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Secondary-school chemistry textbooks in the 19th century

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Abstract: The teaching of chemistry in Serbia as a separate subject dates from 1874. The first secondary-school chemistry textbooks appeared in the second half of the 19th century. The aim of this paper is to gain insight, by analysing two secondary-school chemistry textbooks, written by Sima Lozanić (1895) and Mita Petrović (1892), into what amount of scientific knowledge from the sphere of chemistry was presented to secondary school students in Serbia in the second half of the 19th century, and what principles textbooks written at the time were based on. Within the framework of the research conducted, we defined the criteria for assessing the quality of secondary-school chemistry textbooks in the context of the time they were written in. The most important difference between the two textbooks under analysis that we found pertained to the way in which their contents were organised. Sima Lozanić's textbook is characterised by a greater degree of systematicness when it comes to the manner of presenting its contents and consistency of approach throughout the book. In both textbooks one can perceive the authors' attempts to link chemistry-related subjects to everyday life, and to point out the practical significance of various substances, as well as their toxicness.

Keywords: chemistry teaching; chemistry textbook; the structural components of a textbook; textbook quality.

INTRODUCTION

Textbooks are representative samples of the time they are written in, for they reflect the trends and principles that existed in a particular area of education.[1] In a way, they are built into the generations of students to whom they were taught, for it is through them that a certain way of thinking, a strategy of learning, general intellectual skills and habits, one's attitude towards that which is being learned, towards science and knowledge in general, is cultivated.[2] A review and analysis of various chemistry textbooks from their beginnings to the present day affords insight into the development of ideas about chemistry and the intellectual

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achievements of many generations of students in the realm of this science.[3] A textbook reflects the characteristics of the context that it was created in, as well as the academic knowledge and beliefs of its author(s), reflecting their views of what science is or what it should be.[4] It may be viewed as a conversation between chemistry as a scientific discipline, the context for teaching/learning, the author's personal characteristics and the burden that each society imposes upon one.[5] Textbook writers are confined on the margins of scientific communities, they share various cultures and they are under strong social, economic, and political pressures.[6] Moreover, textbooks are read and used by a great variety of audiences with different aims, expectations and reading practices. Scientific textbooks are therefore at the crossroad between disciplines such as history of science, history of education and history of books and reading.[7] On the basis of analysing textbooks that were used in the past, one can form a picture of the quality of teaching at that time, gain insight into the relationship between science and education, into how fast scientific knowledge was built, into the process of education and to what extent they represented a response to the needs of society at the time. We can say that they are sorts of archaeological traces of former regimes of knowledge.[6] Textbooks can be viewed as focal points for many of the historical contingencies that shape both scientific practice as well as the roles of science and the scientist in society. Although most easily treated as part of the history of the book, they also carry historical significances that transcend that genre.[8]

Textbooks turned into an independent and characteristic genre of scientific publication in the 19th century when science education became compulsory in a number of European universities as well as in primary and secondary education. A reason for the rise of the textbook was its instrumentality in the development of national structures of education, in particular, the nineteenth-century implementation of secondary education.[9]

The teaching of chemistry, as an independent subject in secondary schools in Serbia, dates from 1874.[10] Prior to that, chemistry was studied within the framework of physics and mineralogy. It was taught in the fourth grade, four classes per week. In the guidelines sent to teachers in 1874, it said that they should teach inorganic and organic chemistry with experiments. Of the total of four classes per week, one had to be dedicated to conducting experiments, which is indicative of the significance attached to experimental work in the course of teaching chemistry.

The aim of this paper is to gain insight, by analysing two secondary-school chemistry textbooks, written by Sima Lozanić (1895) and Mita Petrović (1892), into what amount of scientific knowledge from the sphere of chemistry was presented to young people in Serbia in the second half of the 19th century, and what principles textbooks written at the time were based on.

Sima Lozanić (1847-1935) was a chemist, scientist, Professor, Chairman of the Academy of Sciences, the first Rector of Belgrade University, Ambassador to London, Minister of the Economy and Minister of Foreign Affairs, a diplomat. In the mid-1880's, at the time of a reform and modernisation of grammar school, Lozanić worked on compiling a modern chemistry curriculum and introducing teaching through experiments in secondary schools.[11] Apart from chemistry, Sima Lozanić also studied pedagogy (1868-1870) at the well-known school of pedagogy in Küsnacht near Zurich. At Zurich University, Lozanić studied chemistry under Johannes Wislicenus (1835-1902), and subsequently spent one year at August Wilhelm von Hofmann's (1818-1892) laboratory for organic chemistry.[12]

