AN EXAMPLE OF INTERACTION BETWEEN HIGH SCHOOL AND UNIVERSITY

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Abstract

The transition of young people from high school students to university students can be a rather stressful phase in their life. Initiating joint activities between high school and university would reduce this stress. A description of such an activity and its results is subject of this article.

Physics laboratory classes have been conducted with the 10th grade students from Dr. Petar Beron High School of Mathematics in Varna, Bulgaria. The exercises took place in the physics and biophysics laboratory of Varna Medical University "Prof. Dr. Paraskev Stoyanov". They were supervised by the author of this article, who is also assistant-professor at the university. The university lab equipment was used for the purposes of the classes.

Key words: *students, high school, university, education, activity*

1. INTRODUCTION

Physics laboratory classes are compulsory in the high school education as they illustrate the learned theory. Besides, this is not their single goal. During the exercises the students are taught how to use laboratory equipment, how do experiments, record data, draw graphs and deduce conclusions on the basis of the received results. All these activities are defined as practical educational goals. Further, the laboratory practice raises the interest of the students in science, increases their curiosity and focuses their attention. As a whole, it is a really helpful activity to form their views.

The physics classrooms in the high schools are well-equipped for working out the exercises. However, the author and the physics teacher from the Mathematics High School in Varna have decided to break the standard and to take the students to the university laboratory. The classes conducted there turned into Open Days in the Department of Physics of Varna Medical University. Simultaneously, the students got the chance to try the medical students' facilities with the consent of all the participants.

The main goal of the educators was to answer the question, "Will the change of the school environment lead to different attitude of the students towards physics classes and to what extend?"

The specific issues of this experiment were as follows:

- How the students will react to the unconventional way of conducting laboratory exercises in a new setting, using different equipment and conducted by a new teacher?
- In what extend the interest, attention and eagerness of students' will change?
- Can the new learning environment influence their career choice?
- What kind of difficulties the students meet while working in an unfamiliar place?

2. LABORATORY CLASSES PREPARATIONS

Actually, the preparatory work for the experiment was quite hard. The students had to complete two questionnaires – one before and another one after the exercises. The laboratory set-up for the students was selected very carefully. This choice was based on the knowledge of physics in the 10th grade. Moreover, one of the tasks was to work with completely unknown devices, having the idea to observe their abilities and skills in this situation. The topics of the conducted classes had been taken from the

syllabus of the university subjects of Medical Physics and Biophysics of the specialty medicine. Four exercises have been chosen, adapted to the knowledge of 10th grade students in the high school.

Table 1 displays the differences between the original university laboratory exercises and the school-adapted laboratory exercises.

№	**University program of Medical Physics and Biophysics of specialty medicine**	**School program of Physics for 10th grade**
1.	Physical model of diffusion through membrane (Biophysics)	Investigation of electrical current and voltage change in an electrical circuit with a capacitor and active resistance
2.	Measurement performed by electrical measuring equipment (Medical Physics)	Verification of Ohm's law for a part of the circuit
3.	Measurement of the reactance and determining the inductance of a coil and the capacitance of a capacitor by Ohm's law (Medical Physics)	Measurement of inductive and capacitive resistance.
4.	Audiometry. Determining the spectral dependence of the threshold of audibility. (Medical Physics)	Determining threshold of audibility of man

Table 1. The names of the laboratory practices of the program "Medical Physics" and "Biophysics" of specialty Medicine and the corresponding program of the course "Physics" of the school course in physics for 10th grade.

Through these exercises, we decided to add new knowledge in physics and medicine. We made this choice very carefully, taking into consideration a number of factors:

- The level of knowledge in physics;
- The level of knowledge in biology and anatomy;
- The broad cultural world-view of the students in an elite high school;
- Satisfying the natural human curiosity;
- The level of intelligence;
- The age features;
- The danger of information overload;
- Possible future orientation towards professions related to medicine and others.

The timing of the exercises was consistent with employment of students and employment to the laboratories with the available equipment of the Department "Physics and Biophysics." We made them at the time of the university students' exams at the end of second term of the students of Mathematics High School.

