PHYSICS TEACHERS ON TEACHING THE RADIOACTIVE DECAY LAW

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ABSTRACT

Teaching the law of radioactive decay is a mandatory task in Hungarian secondary schools. It is also one of the major problems in methodology. A survey was done among practicing teachers of physics in secondary schools in this topic. I am seeking to answer the questions below that were asked in the survey:

- *How do colleagues cope with this task?*
- *What aspects and motives can they rate high or name as the main insufficiencies?*
- *What methodological solutions are known? Which ones are in use? Which ones are liked?*

The survey aims to suggest what conditions and needs are to be met in the methodological solutions in order to support success in the teaching practice in the secondary school classrooms. I will also present a project which can give a new solution in didactics to the problem. It is planned based on the "hands-on, minds-on" approach.

INTRODUCTION

The law of radioactive decay is well known in two ways. The law can be put like this using the number of radioactive nuclei:

$$N(t)= N(0)\cdot 2^{-t/T} \quad (1)$$

The law of radioactive decay is also known using the concept of activity:

$$A(t)=A(0)\cdot 2^{-t/T} \quad (2)$$

In both formulae the concept of half-life is essential. As we can see from the formulae above, this law is a representative of the exponential laws in science. Teaching the law of radioactive decay is one of the most problematic issues in physics didactics.

In Hungary the radioactive decay law is in the syllabus of the compulsory physics course for all high school students. According to the national syllabus, the law is to be studied in grade 11, at the age of 17-18.

In a survey a number of active high school physics teachers were asked to report on how they can cope with the task in their everyday practice.

COLLECTING THE DATA

In Hungary there is an annual meeting for physics teacher organized by the Roland Eötvös Physical Society. The one organized in 2015 was held at Hévíz (Fig.1.) from 27th to 30th of March.

The attendance of the event was about 160 people, from which the estimated number of high school teachers present was 65-70. We estimate the number of practicing high school physics teachers at 2500+ in Hungary. Others at the conference were lecturers, experts from companies or universities, colleagues who work in primary schools or others who are interested in physics teaching.

Fig.1. Hévíz, the Hungarian spa

We left the survey sheets at the registration desk, but only five colleagues took one with themselves to support our work. Personal contacts are very important, so based upon this, 47 accepted the sheet, and 35 of them returned it filled.

THE SAMPLE OF COLLEAGUES

First, we need to see who are represented in the survey. The first task was to circle the type of high school the respondent has practice in. Some of the colleagues had practice in several types of schools. We counted each answer as a separate one, so we had 39 checkmarks. Table 1 shows what background of experience we can get information from.

Table 1. Number of teachers who gained experience in the given type of school

<table>
<tr><td>type of high school</td><td>top third</td><td>medium third</td><td>bottom third</td><td>number of checkmarks</td></tr>
<tr><td>secondary grammar</td><td>7</td><td>10</td><td>4</td><td>21</td></tr>
<tr><td>secondary technical</td><td>5</td><td>7</td><td>3</td><td>15</td></tr>
<tr><td>vocational</td><td colspan="3">3</td><td>3</td></tr>
</table>

MONITORING REALITY

The survey was anonymous, because in our country following the syllabus is a compulsory task for the teacher. We chose this since we wanted to find out as reliably as possible how or whether teaching this law really happens in the Hungarian classrooms.

The second task in the survey was to provide information at what extent teaching the law happens in practice. Many of our colleagues made a note saying “depending on the class”, so we considered each mark as separate answers. We gained 46 answers this way. The results the respondents gave are shown in Fig.2. In Fig.2.a) you can see the full scale, whereas in Fig.2.b) we specify the answers of those who need to face problems in their practice.

We can conclude that one third of our colleagues are not satisfied with the work they can perform in their practice. It is definitely an issue we need to pay attention to.

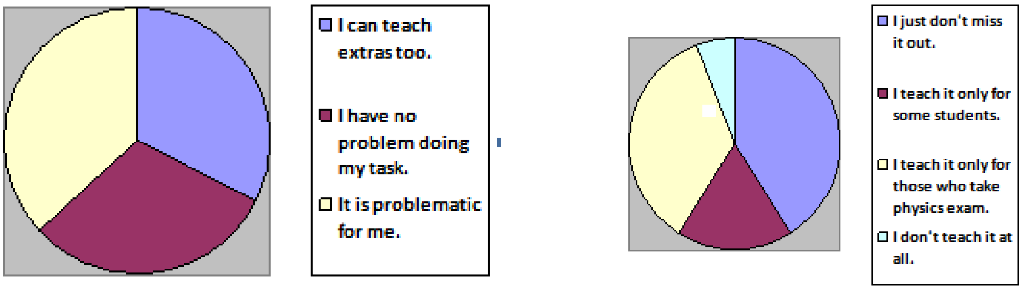

Fig.2. a) Can you teach it? b) Do you mention it at all?

