THE BENDS!: TEACHER GUIDE

Subject: Physical Science
Grade Level: Middle School
Last Updated: November 6, 2008

Case Summary

Two cousins are SCUBA diving in the tropics, but when it's time to head back to the surface for lunch, one cousin swims up to the surface quickly while the other cousin swims slowly. Within a few hours, the first cousin gets really sick while the other is fine. They don't know what made one of them sick, but as the ill cousin's symptoms get serious, they realize they need to do something fast.

Credits

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This case was adapted from The Bends (Ram, n.d.).

Ram, Preetha (unpub.). The Bends. Conceptualized following a discussion with Dr. Ram Fall 2004 at Emory University.

Learning Objectives

At the end of this case, students will:

1. Analyze the relationships between pressure, temperature and gas volume.
2. Describe Boyle's and Charles' Laws and the Ideal Gas Law
3. Graph the relationships between pressure and gas volume and between temperature and gas volume
4. Analyze the relationship between pressure and solubility of gases
5. Analyze the relationship between depth and water pressure
6. Explore some of the effects that pressure can have on gases in the body and resulting health problems.
7. Identify and describe the symptoms and causes of the bends.

Georgia Performance Standards

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science. (NSES Content Standard A)

S8P1. Students will examine the scientific view of the nature of matter. (NSES Content Standard B)

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c. Describe the movement of particles in solids, liquids, gases, and plasmas states.

Assessment

Students will create box charts for each scene that will be turned in for grading based on organization, detail and insight (To create a box chart, fold a piece of paper into fourths, and label each quadrant with Facts, Questions, Hypotheses or Learning Issues. A Learning issue is something that a student identifies as needing to be investigated or looked up/ researched in order to answer one of their questions, define an unknown term or test one of their hypotheses).

In groups of four or five, students will create posters that include written and illustrated descriptions of the bends and its symptoms as well as Boyle's and Charles' Laws, the relationship between gas solubility and pressure and how these things explain what happened in the case scenes (*For the **Poster Handout**, see Student Materials for this case*). They will include graphs illustrating the two laws using data of pressure and gas volume in the lungs (without SCUBA tanks) at specified depths and data of gas volume in a SCUBA tank at various temperatures; both sets of data are created and provided by the teacher/facilitators. These posters are graded for organization, content inclusion and creativity; while all group members are in theory assigned the same grade, imbalances in participation or effort among group members will be taken into consideration based on the evaluation that each student fills out at the end of the case (*For a sample **Evaluation** see Student Materials for this case*).

Sample Data:
Example…air temp of 50°C

Scene 3: Formula for calculating air pressure with changing temperature in Trey's air tanks (helpful in creating data to give the students on temperature, pressure and gas volume and establishing the threshold temperature after which Trey's tank bursts).

(50.0 + 273.15) K / (25.0 + 273.15) K = 323.15/298.15 or 1.0839 will increase the pressure by a factor of 1.0335, so the tank MWP at 50.0°C is 1.0839×3000 psi = 3251.7 psi. This exceeds the maximum & the tank bursts.

Implementation Strategy

This case involves three scripted scenes, which are read and investigated by students working in groups of 4-5 individuals. This case can be facilitated by two facilitators or even a single teacher, because rather than placing a facilitator with every group, the students spend time brainstorming with their group and then as a whole class.

The brainstorming session described below involves students reading, discussing and taking notes in their groups in 10-minute blocks (totaling about 25 minutes per scene), then reconvening as a whole class to volunteer their observations, questions, hypotheses and learning issues (learning issues are things that students say they need to know or look up to define unknown terms, answer their questions, and/or test their hypotheses) at the end of every 10-minute block. During the group brainstorming, the teacher/facilitators float from

group to group, checking progress and helping students with any stumbling blocks they may have. During the whole-class volunteering time, the teacher/one of the facilitators takes notes on an overhead or with a Smart Board. In this way, students can learn to work as a team while still benefiting from sharing their information as a whole class or even competing with other groups for volunteering, while the teacher can make sure that all students are at the same point in the case at each step.

This case was implemented to four classes, each of which meets for 60 minutes on Monday and 90 minutes on Tuesdays or Wednesdays and Thursdays or Fridays.