For an introduction to some of the new knowledge which was scheduled to receive students, we decided to offer them to write a series of reports. They received a list of necessary topics from which they had to make their choice. They were given the opportunity to work in a team of two participants. They had a task to look for information on the topic and to prepare a presentation, which had to be presented to the class. For this purpose, the teacher of physics provided three consecutive hours from classes in physics at the school. The purpose of these presentations was to acquaint all students with the new phenomena, processes and concepts for the exercises. Even at this first step the students demonstrated exciting interest. The enthusiasm with of the students towards their task was very

indicative. Correct and well-illustrated and precise presentation formed the idea of new phenomena, processes and concepts that all students had to learn. Finding the materials, preparation of presentations and good representation were assisted and supported by the author, but most of all by the physics teacher of these students. Students also sought help from their biology teachers.

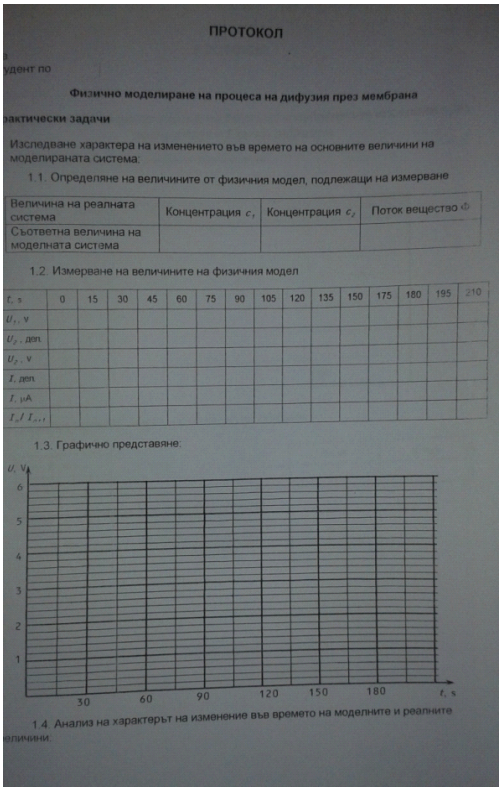
Here is the list of topics on which students worked:

- Physical models in medicine - concept and examples.
- Cell membrane - definition and purpose.
- Electrical current in living organisms (examples).
- Medical diagnostic equipment using electricity.
- Medical equipment for treatment using electricity.
- Electrical resistance of the human body - definition, values and types.
- Impedance change of the human body for diagnosis and treatment.
- Use of circuit elements - a coil and capacitor in medical equipment.
- Human ear - structure and function.
- Characteristics of hearing: threshold of audibility and threshold of pain.
- Types of hearing impairment in humans and changes in the human ear, causing this.
- Audiometry - definition, applications and types.
- Audiometer - definition, application and specifications.

3. CONDUCTING LABORATORY EXERCISES

The laboratory exercises were held in seven classes of 10th grade of the mathematical school. For each class, there was a fixed day and time in which to perform consistently four exercises. For this purpose, all necessary equipment and materials were placed in the same laboratory room. Instruction for safety in the lab was held in each of the classes.

The first difficulty faced by both students and teachers was the lack of sitting places. The laboratories have capacity of 15 students, and in our case the students were much more - from 24 to 26 per class. This was an error in the preparation of laboratory exercises. We could avoid this problem by splitting each class in two separate groups. After overcoming this inconvenience, the students looked forward to beginning the exercises with impatience. The second difficulty was that in fact there were two students per laboratory set-up. Each of the students wanted to work with the laboratory set-up. This difficulty was overcome, by doing each exercise twice, dividing the class into two groups. Each group was doing different exercises after which they were exchanged. There was the same kind of mistake in the preparation. It was necessary premeditation options to be provided. The problem was minimized by the active participation of the teacher of physics working with the different groups. Besides, we proposed students to form several teams of two students to carry out specific actions during the exercise.


