Problems in teaching physics in primary and secondary school, as seen by young Polish she-teachers

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Abstract: In recent years, in spite of the availability of information on Internet and educational TVs, Physics became one of the less popular subjects in Polish schools. Reasons are numerous, and should be searched first of all in the system of Physics teachers training. Questioning young teachers on their problems is one of the way to reach the relevant solutions.

Introduction
The educational problem of faint interest in Physics lies not only on the side of pupils but also on the teachers’ one. Teaching is frequently done in a boring manner: mainly textbook reading during lessons, instead of real experiments [1] or multimedia teaching methods [2]. Lesson are schematic, with no innovative scenarios, like role-playing, reporting, competitions and so on. A negative perception of Physics creates a kind of a negative feedback – in lower secondary school (Gymnasium) Physics lessons are reduced to the very minimum of 4 hours in total, in the whole 3-years cycle. A way of overcoming this difficulty would be making physics interdisciplinary, i.e. teaching Science, with element of Biology, Geography, Astronomy, instead of Physics alone. Unfortunately, no Polish university prepares teachers to such a role.

Another problem are poorly equipped laboratories, usually possessing only old experiments, with no explanations or teaching scenarios. Innovative textbooks would be required and new experimental set-ups. To overcome this problem we prepared new experiments, from electromagnetism [3] to computer guided laboratories [4]. We proposed some innovations for the textbook at the first level of Gymnasium [5], like introducing elements of the Material Science, Astronomy, Chemistry. The tradition teaching only kinematics, with numerous mathematical formula, essentially to be remembered, is too boring. A new list of experiments desired has been recently announced by the Ministry of Educations. Again, explanations and scenarios are needed [6].

Problem no. 1: bureaucracy
M. Sadowska: “I have been teaching since 5 years and I’ve experienced two changes of national curriculum in Mathematics and one change in Physics. There is a lot of bureaucracy in Polish system of education. It means that Polish teachers have to create lot of documents – different types of plans such as: educational plan, preventive plan, result plan, corrective plan etc. Changes in national curricula lead to changes in teacher’s documents. Instead of preparing new interesting lessons teachers have to create new documents. Those changes make the work with students much more difficult because materials become out of date and the teacher is obligated to create new ones. Using the word ‘material’ I mean worksheets, Power Point presentations, tests etc. It is easier to improve the ‘old’ material than create a new one (which is time-consuming) that is obligated by changes in educational law.

Problem 2: quality of textbooks
First, there is a lot of educational publishers in Poland that in many different ways try to convince teachers to select their textbooks. There are several handbooks for students being more or less on the same educational level; moreover the same publisher frequently sells two different types of handbooks.
The changes in curriculum result in "small" changes in handbooks. Publishers delete some chapters from the old textbooks, sometimes without making appropriate corrections or explanations. Publishers want to be on time with new student books. Textbooks are written quickly because they must be available for students very fast. Quick changes in books cause that they are inaccessible and fuzzy for students. There is possibility that in handbooks there are misprints, misleading conceptions i.e. inaccurate drawings or photos, chapters without good introduction, chapters without examples or with very difficult examples etc. Moreover lot of books have only one or two authors who are not able to notice some shortcoming in handbooks.

Let’s analyse first lesson about electromagnetism for third class of low secondary school that is published in two very popular handbooks. First textbook is published by "Gdańskie Wydawnictwo Oświatowe", its authors are Krzysztof Horodecki and Artur Ludwikowski [6].

Comments about this lesson:
1. In paragraph „Magnetic poles of magnets” there are written names of poles without any experiment, in previous paragraph there is no introduction about magnetic poles. The student has to believe that there are two types of magnetic poles and he/she doesn’t have any proofs that author of textbook are right. And what about magnetic monopolies?
2. A misleading fact is that the north magnetic pole is marked by blue and south magnetic pole is marked by red. We know that in some countries the north pole is marked by green. In my school laboratory I have magnet which north pole is marked by red and south pole is marked by blue.
3. There are misleading photographyes. We can’t see on which picture magnets attract themselves and on which they repel.
4. A picture shows arrangement of iron filings in magnetic field. The student doesn’t know how magnet is arranged under a paper because the magnet is not shown.
5. A picture shows that lines of the magnetic field disperse not only from magnetic poles but also from sidelong of the magnetic pole. Has this picture been checked with the scientific literature?
6. The Student reads only about ferromagnetic materials. After reading this paragraph he/she doesn’t know about another material’s types, I mean diamagnetic and paramagnetic. There is a lack of information that magnetic characteristic changes with temperature’s change. It would be much easier to start speaking about “magnetic” and “non-magnetic” materials at the very beginning.

A second textbook is published by "OPERON", its author is Roman Grzybowski [7].

Comments about lessons in that book:
1. There is a picture that shows magnets. There are letters describing magnetic poles but in this paragraph there is no comment about poles. The student must go further to find information about magnetic poles.
2. There is lot of schemes how to make experiments. In my opinion there should be also photos showing how to make them because students have to do them by themselves. Description of making experiments are quite good.
3. Definition: Magnetic field exist in space in which magnetic forces act on a moving charge. Such a definition of the magnetic field, via Lorentz force, is scientifically correct and is used in several university textbooks. However, it is very difficult and student can’t understand it.

