Natural science in the joint programme chemistry and nature

Ciencias naturales en el programa integral química y naturaleza

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Abstract

The article discusses the undergraduate teacher training course at the Faculty of Chemistry at Adam Mickiewicz University (AMU). This new course was introduced two years ago, as the first programme of this kind in Poland, in order to educate future teachers of chemistry and nature (a recently created subject combining natural sciences and geography). The paper ponders in detail over the process of preparing chemistry students to teach nature as well as it scrutinizes a sample lesson taught by the students engaged in the programme. In teaching the lesson, the students utilized some of informational technology's (IT's) latest achievements.

Key words: *multimedia, computers , science, teaching , learning, chemistry.*

Resumen

La Facultad de Química de la Universidad de A. Mickiewicz es la única en Polonia que tiene esta especialidad para profesores de química y ciencias naturales, desde hace dos años. Este artículo presenta el ciclo de la educación en los estudios para los profesores de dos facultades: química y ciencias naturales (esta última es una asignatura de carácter integrado que une biología, geografía, química y física). Detalladamente describe la preparación de los estudiantes para la enseñanza de las ciencias naturales y el currículo llevado por ellos con el uso de computadores e Internet.

Palabras clave: *multimedia, computadores, enseñanza, aprendizaje, química.*

INTRODUCTION

Education

In most European countries, children begin their education at the age of six. However, there are some exceptions to this rule. Nobody in Europe is obliged to attend school as soon as in Northern Ireland, where children start going to school aged four, while in the Netherlands and the remainder of the UK, the process commences at the age of five. It is in the countries of Eastern Europe, including Poland, where children begin their education at the latest, i.e. aged seven.

In most of Europe, children are taught five days a week, except for Luxembourg and some regions of Italy. Depending on state regulations and learners' age, school timetables vary. For instance, annual schedules for ten-year-olds in the Netherlands, Cyprus, Latvia, and most of Eastern Europe amount respectively to ca. 1,000, 812, 490, and 600

hours a year, while in Poland, such a schedule totals to 635 hours a year.

Apart from different schedules, it is also the approach towards learners that varies. There are countries in which those who either do not manage to acquire new knowledge to at least a satisfactory extent, or remain psychologically immature, have to repeat a year. However, in some of those countries, the percentage of students actually repeating a year is kept down at a very low rate of 0.6% in Italy, and 0.5% in Finland. Other states, on the contrary, have chosen, up to the end of the obligatory stage of education, to automatically promote students to following grades and offer extra help to those who need it. While such a system eliminates the stress factor when it comes to teaching younger children, it also requires additional expenditure on assistance to the less gifted students (WARE S., 1997; ORLIK, 2000; ORPWOOD G., 1997)

Education in Poland

The educational reform of 1999 introduced some new, interdisciplinary subjects to Polish schools. For example, the traditional division of subjects at the second stage of children's education (i.e. the three years from 4th to 6th grade in primary schools) was replaced by a new scheme comprising four major blocks:

- Culture and Polish (16 hours throughout three years, e.g. 5 hours weekly in 4th grade, 5 in 6th grade and 6 in 6th grade. the number of hours is variable depending individually on each teacher, but it must meet the total at the end of the 6th grade).
- Mathematics (12 hours throughout three years).
- Nature (9 hours throughout three years).
- History and social studies (4 hours throughout three years).

Apart from these, the scheme contains four other thematic blocks. They are:

- Foreign languages (8 hours throughout three years).
- Physical education (9 hours throughout three years).
- Art (2 hours throughout three years).
- Arts and crafts (2 hours throughout three years).