ПРОТОКОЛ

Физично моделиране на процеса на дифузия през мембрана

Изследване характера на изменението във времето на основните величини на моделираната система:

1.1. Определяне на величините от физичния модел, подлежащи на измерване

Величина на реалната система	Концентрация c_1	Концентрация c_2	Поток вещество Φ
Съответна величина на моделната система			

1.2. Измерване на величините на физичния модел

t, s	0	15	30	45	60	75	90	105	120	135	150	175	180	195	210
U_1, V															
$U_{2\,деп}$															
U_2, V															
I, деп.															
I, μA															
I_n / I_{n+1}															

1.3. Графично представяне:

1.4. Анализ на характерът на изменение във времето на моделните и реалните величини:

Figure 1. The Report of medical students; part of it students will complete during exercise


1.2. Измерване на величините на физичния модел

t, s	0	15	30	45	60	75	90	105	120	135	150	175	180	195	210
U_1, V	6	5,5	5	4,6	4,4	4,1	3,9	3,7	3,6	3,5	3,5	3,4	3,4	3,3	3,3
$U_{2\,деп}$															
U_2, V	1	1,6	1,9	2,2	2,5	2,7	2,8	2,9	3	3	3,1	3,1	3,2	3,2	3,2
I, деп.	110	85	66	51	40	32	25	19	15	11	8	6,5	5	4	2,5
I, μA															
I_n / I_{n+1}															

Figure 2. Table filled with results from the measurement of students

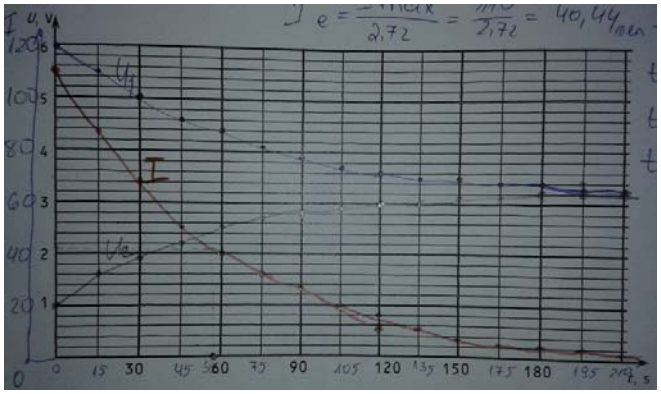


Figure 3. Graph drawn by using the reported data by the students

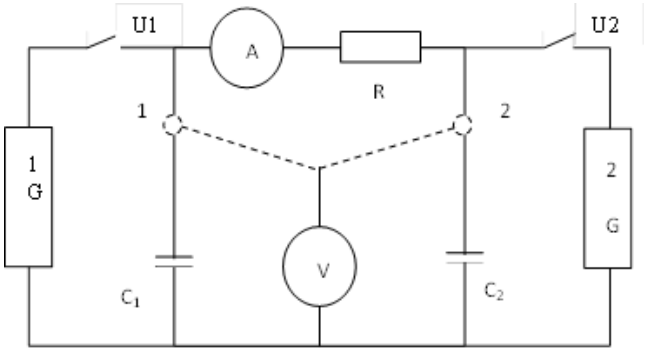


Figure 4. Electrical circuit



Figure 5. Ammeter



Figure 6. Oscilloscope

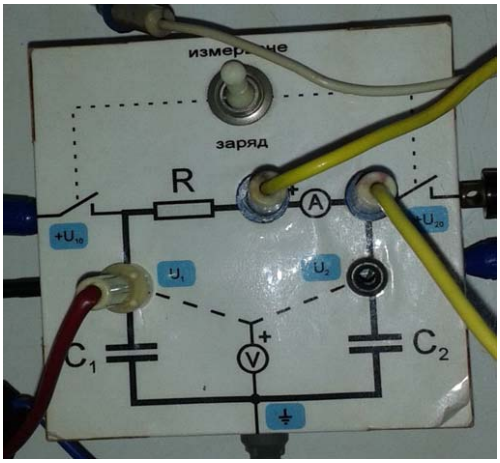


Figure 7. Physical model - Electrical circuit

4. PERFORMANCE OF THE LABORATORY EXERCISE

We will present explicitly the work of the first exercise. The exercise was presented to the students under the name of "Biophysics course of medical students - Physical model of the process diffusion through membrane". They were already familiar with the concepts of "physical model in medicine" and "cell membrane". It was told that from a physical point of view, the cell membrane is a barrier for passing of substances. Substances of the inner side of the cell membrane are charging negative and those on the outer side - positive. Consequently, the processes in the cell membrane can be represented by a physical model - electrical circuit with two capacitors connected in parallel and a resistor (active resistance) connected between them (Figure 4).

