“Earth belongs to all of us” – an interschool project on the impact of mineral fertilizers

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Abstract

The study of nature and the incorporating of chemical and biological knowledge from the perspective of steady environmental development is a prerequisite for environmental awareness. The project aims to show the positive and negative aspects of the use of mineral fertilizers. A more precise description of the problem is rendered by some cross-disciplinary relations between chemistry and biology. The cooperation between a vocational secondary school, on one hand and a college where students are taught in accordance with internationally acknowledged curriculum, where experimental activities are put to the front, on the other, breaks away from the standard ways of teaching

The project shows some activities and relative outcomes that have enabled the students from the partner schools to exchange ideas, information, experimental data with regard to the increasing of their motivation to free betting tips study Chemistry and improving their teamwork skills.

The students from “A. S. Popov” Vocational School of Electronics develop their skills to sort out and present theoretical information on mineral fertilizers from chemical point of view by using Internet based resources. A thorough survey of the posts on the issue helps to draw conclusions about the optimal amount of nitrates in soil and food as well as the health risks and the possible damages to the environment in case of overdose.

The students at American College Arcus implement their knowledge in experiments concerning the positive and negative impact that mineral fertilizers have on the growing of plants.

In the concluding part of the project the students from the partner schools are expected to fill in a questionnaire in order to provide feedback on the efficiency of the implemented innovative teaching and experience-sharing methods.

I. Project idea. Selecting the project topic and activities

In today’s information age the roles of the teacher and the student in the educational process have been changed radically. The narration and explanation on behalf of the teacher and the listening on behalf of the students have dominated the teaching-learning process for quite a long time and as a matter of fact they still do. Such an approach does not prepare young people for independent decision-making, although both methods have not lost their meaning [1].

Today, the focus is placed on the development of the students. They are in school to seek and find what is best for their personal development with the help of their teacher.

The idea for this project was initiated by previous joint trainings of students from both partner schools in other subjects. The choice of the topic about mineral fertilizers was a result from common questions asked by students as to how helpful or harmful mineral fertilizers were and what their impact on the environment was. The design of the binary lesson and the chosen topic allowed us to reveal the relationship between theoretical knowledge and practice and addressed a problem forming environmental awareness.

The objectives of the inter-school project are related to: the stimulation of the researching approach and thus to turn the students into active participants in the learning process; by emphasizing the practical application to deepen their interest in chemistry; to increase interest in current issues of modern life. During the implementation of the project different skills such as: the use of reliable information sources (computer programs and the Internet), the use of rational methods of learning (observation, experiment), safety in the laboratory and use of biological and chemical knowledge in life, as well as ability for team working, were aimed at.

The initial preparation included the formulation of a specific problem about how harmful mineral fertilizers are and allocating specific tasks to two groups of students.

The choice of appropriate methods for the implementation of the project was consistent with the working environment of each of the two schools – lab equipment, availability of supplies and reagents and the skills that the students have. Two methods were used during the implementation of the project: theoretical analysis and pedagogical experiment. Using experiments in a particular

problematic situation is related to the fact that the students already have sufficient stock of theoretical knowledge to build a reasonable hypothesis, and the experiment itself, to confirm the hypothesis [2].

The group from the Vocational school included students from Grade 9 who have an increased interest in the science of chemistry and good computer skills. Their task was to research and prepare reports about the benefits and harms from the use of mineral fertilizers, to trace the values of nitrate in the soil and food, and the consequences for the environment and human health. Summarizing the data collected by this group, the students arrived at the conclusion that the use of nitrates is beneficial for the growth and development of plants, but only within limits for obtaining good yields without the environmental risks. While doing this task, the students used Internet based resources which led to the development of their mental activity. As a result of their studies they discovered another relation between the composition of the soil and the need for fertilization. They presented their conclusions to the students from the second group.

The task of the second group was to prove the conclusions expressed, by experiment and subsequently to compare the results obtained with the hypothesis formulated by the first group and to make generalizations and conclusions together. Specific tasks were related to defining the composition of the soil and the influence of nitrate on the formation of chlorophyll necessary for photosynthesis. Participants in this group were students working on the international program International Baccalaureate Diploma Programme.

