Review article

Lubomir Makedonski*, Zlatina Peteva, Katya Peycheva, Mona Stancheva

Laboratory manual in teaching medical chemistry in English language course for the student of medicine and dental medicine

ABSTRACT

Chemistry is an experimental science. It is not an inanimate science, but one that help us to understand the behavior of living systems.
This manual was designed especially to follow the lecture portion of the student class.
The laboratory activities include materials that students may be familiar with, such as household products, drinks, and various medicines. In such way, chemical topics are related to the real world and to the student's own science experience. Some of the lab exercises teach basic skills while others encourage students to extend scientific curiosity beyond the lab.
The laboratory class gives an opportunity to go beyond the lectures and words in the textbook and experience the scientific processes from which conclusions and theories concerning chemical behavior are drawn. The concepts of some experiments have health and biological aspects.

Keywords: chemistry, manual, students of medicine, English program, laboratory work

Introduction

Varna Medical University was established in 1961 when the first students began their academic studies in medicine. The structure of Varna Medical University includes Faculty of Medicine, Faculty of Dental Medicine, Faculty of Pharmacy, Faculty of Public Health Protection and Medical College. The academic and research activities carried out at Varna Medical University are provided by modern facilities

* Correspondence address: Lubomir Makedonski, PhD, Medical University of Varna "Prof. Dr.Paraskev Stoyanov", Faculty of Pharmacy, Department of Chemistry, Marin Drinov Str. 55, 9000 Varna, Bulgaria, e-mail: lubomir60@yahoo.com

and equipment as well as information technologies corresponding to the modern requirements of academic training standards.

The Department of Chemistry was established in 1962 as a part of the former Institute of Higher Education, now part of Faculty of Pharmacy, Medical University of Varna. Associate Prof. Mona Stancheva has been the head of the Department since 1997.Associate Prof. Mona Stancheva, Associate Prof. L.Makedonski and their associates established a Laboratory of Safety and Quality of Foods, which is equipped with gas chromatography- mass spectrometer, HPLC with different detectors, financed with project of Ministry of Education.

Foreign students from all over the world have being educated at the university for almost 15 years.

A prior to their first academic year students are having a preparatory course of chemistry. The student's course includes theoretical part and practical exercises in the major of general, inorganic and organic chemistry.

The need of an adapted manual

Writing and publishing the Laboratory Manual come as an outcome of our science and teaching work. Obviously the increased number of our students involves the need of ordering, completing and fitting the class lectures on paper. A great deal of learned content remains unutilized as the students fail to determine the connection between the content and their practical applicability in dealing with patient[1].

Traditionally, medical students were taught what were considered to be the science on with medicine was based as separate subjects, reflecting the distinctive identity of the academic departments that undertook the teaching. [2] We have the idea to combine and integrate topics from other science's disciplines in order to give much more attention to the teaching, and hence the medical students' learning process. To avoid this situation we also adapt the chemical curriculum to the specific interests of the students of medicine and dental medicine including use and application of important for medical and dental medical practice substances and techniques (Table 1).

[1] Zubair Amin, *Basics in Medical Education,* World Scientific, 2003 p.5

[2] Della Fish,*Medical Education,* McGraw-Hill International, 2005

Table 1. Example 2 of adapting the chemical curriculum to the specific interests of the students of medicine and dental medicine (Testing for cations and anions, p. 30)

Ions	Occurrence	Functional Significance	Source	Result of Too Little	Result of Too Much
Na^+	Principal cation outside the cell	Regulation and control of body fluids volume	Salt, cheese, pickles	Hyponatremia, anxiety, diarrhea, circulatory failure, decrease in body fluid volume	Hypernatremia, little urine, thirst, edema
K^+	Principal cation inside the cell	Regulation of body fluids and cellular functions	Bananas, ornage juice, milk, prunes, potatoes	Hypokalemia, lethargy, muscle weakness, failure of nerve impulse transmission	Hyperkalemia, irritability, nausea, little urine, cardiac arrest
Ca^{2+}	Cation outside the cell; 90 % of calcium in the body as $Ca_3(PO_4)_2$ or $CaCO_3$	Major component of the skeletal system, bones and teeth, cofactor of blood clotting factors	Milk, yogurt, cheese, greens and spinach	Hypocalcemia, tingling, fingertips, muscle cramps, osteoporosis, rickets (in children), osteomalacia (in adults)	Hypercalcemia, relaxed muscle, kidney stones, deep bone pain, tetany
Mg^{2+}	Cation outside the cell; 70 % of Mg^{2+} in the body in bone structure	A cofactor for enzymes in the body, muscles, and nerve control	Widely distributed (part of chlorophyll of all green plants), nuts, whole grains	Disorientation, hypertension, tremor, slow pulse	Drowsiness
Cu^{2+}	Cation carried mostly in the bloodstream	It is found as acofactor of a variety of enzymes. Also it is used as a component of redox-systems in a mitochondrial electron transport chain	Whole grains, legumes, organ meats, cherries, nuts, dark chocolate	Anemia, skin problems, swollen ankles, hallucinations, depression	Headaches, hypoglycemia, increased heart rate, nausea, copper storage disease (Wilson disease).
Fe^{2+} / Fe^{3+}	Intracellular: stored in a form of ferritin; Extracellular: bound to a cpecific transport protein transferrin.	component of: biologically important redox-systems of respiratory chains; Hemoglobin ($Fe^{2+;}$) binds oxygen forming oxyhemoglobin; ensures oxygen transport to the tissues; enzyme cofactor	Chicken liver, oysters, turkey, tuna	Anemia	Excess of iron in the body (hemochromatosis). Results in damages of the heart, liver, gonads and other organs