Solution of the problem no 2: "quality of textbooks"
Our Department of the Education of Physics proposes solution in this case. We prepared a handbook of Physics called "Torunski porecznik do fizyki". It was written as supplementary material that is useful for students of low-secondary schools (Gymnasium). Authors of this
textbook would like to help students in creating their knowledge about the world. Next to obligatory material in "Torunski porecznik do fizyki" authors present the current knowledge, its use in everyday life, technology, medicine etc. This handbook doesn't focus on requirements of national curriculum but on the interdisciplinary of Physics and its practical use. Aims of the textbook are: interest students in Physics, increase of learning motivation, stimulate to getting knowledge about modern science and technology. They hope that students understand meaning of learning and technological progress instead of formal school knowledge. At the end of the textbook authors underline that adults should know f.e. what kind of diagnostic devices and physical phenomenon are used in medicine.

Example of lesson about state of matter

In every traditional textbook there is a list of state of matter that consists: solid, liquid and gaseous state. None of handbook doesn't show or present different state of aggregation. Textbook should show the modern knowledge about science so it might present others state of matter such as: plasma, liquid crystals, condensate of Bose - Einstein. This information students find in "Torunski porecznik". Moreover they can see f.e. different use of liquid crystals (see fig.1).

**Fig.1. State of matter: glass as overcooled liquid, liquid crystals, "sally putty" and other [5].**

**Fig.2. Apparatus for creating condensate of Bose - Einstein used in FAMO laboratory in Torun.**

After few lessons with "Torunski porecznik do fizyki" twenty students of Zespol Szkol in Kalisz (Poland) noted it. They could give notes from one to five and one it was the worse of note and five - the best.
<table>
<thead>
<tr>
<th>Element of textbook</th>
<th>Graphics</th>
<th>Number of figures and photos</th>
<th>Number and quality of graphs</th>
<th>Number of examples of solve problems</th>
<th>Number of examples from everyday life</th>
<th>Strikeout of definitions and formulas</th>
<th>Language of narration</th>
<th>Together</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average note</td>
<td>4.6</td>
<td>4.6</td>
<td>3.7</td>
<td>3.8</td>
<td>4.2</td>
<td>4.5</td>
<td>4.5</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Tab.1. Students' note of the textbook - "Torunski porecznik do fizyki". Analyzes was made by M.S.

**Problem no 3: Physics' laboratory in school**

In schools' laboratories there are old experimental sets that are usually incomplete. There is also a problem that young teachers have difficulties because studies do not prepare them to work in school with old sets. Schools are not able to buy new ones because in their budgets always are some more important expenditures. There is also a possibility that an experiment set is available in school but the teacher does not use it because she/he doesn’t have facilities to make experiment (e.g. he/she has: lesson in a classroom not in a laboratory, too little time). In school laboratories experiments controlled by computers are completely absent. In my city (Kalisz) in a low-secondary school I have not even seen such an experiment. Some of high-secondary schools have experiment sets such us COACH LAB or PASCO but in Polish schools it is very sporadic.

Another problem is fact that some of experiments should be done by students (it is obligatory because it is written in national curriculum). It is often impossible because school laboratory has one or two sets but in class there is about 25 – 30 students.

**Solution of the problem no : "Physics' laboratory in school"**

**Exhibitions**

Polish Universities try to help schools in this problem opening their laboratories, organizing lessons for students of lower-secondary schools or exhibitions for children and teenagers. Nowadays science exhibitions are integral part of every popular-scientific events. In Poland the first exhibitions was organized by Pomeranian Academy in Słupsk in 1998. The first exhibition was visited by fourteen thousands people for two weeks. The interest was so big that it was organized virtual exhibition called "Physics and Toys" (see on web http://dydaktyka.fizyka.umk.pl/zabawki1/index-en.html). Lots of materials were prepared and put into the web but unfortunately there is no publications so far.

![Photo 1. The exhibition Physics and Toys, Primary School number 5 in Slupsk. (AK)](image-url)
Teaching electromagnetism with a new experimental set

I started (M.S.) my work with the new electromagnetic set produced at Nicolaus Copernicus University in May 2009. After few (4-5) lessons I observed that students were very interested in simple experiments that they could see or make.

Photo 2. Students of Zespol Szkol in Kalisz during lessons were making experiments with the new set. (M.S.)

Students asked me before lesson what kind of experiments we would make during the lesson and were motivated to come to Physics lesson. The school year was finishing so I could repeat some parts of material and make experiments. We made about 25 experiments from the list, see [http://dydaktyka.fizyka.umk.pl/Low-Tech_kit/html](http://dydaktyka.fizyka.umk.pl/Low-Tech_kit/html).

After this few lessons I asked my students about their opinion about this experiments. Lots of them write that:

- Experiments are very interesting.
- Instructions are clearly.
- I don’t have to ask the teacher to help me in making experiment.
- Experiments help me to understand some phenomena.
- I can see that knowledge of Physics is helpful in life.

Summary and conclusions

The most important difficulty in teaching physics in Poland as seen by young she-teachers is bureaucracy.

Other problems which make teaching physics difficult are: the classes are too numerous (sometimes 34 students), school labs are old-fashioned, not sufficiently equipped in computers and experimental sets, the quality of textbooks still leaves a great deal to be desired.

Summarizing we can claim that one of problems is also lack of complex actions that would integrate printed word with multimedia material (f.e. CD-discs) or Internet version of book and finally the lack of exercises for self-learning. Not only our research [9] shows that it is necessary to use "blended-learning".

In spite of all difficulties and problems the view of kids faces making their own discoveries is priceless 😊😊.

References

[1] See, for example, interactive lessons [http://dydaktyka.fizyka.umk.pl/nowa_strona/?q=node/142](http://dydaktyka.fizyka.umk.pl/nowa_strona/?q=node/142)