A SURVEY OF THE MOST OUTSTANDING PROBLEMS IN TEACHING THE LAW

We asked the teachers to grade 10 statements. To match the Hungarian evaluation system as much as possible, the grades were 1-5. (1 showing that the statement does not have a great influence on the problems, 5 meaning it is a very important factor.) The statements were put into 3 sets according to the potential causes. Table 2 shows the sets of statements.

Table 2. Types of statements

questions	sets of influence
A1, A2, A3, A4	the students' attitude as a factor of the problems
M1,M2, M3	mathematical skills as causes of the problems
S1, S2, S3	monitoring some scientific issues

Monitoring the students' attitude

We mentioned four aspects in this set (Fig.3. shows the grades for the "A" statements):

A1 Physics among our students is not popular: they don't like, understand, or study this subject.

A2 The attitude of our students is negative to nuclear physics.

A3 They already have fact-fragments in this topic from the media.

A4 This topic is in the last year of the secondary physics course, and it is not a compulsory subject in the High School Leaving Exam (érettségi).

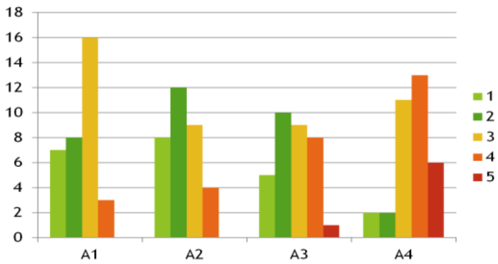

Fig.3. "A" statements graded

Monitoring the students' poor mathematical skills

We mentioned 3 aspects of mathematical skills (Fig.4. shows the grades for the "M" statements):

M1 The law is one of the exponential formulae. The students don't know the exponential functions properly.

M2 The effect of the low mathematical competence of the students is that they are not able to apply their knowledge.

M3 In mathematics classes there are not enough exercises for using mathematics in real problems and applications.

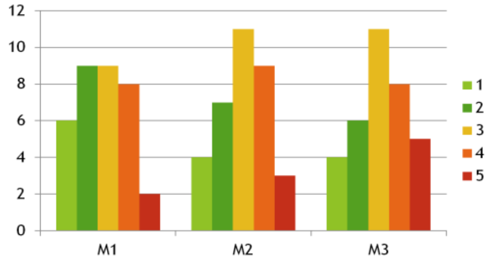

Fig.4. “M” statements graded

Monitoring scientific issues

On the sheet the respondents found 3 statements. They had to grade them just like the previous ones (Fig.5. shows the grades for the “S” statements):

S1 There is no possibility to carry out experiments.

S2 The scientific model students should use is too abstract for them.

S3 There is a lack of knowledge in the model they should also study it in chemistry.

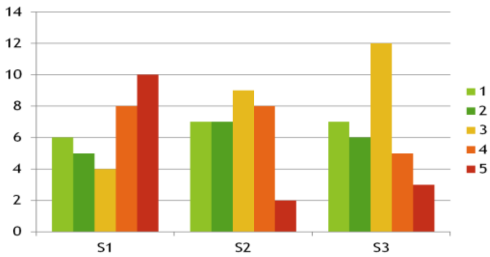

Fig.5. “S” statements graded

Analysing the data

The mean values of the grades for the statements are given in Table 3.

Table 3. The mean values of the grades

	Attitude				Mathematics			Scientific issues		
means (statement)	2.44	2.27	2.70	3.56	2.74	3.00	3.12	3.33	2.73	2.73
means (set)	2.75				2.95			2.93		

So the main problems that were highlighted by the teachers are as follows:

1) 3.56 (A4) This topic is in the last year of the secondary physics course, and it is not a compulsory subject in the High School Leaving Exam (érettségi).
2) 3.33 (S1) There is no possibility to carry out experiments.
3) 3.12 (M3) In mathematics classes there are not enough exercises for using mathematics in real problems and applications.

When studying the answers, two remarks arose. These are really worth mentioning.

* We can envy some colleagues: they graded each but one problem to 1 (2 for S1). It might mean that they don’t find teaching this law a problematic task.

* International surveys show a bad attitude. Hungarian colleagues don’t experience it, they think about it as a result rather than as a cause, or just don’t rate it high as a problem.

Further causes

In the survey we gave opportunity to share further causes and remarks to the mentioned topic for those who gave their opinion. It was an open ended question. The remarks we got are all listed. Our remarks are in brackets.

