Learning To Teach Physics from Lessons of Maria Sklodowska-Curie

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You have to be persistent
and believe that you are able
to do something well…
Maria Skłodowska-Curie

Introduction

We have just entered 21st century, but our today school students will be professionally most active not before 40's of this century. Thus, it is reasonably to ask – what kind of knowledge and skills they will need for their life and work? The revolutionary and quick recent development of educational technology makes difficulties in answering this question precisely. However, it seems to us that such key skills and competencies as: abilities to learn, to collect and evaluate information, to plan own work, to solve problems in a creative way, to communicate and work with others, as well as to use Information and Communication Technology (ICT) effectively will be of a great value. Taking this into account, at present schools, we have to apply active methods of teaching, which are necessary for development of the above skills.

Active methods of teaching

There are many various active methods commonly used in education, including also physics education [1-8]. Let us list for example:

- brainstorming,
- hands-on experiments and demonstrations in the real time,
- using history of science and historical experiments,
- drawing and designing the map of concepts,
- educational games,
- using of everyday and low-cost materials and toys,
- team discussions and debates,
- questioning and problem solving,
- project method (planning, execution and evaluation of project),
- writing reports and papers,
- filling in forms, questionnaires and worksheets,
- designing the list of questions,
- role playing and drama,
- analysis, case studies,
- working with the text resources,
- public lectures accompanied by on-line demonstrations,
- designing the plan of actions,
- designing and performing presentations,

- doing the real things,
- using ICT resources for learning.

We have to remember that in active teaching, the teacher should be a guide, but students should solve the problems themselves, being creative and open-minded. To make students' learning much more effective, teaching should engage their different senses and emotions and prepare them to the team work. Furthermore, active teaching requires: good organization (scenario of lesson, time table and suitable materials), friendly atmosphere, adequate competencies of teacher (subject knowledge, methodological and interpersonal experience), high motivation of students (they know and accept aims, are interested in the topic and have sense of responsibility for their own learning).

The described above active teaching methods according to the Dale's Cone of Experience (Fig. 1) has many advantages and is often advised, especially by the physics educators, because it allows to understand better the difficult physics concepts and in this way to avoid the most common misconceptions.

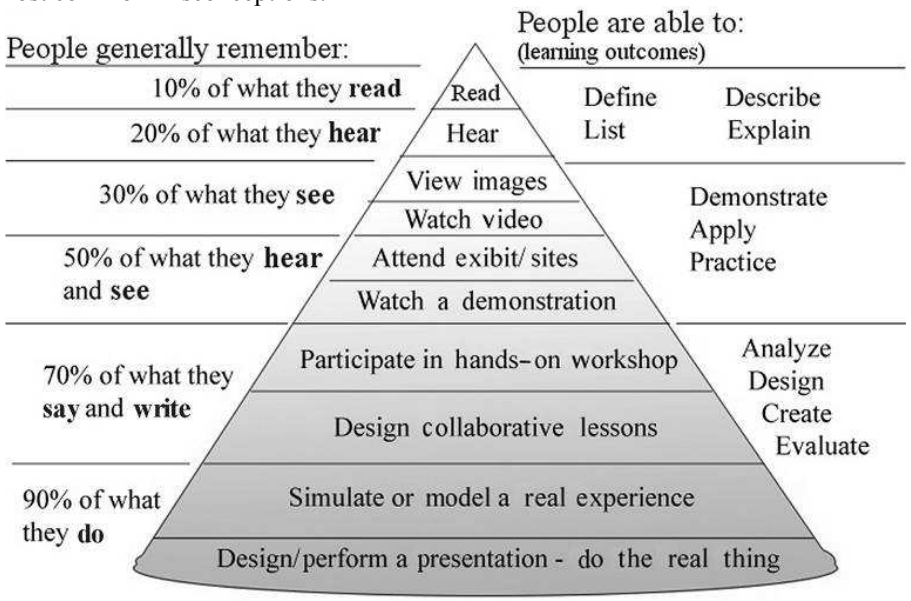

Fig. 1: Dale's Cone of Experience

Original and novel physics lessons of Maria Skłodowska-Curie

Maria Skłodowska was born in Warsaw in 1867. In 1876 her mother died. In 1877 she was attending private school of Madame Sikorska. During the years 1878 – 1883 she learnt at gymnasium and in years 1891 – 1894 she studied at Sorbonne University, obtaining two BSc: in physics and in mathematics. In 1895 she married Pierre Curie and they together accompanied Henri Becquerel in investigations of radioactivity. In 1898 they discovered, for example, two radioactive elements: polonium (named such in tribute to Poland) and radium, what was awarded in 1903 by the Nobel Prize in physics. The Curies had two daughters (Irene and Eve), but unfortunately, Pierre tragically died in 1906. Maria was continuing the hard work on radioactivity (Fig. 2.), trying to exhale of pure radium from uranium ore. In 1910 she got one decigram of radium chloride, and in the next year she obtained for that Nobel Prize in chemistry.

