

Interdisciplinary Days: Learning by Emotions

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Nature offers many topics which can be treated in an informal and interdisciplinary way during a school day. The organization, objectives, results and the evaluation of two interdisciplinary days are presented: The Surprise Egg and We Need a Flower...

Introduction

A typical, classical exercise of physics teaching in secondary schools is the following:

Determine the density of a liquid if the buoyant force on a body is 2 N and the volume of the displaced liquid is 200 mm³.

For almost 70% of the students this problem is:

- difficult
- not attractive
- insignificant
- they have no idea how to solve it.

One example of a “solution” is shown in Fig. 1.

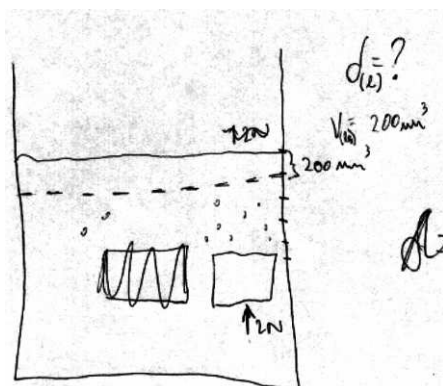


Fig. 1: Answer of a student to the problem stated in the text.

By sure, a task of this kind excludes motivation for physics. Formal teaching, and the problem is a typical example of it, has only success:

- If students have already a spectrum of everyday experiences which permit them to elaborate and to construct abstract concepts.
- If students have already developed a good level of logical-abstract thinking.

The question is how much a teacher can or must contribute to this process. To my opinion, the role of the teacher is very important, but the guidance should be done with care considering the ability and interest of the students. Informal teaching can be one way to this goal.

Starting from the students

A teacher can observe during a physics lesson, introducing an example from the everyday life, that some students are convinced they know the situation very well, others explain the same situation in a very different way, a third group is in doubt and part of the students have no idea, but they become curious.

One example with regard to buoyancy: the teacher asks “In your opinion, which egg sinks in the water: a fresh one, a hard-boiled egg or a one-week-old egg?”. One part of the students are very convinced that only the fresh egg sinks in the water, another part claims, also convinced, that all eggs float in the water.

Another example could be the interpretation how water from the earth reaches the flower in a plant: part of the students explain that the flowers absorb the water from the earth; another part explain that water goes to the flower via tin tubes.

It is very important for a teacher to know the opinions, ideas, the conceptions of the students. He/she must construct the own teaching based on this knowledge. Then he/she will be able to develop the knowledge and ability of the students.

The mental development in the adolescent phase is mainly influenced by three factors¹⁾:

1. An adolescent is critic, provocative: he/she wants to construct, to inquire, to communicate,
2. An adolescent is stimulated in a positive or negative way by groups,
3. An adolescent acquires everyday experiences in a total way, he/she wants to know and to discuss about all aspects of a situation.

Interdisciplinary days

Nature offers many topics which can be treated in an interdisciplinary way, also during a single school day. Stimulated by the discussion about eggs and buoyancy during a physics lesson I decided two years ago to organize an interdisciplinary day dedicated to eggs with the title “The Surprise Egg”. I proposed eight workshops to 40 students from 14 to 17 years old and to 8 teachers:

- *egg on internet*
- *cooking with eggs*
- *the egg in the bottle* (chemistry)
- *the shape of the egg* (mathematics)
- *which egg sinks?* (physics)
- *egg in the European traditions*
- *painting with eggs*
- *inside the egg* (biology)

The students decided to participate in the workshop following their own interest. In groups of 4-5 students, distributed in different corners in the school, students discussed, proposed and made activities, experiments, pictures, internet researches, cooked, videotaped, interviewed, composed songs....all coordinated by the teachers. At the end of the school day, each group presented the results of their work to the others. Materials, collected and selected, have been published.

At the request of my students and also of some parents I repeated this experience last year dedicating it to flowers. We entitled the day “We Need a Flower...” and students worked again in eight different workshops:

- *flower on the internet*
- *cooking with flowers,*
- *flowers are fractals* (mathematics)
- *capillarity and osmosis* (physics)

- *colors of flowers* (chemistry)
- *flowers in poetry and music*
- *flowers as symbols* (art)
- *flowers and health* (biology)

Impressions of the interdisciplinary days

Which egg sinks?

