Using the Story

The story provides an indirect way for children to learn new information. The presentation of this story, which warns against drinking any clear liquid, could be tailored to fit a wide range of ages; 5- to 15-year-olds, say. The story might also form the basis of a game to be played or a drama to be acted out in the classroom.

Some children will also learn that it is not so good to be like the troublesome chick, and that you should therefore listen to the advice of adults and be careful not to touch strange or unknown things. Some will appreciate the good role model of Dr Rooster in helping other people.

The science story can activate the imagination of the child and support new elements of imagination. In this story, in which the animals behave like people, the child makes the connection between imagination and reality. Children of all ages adore stories, and science stories are a valuable tool for teaching aspects of scientific knowledge.

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The “Magical” Sphere: Uncovering the Secret

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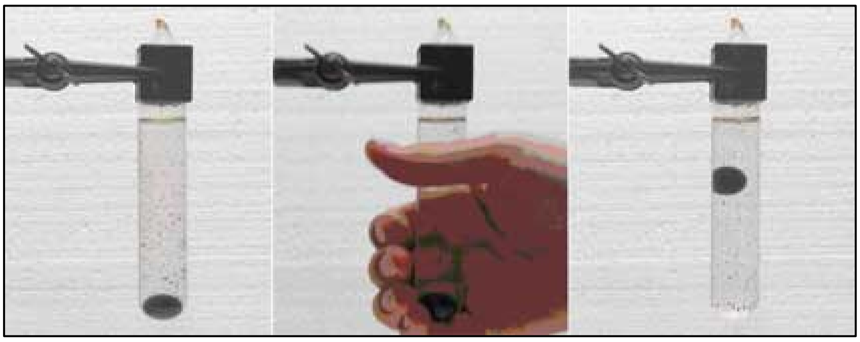
Abstract

A red sphere is seen at the bottom of a sealed glass tube filled with a colorless, transparent liquid. Holding the tube for a short period makes the sphere rise slowly from the bottom until it finally floats on the surface of the liquid. Instructions for preparing the demonstration are given, together with an explanation of the phenomenon. A similarity with the Galileo thermometer is pointed to. An example of guiding the discussion with students in the course of uncovering the secret behind the behaviour of the sphere is also given in the form of Socratic dialogue, relying on carefully selected questions that stimulate the students to think in a scientific way. The latter may also serve as an example of a teacher’s approach during inquiry-based learning.

The “Magical” Sphere Demonstration

A sealed tube containing a transparent, colourless liquid was fastened on a stand. A red sphere could be seen at the bottom of the tube (Figure 1a). Students were invited to observe it for a minute or so.

The “magician” (instructor) approached the demonstration table and announced that he will make the sphere float in the liquid. He placed his hand over the lower part of the tube, where the red sphere was at rest, and held it for about 15 seconds (Figure 1b). The magician removed his hand from the tube. The audience witnessed the red sphere moving slowly through the colourless liquid, towards the top of the tube (Figure 1c). "True magic, isn't it?" concluded the magician. The instructor then initiated discussion with the students aimed at answering the questions: (1) What is inside the tube? (2) How does it work?



(a) (b) (c)

Figure 1. The red sphere rests at the bottom of a sealed tube (a). After holding the tube for about 15 seconds (b), the sphere slowly rises (c).

Construction Details

The sealed tube is made of a large test-tube. First, by strong heating (Bunsen burner was used), the open end of the test tube was stretched and partially closed to form a narrow-neck ampoule. The ampoule was about two-thirds filled with a water solution of ammonium chloride (although ordinary salt [sodium chloride] could also be used as a much cheaper and more readily available alternative) and about 1 to 1.5 mL of liquid aniline was added.

The concentration of the ammonium chloride solution was chosen so that its density was just slightly lower than the density of liquid aniline. The easiest way to accomplish this would be to first prepare a solution of ammonium chloride with $w(NH_4Cl) = 9$ %, or a solution of sodium chloride with $w(NaCl) = 4$ %. This solution is then carefully diluted until its density is such that the pink aniline sphere slowly sinks to the bottom of the ampoule. Finally, the ampoule is sealed using the Bunsen burner.