Despite the new division of subjects, most Polish universities and colleges still stick to the old mode of training new teachers, i.e. they prepare students to become teachers of just one subject, be it biology, chemistry, geography or physics. Thus, the graduates who begin their teaching careers do not have sufficient knowledge to teach subjects according to the new, complex model. Taking these problems into account, the Faculty of Chemistry at Adam Mickiewicz University launched a new course at the beginning of the academic year 2004/2005, namely the joint teacher training programme for students of chemistry who intend to teach chemistry and nature. The students involved in the course are expected to:

- Learn how to teach chemistry, biology, physics and geography classes in laboratories.
- Learn to classify knowledge of these backgrounds.
- Be able to apply IT to teaching.
- learn the basics of methodology and psychology.
- Acquire the knowledge of how to manage the class, utilize IT and media in teaching, and create new curricula.
- Learn a foreign language in accordance with the EU teachers policy.

The joint teacher training programme's curriculum was designed according to national criteria for teacher training at courses for undergraduate students.

The range of material taught in the programme comprises:

- Subjects taught within the basic undergraduate programme (in this case elementary chemistry),
- Subjects related to teaching nature (physics, biology and geography) taught by lecturers from other departments (a total of at least 400 hours),
- Methodology (a total of at least 360 hours), comprising.
  - Psychology.
  - Methodology.
  - Didactics of chemistry and nature.
- Supplementary subjects, i.e. speaking skills (? I wasn't sure about this meaning), health and safety course.
- IT classes.
- teaching practices (both major and minor subjects).

The detailed schedule of the programme is illustrated by the following charts:

1st semester

No.	Subject	Number of Hours					Exam	ECTS points
		L	C	P	LC	Total		
1.	Mathematics	30	45			75	Yes	7
2.	Physics	30	15		30	75	Yes	7
3.	Elementary Chemistry	30	30	15	75	150	Yes	12
4.	IT				30	30	final test	2
5.	Health and Safety + Ergonomics	15				15	final test	1
6.	English		30			30	final test	1
7.	Physical Education		30			30		
						405		30

2nd semester

No.	Subject	Number of Hours					Exam	ECTS
		W	C	P	LC	Total		
1.	Mathematics	30	45			75	Yes	7
2	Analytical Chemistry	30	15		60	105		9
3.	Inorganic Chemistry	30		15	90	135	Yes	10
4.	**Ecology**	15	15			30		1
5.	Intellectual Property Rights	15				15	final test	1
6.	English		30			30	final test	1
7.	Physical Education		30			30		
						420		29

+ 135 hours from the methodology course (mandatory)
+ teaching practices: nature in primary schools

3rd semester

No.	Subject	Number of Hours					Exam	ECTS
		W	C	P	LC	Total		
1.	Analytical chemistry				60	60	Yes	6
2.	Inorganic Chemistry	30		15		45	Yes	5
3.	Organic Chemistry	45	30			75	Yes	8
4.	Basics of Environmental Protection	45		15	60	120	Yes	9
5.	**Didactics of Nature**	15			30	45	final test	3
6.	English		30			30	final test	1
7.	Physical Education		30			30		
						435		32

+ 75 hours from the methodology course (mandatory)

4th semester

No.	Subject	Number of Hours					Exam	ECTS
		L	C	P	LC	Total		
1.	Organic Chemistry	30	30		150	210	Yes	14
2.	Physical Chemistry	45	15	15	60	135	Yes	12
3.	Toxicology	30				30	Yes	3
4.	English		30			30	Final test	1
5.	Physical Education		30			30		
						435		29

+ 120 hours from the methodology course (mandatory)
+ teaching practices: chemistry in secondary junior schools

5th semester

No.	Subject	Number of Hours					Exam	ECTS
		L	C	P	LC	Total		
1.	Physical chemistry	45	15		60	120	Yes	10
3.	Biochemistry	15			30	45	Yes	5
3.	Nuclear chemistry	15			30	45	Yes	3
4.	**Elementary biology**	30			45	75	Final test	4
5.	**Elementary geography**	15			45	60	Final test	4
6.	**Chemical experiments**	15			15	30		3
7.	English		30			30		1
						405		30