- “Many have misconceptions; they can’t differentiate it from the distorted esoteric knowledge.”
- “Hungarian physicists’ activity in the last century.” (We can’t see clearly what is meant by this remark. But we do not have a chance to figure it out.)
- “They study no other exponential law, they have nothing to bind to.” (A very important point was highlighted.)
- “In mathematics the statistical nature of the phenomenon, the incidental events are difficult to comprehend. But some students can get fired up just because of this.” (We find it a very important comment from a colleague.)
- “I didn’t rate anything to 5, because my highest mark goes to *Severe Literacy Problems*.” (It is a problem far beyond the physics methodology.)

INTERPRETATION OF DIDACTICAL SOLUTIONS

The evaluation system

We also studied what methodological or didactical solutions are liked, known and used in the teaching practice among our colleagues. We provided a list of didactical solutions they had to grade from two perspectives:

in column 1	in column 2
A – “I know and like the mentioned solution.”	A – “Mostly this is used in my classes.”
B – “I am familiar with the method.”	B – “I have experience with the method.”
C – “I don’t know that method.”	C – “I have no experience with it.”

Evaluating the didactical solutions

Table 4 shows the listed didactical solutions and the results of the evaluation.

Table 4. Evaluation of the didactical solutions

didactical solution	Known? A — B — C			Used? A — B — C		
Presentation & interpretation by the teacher.	22	9	0	30	3	0
Presenting on an educational film.	11	18	3	8	16	7
Processing literature (alone or in a group).	5	20	7	2	9	23
Project or drama pedagogy.	1	13	19	0	3	31
Home essay or student’s presentation.	13	16	1	8	16	8
Computer simulation.	18	9	4	13	15	6
Simulation game.	7	9	15	2	7	20
Data-processing, simulation game, in-situ measurement project, “hands-on, minds-on” way.	4	10	17	0	10	23

We found that our teachers present and interpret the law for their students, and a third of them adds spice to it with a computer simulation or in some other way. A number of methods are known, referring to the fact that our colleagues are open to widen their palette.

Notes, remarks

As an open ended question we asked those who answered to share their further comments in this topic with us.

We can gain ideas from the comments (our notes are added):

- “I am not familiar with the hands-on, minds-on method, though I’d expect I’d like it.”

- "I organize a presentation of measurement for the entire school every year. I warmly recommend it to others!" (Great idea, really!)
- "Keep in contact with companies, and visit a factory." (Great, but not exceptional.)
- "Measuring activity with a Geiger-Muller tube, the sample is prepared with vacuum-cleaner and gauze." (A great idea from the "Physics Teachers in the CERN Program".)
- "Modelling the decay with beer-foam." (This process hasn't an exponential nexus.)

CONCLUSIONS OF THE SURVEY

- The respondents are not a representative group of active physics teachers in Hungary.
- One third of the respondents has problems with teaching the law of radioactive decay.
- Most teachers alter the methods they use to best suit the classes.
- In the opinion of the colleagues mathematical and scientific issues are more influential problems than the students' attitude.
- In the respondents' opinion the most outstanding problems are respectively: no compulsory test in physics, no experiments, not enough applications in maths classes.
- Teachers' presentation and interpretation spiced with computer simulation are the methods used in the Hungarian classrooms.
- These colleagues know other methods as well and might be persuaded to try them.

"PROBLEMS CANNOT BE SOLVED BY THE SAME MIND SET THAT CREATED THEM"

The quote mentioned above is attributed to Albert Einstein [1]. The fact that there are more wordings in the original English suggests that it is a paraphrase of what we can read from him published in the New York Times on 25th May 1946 or 23rd June 1946.

Didactical research had been in progress since the autumn of 2012. Four classes in a Technical High School were divided into eight groups. Four were taught using the "hands-on, mind-on" method. These were tested against the other four groups as reference groups.

As an introductory part of the project, a topic titled "The wonderful world of measurements" gave a base to in-situ measuring project in classical physics. Having experience with the method, special attention was drawn to the exponential laws. First, the "Newton's law of cooling" project represented these tasks: sensing + measuring + data processing. Then, the project titled "Discharging a capacitor" provided measuring + data processing tasks to the students.

In a period lasting from February to April in 2015 the students investigated half-life by data processing. They studied the decay with a simulation game relying on their active participation. Finally, they estimated the number of nuclei in a sample based on "in-situ" measurements and commented on the reliability of the outcome.

This method is appropriate to teaching and also meets the needs and suggestions of experienced colleagues.

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REFERENCES

1. http://icarus-falling.blogspot.hu/2009/06/einstein-enigma.html