Day 1 (Tues/Wed) – Read Scenes 1 and 2; brainstorm and fill out box charts for each scene.

Homework – Reread Scenes 1 and 2; finish box chart

Day 2 (Thurs/Fri)

Lab activity: Students will do several mini-labs exploring gas pressure using everyday objects.

Computer lab: Students will research learning issues identified in their box charts using the PRISM-Columbia Middle website and its links.

Homework – Continue research using internet, textbook etc.

Day 3 (Tues/Wed)

Follows the Thanksgiving holiday, so students will review the scenes and their research findings in their groups (20 minutes) followed by a class review led by the facilitators (20 minutes).

Read scene 3 in their groups, brainstorm and complete a Scene 3 box chart (~45 minutes).

Homework – Reread Scene 3, finish box chart, begin researching learning issues in their textbooks

Day 4 (Thurs/Fri)

Computer lab (~25 minutes): Return to computer lab to research scene 3.

In-class exercises graphing gas relationships (Create a set of data on the board for students to graph) (20 minutes)

Go over the poster assignment (see **Poster Handout**).

Homework – Work on poster design & ID what's needed

Day 5 (Tues/Wed) – Work on poster (90 minutes)

Day 6 (Thurs/Fri) – Finish (45 minutes) and present (20 minutes) posters; case evaluation and wrap-up.

Case Notes

Things That Went Well:

1. The students are adapting well to the PBL structure and were much more independently motivated to read the cases and complete their box charts, with two facilitators floating between groups to facilitate and guide discussion. They also seemed to like the characters and the storyline in general.

2. The use of several mini-lab activities on gas pressure was very helpful, since students began to make connections between the activities and the case scenes. The lab activities were really simple and quick, and were fun as well.
3. The webpage of case-specific resources continues to be helpful in structuring and guiding online research, especially since most websites on the physics of SCUBA diving are for older and more advanced readers (i.e., high school and above). For younger students, this is a really necessary component of their research.
4. We demonstrated the relationship between gas solubility and pressure by allowing a student volunteer to shake up and quickly open a bottle of seltzer water in each class, pretending that the bottle represented the tissues and blood of the character who came down with the bends and that rapidly opening the bottle represented his too-quick return to the surface. As always, messes are fun *and* educational! Also, students recalled solubility concepts from their previous case; their retention of the material was very promising.
5. The students picked up very well on the graphing assignments that we gave them as part of their group poster, and did well at constructing scales and even using a reversed Y-axis (representing pressure at increasing ocean depths). Also, the students were allowed to divide up tasks based on what they believed to be their strengths, such as artistic ability, writing talent, graphing and calculations or design.

Things That Could Be Improved:

1. Time management!!! Because this case was implemented towards the end of November and beginning of December, field trips, standardized testing and holiday breaks broke the flow of the case. Re-capping the case using both brief group discussion and whole-class discussion was helpful, but the case would have likely gone much smoother had we implemented it nearing the holiday season. The students tended to forget material or get distracted because their case work was interrupted or they were excited because of the upcoming holidays.
2. Some students had difficulty with gas law concepts and with extrapolating them to SCUBA; while we found that punctuating group work with class-wide discussions helped resolve this, perhaps we moved too fast through the case in our efforts to finish up before the holiday break. We think that future implementation should allocate an extra day of hypothesis generation and if not learning issue research, perhaps group "rumination" with facilitators for better understanding.
3. For the poster activities, an extra facilitator or two could be very useful in helping students construct their graphs and design their poster layouts, since this takes much more time than we originally thought. The students were on task and did a good job, but we found ourselves repeating the same advice and concentrating on the same tasks among the groups and since it was just the two of us, we ended up not using the time as efficiently as if there were more facilitators around to lend a hand.
4. We were unable to find a video at the school that discussed SCUBA diving in terms of physics, but future implementation would likely benefit from some video clips of SCUBA divers so that students who have never dived could better visualize the written description in the scenes. If students who have dived would be willing to bring in pictures

to make overheads or even give a small presentation, we could help the students more readily relate the material to their own lives.

Resources:

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