Ions	Occurrence	Functional Significance	Source	Result of Too Little	Result of Too Much
Zn^{2+}	Cells, muscle	It is an activator of certain enzymes. Responsible for the DNA formation. Key factor in prostate gland function and reproductive organ growth.	Shellfish, beef, egg yolk, pork, whole grains, nuts, oysters, pumpkin seeds	Anorexia, slow wound healing, skin disorders and night blindness.	Nausea, vomiting, diarrhea, weekend immune system
Mn^{2+}	Cells	Enzyme activator. A component of metalloenzymes.	Mustard greens, kale, chard, raspberries, pineapple, spinach, garlic	Skeletal abnormalities, nausea, vomiting, high blood sugar levels, skin rash	Neurological disturbances-tremors, difficulty walking and facial spasms

The following problem shows adapting the chemical curriculum to the specific interests of the students of medicine and dental medicine

An intoxicated driver has a 0.2 v/v % alcohol in his blood. How much alcohol contains in the total 6 l blood of this individual. (Solutions. Concentration and its units, p. 22)

Recognizing the difficulties which students experience not only with the chemical concepts but also with the use of specific laboratory English terms, we highlight their attention with plain text, bolding, underlining and illustrating important and tough notions.

The manual is necessary to summarize subject in topics (Table 2) and for organization the laboratory work, so the students have a follow-up plan in their laboratory work.

Table 2. Content of chemical topics 2012/2013

CONTENT

Teaching Chemistry with tricks

Chemistry is a science of matter, especially its chemical reactions, but also its composition, structure and properties. To be effective science trainers[3] we believe and act in these ways:

- Respect and accept the unique perceptions of individual learners.
- Reflect on and consider learners' prior knowledge and interests when selecting and using specific teaching strategies and techniques.
- Believe that all students can and will learn.
- Create a challenging, but non-threatening, learning environment.
- Commit to the learning and intellectual growth of all learners.
- View oneself as capable, dependable, and generally positive.
- Believe that one can teach effectively and that effective teaching will lead to positive learning outcomes.

Chemistry operates with lots of formulas which have to be studied. That's why most of the illustrations in the manual are just chemical formulas. Often functional groups or atoms are colored or circled, so the students would pay more attention to them. The formulas and structures take a large space of the pages so chemical symbols could be easily distinguished. Bold arrows and symbols in interactions and chemical equations are remarkable. However figures and illustrations are closed to the corresponding text and the reader can easily make an association.

Students of medicine and dental medicine in the English language program speak English well and even fluently, and all of them are having hard time with expressing and working with specific chemical concepts. The reason for that misunderstanding is that academic chemistry is a new subject for students that involves a lot of new English terms and phrases. This problem is solved by combining new concepts with explanation and formulas/figures/equations.

For example when introducing the term ***hydrolysis of disaccharides*** both explanation and equation are present:

*Dissaccharides **hydrolize** in the presence of an acid to give the individual monosaccharides:*

$$\text{Sucrose} + H_2O \xrightarrow{H^+} \text{Glucose} + \text{Fructose}$$

(Hydrolysis of disaccharides, p. 219)

[3] J. R. Staver, *Teaching science,* p.8

Contrasting color is also advisable.

The next example shows other way of presenting corresponding terms.

When sucrose is hydrolized , it forms a mixture of glucose and fructose . This ***50:50 mixture*** *of glucose and fructose is called an* ***invert sugar****.*

(Hydrolysis of Disaccharides and Polysaccharides, p.182)

One of the important directions of the work of our laboratory is *Food quality and Nutritional value of Black Sea Fishes*[4]. We realize the importance of relevance between pure science and real world. That's why most of the experiments and information in the text are related to application and use of substances and processes:

Certain insects, such as honeybees, have enzymes called invertases that catalyze the hydrolysis of sucrose to glucose and fructose. Honey, in fact, is primary a mixture of glucose, fructose, and sucrose.

