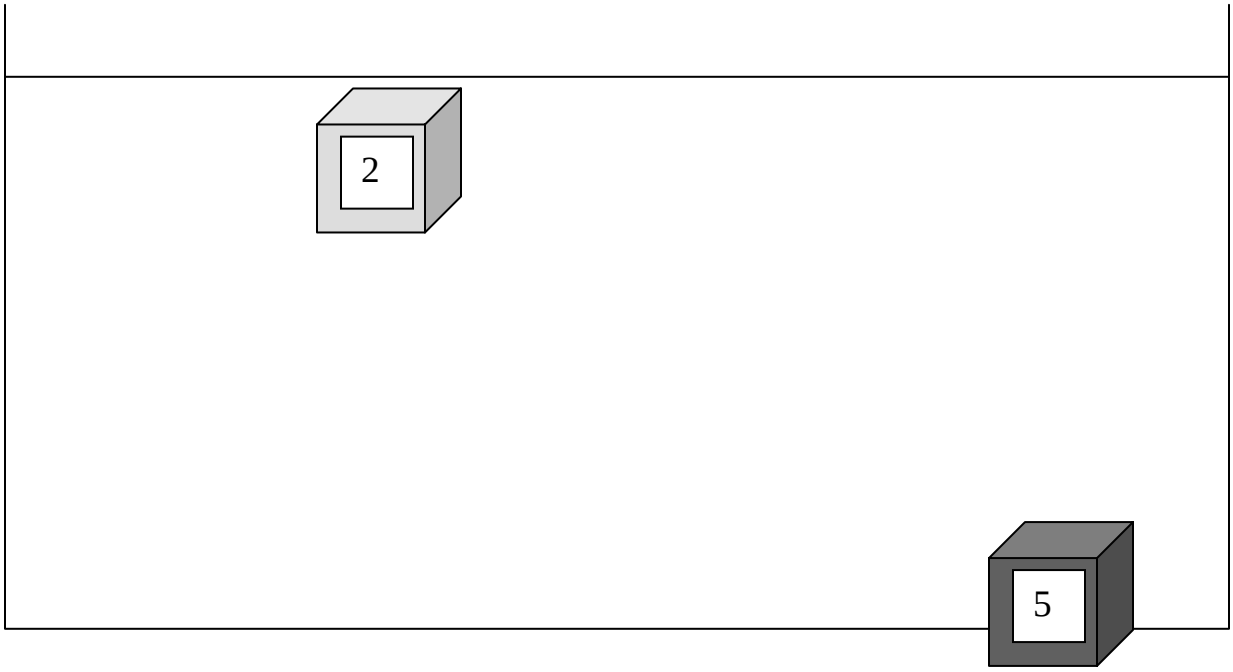
Assessment III: Pictorials and Drawings - Block Diagram
(based on Loverude et al. 2003)

The five blocks below have the same size and shape but differ in their masses. The blocks are numbered in order of increasing mass.



$m_1 < m_2 < m_3 < m_4 < m_5$

All the blocks are held approximately at the halfway point in an aquarium filled with a fluid and then released. The final positions of blocks 2 and 5 are shown below. On the diagram sketch the final position of blocks 1, 3 & 4. Explain your reasoning and if you make some assumptions, state them clearly. You are allowed to discuss it within your group, but each student shall submit an explanation written in her/his own words.



BUOYANCY ASSESSMENT: EXPLANATIONS FOR LAB ACTIVITIES

Assessment I: Quiz (Discussed in Class)

Assessment II: Debate (Rock in a Boat)

When the boat + rock are not sinking, nor rising, there is no net force acting on them, $F_{buoyancy} = F_{gravity}$ and hence,

$$m_{object} g = \rho_{object} V_{object} g = \rho_{fluid} V_{displaced} g$$

Since $\rho_{object} < \rho_{fluid}$ (it is floating), the volume displaced due to the rock on a boat is computed from:

$$m_{rock}g = \rho_{rock}V_{rock}g = \rho_{fluid}V_{displaced}g \rightarrow V_{displaced} = \rho_{rockt}V_{rock} / \rho_{fluid}$$

