Name: _____ Group: _____

THE PROBLEM

From: Contest “Take a deep breath—be healthy!”
To: Firm of Analysts and Marketing, Inc.
CC: Contest Winners
Date: July 24 2008 08:55
Subject: Assessment and improvement of a spirometer prototype

Dear Sir/Madam,

A team of young scientists has won first prize in the contest “Take a deep breath—be healthy!” with their prototype of a spirometer. This instrument, which examines the relationship between vital lung capacity and physical activity, will be commercialized. Before the spirometer is put on the market, however, we believe it needs to be analyzed to see if it requires any improvements.

We would like you to take care of the testing process because of your knowledge of medical instruments and how to market them. Below is what we want you to do:

Assemble a spirometer and test it to make sure it works properly.
Analyze how it works, producing a design plan and a technical drawing.
Propose modifications for improving the instrument to be done before it is manufactured and put on the market.

The attached document contains the calibration protocol and the user’s guide for the prototype submitted by the winners of the contest.

Sincerely,

Mathieu Lavoie
Contest “Take a deep breath—be healthy!”

Protocol

December 6, 2006

If you wish to measure the impact of your physical activity on your health, use a spirometer. This instrument measures vital lung capacity, that is, the volume of air that a person can blow out of his/her lungs. It has been proven that physical activity increases lung capacity, which has an impact on, among other things, intellectual capacity and performance.

In this LES, you will play an employee of the firm, of Analysts and Marketing, Inc.

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THE PROBLEM (*continued*)

Calibrating the spirometer

Materials

- 4-L plastic bottle with its stopper *or* a rubber stopper
- 100-mL graduated cylinder
- marker

PROCEDURE

1. Using the graduated cylinder, measure 100 mL of water.
2. Pour the 100 mL into the bottle.
3. Mark the water level on the bottle.
4. Repeat the operation until the bottle is full.
5. Empty the bottle and turn it upside down.
6. Write beside each mark the corresponding volume.

The spirometer is now calibrated. Each mark on the bottle corresponds to a volume of 100 mL.

Measuring vital lung capacity

PROCEDURE

1. Fill the calibrated bottle with water.
2. Use the stopper to close the bottle.
3. Pour water into a basin or a sink until it is about 5 cm deep.
4. Place the bottle, upside down, in the basin and make sure the bottle opening is under water.
5. Remove the stopper.
6. Insert the end of the tubing in the bottle.
7. Ask the subject to take a deep breath and then to blow as long as possible into the tubing.
8. Record the volume of air in the bottle.
9. Perform this protocol another time with this subject and then two times for each of the remaining subjects.

Note: The end of the tubing must be cleaned with rubbing alcohol.

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CREATING THE CONTEXT

I ask myself questions

1. What is vital lung capacity?

2. What is a design plan?

3. What is a technical drawing?

4. Who is involved in solving this problem?

5. What questions could you ask before beginning your technological analysis of the spirometer prototype?

I must

6. Redefine the problem's goal.

I think

7. In your opinion, what are some of the factors that could influence the commercialization of the spirometer? Explain your answer.

Name: _____ Group: _____

CREATING THE CONTEXT (*continued*)

What I know and what I must find out

8. Make lists of the information you have and of the information you need to find out.

I know . . .	**I must find out . . .**

I prepare my work

9. Where and how could you find the information you need to propose improvements to the spirometer prototype?

10. List, in chronological order, the principal steps for your work.

Reflection

	Yes	No
Do I understand everything that needs to be done?	☐	☐

Name: _____ Group: _____

GATHERING INFORMATION

I do research

1. What is a fluid?

_____

_____

2. What is an incompressible fluid? Is there one such fluid that plays a part in the function of a spirometer? If so, what is the fluid?

_____

_____

3. What is a compressible fluid? Is there one such fluid that plays a part in the function of the spirometer? If so, what is the fluid?

_____

_____

4. What is pressure?

_____

_____

5. What is force?

_____

_____

6. How does pressure act on the volume of a compressible fluid?

_____

_____

7. What happens when pressure is applied to the surface of a fluid in a closed container?

_____

_____

8. How does a fluid behave?

_____

_____

_____

Name: _____ Group: _____

GATHERING INFORMATION (*continued*)

I analyze my results

1. Using page 2 in your student log, calibrate and assemble the spirometer.

2. Using the spirometer, measure the vital lung capacity of each member of your team at least three times. If necessary, refer back to page 2 of the student log.