(Hydrolysis of Disaccharides and Polysaccharides, p.182)

Didactic structure of the manual

Didactic structure of the manual includes theoretic part, lab work part and practice part. Goals and pre-lab questions are discussed at the beginning of each laboratory lesson. Main concepts are next, just before the experimental procedures. Appending questions and problems revise theory and lab work As a whole there are two parts in the manual:first part is General Chemistry and second part is Organic chemistry, totally of 290 pages and is adapted to official accreditation documents[5]. Per academic year 100 hours are in the curriculum of students of medicine and 75 for the students of dental medicine. In a lab class 8-12 students are presented.

There are different ways of managing a laboratory. It depends on the topic, students and equipment. We tried to unify the lab work using these techniques[6] to promote deep scientific understanding:

- To determine if tasks are problems or exercises for students, ask all students if they have a good-to-excellent idea or little-to-no idea how to do specific tasks.

[4] http://lab-varna.bg/index.html

[5] www.mu-varna.bg

[6] J. R. Staver, *Teaching science,* p.12

- Organize cooperative student groups that reflect intellectual, gender, and cultural diversity; have members of the group share and discuss their representations of the gap and proposed solution strategies.
- Use guided-inquiry teaching strategies that lead learners to continue developing and modifying their knowledge.
- Aim problem-solving instruction slightly beyond what students can do alone but within the boundaries of what they can do with assistance from others.
- Use science concepts and processes as contexts for students to write persuasive essays, engage in oral discussions, connect data with scientific theories, and solve problems requiring mathematical reasoning.
- Design discussions and negotiations among students as on-going learning experiences.
- Provide opportunities for students to claim ownership of their learning.

We always start with considering the goals of the topic: identifying functional groups, substances or processes, describing common substances, distinguishing different substances in same group trough performing chemical tests, determining chemical properties, setting up the equipment, performing different lab techniques etc. Students have answered at home the pre-lab questions and a control of the answers follows. These questions are related with the present topic and require a revision of old knowledge. (Figure 1)

Report Sheet-Lab 16

Studenta Name . . . . . Date:. . . . . .

Student Group: . . . . . Instructor signature. . . . . .

Pre-lab Study Questions

1. What are some sources of carbohydrates in your diet?

2. What does the D in D-glucose mean?

3. What is the bond that links monosaccharides in di- and polysaccharides?

A. Monosaccharides
A.1. Fisher projections

L-glyceraldehyde D- glyceralaldehyde

Figure 1. Pre-lab Study Questions. Carbohydrates, p. 175

In the topic ***Carbohydrates,*** for instance, answering pre-lab questions requires revision of structural theory and types of bonding and thinking over the components of your own diet.

A discussion of chemical concepts follows. The text includes tables and formulas for illustrating the information (Figure 2).

A. Disaccharides

The disaccharides contain two of the common monosaccharides. Some common disaccharides include maltose, sucrose (table sugar), cellobiose and lactose (milk sugar).

Disaccharides	Sources	Monosaccharides
Sucrose	Sugar cane, sugar beets	α-glucose + fructose
Maltose	Geminating grains, starch hydrolysis	α-D-glucose + α-D-glucose
Cellobiose	Cotton, jute, paper	β-D-glucose + β-D-glucose
Lactose	Milk, yogurt, ice cream	β-D-galactose + β-D-glucose

Figure 2. Table for illustrating the information about disaccharides, p.171

Disaccharides can be found in common food products or their sources.

Again in the topic ***Carbohydrates*** the transformation of glucose in ring structure through a hemiacetal bond is presented with a formula, which also shows the difference between α- and β- glucose .Generally composing and writing their formulas bother the students. Pointing the linkage (through different color and number) may assist the oral explanation (Figure 3).