Explanation of the Phenomenon

The density of pure aniline ($\rho \approx 1.02$ g cm^{-3}) is somewhat higher than the density of pure water ($\rho \approx 1.00$ g cm^{-3}) (Weast, 1987). However, upon dissolving salts (like the above mentioned ammonium chloride or sodium chloride) in water, the density of the solution increases. It is thus fairly easy to prepare a water solution of table salt that will be of slightly lower density than the added aniline. The aniline, having the shape of a slightly deformed sphere, will sink to the bottom of the vessel.

When the liquids are warmed slightly, things change gradually, with the densities of both the water solution of salt and aniline decreasing. However, the rates of these changes are markedly different. For temperatures close to room temperature (≈ 20 °C), there exist data (e.g., Engineers Edge, 2006) that enable one to calculate the temperature coefficients of the densities,

$$\frac{\Delta\rho_{\text{water}}}{\Delta T} \approx -0.2\ \text{mg cm}^{-3}\ \text{K}^{-1} \quad \text{and} \quad \frac{\Delta\rho_{\text{aniline}}}{\Delta T} \approx -0.9\ \text{mg cm}^{-3}\ \text{K}^{-1}.$$

This means that, if initially $\rho_{water} < \rho_{aniline}$, a temperature change of a few degrees might result in $\rho_{water} > \rho_{aniline}$, and the red sphere (aniline) will slowly rise and travel through the solution until it eventually reaches the top.

The phenomenon bears resemblance with the Galileo thermometer (Figure 2). The Galileo thermometer is a sealed glass cylinder (height ≈ 30 to 35 cm and diameter ≈ 4 to 5 cm). It is filled with a non-toxic liquid (mineral oil) of practically uniform density (an excellent approximation, given that liquids are practically incompressible). There are multi-coloured globes inside the thermometer (they all have the same volume and shape, but each one is of different weight). The globes have gold tags that read the temperature in 2 °C increments. As the temperature increases, the density of the surrounding liquid decreases and the globes sink, one by one, to the bottom of the vessel, a behaviour opposite to that described in the present demonstration.

Hints for the Discussion

There are virtually unlimited possibilities as to how the ensuing discussion might be guided in the classroom, including asking students to describe what they see, propose possible reasons behind the phenomenon, make decisions, and draw conclusions. The idea is to keep the information given to students to a bare minimum, so that they are "forced" to think about the problem (the "magic") and to arrive at an explanation. The text that follows provides an example. For simplicity, it is presented in the form of a conversation between the instructor and a student, although in reality an instructor would be interacting with a group of students.

Figure 2. A Galileo thermometer.

Instructor: Alright. Let's try now to look "behind the magic." First, can you describe what we saw?
Student: Yes. Soon after you put your hand over the tube, the sphere started to rise.
Instructor: Correct. Now, what does it mean?
Student: Well . . . I'm not sure, what is the question?
Instructor: The sphere rests at the bottom, in the beginning of the "magic." Right?
Student: Right.
Instructor: So, what about its density? Is it higher or lower than the density of the surrounding liquid?
Student: It must be higher.
Instructor: And after I removed my hand, the sphere slowly rose. Can you explain that?
Student: Well, it must have changed somehow and its density is lower now . . . .