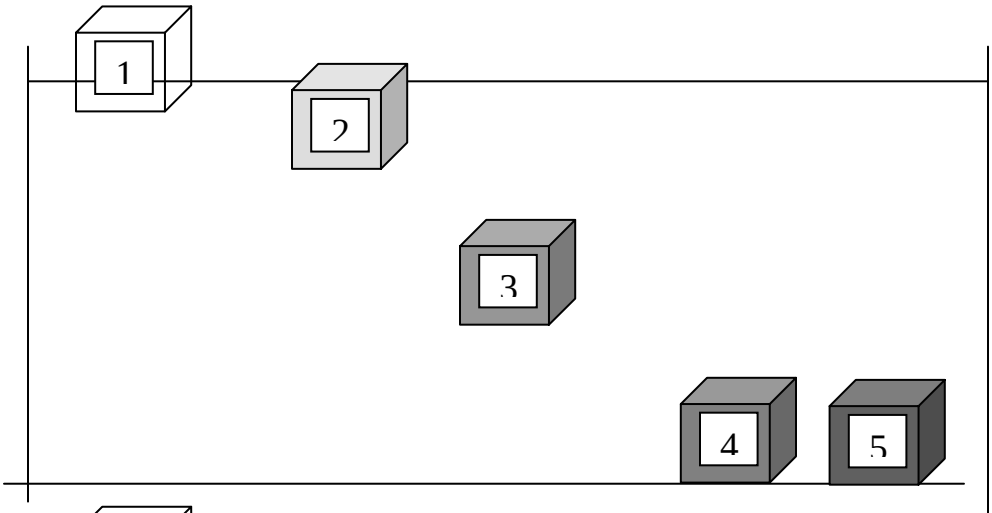
Thus the volume displaced is larger than the volume of the rock. When the rock is fully immersed in water it only displaces water, which has a volume equal to its own volume. Therefore, the water level of the pond will go down when you throw the rock in and it sinks to the bottom.

Since $\rho_{object} < \rho_{fluid}$ (it is floating), the volume displaced by the rock floating on a boat must be larger than the volume displaced by it when it is fully immersed in water Therefore, the water level of the pond will go down when you throw the rock in and it sinks to the bottom.

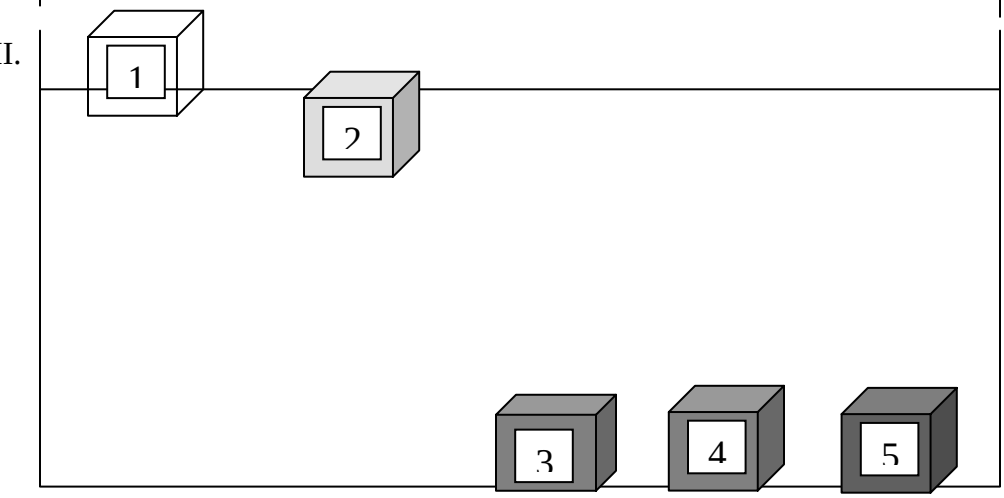
Assessment III: Pictorials and Drawings - Block Diagram
(based on Loverude et al. 2003)

Since $m_1 < m_2$, block 1 must float higher than block 2. There are two solutions for the final positions of blocks 3 & 4 (assuming incompressible, unstratified fluid; see below).