II. Development of the project activities

1. Collection of theoretical information about the use of mineral fertilizers by the students from the Vocational secondary school

At the first stage of the Project development students from the Vocational school were asked to review, select and systemize available facts and scientific information about the use of mineral fertilizers. They summarized the information and came to some important conclusions:

- The number of people on the planet increases by one person every 11 seconds by five - every minute by 325 - every hour, 800 every day, every week by 56 000 and 3mln. each year. Annually large areas drop out of the agricultural fund as a result of global processes of erosion and the construction needs of the industrial areas, residential areas, sports facilities, highways, recreational areas. The anticipated need of farming land and agricultural produce arises concerns.

The rapid population growth and the increasing demand for meat requires more producers intended for feeding livestock. The modern technology of farming offers a solution to solve the dilemma arising from future shortage of fertile lands, namely: the reinforcement of the dwindling natural stocks of mineral nutrients in the soil by the mass introduction of mineral fertilizers. The studies of many scientists suggest that the introduction of fertilizers leads to disruption of the balance of energy and circulation of substances in the agro-ecosystems which instead of remaining natural become anthropogenic [3].

- **Advantages to the use of mineral fertilizers**

Plants use nitrogen for the synthesis of amino acids and proteins that provide the processes of growth, respiration and photosynthesis. Nitrate fertilizers are easily and quickly dissolved by soil moisture, in which sodium and calcium displace from the soil absorbing complex, an equivalent amount of other cations. By fertilization with sodium nitrate, the sodium displaces the calcium from the absorbing complex and deteriorates the structure and the agrochemical properties of the soil. Upon fertilization with calcium nitrate, as a result of its interaction with the carbonic acid contained in the soil calcium bicarbonate is formed, which favors the reduction of the acidity of soils. This has a positive effect on soil structure.

- **Disadvantages to the use of mineral fertilizers**

Nitrates enter the body through drinking water and food. The maximum quantity of nitrates in drinking water is 50g/mol. Of all the food, richest in nitrates are the vegetables and the processed meat (sausages, smoked meat). Much less and even insignificant quantity there is in the dairy products and fish. Some plants have the ability to accumulate more nitrates. These are the vegetables (lettuce, garlic, onions, carrots, spinach, , dill, beetroot, radishes, zucchini, broccoli, etc.). They can be dangerous to our health only if consumed in large quantities.

Overuse of nitrogen fertilizers is indirectly responsible for the increased rate of methemoglobinemia – a severe blood disease. Obviously excess nitrates not absorbed by plant roots can be washed away by rain into groundwater and eventually contaminate drinking water. Nitrate itself is not that harmful,

but when it enters the digestive system of children it turns into nitrite. Nitrite combines with the hemoglobin in the blood to form methemoglobin, which is less able to transport oxygen than hemoglobin. As a consequence, the child tries to compensate for the lack of oxygen by breathing deeply and more frequently. Upon the entry of large doses of nitrates into the body nausea, shortness of breath, diarrhea, bluish skin and visible mucous membranes appear after 4 to 6 hours due to the accumulation of high amounts methomoglobin and under-oxidized blood. In particularly severe occasions the mental capacity may be affected because of oxygen insufficiency in the brain. At low acidity of gastric juice, nitrite can be converted to nitrosamines which are carcinogenic. The use of mineral fertilizers can reduce the content of other nutrients. Along with the nutrients very toxic substances, metals and metalloids are deposited in the soil. With the excessive use of chemical fertilizers, soil contamination can reach serious proportions and humanity will face the real risk of environmental contamination of soil resources, and hence of the agricultural production with toxic elements, which will eventually deteriorate the health status of the entire population [4].

2. Experimental studies about the positive and negative effect of mineral fertilizers on the growth and development of plants

2.1. Methodology of the experimental classes and writing lab reports

Working on this project together the students from the two partner schools:“A. S. Popov” Vocational School of Electronics and the American College Arcus, Veliko Tarnovo, Bulgaria decided to investigate experimentally the effect of mineral fertilizers on the plants’ growth and development.
They adopted a methodology which the students from the American College Arcus use as a part of their International Baccalaureate Diploma Programme in order to develop practical skills in Science. This specific methodology follows the steps of the scientific investigation. After performing an experiment the students learn how to write a good Lab report. The key steps in preparing of the Lab report are as follow:

- **Introduction (Theoretical background)**

1. First he Teacher should give the students the aim of the investigation. It should be clear and concise. If the teacher states the aim the students shouldn’t just copy that down, they need to change it according to their personal understanding.
2. Second, the students need to write the hypothesis and prediction of the investigation. The hypothesis needs to be very clear, giving an exact and complete description of what might happen (and why). The prediction is written like: If …then…
3. The students can also give a general background to the study if they feel like it’s relevant and necessary.
4. In the Introduction part of the Lab report the students should present the different variables. The independent variable is the one that is altered throughout your experiment. For an example, if the students investigate the effect of temperature on yeast fermentation, then the different temperatures that they use are the independent variable.
5. The dependent variable is the variable that is measured. Using the yeast example, the dependent variable would be the amount of CO_2 produced by the yeast (this shows how well the fermentation is going).
6. The controlled variables are the ones that is kept constant throughout the experiment so that they don’t affect it. If investigating the effect of temperature in yeast fermentation, the controlled variables would be the amount of yeast and water, the time for fermentation, etc.

- **Description of Materials and Methods**

1. First is given a list of all the equipment used in the experiment including the size of beakers/measuring cylinders, etc., the names of any chemicals that are used in the experiment.
2. The students can use a diagram (picture) to show the experimental set up if they find it necessary.
3. The students should describe the method. It should be written in passive tense. The steps in the experiment are either self-evident or explained.
4. In this part the students should explain the different variables. They have to write how the independent variable was varied. Using the yeast example, the independent variable can be varied by placing the fermentation tubes in hot water baths of different temperatures.

5. The students have to explain how changes of the dependent variable were monitored. They should write how they got their results, e.g. by reading from the scale on the fermentation tube to see how much CO_2 that has been produced.
6. The students have to write how the controlled variables were controlled. Using the yeast example, they write that they made sure that the amount of yeast used in each fermentation tube was the same (because they used a scale), that they used a watch to make sure that the time that the tubes were allowed to ferment was the same for all tubes.
7. The students have to write how they made sure that the sufficient relevant data was recorded. The method for data collection has to be described, i.e. if the students had several trials, if they used controls, methods of measurements, if their calculations are correct, etc.

- **Collection, Processing , Graphical Interpretation and Evaluation of Experimental Data**

Data collection
1. The students record all their raw data in tables. The tables should be numbered and have captions in which they briefly describe the contents of the tables and how they recorded the results. Titles, units and the uncertainty should be given in the headings of the tables.
2. Underneath the table the students can briefly describe the results. They can describe the main trends and account for any anomalous result. They don't have to discuss the significance of the results to the aim of the investigation.

Data Processing and presentation
1. The data should be processed (calculated) correctly and presented in tables (as above) and graphs. If the students use graphs, they should have a caption in which they describe the contents of the graph. The axes of the graphs have to be labelled with units and the points have to be plotted correctly. The students have to make sure that they use the correct type of graphs. If both variables are continuous, a point graph must be used.
2. For students who study Chemistry and Biology at Higher Level: Error analysis should be carried out if possible (calculate the percentage uncertainty, etc).

Conclusion and Evaluation
1. In the conclusion the students should discuss the results they obtained in relation with their hypothesis. The conclusion has to be based on an interpretation of the gathered results.
2. The results which are obtained should be compared with literature values if possible.
3. In the evaluation the students should evaluate the method used. They have to write about the main weakness of the method used and the weakness in the method of manipulation of data.
4. The students have to write about the source of error, but not about personal mistakes.
5. The students should suggest real improvements (that can be carried out in the school lab) to the investigation.
6. The students should discuss further investigations that are of interest and can be carried out and new questions that could be posed.

2.2. Experimental Classes 1: Diagnostics the necessity of fertilizing-Investigating the soil content - Potassium, Phosphorus, Nitrate and pH test of soil samples

Crops should be fertilized by as much as necessary to obtain good yields without involving environmental risks. In determining the need for fertilization it is essential to answer to the following questions, on the basis of agrochemical research and analysis: which nutrients are deficient in the soil for the crop, how much of each element must be used, what is the appropriate element according to the pH of the soil.

In this respect the students from the Private Specialized High School American College Arcus have provided an experiment through which they tried to find out what is the content of two soil types- one from the garden and the other one which is steer manure. They made Potassium test, Phosphorus test, Nitrate test and pH test of the investigated soil types. Before the tests the students received detailed instructions from the teacher about the main aim of this investigation - to find out the chemical content of different types of soil in order to compare their appropriateness for the normal development of the plants - and relevant information about the theoretical background of the problem and the experimental procedure, for example:

"**Potassium test**

The amount of Potassium you require in your soil depends on the type of crops you are growing/intend to grow. The manufacturer of the fertilizer will be able to give you a specific breakdown.

