

“What Is the Wick in the Candle For?” – An Example of the Methodological Sequence in the “Eureka” Project

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1. Introduction

The main aim of the Heureka (“Heureka” means “Eureka” in English) project is to improve physics education in the Czech Republic. Its title suggests the heuristic method of teaching. The Heureka project started in 1991, when several teachers looked for a way of teaching physics in a more interesting and in the same time more effective way. We use the term “Heureka” in Czech to characterize some important features of our approach to teaching and learning.

It does not mean that Heureka is limited to the old “learning by discovering” approach (which is sometimes criticised for ignoring pupils’ preconcepts, the context of learning etc.).

It would be fashionable to claim that Heureka is based on constructivism, “social constructivism” or some such. Surely, there are many common points. But, to be fair, it must be said that the “principles of the Heureka approach” were created by teachers, who were at that time not aware of the latest trends in education in Western countries. Maybe it is sad - but it is interesting to see how the “principles of Heureka” resonate with many ideas and recommendations resulting from these trends and from the area of physics education research.

In the above, it was said that the principles of Heureka were “created”. It would be more appropriate to say that these principles emerged. They arose from the work of several teachers and other people deeply perceiving the need to improve the teaching of physics. This work was intensive and lasted for years.

At first the Heureka project concentrated on physics education for the age group 12-15. Now it covers a much broader scope. It remains a project for both pupils and students at schools and future teachers. Nowadays it is mainly concentrated on continuing education of physics teachers.

The Heureka project is also an example of cooperation between teachers at schools, future teachers, and teachers from the University.

2. Some basic principles of the Heureka project

Why might the Heureka project be interesting for people from other countries?

- It started “from below”, without any official support.
- Its basic principles are in agreement with many modern trends in physics education worldwide, in spite of the fact that the authors had at that time very little information

about those trends (at the beginning of the 90's it was very hard to obtain foreign pedagogical literature in the Czech Republic for the teachers).

Several of these principles are:

- A high rate of student/teacher interaction.
- An inquiry-based approach to teaching.
- Mistakes are normal and an important part of the learning process.
- The criterion of truth is reality, not the words of the teacher.
- The starting point of education is a question.
- The specific physical terms are defined at the end, as a result of observations.
- We start from things that children know from everyday life.

3. Seminars for teachers

We use these principles in teaching physics not only at school, but also at seminars for teachers and future teachers. We organize several types of seminars (both for new participants and for more experienced teachers) and also an annual conference “The Heureka Workshops” for participants from all types of seminars which is open to teachers both in the Czech Republic and from abroad.

The main characteristics of the seminars for teachers are:

- All seminars are completely voluntary; participants obtain no advancement or benefits at their schools. Their only rewards are their own experiences and the teaching methods, plans of lectures, physics tasks and themes of lab work they obtain during the seminars.
- All seminars are free of charge.
- Seminars of our project take place at a school, so they are very informal. We offer “lodging excluding meals” - participants sleep in their sleeping-bags in classrooms and they have to bring meals with them. In spite of these conditions we have almost 100 active participants.

4. Example of the methodological sequence

As an example of the method we offer you a “scenario” of the first physics lesson in the 6th class of a junior secondary school in the Czech Republic (children about 12 years old) – the topic is *Basic properties of the three states of matter*. The material is aimed at teachers who are working in the Heureka project. Although it is written as a lesson plan, it is vital that each single lesson take shape from the children, their reactions, ideas etc. This material only helps the teacher to lead the children to search and discover. (In the following text the letter T shows the speech of a teacher, the letter P shows an expected answer of a pupil.)

Physical phenomena studied:

Solid, liquid, and fluid materials, their properties and comparison

Required instruments:

candles, matches, wooden skewer, lead in a can, steel screw, gas burner, laboratory assembly and a grating (over the burner), 2 cans, ice, water, blackened bulb, 2 bigger beakers (1 litre volume), transparent syringe, piece of tinfoil, lighter refill gas (butane or propane-butane) in a container that can spray

First part of the lesson

Place a candle, a can containing lead and a piece of ice on the table.