I.



II.



If the density of block 3 is larger than that of block 2 but exactly that of the fluid (block 2 is slightly less dense than water), the block is neutrally buoyant and will remain where released. This implies that blocks 4 and 5 are denser than the fluid and therefore it will sink to the bottom of the aquarium. The second scenario is that the densities of blocks 3-5 are larger than the density of the fluid and they will all sink to the bottom of the aquarium.

You can modify this pictorial activity and turn it into a demonstration:

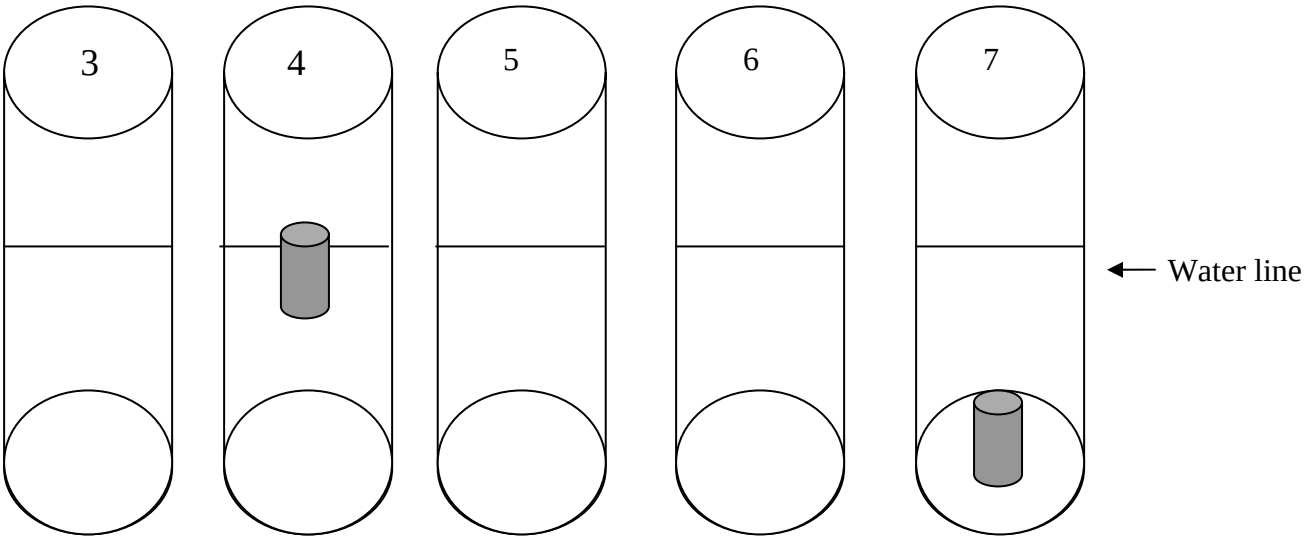
(Note: for the example shown below you will have to revise the original question; instead of having the blocks held at the half way point and then being released you can ask the students to predict the position of the bottles after placing them at the surface of the water.

***Materials**:*

- Five glass bottles filled with different amounts of gravel (here we used cheap perfume bottles bought at a Dollar Store)
- Five large clear cylinders filled with tap water (make sure the water level is the same for all).

Instructions:

1. You have five glass bottles filled with different amounts of gravel (labeled 3, 4, 5, 6, and 7). The cylinders are of identical size and shape but varying mass (m) with bottle 3 being the lightest and bottle 7 being the heaviest ($m_3 < m_4 < m_5 < m_6 < m_7$).
2. Place bottle 4 in cylinder 4 and bottle 7 in cylinder 7. Observe their sinking and floating behavior.
3. Based on your observation, can you predict the sinking and floating behavior of the other bottles?
4. In the diagram below sketch the final position of each bottle in the water column and explain your reasoning.



5. Test your prediction. Does your observation agree with your prediction?