Instructor: Correct again. Look now at the transparent liquid in the tube. Any idea what it is?
Student: It is colourless . . . might be water?
Instructor: It might be. But can you tell water from sugar solution?
Student: I can, by taste. But not by sight . . . so it could be a solution of sugar.
Instructor: It surely could be. It could also be a solution of salt, or for that matter of any colourless material. This one here is a solution of salt. What about the red sphere?
Student: It is obvious now that it is also a liquid . . . we could not be sure about it when it was sinking and moving through the liquid. But it is coloured.
Instructor: Any idea about its nature?
Student: Sorry, I have no clue.
Instructor: Is it possible that it is also water? Coloured water?
Student: Yes, it could . . . No! It can't be. Coloured water would mix with the other water and soon it would become pink.
Instructor: Very good. Now, would you agree if I say that it is some liquid that is not miscible with water?
Student: I think I would.
Instructor: OK. The liquid is called aniline. It is used in the production of dyes. Now, what can we say about the temperature effect on liquids?
Student: They are heated?
Instructor: Actually, when liquids are heated, their temperature increases. But what is the effect of the temperature?
Student: I don't understand the question.
Instructor: Think about a common thermometer. A mercury or alcohol one will do. What do you see when you heat the thermometer? How can you confirm that the temperature really increases?
Student: Oh, you mean the liquid expands?
Instructor: I mean exactly that. Now, upon expansion, will the mass of the liquid change?
Student: No. It is just its volume becoming larger.
Instructor: And what about its density? Does it change?
Student: The density is the ratio of the mass to the volume. And the mass is a constant . . . so the density actually decreases.
Instructor: Excellent! That was the point. It is quite a general rule that the density of a liquid decreases upon heating. The important exception is water, in the temperature interval between 0 and 4 °C. Are you familiar with that?
Student: Sure. Actually, this is the known anomaly of water. It makes life possible in water during cold periods, because below the ice there is liquid water.
Instructor: Right. Now, back to our problem. Knowing that the density of a liquid decreases upon heating, can you offer some explanation of what we saw?
Student: I think I can. Your hand had the role of a heater. Upon heating, the density of the red liquid decreases and it moves upward.
Instructor: That is almost perfect. However, there is another liquid in the tube; the solution of salt surrounding the aniline sphere. Don't you expect that this liquid will also expand upon heating?
Student: Hmmm . . . yes I would. But if both liquids expand, then the density of both will decrease.
Instructor: Very well. Please continue.
Student: In that case, the density of aniline will still be higher than the density of the water solution of salt, unless . . . .
Instructor: Unless?
Student: Is it possible that the density of aniline decreases more than the density of the solution?

Instructor: Surely it is possible! And this is actually the solution here. Well done!

Note: A video-clip of the demonstration (~ 6.5 Mb) is available upon request from the authors.

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Critical Incident

An Invitation

Readers are invited to send, to the Editor at editor@ScienceEducationReview.com , a summary of a critical incident in which you have been involved. A critical incident is an event, or situation, that marks a significant turning point, or change, for a teacher. The majority of critical incidents are not dramatic or obvious, but are rendered critical through the analysis of the teacher (see Volume 3, p. 13 for further detail). You might describe the educational context and the incident (please use pseudonyms), analyse the incident (e.g., provide reasons to explain your observations), and reflect on the impact the incident made on your views about the learning and teaching process. Upon request, authors may remain anonymous.

We have undoubtedly all done things about which we were very pleased, and perhaps done other things about which we did not feel so pleased, and we all need to remain reflexive of our practice. While teachers will view an incident through the lenses of their own professional experiences, and may therefore explain it differently, this does not detract from the potential benefits to be gained from our willingness to share our experiences and thus better inform the practice of other teachers.

A Critical Incident Leads to Classroom Success With "Homebrew" Radio Kits

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After reading the definition of a critical incident is a pervious edition of *The Science Education Review*, I recalled several events of this kind that took place during my teaching career. These events changed not only the way I teach, but also the way I view the process of teaching. In this article, I'll describe the most recent such critical incident, during a unit on electricity and magnetism pedagogy, when a student told me: "I'll never understand this!" Perhaps something similar has happened to you.

The instructional context. The elementary education students in my teaching methods classes generally feel the least comfortable about their content knowledge and teaching abilities in the physical sciences. Much like the well-known phenomenon of math anxiety, I've observed over the years that many elementary education students have science anxiety, particularly in regard to anything they consider to be in the arena of the physical sciences. It was not a surprise to me to find that physical sciences are the least taught science topic in elementary schools in the United States, a phenomenon evident to both educational researchers and casual observers. Thus, I make it one of my personal instructional goals to engage elementary education students in learning