In this exercise, the change of the current magnitude through the resistance and voltage change across the capacitors must be measured. The students were explained the working methods. The circuit is shown in Figure 4 and the device in Figure 7. The devices used to measure changes in current and voltage are: ammeter - for the current (Figure 5) and oscilloscope - for the voltage (Figure 6).

The students fill in the results in Laboratory Practice Report for medical students given in Figure 1. Since the laboratory exercise is adapted for high school, the students did not have to fill in all the required information. They filled only part of this Report. Measurement data of current and voltage they fill in the given table (they did not fill all the rows of the table) (Figure 2). Then they draw the graph using these data (Figure 3).

A new instrument for them was the oscilloscope. This challenge incited their curiosity and interest and each student in the group wanted to work with it. The time interval at which the voltage was reported is 15 seconds. This enabled each change of the voltage to be reported by a different student. In this way, each student received the chance to try to work with the oscilloscope.

For overall work performance of this exercise we divided the students into following groups:

- A team for timing with a stopwatch (the stopwatch of a mobile phone);
- A team for reading the change of electrical current by the amperemeter;
- A team for reading the voltage change by the oscilloscope;
- An engineering team - connecting the electrical circuit to measure various parameters on it.

The timing and engineering teams consisted of two members. The current and the voltage teams consisted of four members - two to monitor the scale of the instrument and taking readings and two recording the reported data. The laboratory exercise was carried out in two stages: measuring the current change and voltage when the first capacitor C1 is switched on and when the second capacitor C2 is switched on. For each stage the teams exchanged. So, students performed various operations. After completing the measurements, each group draw graphics with the data received. The graphics rare three - change of voltages U1 and U2, and change of current I. After drawing the graphs the students held the last experiment. In this experiment, they again exchanged teams work. The last attempt was to determine the time constant of the process - this is the time for which the current reduced e-times. (e = 2.72 - Neper's number).

Using the maximum current value received from previous measurements, the students found the value where the current reduced e-times. They found that value on the scale of the amperemeter and reported the time for current decrease from the maximum value to the calculated value with the stopwatch. This operation was carried out three times and the average was calculated and recorded. Then, they found the calculated value on the graph (e- times reduced current) and marked the received point on the graph of the current. Then they mark the value of the time responsible on this point. In this way, the students checked the accuracy of their work. If the experimental and graphical time data matched or were close, they worked correctly and accurately.

The organization of work and the implementation of other exercises were similar to the previously described ones.

5. RESULTS

Each student filled in a questionnaire at the beginning and at the end of the laboratory practices. The total number of students who completed questionnaires is 151, of them - 99 boys and 52 - girls. The questions and the results of their answers are shown in Tables 2 and 3.

№	Question	Yes	Rather yes	No	Rather no	No opinion
1.	Were the topics of reports that you worked out in the preparation of these exercises interesting?	99/59/40	18/11/6	-	24/24/-	10/4/6
2.	Did you like working on the preparation and presentation of your report?	111/79/32	4/3/1	18/13/5	5/4/1	5/3/2
3.	Did you get new knowledge during your work?	117/67/40	31/30/11	-	2/2/-	1/-/1
4.	Did you get new knowledge from the presentations of your classmates?	119/80/39	14/7/7	-	11/10/1	7/2/5
5.	Do you think that such a preparation for laboratory is needed?	79/58/21	54/35/19	-	12/4/8	6/2/4
6.	Do you like laboratory work?	109/81/28	27/7/20	1/-/1	9/9 /-	5/2/3

7.	Were you impatient to come to the laboratory at the Medical University?	76/53/23	52/33/19	3/1/2	8/4/4	12/8/4
8.	Would you like to continue your education in a medical university?	12/5/7	3/-/3	71/50/21	46/28/18	19/16/3
9.	What subject would you choose?	Medicine 4/1/3	Dental medicine 2/1/1	Pharmacy 2/-/2	Medical optician -	Others -
10.	Would you work as teachers in physics?	1/1/-	2/1/1	67/47/20	78/49/29	3/1/2

Table 2. The questionnaire was completed by the students before the start of the laboratory and the results of its completion. The data are number of students, separated by a slash. The first number denotes the answers to all students of the matter. The second number - the number of boys and the third - the number of girls.

