

Teaching Natural Sciences in Basic Education

Héctor G. Riveros

Institute of Physics UNAM

Instituto de Física

Universidad Nacional Autónoma de México

México D.F. México

riveros@fisica.unam.mx

(Received 24.11.2019, Accepted 02.01.2020)

Abstract

The aims of teaching have evolved along with the society in which we live, from a teaching based in memory to a one that teaches to reason, in order to adapt to the accelerated rate of change imposed by the application of scientific discoveries in our society. We have a society in continuous learning, which requires the ability to reason in order to adapt quickly. We are defining quality in teaching as your ability to teach to reason. This definition covers all new approaches: competencies, student-centered teaching, flipped classroom, etc. Each subject of the program is a pretext to teach to deduce or to induce, which are the two types of reasoning known. The teacher decides on each topic if he deduces it from previous knowledge or induces it from a demonstration or experimental data.

INTRODUCTION

Education is a multidimensional process through which knowledge, values, customs and ways of acting are transmitted. Education not only occurs through the word, it is present in all our actions, feelings and attitudes. The teaching of Natural Sciences focuses on knowledge, although the behavior of teachers influences all aspects of the educational process, from now on we will only touch on the knowledge that we expect students to learn.

Education in The World

Education is the engine of a country's development. The results of the PISA Test are used to measure the education of the OECD countries, the countries with the best results are countries with reasonable development (PISA, 2012). Mexico is among the last places in this test that measures the reasoning abilities of the participating students. We are not making students competent to take advantage of the world we live in (Competencies, 2017).

Education in Mexico

In general, with notable exceptions, we continue educating like about 50 years ago; before computers and the Internet. The best grades are given to students with good memory, as national assessments use questions whose answers require memorizing. PISA questions require understanding and reasoning, for which they are not prepared. It is intended to solve the problem by giving computers to a few children in ages 11 and 12, without having programmed activities that require its use. The rational thing should be to start with computers in the bachelor's and high school degrees, rather than the basic.

In Mexico, The Ministry of Public Education SEP controls all stages of basic education. Establish curricula, write unique textbooks and apply assessments. The groups of experts who write these three stages tend to be different. The contents growth over time and there is consensus that they are excessive, but worldwide, they are all similar. The program of a given course is described in a few pages, so that different teachers can teach different courses, but fulfilling the same program. This is avoided, entrusting to a commission the writing of the single textbook. Approved textbooks for Natural Sciences are essentially informative, with interesting data. The PISA test shows the educational poverty of the books of the SEP, which in their prologue said (2010) “in the framework of the Comprehensive Reform of Basic Education, poses a new textbook approach that emphasizes work and the activities of the students for the development of the basic competencies for life and work”. The intention sounds very good, but the contents and evaluations of the SEP remain memoristic, they are not consistent with the previous sentence. Those of 2018-2019 do not mention the phrase, but the contents are basically the same (Books SEP Mexico, 2019).

If we accept that the approved programs are relevant, we can review those books topic by topic. A quality education contains topics that make the student competent in the application of his knowledge or that allow him to show how to reason. Topics that only give information,

we can leave them pending when we have defined the basic content. Having defined the topics we want to teach, we must write coherent assessments, which measure whether the student learned the desired reasoning. This is PISA type questions, which require understanding and reasoning. Writing these questions helps to decide the appropriate teaching strategies: demonstrations, experiments and audiovisual materials to induce knowledge or arguments to deduce it. This is the time to test the demonstrations and experiments that students will be asked for. It is reprehensible that students are asked for experiments that do not come out, because the authors did not test them. You cannot teach what is not known, but the SEP should go to experts in the field to ask for advice.

To write the questions for a given topic, it is when you should consult the teachers in practice. The questions should be much more than those used in an exam, to be used in national assessments. This implies that experts from the National Institute for Educational Evaluation INEE must participate in these stages of the preparation of textbooks. All teachers in the country have the right to know what they are going to ask their students and collaborate in their elaboration. In an evaluation a small sample of the question bank will be used, generating exams by means of a random number generator between questions considered equivalent in degree of difficulty.