T: What is on my table?

P: A piece of ice.

P: A candle.

P: A can with some metal

There are more possible answers (tin for example). It is necessary to realize that students are not capable of distinguishing various metals. The teacher has to accept that it could be any of these metals and then specify that it is lead.

T: Yes, you're right. Tell me what properties are common and what properties are different for those materials.

Write the children's ideas on the blackboard. Use their language; don't rewrite them to the "right physical terminology".

T: Now we are going to play a bit. Watch me.

Burn the candle and leave it burning for a while, to let the wax melt. In the meantime light the gas burner and start heating the lead.

T: What do you see?

P: The candle is burning.

T: That's true. However, now watch the wax.

P: It flows.

T: The lead has also warmed up, come and look at it.

T: Can a screw swim?

P: No.

T: Well, look.

Put the screw onto the molten lead. Using the skewer you can show the students that even after submerging the screw returns to back to surface.

P: The lead is flowing as well.

P: The screw is swimming on the lead.

T: And now we will think about this piece of ice. Could it also flow?

P: Of course, if we warmed it up it would become water and flow.

Warm up a piece of ice in the beaker. Wait until it melts and becomes water. Pour it out of the can to show it flows. Put the rest of the ice into one can and hold an empty can in your other hand.

T: Now I've got ice in this can. How can I move it into the other can?

P: I will dump it there.

T: Could we dump the solid wax or the piece of lead the same way?

P: Yes, we can.

T: Would the shape of the dumped piece change?

P: No.

T: And what if I fill the can with water. How could I get the water into the other can?

P: The same way.

T: Please come here and show us, how you would do that.

Let the pupil a few times pour the water from one can to another at first with open eyes and after with closed eyes. If someone is really doing badly, it may be necessary to advise him to imagine, how the water is pouring.

In the same manner show, how the liquid wax can be poured (right from the candle into the can) and tell the pupils, that the lead could be poured as well if it is liquid.

T: Here we have a syringe that can be filled with water. How is it possible to ensure that there is water inside?

P: I can see that.

T: Yes. Is there any other way?

P: I can splash it out.

T: True. Has anyone got any other idea?

P: If I block the syringe with my finger, I won't be able to press the piston.

(It is crucial to lead the pupils to find out this answer themselves, because this method is going to be used in following lessons.)

T: Yes, that's true. An appropriate syringe could be filled with molten wax and lead.

Ask pupils about the properties of liquid materials and write them on the blackboard the same way as you wrote the properties of solid materials.

T: We will now write down what we have found out about water, lead and wax.

- Water
 - Is hard
 - Flows
- Lead
 - Is hard
 - Flows
- Wax

- Is hard
- Flows

The terms “solid”, “liquid” and “fluid” have not been used before. We are creating them now by experience. We write various children’s words to describe the state of material because these are exactly the words that the children have used.

T: What more can we do with the water?

Lead the pupils to notice, that water can be “changed” into vapour.

Put a beaker with water above the burner and start heating it. Upon the top of first beaker hold the other one. Its bottom will quickly fog up.

T: Well, we can now list a third quality for the water.

- Water
 - Is hard
 - Flows
 - Creates vapour

T: I will show you some magic.

Prepare a burning skewer. Blow out the candle with a sharp breath and insert the skewer into the rising smoke. The wax vapour will quickly ignite and will set the wick on fire. Let the pupils try it again themselves at their desks. Demand a description of the observed phenomenon before advancing further.

T: Try to describe how to do this experiment successfully.

P: It is necessary to insert the skewer into the smoke.

T: Isn’t it strange that the smoke burns so well? Why do we release the smoke from the stove to the chimney and we don’t convey it back to the stove?

P: Maybe it is not the smoke, but I don’t know what it is.

T: I can help you. Look at this experiment.

Put a piece of wax in a small bowl made from tinfoil. Hold the tinfoil in pliers and put over the burning candle. After a while the wax warms up and some white smoke starts to rise from it. This smoke is the wax vapour and can be easily lit with a burning skewer.