Vital lung capacity of team members				
Measurement / **Team member**	**1st measurement** (mL)	**2nd measurement** (mL)	**3rd measurement** (mL)	**Average vital lung capacity** (mL)
1				
2				
3				
4				

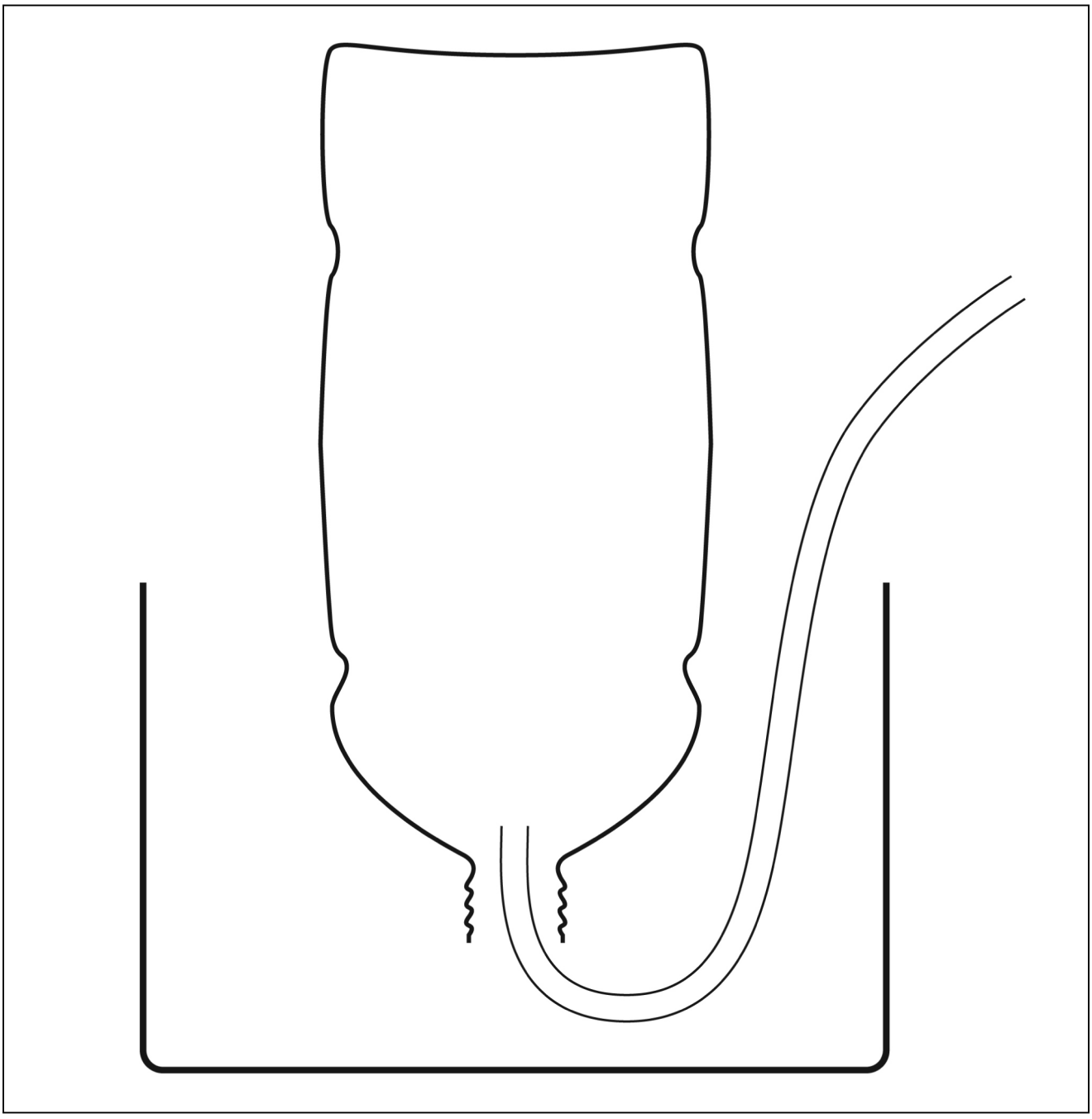
3. Explain how the spirometer works.