Teaching to reason (Riveros, 2014) is a clearer objective, the subjects should be chosen as a pretext to teach to deduce or to induce, removing the subjects that do not lend themselves to reason. The excess of topics prevents quality in teaching. What matters is not the subject, it is how is taught; We must teach to generate knowledge. The Natural Sciences have themes that allow inducing reasoning and are taught from the 4th year of primary school. The teacher requires suggestions on how to present them so that they can induce reasoning in a mind that begins to reason. Reviewing the books of Natural Sciences of 4th, 5th and 6th grade in Physics topics we find examples of activities or experiments that can be done at home. We will now see examples of experiments for Natural Sciences.

Solubility Concepts

Liquids dissolve different substances, with difficulty. Water dissolves many substances. There are maximums in the amount of dissolved substance, and this can be recovered by evaporating the water used as a solvent. It can be used to separate soluble from insoluble substances. These theme properties generate the evaluations.

In the book of Natural Sciences of 5th grade, children are asked to build a dynamometer and see if tablespoons of salt, sugar, oil, alcohol and sand dissolve in half a glass of water or vinegar. They are informed that: "Solubility is the ability of a material to dissolve in another, for example, sugar and salt dissolve when mixed with water, so it seems that they disappear." As for the dynamometer they are asked to build it with a spring and calibrate it with known weights. The dynamometer described requires springs difficult to obtain and is not used at all. In real life we build instruments to use them in some project.

Proposal of experiments. Build a scale (dynamometer) to be used in solubility experiments. Table salt has a solubility of 36 g in 100 ml of water at room temperature. A dynamometer with a capacity of 50 g and a resolution of 1 g is enough. Thin rubber bands can be used as they withstand forces of more than 50 g.

Construction of the Dynamometer of rubber bands. Rubber bands 7-8 cm long and 2 mm wide and thick, stretch about 5 mm with a weight of 50 g. With 10 g they stretch 1 mm, but we want a sensitivity of 1 g; therefore, it is required to use 10 rubber bands in series, which can be easily tied. To calibrate the dynamometer, we can use clean water, if we have a container calibrated with 10 cc. The Mexican coins of 1 peso have a weight close to 4 grams and those of 10 pesos weigh 10.2 g. As a container for the objects to be weighed, a trimmed plastic bottle hung on three threads with a paper clip is used. The length of the rubber bands is measured with a rule. By adding 1 coin at a time, the calibration line shown in Figure 1 was obtained.