Preparing the filtering device

Unscrew the cap on the filtering device and remove plunger

Place one of the filter papers into the bottom of the plunger, ensuring a neat fit by using the end of the spoon. (NB! If the soil is particularly clay based or the solution that comes through is too cloudy, use two filter disks together)

Filtering the nutrients

Fill the barrel to the 0, 5 ml mark with the dry soil and add K1 test solution to the 2 ml mark.

Insert plunger just inside barrel of device and gently shake mixture for 30 seconds.

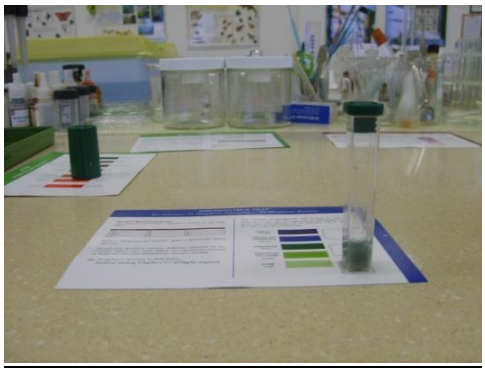
Press the plunger down slowly until it touches the mixture, place on the cap and screw down slowly until you see the solution filter into the plunger. Compress out as much solution as is possible without forcing the cap.

Unscrew the cap and pour solution into one of the rest tubes to the 1 ml mark. Now add K2 test solution to the 1, 5 ml mark.

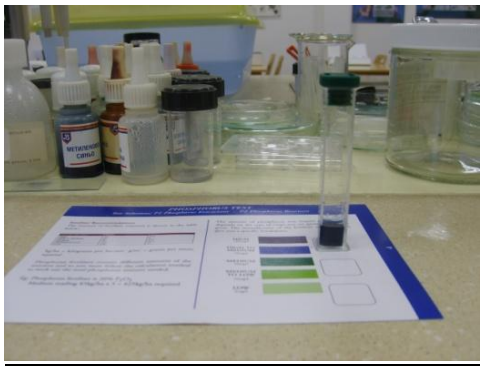
Let the solution stand for 5 minutes before taking a reading. The solution will have degree of cloudiness according to how much potassium is present.

Place the test tube on the square printed over the black and shaded rectangles in the reading chart. Place on the high reading first and move it down the chart until one of the boxes is just visible".

The experiments were carried out with two different types of soil using Nasco Science Lab Kit (fig.1 a and b).



a). soil from the garden



b). soil steer manure

Fig. 1. Example Soil investigation: a). soil from the garden; b). soil steer manure

Then students were asked to try to systemize in two types of tables results obtained after performing the potassium, phosphorus, nitrate and pH tests:

- First type – table systemizing results obtained after performing of the tests for each of studied type of soils - for example Table 1.

Table 1. Potassium, Phosphorus, Nitrate content and pH of a soil sample from steer manure (raw data).

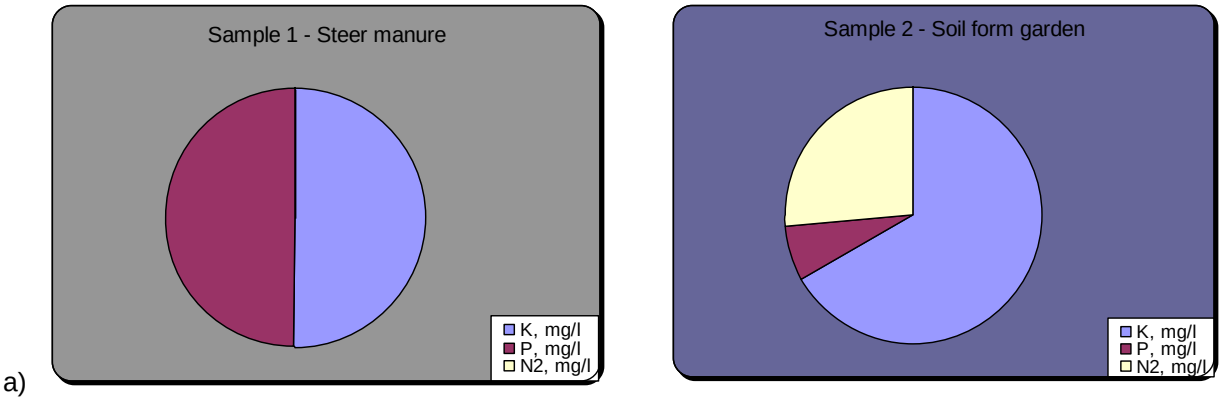
	Test	*Level of **K/P/N_2; pH** value*
Steer manure	Potassium test	0-50mg/l (low content)
	Phosphorus test	50mg/l (high to medium content)
	Nitrate test	0mg/l (low content)
	pH test	pH=7, 0 (neutral)