6th semester

No.	Subject	Number of Hours					Exam	ECTS
		L	C	P	LC	Total		
1.	Chemical technology	30	15		30	75	Yes	7
2.	**Methodology**	15			15	30		3
3.	**Didactic means**	15			15	30		3
4.	**Elementary physics (within the didactics of nature)**	15			30	45	Final test	4
5.	Environmental monitoring	15			45	60	Final test	5
6.	Metrology in chemistry	15			15	30	Final test	2
7.	Legal aspects of environmental protection.	15				15	Final test	1
8.	The humanities (1 selected subject)	60				60		4
9.	English		30			30	*	1
						375		30

Joint total: 2475
(without the methodology course)

METHODOLOGY COURSE

	Subjet	1st semester (summer)		3rd semester (winter)		4th semester (summer)		5th semester (winter)		6th semester (summer)	
1st level Preparation for teaching chemistry in secondary junior schools	Didactics of chemistry	15	30								
	Didactics of chemistry			15	30						
	Psychology	45	45								
	IT at school			15	15						
	Methodology					30	30				
	Voice production					5	10				
	Health and safety in labs						15				
	Computer workshops						30				
Faculty	Chemical experiments							15	30		
	Didactic means									15	30
		L		Teaching practices 150 hours							

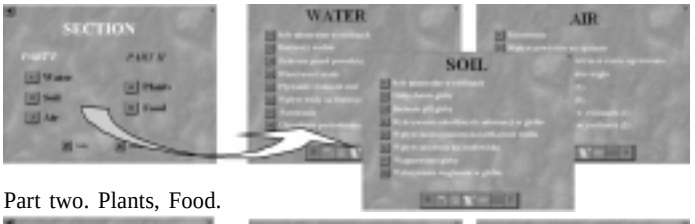
Legend:
L – lectures, **C** – classes, **P** – proseminars, **LC** – laboratory classes
(EUROPEAN CREDIT DEGREE PROGRAMME. TRANSFER SYSTEM)

Apart from their major subjects, all students of chemistry within the joint teacher training programme are taught subjects related to their minor, such as elementary biology, geography, physics, as well as the didactics of nature, ecology, elements of environmental chemistry (all these subjects have been included in the methodology course). Moreover, students are obliged to attend practice teaching sessions within their minor (in this case nature). The undergraduate degree entitles the students to teach nature in primary schools and teach chemistry both in primary and secondary junior schools. In order to be able to teach chemistry in grammar schools, students are additionally obliged to develop their teaching skills in the course of the two years M.A. programme which comprises an extension of the methodology course combined with practice teaching sessions in secondary schools.

The aim of the didactics of nature is to teach students how to utilize their newly acquired knowledge of chemistry, biology, physics and geography in teaching.

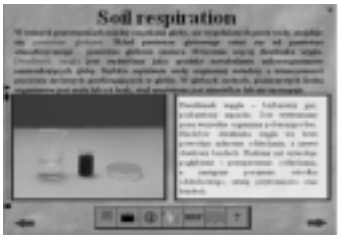
The initial part of the course is devoted to applying IT to teaching. During computer workshops, the students get acquainted with media software available on the market, such as *Nature: Selected Experiments* - a program prepared at the AMU Department of Chemical Education (GULINSKA, BARTOSZEWICZ, 2003). The program, recommended by the Polish Ministry of Education, which included it in its list of suggested teaching devices, is composed of two parts, which together comprise five thematic modules. Each of the five modules contains eight thematic subchapters.

Each of the thematic modules is divided into the following elements:
Part One. Water, Soil, Air.

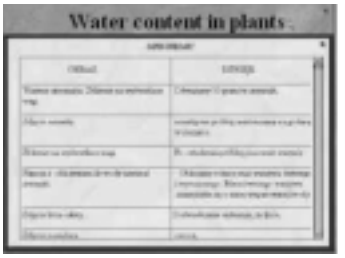


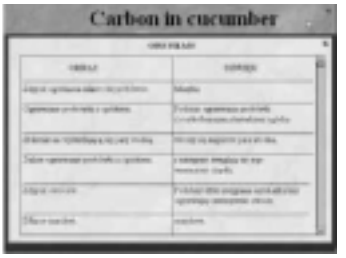
Part two. Plants, Food.