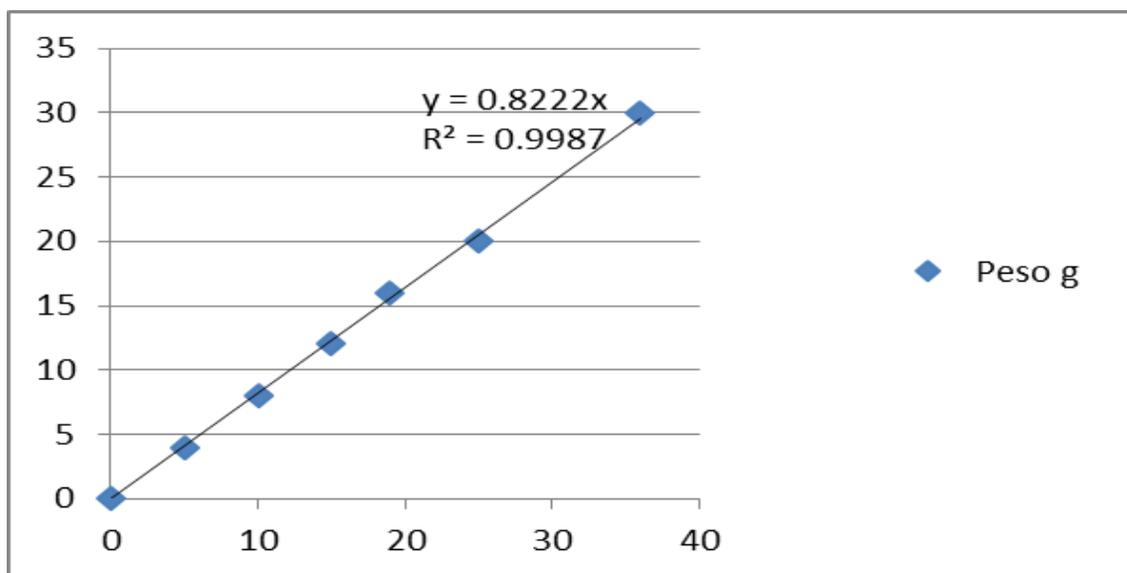


Figure 1. Rubber bands data, horizontal edge elongation in mm.

Problem 1. Find out how much salt can be dissolved in 50 cc of water.

Materials: Flat bottom light container. Diameter of 8-10 cm so that it has a lot of area to evaporate. It can be disposable container of yoghurt or cream.

Water 50 cc, Salt 20 g in 4 packs of 5 g, Glass for dissolving salt, Spoon

Procedure: 50 cc of water is placed in the glass. Add the first 5 g of salt and stir with the spoon until they disappear. Another 5 g are added that also disappear. Another 5 g are added that also disappear. By adding the last 5 g of salt it is no longer possible to disappear, even if the solution is stirred. The water dissolved the maximum amount of salt that it could at the temperature of the water.

How can we measure how much salt is dissolved in the solution?

Let the glass rest with the salt dissolved for 5 minutes, so that the excess of undissolved salt settles at the bottom of the glass. Weigh the flat bottom container on the rubber bands. In the flat-bottomed container, we empty without stirring the solution, without taking any of the salt in the bottom. Weigh the container with the recovered solution. We leave the container half covered, so that it does not fall dust and evaporate in 1 or 2 days. When evaporating, only the water comes out as steam, the salt precipitates from the solution in the form of crystals. The slower the evaporation, the more beautiful the salt crystals recovered. Weighing the dry container with salt, we can calculate the weight of the evaporated water and the weight of the dissolved salt. Water at room temperature dissolves about 0.36 g of salt per gram of water.

Problem 2. Estimate which brand of chicken broth cubes have more salt

Materials: The same as problem 1

Chicken broth cube or 5 grams of chicken broth powder

A coffee filter or a compact cloth to filter the solution.

Chicken broth contains insoluble and water-soluble substances. To separate them, the chicken broth is dissolved in 30 cc of water in the dissolving glass. It can be heated to 40 ° C to facilitate dissolution. First, the filter or cloth and the flat bottom container are weighed. The filtered

solution contains soluble materials, including table salt. The filter can dry to weigh how much insoluble matter the chicken broth contains. The flat bottom vessel is weighed with the solution and the water is allowed to evaporate for one or two days. The slower the evaporation, the larger the white crystals of salt will be. Dark green substances are the nutritional components of chicken broth. Compare your results with those who used other brands.

