

Heureka: Hands- and Minds-on Physics at School

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Abstract

Heureka is a project started ‘from bottom-up’ by several Czech physics teachers about 12 years ago – and it not only still lives but recently evolves and gains more influence. A small part of lecture “according to Heureka” demonstrated at GIREP conference (with the audience playing the role of pupils) is shortly described here together with some comments to present the main aims of the project.

Introduction

“Heureka” is an approach to teaching physics developed rather independently by a few Czech teachers. (See [1], [2].) It gradually evolved into a project involving more participants, comprising number of weekend seminars etc. ([3]). Still, the main reason why it may be interesting is that it seems to work in a classroom.

1 How we try to teach physics in Heureka project

Are the principles according which we try to teach, the “Heureka principles”, something completely different from what one can find in modern approaches to physics education? Certainly not. Some of them seem quite obvious – but they still differ considerably from a “classical approach” used at many (and maybe majority of) classrooms.

When teaching we apply e.g. following principles:

- Teacher should not just “tell physics” to his/her pupils (perhaps with demonstrational experiments). Learning must be an active process, pupils themselves, with teacher’s help, should discover as much as possible.
- “An error is normal”. In seeking the truth pupils should guess, suggest hypothesis etc. – so it is natural that some of them are false. (And they should not be laughed at. A “safe environment” is necessary for good active learning.)
- Teaching and learning begins from what children already know (from common life etc.). The starting point is a question.
- It is not a teacher who decides what is true but the reality. (Sometimes a teacher provokes by arguing for wrong hypothesis – and the experiment is what decides.)

- Teacher treats pupils as partners. On the other hand, it means that pupils themselves are to great extent responsible for their education.

These are not all basic principles: e.g. intensive communication between pupils and a teacher is also very important. But this short description could hardly express more than just a “flavor” of our approach. And, of course, no principles act by themselves and in isolation. It is better to look at a teaching of some concrete topic.

2 Example: an introduction to solids, liquids and gases

It is not possible to present here even a fragment of a real physics lesson. But we try to describe few, perhaps interesting, points from an introductory lesson in 6th class (i.e. for the pupils 12 years old) where physics begins as a separate subject.

Pupils are at first asked to mention the properties of solids, liquids and gases they know. They say for example a certain shape etc. A teacher writes down the properties *exactly as pupils formulate them*, without correcting their formulations to “right physics terms”. And immediately he or she asks pupils: “Have solids this property? And what about liquids? ...” Answers result from the work of the whole class. Everybody can give examples and counterexamples, opinions are discussed... but of course all this is a guided discussion. The final result is a table of general properties of solids, liquids and gases – but the table created basically by pupils themselves, not the information “put on them” by the authority of a teacher or a textbook.

Then the possibility to change solids to liquids and even to gases is discussed. And not only discussed. The wax is an ideal model – it melts in a burning candle and if we put out the candle we can see a wax “vapor” above a wick. And, moreover, we can light the candle again at the distance of several centimeters by lighting up the “vapor”.

It is not only the teacher who (as a wizard) lights a candle at a distance. All pupils now get their candles and do their own experiments. And they are encouraged to show them at home to their parents.

And then it goes on and on. Again with some special points. Let us mention just one:

When pouring water from one glass to another, pupils try to do it also with closed eyes. It may seem strange but

it is a good training for later pouring of gases. (You pour something you cannot see. In a sense, it is more far-reaching than it seems at first sight: in physics you often work with something you cannot see...)

3 Is it just playing and fun?

Sometimes we meet an opinion that “modern methods” of teaching physics lead to worse knowledge. That they are less demanding, take more time etc. That the “real work” is substituted by “just play and fun”.

The above mentioned principle “an error is normal” would probably persuade the proponents of such opinions that we are enemies of a “proper education”. But it would be a misunderstanding.

“An error is normal” does not mean that errors and wrong answers are tolerated in final tests. And, in fact, some test questions answered by 12-15 years old pupils taught “according to Heureka” may sometimes cause difficulties even to much older students. The reason is clear: these are not “standard textbook question” easily answered by putting few numbers into a formula.

Consider few examples of interesting questions:

- A light ray comes from general direction to a general point of a thin lens. To which direction will it refract?
- The same *volumes* of iron and lead are hanging on the other sides of a lever so that the lever is balanced. We will dip both weights into water. Will it destroy the balance?
- An old sailor tells that once he sat at a chair several meters *below* the surface of the sea, smoked the pipe and fished with a fishhook. Could he tell the truth?

We probably need not stress that all answers should be explained. To answer just “yes” or “no” is not sufficient. And the shortage of space prevents to present here more open “voluntary problems” pupils can solve.

An experience shows that “Heureka approach” is rather more demanding than “classical one”. (It requires really to think.) But, no wonder, it is more rewarding. And later results of pupils taught in this style do not show that their education would have been worse.

4 More than ‘learning by discovering’

Although its name “Heureka” reminds to “heuristic method”, it is hopefully clear that it is more in it than just an old one “learning by discovering” approach.

“Heureka approach” stresses that it is necessary to start from preliminary knowledge of pupils – in an agreement with a constructivist approach. A communication between pupils and a teacher makes very important part of teaching “according to Heureka” and an intense interaction between pupils is a natural part of a number of classroom activities – in clear connection with social constructivism. Connections to approaches stressing the

role of language can be also easily found not to mention a connection to a “context-based approach”.

Of course, it would be ridiculous to pretend that Czech teachers independently discovered all important modern trends in science education. But neither it is so that Heureka is just eclectic mixture of “trendy ideas” or even just “fashionable words”. Rather it is an example how reflective teachers can really independently arrive at methods and ideas which have some interesting common points with current trends in science and physics education. (To an optimist this may mean an encouraging indication that the ways we all try to follow are reasonable. Well, at least they are similar. :-)

5 Related activities

Heureka is a project aimed not only at pupils but also at teachers. It seems to have succeeded in creating a small but vivid informal network connecting physics teachers at schools, future teachers and people from university. This aspect of the project and some other related activities (summer math-phys camps etc.) are mentioned in an accompanying article [3] and also at new English web pages [4] of the project.

Conclusions

Learning physics “according to Heureka” is appreciated by pupils and students and their results seem to be encouraging. Much of what we do is of course not earthshakingly new and may be perceived as quite natural. But perhaps some details and ideas may provide an inspiration not only to several tens of Czech and Slovak teachers already involved.

In case you would like to know more and/or to offer your own comments and experiences, let us know. We try to evolve the project further and so it is natural we look for new contacts, opinions and ideas. We will look forward to yours ones...

References

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- [3] KOUDELKOVÁ I., DVOŘÁK L.: Heureka Project – for both Pupils and Teachers. In: *this proceedings*.
- [4] <http://kdf.mff.cuni.cz/Heureka/en>