Fig. 2: Maria Skłodowska-Curie in her research laboratory.

It is worth to notice, that despite being so great and famous scientist Maria Skłodowska-Curie found also time for teaching physics at the elementary level.
To celebrate 100th anniversary of Maria Skłodowska-Curie Nobel Prize for investigation of radioactivity phenomenon in 2003, the unexpected book on: *Leçons de Marie Curie* has been edited in France [9] and translated into Polish.
These lessons have taken place in 1907-1908 in Paris. Maria Skłodowska-Curie created an unusual, private school for pupils 10-12 years old (one of them was Isabelle Chavannes - the author of notes of Mrs Curie physics lessons). The lessons were given by the members of Company of Scientists for Experimental Teaching (created by Maria Skłodowska-Curie in 1907): Maria Curie was teaching physics, Jean Perrin – chemistry, Paul Langevin – mathematics, Henri Mouton – science, Henrietta Perrin – French and history, Alice Chavannes – English, German and geography, Jean Magrou – drawing.
In the picture below (Fig.3) you can see the example of original drawing by Isabelle Chavannes, describing physics experiments with the air and vacuum.

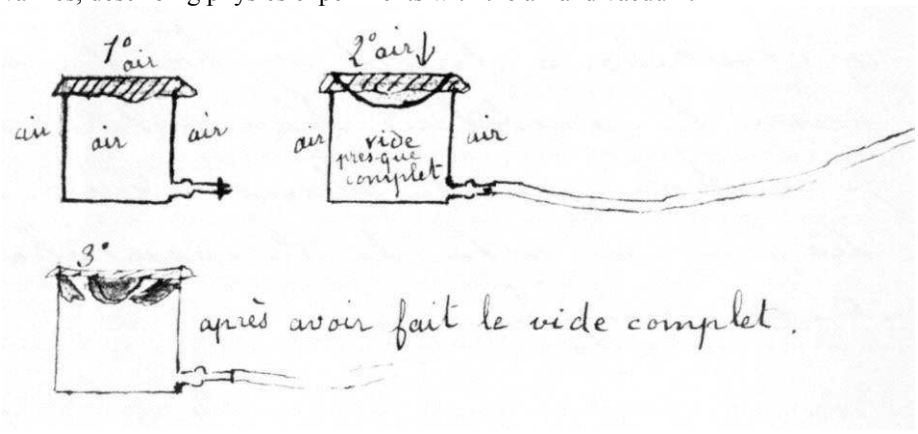

Fig. 3: The original drawing of Isabelle Chavannes showing 3 stages of experiment with destroying the film of gum on the top of vacuum tube, taken from [9].

The original and novel in teaching method in that experimental school of Marie Curie was:

- not verbal teaching,
- learning from nature, demonstration of exciting science hands-on experiments, using low-cost materials, explained by the great scientists,
- activity of students by doing individual, hands-on investigations,
- lively discussions (brainstorming) with the use of simple and understandable language,
- acquiring valuable social skills through personal examples of teacher genius: hard-working, persistence, honesty, sensitivity for needs of others, etc.

As this method of teaching was extraordinary for that time, there was a strong opposition in the society – not all accepted experimental and active learning. For example, one of the journalists wrote: "These persons, who even can't read fluently can make any kind of experiments, construct equipment and try to perform chemical reactions! Sorbonne University and building at Cuvier Street didn't blow up yet, but don't loose a hope!" Despite this the most of students of that school were succeed in science. For example: Irena Curie-Joliot got Nobel Prize in 1935 for discovery of artificial radioactivity, Francis Perrin was outstanding nuclear physicist, member of French Academy of Science, Andre and Jean Langevin were nuclear physicists, Isabelle Chavannes was chemistry engineer, what was very rare for women in that time.