Name: _____ Group: _____

GATHERING INFORMATION (*continued*)

4. Complete the following design plan, which will help you to analyze how your spirometer works. Your design plan should include the following information:

- names of the parts
- names of the fluids and their types
- forces at work
- zones of high and low pressure for each of the fluids
- behaviour of the fluids



Name: _____ Group: _____

GATHERING INFORMATION (*continued*)

5. Complete the following technical drawing for the spirometer. Ensure that the following information appears on the drawing:

- names of the parts
- materials used
- other useful information for manufacturing
- the spirometer

Reflection

	Yes	No
Do I have a good understanding of:		
• Compressible and incompressible fluids?	☐	☐
• Pressure?	☐	☐
• The relationship between pressure and volume?	☐	☐
• The behaviour of fluids?	☐	☐

Name: _____ Group: _____

COMPLETING THE PROJECT

I propose

1. What are the advantages of the spirometer?

2. What are the disadvantages of the spirometer?

3. Which improvements would you make to the spirometer? List at least three.

I reflect

	Yes	No
Can I think of any other solutions or explanations?	☐	☐

Name: _____ Group: _____

VALIDATING THE PROJECT

I explain

1. Justify each of the improvements that you propose to improve the design of the spirometer. Refer back to your analysis of how the instrument works.

Name: _____ Group: _____

MY EVALUATION

Use the evaluation grid on the following page to do a self-evaluation. Write A, B, C, D or E in the appropriate place in the table.

SSC2 Makes the most of his/her knowledge of science and technology				
Criteria*	**Observable indicators**	**Me**	**Teacher**	**Comments**
1	**Creating the context** Definition of the goal and formulation of the questions for analyzing the spirometer		☐ With help	
2	**Gathering Information** Production of a design plan and a technical drawing		☐ With help	
3	**Completing the project** Formulation of improvements to be made		☐ With help	
4	**Validating the project** Justification for each proposed improvement		☐ With help	

*** Evaluation criteria**

1 Formulation of appropriate questions
2 Appropriate use of scientific and technological concepts, laws, models and theories
3 Relevant explanations or solutions
4 Suitable justification of explanations, solutions or opinions

EVALUATION GRID

Name: _____ Group: _____

SSC 2 Makes the most of his/her knowledge of science and technology

Criteria*	Observable indicators	A	B	C	D	E
1	**CREATING THE CONTEXT** Definition of the goal and formulation of the questions for an analysis of the spirometer	The goal is very clearly defined. The questions for analyzing the spirometer are pertinent.	The goal is clearly defined. The questions for analyzing the spirometer are pertinent.	The goal is defined more or less clearly OR the questions for analyzing the spirometer are more or less pertinent.	The goal is defined more or less clearly AND the questions for analyzing the spirometer are more or less pertinent.	The work needs to be redone.
2	**GATHERING INFORMATION** Production of a design plan and a technical drawing	The design plan and technical drawing are complete.	The design plan and technical drawing are complete, but contain some minor errors.	The design plan and technical drawing are incomplete OR they contain many errors.	The design plan and technical drawing are incomplete AND contain many errors.	The work needs to be redone.
3	**COMPLETING THE PROJECT** Formulation of improvements to be made	More than three improvements were proposed. They are all very clearly formulated and relevant.	The three proposed improvements are clearly formulated and relevant.	One or two of the proposed improvements are clearly formulated and relevant.	The proposed improvements are more or less relevant.	The work needs to be redone.
4	**VALIDATING THE PROJECT** Justification for each proposed improvement	All of the justifications are relevant.	Most of the justifications are relevant.	Some of the justifications are relevant.	The justifications are not very relevant.	The work needs to be redone.

*** Evaluation criteria**

1 Formulation of appropriate questions
2 Appropriate use of scientific and technological concepts, laws, models and theories
3 Relevant explanations or solutions
4 Suitable justification of explanations, solutions, decisions or opinions