T: Are you able to explain this experiment?

Let the pupils develop, consult and defend their ideas.

T: So we see that the wax vapour exists. Could you now explain the previous experiment when we burnt the candle without touching the wick?

P: Yes, we burnt the wax vapour. We can add this item the list of properties for wax.

- Wax
 - Is hard
 - Flows
 - Creates vapour

T: We know that both water vapour and wax vapour exist. Do you think that there is also any lead vapour?

P: Maybe yes. I have heard that exhaust fumes are dangerous due to lead vapour.

T: Yes, you are right. It exists, but I'm not able to demonstrate its existence here. However, examine this bulb. Why do you think it is so black?

Show the blackened bulb (usually a burned-out one). Lead the pupils to the conclusion, that the fibre (made of metal) evaporates and that the "black cover" is this vapour which has condensed.

T: Now we can complete our table

- Lead
 - Is hard
 - Flows
 - Creates vapour

Second part of the lesson

In your office prepare a bigger glass beaker. Inside the beaker inject some butane (from the lighter refill). Cover the beaker, e.g. with a sheet of paper, and bring it into the class as if it was some really mysterious stuff.

T: I have brought a beaker. What do you think, does it contain anything?

P: The air.

T: May be but we are not interested in the air now. Think about it – is it possible that the beaker contains anything else? How can we find out?

Let them begin a discussion about the methods. Pupils can figure out interesting ways to find out what is inside. The idea to warm up the beaker will surely appear.

T: Yes, that would be possible, but it's better not to try. It will be quite enough to insert a burning skewer inside.

Do the experiment. It is going to be very surprising for the pupils.

T: Now we can make a conclusion that something was inside the beaker. I will show you, how I put it there.

In front of the children inject a small amount of the propane inside the beaker again.

T: Can we pour this "something" into the other beaker? What do you think?

Check that there isn't propane in the second beaker with a burning skewer. Then pour the gas from one beaker to another. Prove that you have poured the gas with the skewer (it is necessary to check both beakers). Ask one of your students to repeat the experiment. (Be careful about pouring the gas out.)

Point out that in the beginning the pupils have tried pouring water with closed eyes. Even though their eyes are open now, they still can't see what is being poured. In physics we often work with things that exist even though they cannot be seen.

Homework:

At home try to ignite a candle from the biggest distance as possible.

(Remind them to take care when working with fire)

5. Continuation of this methodological sequence

In the next lesson the teacher brings the same beaker filled with carbon dioxide. To pupils' surprise the burning skewer goes out. The teacher shows them how he filled the beaker and tells them what gas is inside. Then the pupils find out some properties of this gas and try to pour it into the other beaker.

At the end of this sequence the teacher comes with the same beaker again and the students now say the burning skewer "doesn't do anything" (e.g. it continues to burn) inside it. The teacher discusses with pupils what gas could be there and then tells them that there is the air in the beaker.

It is interesting to ask pupils why they spent so much time studying butane and carbon dioxide when those gases will not be used later and only the air will be examined. Pupils are usually able to say that air is common; it is interesting only in comparison with other gases which have different properties.

6. Conclusion

We decided to show you a small part of the methodological sequence, which is used in the Heureka project, as an inspiration for your own teaching.

When presenting Heureka at conferences, we usually invite participants to visit our annual conference of the project. We know that for people from Latin America it is not very simple to fly to the Czech Republic for a weekend. In spite of the distance we are inviting you! If you have a possibility to come at the beginning of the October either this year or some following year, let us know. You are welcome.

More information about the Heureka project can be found on our website [1].

The experience from the annual conference written by colleagues from Slovenia and Great Britain is described in [2] and [3].

7. References

[1] <http://kdf.mff.cuni.cz/heureka/en/>

[2] Planinsic, G. (2006). Teachers share experiment know-how. *Physics Education* 41, No.1, 7-8

[3] Swinbank, E. (2005). Reporting from a mattress in Nachod. *Physics Education* 40, No.1, p. 5