- Second type – comparative table, allowing the comparison between the data obtained for the two samples in order to detect whether there is a significant difference in the characteristics – for example Table 2.

Table 2. Comparative study of the soil content of two samples (processed data)

Test	Soil sample	
	Soil from steer manure	**Soil form garden**
Potassium test	low level of K (0-50mg/l)	low level of K (0-50mg/l)
Phosphorus test	high – medium level of P (50mg/l)	low level of P (5mg/l)
Nitrate test	low level of N_2 (0mg/l)	medium level of N_2 (20mg/l)
pH test	neutral pH (7, 0)	slightly acidic pH (6, 5)

The next step was to present data in simple graphical view (pie graphs) - it helped students easily to recognize the difference in the studied characteristics of the two soil samples, for example fig.2:



a) steer manure

b) garden soil

Fig. 2. Pie graphs presenting soil content

Based on the results displayed in the above tables and especially the graphic representation of the soil content students tried to compare the information and to make conclusions about the specificity of each soil type. They concluded that:

- The steer manure sample contains insignificant amount of nitrogen, while the amounts of potassium and phosphorus are approximately equal;
- The garden soil sample contains higher amount of nitrogen and potassium when compared to the steer manure sample; the amount of phosphorus is, however, lower;
- The difference in the soil content of the two samples makes them suitable for the development of specific plant species: the samples are appropriate for the growth of plants that have high phosphorus and potassium requirements (steer manure) and even higher potassium and nitrogen requirements (garden soil).

2.3. Experimental Classes 2: Methodology of the Investigation the effect of KNO_3 on the Chlorophyl biosynthesis in cut leaves (Barley and Wheat)

The second phase of the school project was to perform scientific study on processes and influence of definite factors on their development. The effect of mineral fertilizers on the plants' development process was the example topic. Having the experience in scientific investigation obtained during the first project stage, students from the American College Arcus together with their peers from the "A. S. Popov" Vocational School of Electronics provided an investigation on how do different concentrations of the chemical compound Potassium nitrate (KNO_3) affect the biosynthesis of Chlorophyl in cut leaves (Barley and Wheat). This time they learned about some specific scientific methods and measurement devices as spectral methods and Spectrophotometers, using them to measure the absorbance of the different probes, treated with different concentrations of KNO_3.

Data collected by experiments were systemized in table in order to make visible the effect of different concentrations of Potassium nitrate on the biosynthesis of Chlorophyl in cut leaves (explants).

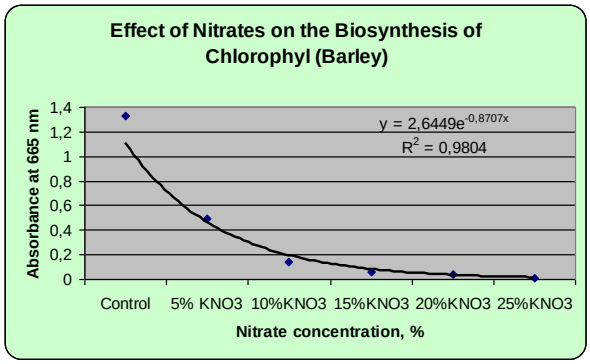
Table 3. Effect of different concentrations of Potassium nitrate on the biosynthesis of Chlorophyl in cut leaves (explants)

Samples	Absorbance at 665 nm, ±0,001					
	Control	**5%KNO_3**	**10%KNO_3**	**15%KNO_3**	**20%KNO_3**	**25%KNO_3**
Barley	1,328	0,496	0,141	0,064	0,044	0,015
Wheat	0,545	0,405	0,127	0,100	0,018	0,011