№	Question	Yes	Rather yes	No	Rather no	No opinion
1.	Were the laboratory exercises conducted at MU-Varna interesting?	90/58/31	16/12/5	-	45/33/12	12/6/6
2.	Did you like doing them?	119/76/43	18/13/5	4/3/1	5/3/2	5/4/1
3.	Did you get new knowledge through laboratory exercises?	107/66/41	36/27/9	5/3/2	-	3/3/-
4.	Would you like to do exercises at MU-Varna next year?	110/65/45	17/12/5	13/13/-	-	11/9/2
5.	How difficult was it while working with laboratory equipment?	-	-	108/71/37	37/24/13	6/4/2
6.	Did you meet any difficulties completing the Report of the exercises?	16/7/9	8/3/5	92/49/33	43/39/4	2/1/1
7.	Do you think it is better to do laboratory work outside school?	106/74/32	-	-	39/22/17	6/3/3
8.	Would you like to continue your education in a medical university?	19/7/12	7/2/5	59/43/16	48/31/17	18/16/2
9.	What subject would you choose?	Medicine 9/3/6	Dental medicine 4/1/3	Pharmacy 3/-/3	Medical optician 1/-/1	Others -
10.	Would you work as teachers in physics?	2/2/-	3/1/2	53/32/21	73/50/23	20/14/6

Table 3. The questionnaire was completed by the students after the laboratory work and the results. The number of students are separated by a slash. The first number denotes the answers of all students of the matter. The second number - the number of boys and the third - the number of girls.

5.1. Results from the entrance opinion poll

The results of the entrance opinion poll showed strong interest and desire to work in the preparation of laboratory exercises. The interest in doing the laboratory exercises is also very high. This can be explained with the innate curiosity of young people and the desire to carry out surveying work, to experiment, to apply their knowledge in practice.

There was a slight decline in interest towards exercises outside the school - at the Medical University. This is most likely due to the fact that so far students have not been doing laboratory work outside school. They had mild anxiety and uncertainty because of the new conditions for the exercises. The minimum interest for medicine and medical specialties could be interpreted by the fact that these are students from High School of Mathematics and their interests are pointed to another direction.

In all the questions, specific differences in the views of girls and boys are not observed.

Most disturbing, however, is that the interest in the teaching profession and especially in physics is at the absolute minimum. Students do not want to work as teachers in physics. This is a very powerful signal to us, the present teachers, that the young generation is not prepared to take on the difficult road of teachers. And without future teachers, the future of coming generations is doomed. This fact alerts us to turn our attention in creating interest and desire in young people to focus on the teaching profession.

5.2. Results from the exit opinion poll

A comparison of the results of input and output shows improvement in all affected questions, even in the interest in teaching, although at very minimal levels (from 1 to 2). It is noteworthy that there is increase in the desire for laboratory classes outside school, in the laboratories of the medical university. It turns out that difficulties in handling devices, both known and unknown for students, are not significant. A minimum difficulty is encountered in completing the report and most in plotting the graphs. But ultimately this is an experience that proved positive for the students. At the end of the exercises everyone, without any exceptions, could properly draw all the graphics. The last task of working out the exercise showed that most of the students had very similar results in finding the time constant and setting it on the chart. This result shows the accuracy of students' work and their ability to deal with new challenges such as unfamiliar surroundings, unfamiliar equipment and new working method.

There is increased interest of students to continue their education in a medical university in various medical specialties. This fact leads to the conclusion that the conduct of laboratory classes outside school, in the laboratories of the Medical University stimulates and directs the students' attention to the choice of future profession.

CONCLUSION

Considering the increased interest of students towards future study in a medical school, the author believes that the laboratory exercises in an environment which is different from the school environment is a powerful incentive to acquire new knowledge skills and competencies of the students. Last but not least, this experience gives the opportunity for career guidance for young people and identifying and targeting their desires and choices for future realization in life. It cannot be denied that by performing the exercises outside the school environment reduces stress on the transfer to next level of education - university education. This is something very important and significant in today's world where reducing stress in everyday life is one of the main goals of modern society.

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