Reconstruction of Maria Skłodowska-Curie lessons by role-playing of pupils

Having not so many informal settings for teaching and learning science out of school as some other countries have, we used opportunity of Science Festival to present the original Maria Skłodowska-Curie physics lessons to the public, including science teachers and students. Students of one Torun secondary school were the actors playing the roles of Marie Skłodowska-Curie's students: Aline and Francis Perrin, Irène Curie, Jean and André Langevin, Pierre, Etienne and Mathieu Hadamard, Paula Magrou, Marguerite and Isabelle Chavannes, André Mounton. These actors, worn the costumes from the beginning of 20 century and performed the historical lessons of physics: *Vacuum and the air*, *Does air has weight?*, *How water reaches tap?*, *Investigation of density of solid bodies*, *Checking the Archimedes law*, *Why ships do not sink?*, *Why oil spheres do not always flow on the fluid surface?*

The content of the above lessons consist of the following selected experiments:

- *Vacuum and the air*: water replacing air in the gum container, students suck water into tubes, principle of syringe work, air in the pig blister, film of gum on the top of vacuum tube (Fig. 3.), balloon in the vacuum chamber, the Magdeburg hemispheres.
- *Does air has weight?*: weighting of empty butt and with the air, weight of air calculation.
- *How water reaches tap?:* delivery of water to lower places, pumping water to higher places.
- *Investigation of density of solid bodies*: evaluation of Pb, Fe and wood cubes densities, measurement of density of solids using overflow dish (Fig. 4.).
- *Checking the Archimedes law*: floating and sinking bodies.
- *Why ships do not sink?:* empty butt is floating, butt with water can float, butt with metallic parts also can float but butt sinks if its weight is big enough.

- *Why oil spheres do not always flow on the fluid surface?:* oil and water in a cylinder, oil and ethanol in the same cylinder, oil spheres float in the mixture of water and ethanol (Fig. 5.).

Fig. 4: Pierre Hadamard is performing experiment using overflow dish, colleagues are observing.

Fig. 5: Maria Curie is showing how spheres of oil float in mixture of water and ethanol

We would like to add, that willing to play the roles of Maria Skłodowska-Curie's students was so many, that we decided to organise two complete groups of actors. We did not have also any gender problems – even more girls were active.

Is it the way to communicate physics to the public?

Some science subjects, especially physics and chemistry belong to the least preferred subjects by students at school. In the last time in many countries of the world we observe a decline in the number of students, willing to continue physics education at higher level. The same tendency has been started already also in Poland. The problem arise - how to communicate physics to the public (teachers, parents and student themselves) to increase understanding, interest and motivation towards physics studies. *The 2005 year – The World Year of Physics, is the good opportunity for promotion not only physics itself, but also physics education in the society*. In the chapter 2 of this paper we listed different kinds of active methods of education. Among them we would like to point out the five: using of everyday and low-cost materials, hands-on experiments and real-time demonstrations, questioning and problem solving, role playing and drama, public lectures accompanied by real demonstrations. The importance of the last method was underlined among others by Hewitt [10] and Walton [11], who said: "In so far as the public lecture demonstration is concerned, this is important point; for the lecture demonstration is pre-eminently a situation in which ideas are *told* or *shown*."

Our performance was an example of role playing method application (which was introduced to physics education, e.g. by J. Solomon [12]), but involved also the elements of other methods: using of everyday and low-cost materials, hands-on experiments and real-time demonstrations as well as questioning and problem solving. So, we were dealing with: problem solving, observations and experiments performed by students themselves, dialog containing reflections related to experiments (i.e. between actions and mind, reality and its vision), the great engagement, simply passion of students, who showed the natural joy of learning and with the direct relations between the outstanding person from the world of science and public. Furthermore, audience had opportunity to observe how Maria

Skłodowska-Curie encouraged her students "to be persistent, patient, work hard and be well organised to reach established goals". Such type of teaching is, for example recommended recently by French Nobel Prize winner G. Charpak, who created the educational programme aiming at development of science teaching methods [13]. Also in UK the Twenty First Century Science Project was performed [14] and New Science Curriculum at Key Stage 4 based on idea of additional applied science from September 2006 will be executed.

The opinions of students-actors and those from audience were very positive. Let's quote some statements of students first: "Being an actor in the Marie Skłodowska-Curie lesson was extremely nice experience for me, but first of all I learned a lot of physics. I'd like to take a part in such lessons every day!", "During preparation of the performance we had a lot of fun", "I learnt to collaborate in group and I understand physics better", "I hope that we will repeat this kind of activity once more".

Some persons from audience said: "Participation in such performance was for me extraordinary. I learnt a lot what will be helpful in understanding the world around me", "It was a very good performance, physics seems to me much easier now!". So, can we hope, that it was one of the effective ways to communicate physics to the public?

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