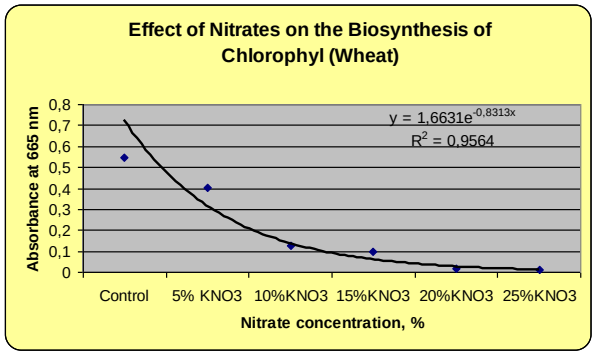
The last step of the project helped students to develop skills in:

- creation of more complicated graphs;
- interpretation of experimental results and searching for possible theoretical equations describing these results – example figures 3, a, b;
- making comparison between groups of experimental data, describing the influence of the one and the same factor on different samples – example figure 4.

Using Excel, they also learned about computer based products for processing and graphical interpretation of experimental data.



a)



b)

Graph 3. Investigating the effect of nitrates on the biosynthesis of Chlorophyl in cut leaves: a) Barley; b) Wheat

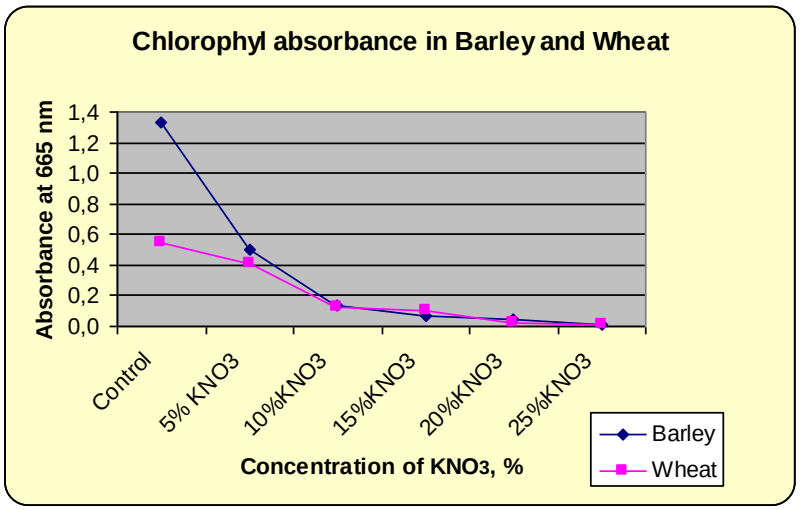


Fig.4. Comparative study of the effect of different concentrations of KNO_3 on the biosynthesis of Chlorophyl in Barley and Wheat

After discussion of the experimental results and their graphical interpretation, with the methodological support of the teacher, the students came to the conclusion that the mineral fertilizer

KNO_3 strongly affects the plants and its concentrations in the soil have to be limited to the allowed values which will improve the protein synthesis but not to be exceeded.

III. Advantages of the chemical and biological knowledge integration and the interschool partnership

The students from the Vocational school showed their skills to interpret information sources and to form conclusions. All the evidence in form of experiments performed by the students from the American College Arcus is convincing and fully supports the theoretical information they have collected.

The conducted experiment, the demonstration of skills for launching an experiment and shaping of graphs, charts, tables of their peers motivated them to be more serious about school work. Interschool partnership allowed the integration of students into a new school environment and showed new ways of learning, promoted teamwork. The methods used in the project provoke students' interest in chemistry. The test results convinced the students that excessive use of fertilizers pollute the environment.

The results of the survey conducted at the end of the project indicate that the students like the idea and prefer the binary lesson to a standard one. When asked to assess the benefits of the project for themselves, students indicated the following answers: I learned something new, I participated in a lesson that is not boring; I realized how other students learn, I got practical confirmation of the theory, I appreciate the importance of chemistry in everyday life.

In conclusion we may add that binary lesson has a high educational value. The excitement of the students in their self-study, their effort during the lesson and enthusiasm in demonstrating their knowledge and skills makes us – teachers feel happy that we have chosen the right direction.

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