For many years, Mita Petrović (1848-1891) worked at the Serbian Teacher-training School in Sombor, where he taught mathematics and natural sciences. He had organized and equipped a chemical laboratory in Sombor where he did research in the sphere of natural sciences, especially physics and chemistry. He also wrote a large number of textbooks on all subjects he taught. These were mainly based on contemporary German language textbooks which Petrović translated and adjusted to the level and needs of his students. He was a correspondent member of the Serbian Academy of Science, and member of numerous other learned societies. Mita Petrović received many accolades for his work.[13]

The rules on writing secondary-school textbooks in Serbia were passed in 1895. A commission was formed whose task it was to establish whether there existed suitable textbooks for all the subjects taught at school. In March 1895, the commission informed the Board of Education that there was no suitable chemistry textbook for the fourth grade of grammar school. Within one year, Lozanić wrote a textbook and submitted it for publication in March 1896 (although on the cover 1895 remained as the year of publication). In March 1896, Lozanić sent the textbook to the Minster of Education and to the Board of Education for review. The reviewer Marko Leko submitted a negative review of the textbook to the Board, containing 36 objections.[14]

The Board of Education, which was composed of secondary school teachers, who were opposed to Lozanić's terminology, decided not to accept Lozanić's book as an official textbook. It was in vain that Lozanić tried to respond to the criticisms addressed to him.[15,16,17,18,19] Through the Board of Education, the polemic between him and Leko continued throughout 1897, until *The Educational Gazette* announced that the editorial board would accept no more correspondence pertaining to the said polemic. The Lozanić's textbook was only recommended for use in secondary schools at the beginning of the 20th century. Until then, Mita Petrović's textbook was used.[11]

THE METHODOLOGY OF THE RESEARCH

The textbook sample analysed within the framework of our research was the first edition of Sima Lozanić's textbook *Chemistry for Secondary Schools*, dating from 1895, and the third edition of Mita Petrović's textbook *Chemistry for Secondary Schools, based on Prokop Prohaszka and Others*, dating from 1892. Sima Lozanić's textbook had a total of five editions (1895, 1897, 1903, 1910, 1925). For the purpose of this analysis, we opted for the first edition, in view of the above-mentioned criticism, which reflects the context in which the textbook was created.

Mita Petrović's textbook *Chemistry for Secondary Schools, based on Prokop Prohaszka and Others*, despite the fact that it was not in accordance with the curriculum dating from 1881, was used in schools with the permission of the Ministry of Education until the beginning of the 20th century, even after the publication of Sima Lozanić's textbook.[12] The first edition of this textbook came out in 1883, but we analysed the third edition, dating from 1892, on account of the fact that the preceding two editions were not available to us.

In order to achieve the goal that we set for ourselves, first we needed to develop the methodology for analysing and evaluating the quality of those textbooks within the context of the period when they were created.

Some characteristics of a textbook can be quantified, whereas others require a qualitative analysis. The main purpose of the qualitative approach is to understand and interpret various meanings that the textbook being analysed carries, following which one establishes the elements of those meanings.[20] Our analysis of the selected secondary-school chemistry textbooks dating from the 19th century was supposed to provide answers to the following questions:

1. What contents were presented in the chemistry textbooks from the second half of the 19th century?
2. To what extent were the contents presented in those textbooks in keeping with the then current level of knowledge in chemistry?
3. What experiments are presented and described in those textbooks?
4. To what extent did the textbooks analysed establish a connection between the textbook contents and everyday life?
5. To what extent does the textbook caution the students to take care when dealing with certain substances?
6. To what extent were the contents of the textbooks in keeping with the chemistry curriculum then in effect?
7. To what extent did the textbooks deal with events from the history of chemistry?
8. How were the textbooks analysed supported in terms of graphic design and illustrations?
9. What are the structural and organisational components of the textbooks analysed?
10. How were the contents of the textbooks shaped in terms of didactics?

We followed the chemistry-related contents of the textbooks analysed through the following: the themes, the index, the symbols and names of the elements mentioned in the textbook, the formulas of chemical compounds and their names, the equations depicting particular chemical reactions. With the exception of the themes reviewed, all the other parameters monitored within the framework of this part of the research were quantified. We assessed the degree to which the contents of the textbooks analysed were in keeping with the then current level of knowledge in chemistry on the basis of the presence of the current

discoveries in the sphere of chemistry in the text (for example, the discovery of the periodical system of the elements, the Arrhenius theory of acids and bases).

We also monitored the extent to which the students' understanding of chemistry was supported through experiments. The described experiments in chemistry textbooks brings the question whether laboratory techniques can be appropriated by students when reading textbooks and provide information about the teaching practices in the context of the local resources.[6] The possibilities for developing meanings on the basis of the textbook (the meaningfulness of the textbook material) and insight into the practical importance of the knowledge of chemistry were monitored on the basis of the existing links between the chemistry-related contents and their application in everyday life, and also on the basis of pointing out the toxicness of certain substances, their influence on man's health and precautions to be taken when dealing with such substances.