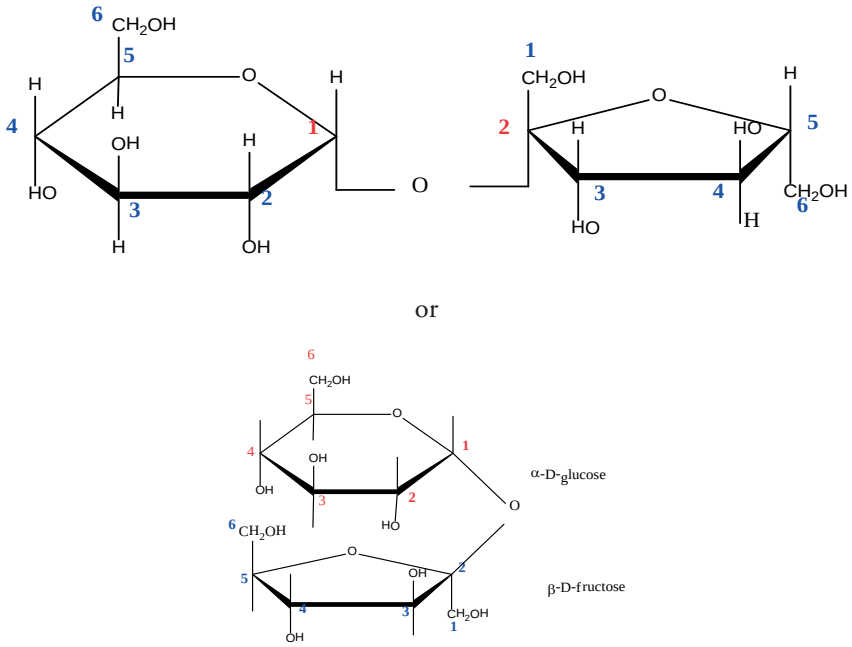
Approximately 1/3 of the time of the laboratory is provided for theoretical questions and problems.

The rest filled in with experiments. An experiment doesn't include only the procedure itself. The consecution in most cases is the following

- Reading the experimental procedures
- Explaining the technique of lab work
- Presenting the necessary laboratory equipment

In this part of the experiment English use (reading, comprehension, oral presentation) and chemical knowledge are needed.

In a disaccharide, two monosaccharides form a glycosidic bond with the loss of water. For example, in maltose, two glucose units are linked by an α-1,4-glycosidic bond. When a specific glycosidic bond (or linkage) between glucose and fructose is made, the result is sucrose.



α, β-1,2-Glycosidic bond

Sucrose

Figure 3. Writing chemical formulas, p. 171, 172

- Performing the experiment
- Observing and finding out the changes in the reactionary set

In the experimental part of each topic of the manual, its authors found a way to design a new laboratory exercise that combines mastering lab skills and improving English knowledge. The manual begins with pictures and application of the most important laboratory equipment that are included in each experimental procedure of the topic.. Students learn how to operate with the laboratory equipment, how to use test tubes, pipettes and water bath. A special attention is devoted to the work with poisonous and mordant substances. Example:

Place 2 cm^3 of starch solution in two test tubes and 2 cm^3 of sucrose solution in two more test tubes. To one sample each of sucrose and starch, add 20 drops of 10 % HCl. To the other samples of sucrose and starch, add 20 drops of H_2O. Label the test tubes and heat in a boiling water bath for 10 min. .

Hydrolysis of Disaccharides and Polysaccharides, p.183

Organizing the educative process

Often students work in a group of 2-3 persons. By working in groups[7] you gain experience and understanding about different tasks . The successful completion of a group assignment usually means that you have acquired many very important skills, particularly communication, analytical and interpersonal skills, which are highly valued by employers. The capacity to listen, question, persuade, respect the opinions of others, help, share and participate is of lifelong value. Working with others also allows for assignments to be broken into tasks and the workload to be distributed evenly. By working together, students are able to bounce ideas off each other and learn from each other. Members can contribute different skills and thus the group can achieve more than individual members could on their own.

During the experiment they work together and English speaking is unavoidable because they are different nationalities.

- Recording the results

Frequently because substances have to be compared, students must fill in a table. Here a general conclusion is asked.

- Discussing the results

Because students are learner and not professionals, after the registration of the result, a discussion is desirable. Asking questions and joining in discussions are important skills for university study[8]. Knowing the main strategies of a discussion, wrong results find their explanation.

- Improving and applying the new knowledge;

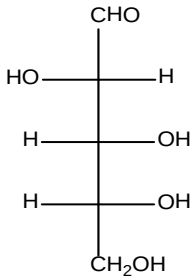
This is performed through answering different questions and solving problems (Figure 4). For example in the topic ***Carbohydrates*** the application of dextrin in the daily life can be looked up in Internet or encyclopedia.

[7] http://deakin.edu.au/current-students/study-support/study-skills/handouts/groups.php

[8] http://www.lc.unsw.edu.au/onlib/disc.html

Q.11. Where can you find a dextrin in our daily life?

Q.12. Write the oxidation and reduction products of D-arabinose.What is the name of the sugar alchohol produced?



Q.13. Describe the similarities and differences in the following:

a. amylose and amylopectin

b. amylopectin and glycogen

Figure 4. Answering different questions and solving problems, p. 186

D-arabinose is not discussed in the text, but its functional group and properties are. So students are supposed to answer this question easily.

Describing the similarities and differences of amylose, amylopectin and glycogen requires generalization and of the text.