- Texts and hypertexts concerning the subject of given experiments. New terms are marked red and explained on request when clicked on.

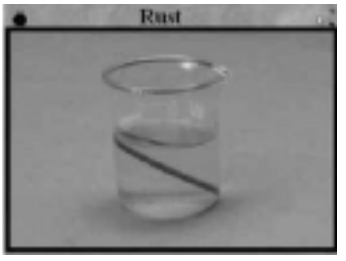


- Scenarios on the bases of which short film sequences were made. The scenarios enable the students to prepare lists of equipment and reagents needed for given experiments, as well as analyze stages of the subsequent experiments, thus instructing the students how to conduct them correctly.

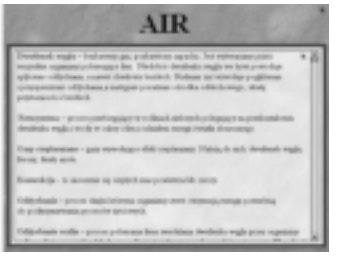




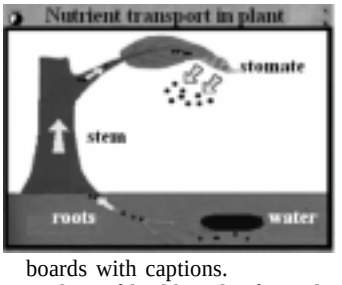
- Short film sequences available for full screen view, which is particularly helpful in analyzing experiments that cannot be conducted in the limited school environment.



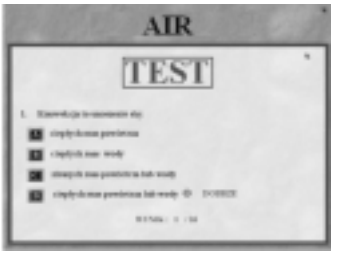
- Glossaries containing words connected with given experiments and thematic modules. There are two types of glossaries: concise glossaries, designed to facilitate certain lesson units, and the advanced ones which approach the modules holistically.



- Additional information and curiosities which extend the students' knowledge in the particular field. They are represented by both pictures and boards with captions.

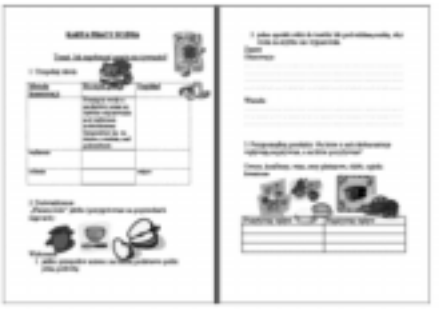


- A chart of health and safety rules for the laboratory environment.
- A set of tests and descriptive assignments which enable the teacher to test the students either at the end of each unit or after the whole module. The questions are picked at random by the computer.



The above illustrated program can be helpful to many pupils, students and teachers, serving either as a presentation at lectures, during classes or laboratory practices, or as an audiovisual instruction preparing the learners to conduct experiments on their own. (GULINSKA, BARTOSZEWICZ, 2003a, 2004).

The second stage of the didactics course is devoted to teaching the students how to prepare supplementary materials for teaching and facilitating their own lessons. Among these materials one can find outline? summary?, animations, didactic games, models, charts, slides and task charts for the students.



While practicing in the chemical laboratory, the students conduct experiments of various complexities. Each experiment is supplied with several variants helping the students choose the solution which is possible to realize even despite some difficulties, such as the lack of access to chemical reagents. An exemplary experiment is illustrated below.

1st variant Put several crystals of potassium manganate (VII) into a conical bulb. Plug the outlet with a cork supplied with a discharge pipe. Heat up the bulb over the flame and collect the exuded gas in a test-tube filled with water and immersed in crystallizer. Now you can define the characteristics of the gathered gas and check how the burning stick acts when put in the test-tube.

2nd variant Put two teaspoons of dried yeast into a conical bulb. Add 2-3 cm^3 hydrogen peroxide (its concentration should amount to 15% or higher). Plug the bulb with a cork and collect the exuded oxygen in a receptacle prepared beforehand. Now you may examine its characteristics.