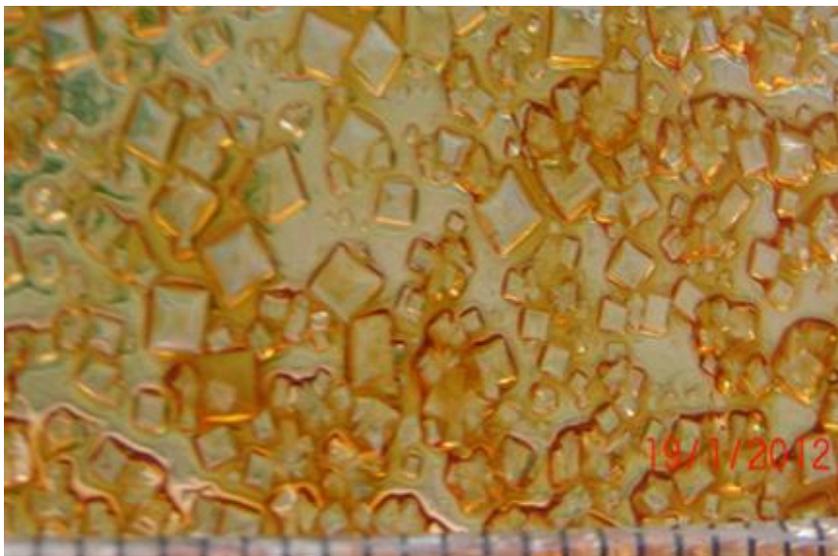


Figure 2. Table salt crystallites obtained by evaporating cube dissolved chicken broth. Black stripes are millimeters of a ruler.

In the book of Natural Sciences of 5th grade is mentioned the word Metabolism and the problems of obesity, they are told to avoid consuming soda and fried foods, so as not to suffer from obesity. This information is incomplete and does not allow reflection on how to control your weight. What is the reasoning linked to lack or excess weight? Weight is the result of a balance between metabolism (the energy dissipated by the cells of the human body) and the energy consumed in food. If you consume foods with more calories than those dissipated, you gain weight, and lose weight otherwise. This reasoning tells the child what to do to gain or lose weight, but it is not included in the Natural Science book.

The most serious thing that I have found by reviewing the book of Natural Sciences of 5th grade is the subject of drug addiction. Drug use is a growing problem in almost everyone. Mexico in recent years presents 50 thousand dead's related to its consumption. Despite this, the

Secretary of Public Education SEP presents a graph with the increasing consumption of inhalants, marijuana and cocaine. They said to the students:

With the direction of your teacher or teacher, carefully observe the graph presented as a group and then reflect on the following questions.

Which substance was consumed the most in 2004? What happened to cocaine use between 1998 and 2004? Which substance increased consumption more since 1998? What substance was consumed less in 2004 than in 1998?

In teams and based on the information analyzed, reflect on the factors that affect drug use. Discuss it with the rest of the group and come to a general conclusion.

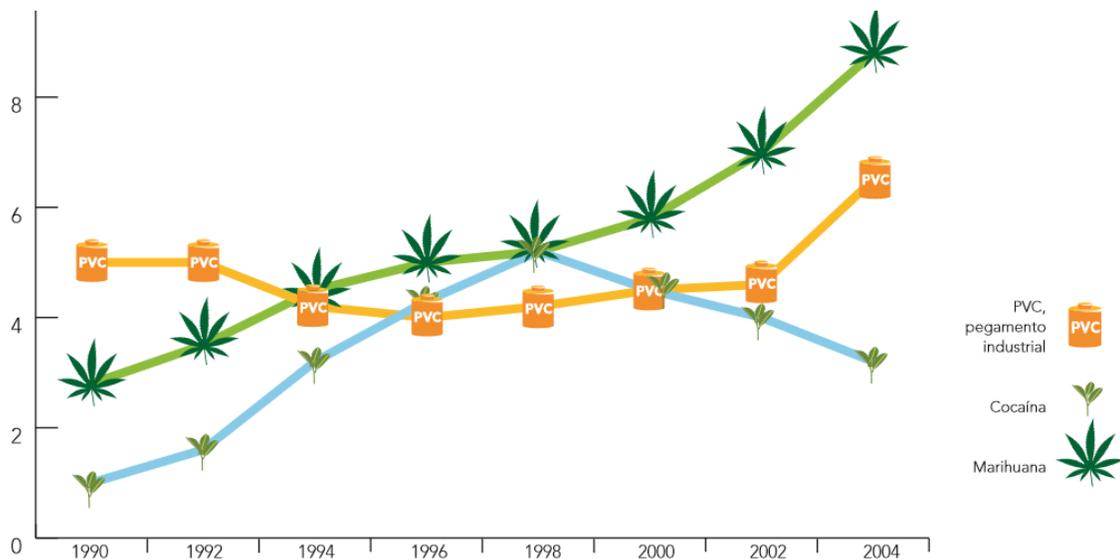


Figure 3. Drug consumption

What can a student in 5th grade say? He or she will be curious about those things whose consumption grows. The child believes that they are his classmates, but the data are from middle and upper secondary students, not primary school; the SEP cheats them. The text does not mention the dangers of these drugs, nor their consequences. The SEP has been asked to change this figure to another in which the increasing number of deaths due to overdose is shown. The new graph should suggest that drugs are not good.