The discussion in the group of students started revisiting Archimedes' law. Students opened a fresh egg, a one-week old egg and a hard-boiled egg. The analysis convinced them that an egg is a non-homogeneous body. They delegated to the internet-group to find the theoretical explanation of buoyant force on non-homogeneous bodies²⁾.

They tried to construct a model of eggs floating in water (*Fig. 2, 3, 4*).



Fig. 2: A fresh egg, a one-week-old egg and a hard-boiled egg in water



Fig. 3: A fresh egg, a one-week-old egg and a hard-boiled egg in a solution of water and sugar



Fig. 4: Student determined the average density of a fresh egg.

The egg in the bottle

A hard-boiled egg without shell can slip into a bottle when one takes away the air in the bottle with a water pump. This was the central event of the day, all students circulated in the chemistry laboratory observing and discussing how and when the event will happen.

Chemistry of an egg shell

Another concrete result was to develop a method for measuring the quantity of CaCO_3 in the egg shell. At the end the group of students, coordinated by chemistry teacher, determined that in the shell of an egg the mass of CaCO_3 is 1,35 g which represents 75% of the whole mass of the shell.

Flowers are fractals

The math teacher proposed to a group of five students to open spring flowers: tulips, snow-drops, violets, narcissus, etc. They should reproduce them in the same dimensions on a millimeter paper and find geometrical figures. One of the students supported the group researching in the internet how fractals can help for understanding the flowers structure. For example, opening the tulip they found a succession of rotated equilateral triangles with sides in a ratio of 10:4:1 (Fig. 5)

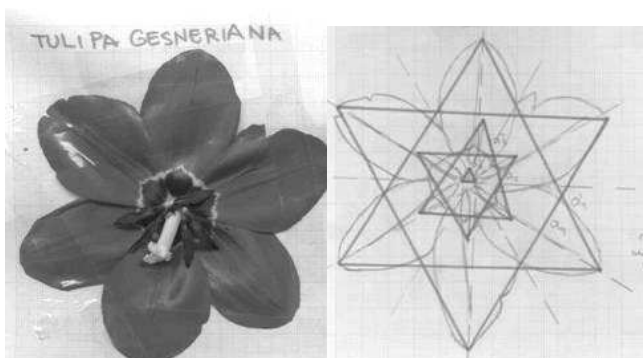


Fig. 5: Geometrical objects in a tulip

Capillarity and osmosis

The physics and biology teachers proposed to a group of students to investigate and reproduce the model of flower stalks for explaining in which way the water reaches the leaves of plants starting from roots. The students cut longitudinally stalks observing inside capillaries. In a glass with blue-colored water they put stalks and tubes with different diameters (Fig. 6). In an easy way they concluded that $h \sim 1/r$ where h is the height of water and r is the radius of the capillary / tube. In the flower stalk the colored water reached half the length of the stalk within a few minutes (Fig. 7)



Fig. 6: Experiments with tubes of different diameters.



Fig. 7: Colored water ascending a flower stalk.

An evaluation of the experiences

Proposing the program of these days we had in mind two aims:

1. with guided experiences to try to give the most complete explanation to well-known objects (egg, flower). The students should “feel” by the quantitative analysis how necessary and important scientific theories and scientific methods are.
2. give to students the possibility for investigation, following their own interest, collaborating in a dynamical, informal way with other students and with teachers.

Students responded very enthusiastically to these experiences. Collecting their impressions two aspects were underlined:

- social aspects, to be together with other students in a close, different way, and

- all things they have learned in such an active and complete way they will never forget.

We agreed with the colleagues that the two days showed:

- Learning by “discovering” is a learning for life
- Each student constructs his own way of learning because she/he decides what to do and how to interact with teachers and with other students
- A mixed group with students of different ages work better
- Students learn and are active when the level of socialization is very high

During the two days students were very curious and interactive. This kind of learning is not a usual one; this is informal learning where not only brain and logic are active but also and in first place emotions created by the surprise of discoveries.

I have had many occasions later to verify that the students' experiences made during the two interdisciplinary days remained and were used in different situations. For example, a month ago I asked one of the students who had investigated about the egg and buoyancy in which way it is possible to measure the volume of a coil. Without hesitation he said: "Putting it in the water and measuring the difference of volume it produces". Then he continued with a smile "Egg! I will never forget!" The student did not only keep in mind the example, he had made some abstraction and could apply it to a different situation.

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