3rd variant Fill a conical bulb with hydrogen peroxide (15%). Add a pinch of manganese oxide (IV) MnO_2. Plug the bulb with a cork and collect the exuded oxygen in a receptacle placed above the bulb. Now try to define the characteristics of the oxygen.

4th variant Fill a conical bulb with hydrogen peroxide (3%). Put a few slices of a raw potato in it. Examine the properties of the exuded gas by putting a burning stick in the bulb. Under the influence of catalasa contained in the potato, the hydrogen peroxide dissolves itself to clear water and oxygen.

All products used in the experiments are safe in use and available at pharmacies, groceries, and drugstores:

- Potassium manganate (VII) $KMnO_4$ - available at pharmacies, has disinfecting properties.
- Dried yeasts - available at most groceries.
- Oxygenated water (hydrogen peroxide) H_2O_2 - can be purchased at pharmacies and drugstores.

Yet another task the students are expected to deal with during the course is microteaching. Introduced at Stanford University in 1960, microteaching has been used since 1985 by the academic teachers at the AMU Department of Teaching Chemistry as a method of training prospect chemistry teachers. According to this method, classes are taught to small groups of students, one of whom is supposed to teach a short, 10-20 minutes long sample lesson. The lesson is later analyzed and evaluated by the group and the teacher. Optionally, the lesson can be presented again in its corrected version. The lesson is video-taped in order to facilitate the subsequent discussion, and taped again if re-taught. Such a method is aimed at quick and precise improvement of teaching abilities of both the lesson's author and its editors.

The students who attend the course are obliged to attend primary schools and observe how experienced teachers teach their lessons. After classes, didactic aims and methods applied by teachers on a given day are discussed and analyzed by the observers and the teachers.

At the sixth stage of the course, students learn how to teach nature using high-end technology (i.e. computers and Starboard Interactive Display). StarBoard is a device which combines the elements of a screen, self-copying board and computer monitor. As the board may be connected to a computer via a cable or via an infra-red connection (wireless) it is possible to carry out dynamic work and continuously save the notes on the hard disk. The electronic pen is a device with which the user may write on the board. The StarBoard software makes it possible to stop the presentation at any moment, transfer any of its elements to the environment compatible with its software and to modify it freely (GULINSKA, BARTOSZEWICZ, 2006).

Below two sample lesson plans are presented.

SAMPLE LESSON PLAN 1 *STARCH*

1. Introduction: general discussion of the subject (in a chemical lab equipped with StarBoard)	
• subject: Potato starch glue – solving a riddle on StarBoard • information about starch (chart from the *Nature: Selected Experiments* program) – enumerating and highlighting the plants containing starch. The marker's color is changed.	
• proportional amount of starch in various grains – watching pictures, putting new data down on the board. The marker's color is changed again. • The shape of grains of starch on the basis of a chart and slides from the Chemistry with elements of ecology program. The slides are presented using the "searcher" tool.	
• Searching for starch in groceries, such as flour, rice, bread, potatoes or fruit (the iodine-starch test – task done by the teacher	
2. Linking part: the experiment. Production of starch glue and its use for gluing pieces of paper together.	
• **Various** uses of starch (the „Info" part of the *Nature* program) – visualization on Starboard Health and safety rules („BHP" section in *Nature*) – visualization on Starboard	
• Production of starch glue. Instructions can be found in the "Film" section of *Nature* – film projection and the list of consecutive steps visualized on Starboard	
• Discussion of the experiment – the use of StarBoard's functions as didactic tools (searcher, pen, pointer). Notes made by students are later printed out.	
• **Experiments.** Students make starch milk, mix and heat up substances and produce the glue) the experiments are followed by the critical analysis of all activities	

3. Recapitulation. Revision and check-up using Starboard.	
• Recapitulation of all computer images– students do tasks, answer questions and draw grains of starch on Starboard • Multiple choice test („Test" in *Nature*– correct answers displayed on the board)	
• Crossword (first individually on paper, later students fill in the crossword on Starboard) • Post test – students' memory and abilities are tested	
• Jelly as a product containing starch. Everyone prepares the jelly.	