When looking for data on those killed by overdoses in Mexico, I found information on the 15 countries that make up the European Union. I chose data from 4 of them with the

maximum number of deaths and two with the minimum number; with them the following graph is constructed:

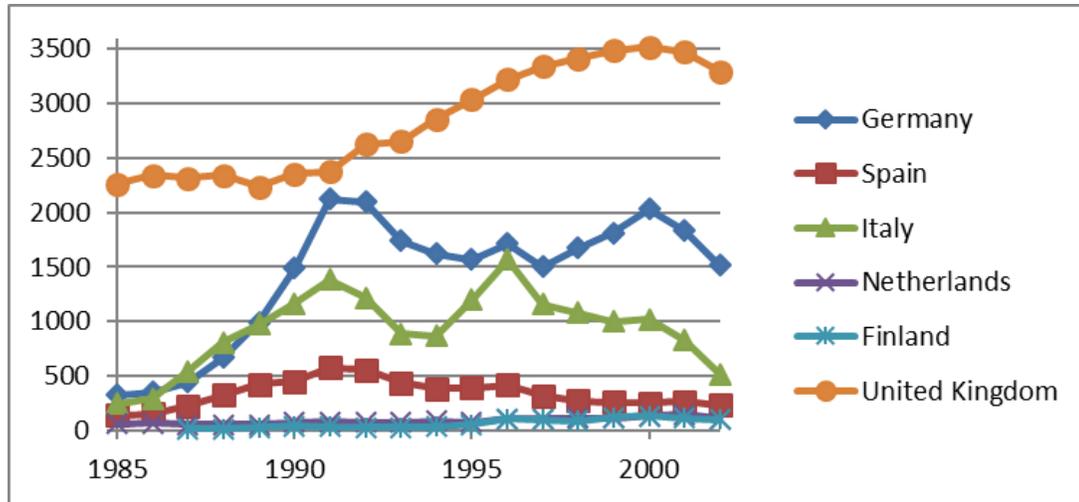


Figure 4. Dead's drug related

We can note that the Netherlands and Finland have the least deaths and it is necessary to convince the SEP of the convenience of using it instead of the one that encourages drug use. That drugs kill is a better message for children, than just the increase in consumption. The 2019 edition has already removed the graph of drug use, after 8 years of asking for it.

SUMMARY

The Natural Sciences books of the SEP have irrelevant evaluations, they do not verify that the student understood the subject, they only measure their memory. The books for the teacher do not suggest questions, they do not even tell you the expected results in the suggested experiments, nor the most frequent mistakes. They give bibliography that the teacher does not have time to read. The Link test has errors and basically measures memory. The PISA test that measures the "competence" of the students, has very well-redacted reagents. To diagnose education in Mexico, the PISA test is enough. To diagnose each student, the PISA test can be extended to all students. The SEP would achieve the evolution of education, if it changes the National Assessments to PISA type reagents; If PISA can, we can too. The teacher wants his students to pass, which would force him to change his teaching methods. The student wants to pass the exams which would force him to change his study methods.

REFERENCES

- Books SEP Mexico. (2019). Bienvenido al Catálogo de libros de educación básica. Ciclo Escolar 2019 – 2020. Retrieved from <https://libros.conaliteg.gob.mx>
- Competencies. (2017). Competencies Learning Competencies or teaching to reason, using Physics. Retrieved from <https://youtu.be/AjPUqUgOTI4>
- PISA. (2012). Retrieved from <https://www.inee.edu.mx/wp-content/uploads/2018/12/PISA-2012-Resumen.pdf>
- Riveros, H. G. (2014). Teaching to Reason. *European Journal of Physics Education*, 5(4), 54-59.