(GULIŃSKA, BARTOSZEWICZ 2005, 2005a)

SAMPLE LESSON PLAN 2 *MINERAL SALTS*

1. Introduction: general discussion of the subject (in a computer lab)	
• subject: mineral salts – students begin with solving a riddle individually • further introduction to the subject – **students** solve a warm-up crossword on their own	
• information on organic and inorganic substances and carbonates (based on *Nature*) – students work individually • group analysis of issues presented in the program	
Differentiating between homogenous and heterogeneous mixtures – group work	

2. Linking part: the experiment. Filtering water polluted with ashes.	
Preparation of the mixture – on behalf of the teacher	
• filtering – audiovisual instructions for the experiment (the „Film" module in *Nature*) – film projection and individual analysis of consecutive steps in the experiment	
• discussion of the experiment –presentation of laboratory activities. All activities are listed on the blackboard	
• **the experiment** (preparation and conducting of the filtering process) – consecutive stages are monitored and analyzed	

3. Recapitulation. Revision and check-up.	
• **Methods** of extracting ingredients from mixtures – students work individually using *Nature* as a learning tool	
• Multiple choice (the „Test" section in *Nature*) – students work individually • crossword – students work individually. Their work is supervised on the blackboard • multiple choice post test.	
• students prepare a digestible homogenous mixture (concentrated juice and water)	

Research carried out during this type of classes showed that:

- pupils who used computers and Starboard in learning new material succeeded in acquiring new knowledge, which shows that both computers and Starboard can be valuable didactic tools if utilized properly by teachers
- the results of our lessons affirmed the high efficiency of Starboard as a didactic tool which, by utilizing media technologies, facilitates the teaching process
- additionally, the results proved the efficacy of lessons designed for classroom environments equipped with computers.

CONCLUSIONS

Drawing a conclusion from the teaching practices supervisors' observation, we can safely claim they received proper training to become independent teachers. The students engaged in the programme prepared their lessons in an interesting way, conducted experiments successfully, used chemical language in their presentations, and made good use of opportunities provided by media devices and computer software. It turned out that the classes which were held in the computer room and utilized the interactive board and media software were immensely attractive to the pupils. In both cases (lessons taught with the help of Starboard and the one utilizing the computer), pupils were engaged in various types of tasks. They diagnosed and resolved problems, developed their deductive reasoning, planned and conducted experiments, drew conclusions from the course of the experiments, hence testing broadly both their psychophysical abilities and their learning skills. Thus:

- the active students preferred group work. They acquired new knowledge via the means of laboratory activities and discussions
- the reflective students would choose to work individually. They would start learning from thinking over a given problem
- the rational students learned by applying provided methods to sort out problems. It was they who checked most often if what they were doing agreed with what was on the screen
- the intuitive students concentrated on analyzing how the qualities of substances involved in experiments changed. They tested, for example, how much water had to be added to glue in order to get rid of its stickiness
- the students who preferred visual methods of learning learned by memorizing patterns visualized on the board, such as pictures, diagrams and films. It were these students who chose Starboard as the best didactic tool
- the students gifted with verbal memory gained most information from explanation provided textually on the computer screen, thus making the computer their favorite learning facility.

It was due to the variety of stimuli provided by the teacher that all students became highly engaged in the lesson. Not only were they active during the class, but also they managed to memorize significantly much information and utilize new abilities.

Therefore, we can conclude by claiming that the teacher training mode discussed above was purposeful. Off course, we do take into account the fact that such positive results of sample lessons may have also been caused by the variety of applied teaching devices. To verify the initial results, further research can be carried out next year when the first group of the three-year B.A. programme's students will graduate and start teaching in schools.

This year's teaching practices confirmed the need of two-subject teaching. Despite fewer students in the schools due to the drop in the birthrate, several graduates of two-subject studies are assured they will be employed at school from september on.

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