We compared the contents of the textbooks analysed with the chemistry curriculum from 1881, the latter being closest in time to their publication dates.

On the basis of the presence of contents related to the history of chemistry, we reviewed the extent to which the textbooks supported the development of an appropriate idea of this science in the students' minds.[21, 22] Furthermore, we monitored the ways in which the textbooks analysed were supported in terms of illustrations and graphic design, what kind of information was supplied through the illustrations, that is to say, what their purpose was. One of the ways of checking the extent to which textbooks achieve their aims is to evaluate the questions that they contain.[23] In the textbooks analysed, we monitored the thought processes that they initiated, that is, the form of learning initiated by them.

The structural and organisational components that were monitored within the framework of this analysis are shown in Table I.

TABLE I. The structural and organisational components monitored in the textbooks analysed

Structural components	Organisational components
The basic text	Overview of the contents
Terms, concepts, principles, theories and laws	An introductory explanation of the textbook structure
Chemical symbols, formulas and chemical equations	Index of the terms used
Contents related to everyday life and health-related contents	Various kinds of supplementary tables
Contents related to the history of chemistry	Literature used
Precautions to be taken when dealing with certain substances	Note on the author
Pointing out new terms	
Photographs, pictures, illustrations	
Experiment descriptions	
Questions, instructions, tasks	
Referring to other parts of the book	

The content of a textbook should be didactically shaped in such a way that it ensures the students' minds are activated, that the basic structure of knowledge is accepted by those for whom the textbook is intended.[20] The indicators of didactic organisation that we followed in the textbooks analysed are as follows: (I) the existence of scientific terms; (II) a functional use of pictural means of expression; (III) the diversity of the examples provided; (IV) the

meaningfulness of the organisation of the textbook contents, and (V) whether the textbook material has any connection with everyday life out of school.

When analysing the textbooks, we also monitored whether the language of the textbook in question was compatible with the current language of the science of chemistry at the time when the textbooks analysed were written.

RESULTS AND DISCUSSION

From the introductory statements of the authors of both textbooks, one can see their intentions and views on how the study of chemistry is to be organised.

In the preface to the first edition of his textbook, Sima Lozanić pointed out that the students found it easier to understand the formulation of the laws of chemistry on the basis of experiments conducted in class. He was of the opinion that it was easier for beginners to learn about the general terms in the sphere of chemistry in a separate section of the book, that doing so made it possible to present that part in a systematic manner, thus forming a basis for understanding inorganic and organic chemistry. The method of "*placing the general part within the framework of a special part*", which was included in the curriculum, could lead to learning without really understanding things. In his introductory statement, Sima Lozanić explained that his approach to organising the contents of organic chemistry was through homologous series. He stressed that he paid greater attention to applied chemistry and to interpreting chemical phenomena in nature, for he was of the opinion that in this way "*young men were not only enriched through knowledge but also developed a greater interest in science*".

At the beginning of the third edition of Mita Petrović's textbook *Chemistry for Secondary Schools, based on Prokop Prohaszka and Others*, dating from 1892, there is a preface to the first edition of this textbook, dating from 1883. In the text of this preface, Mita Petrović says that it is a problem how to present the contents of chemistry, a science whose body of knowledge has greatly increased, in a manner suitable for beginners in this area, at the same time presenting its development as a science. He pointed out that the organisation of the textbook material was such that the theoretical explanations provided by chemistry were not given in succession, but alternated with experimental parts, and were placed so that the students should be able to understand them when they reached them. In his opening statement, the author pointed out that, when deciding on the scope of the textbook material, he was guided by the curriculum prescribed for grammar schools in the Kingdom of Serbia.

The quantitative data on the textbooks analysed are presented in Table II. The scope of the textbook material in the textbooks analysed differs: Sima Lozanić's textbook has 163 pages, whereas Mita Petrović's textbook has 110 pages, and is smaller in format. In Sima Lozanić's textbook, the table of chemical elements, containing their symbols, names and atomic mass, comprises 68 elements, of the 70 that were known at the time. The table presented in Mita

Petrović's textbook contains such data for 36 elements. In Sima Lozanić's textbook, there is a greater number of chemical formulas. Those are, for the most part, molecular formulas, whereas the number of structural formulas is small in both textbooks.

TABLE II. The quantitative data on the textbooks analysed

Quantitative data	Sima Lozanić *Chemistry for Secondary Schools*	Mita Petrović *Chemistry for Secondary Schools, Based on Prokop Prohaszka and Others*
Number of pages	163	110
Number of titles and subtitles	259	118
Number of propound terms	420	482
Number of terms in the index	490	439
Number of elements whose symbols, names and atomic mass are stated	68	36
Number of formulas of compounds	383	202
Number of equations of chemical reactions	119	25
Number of experiments presented	13	29
Number of examples connecting knowledge from the sphere of chemistry with its practical application in everyday life	158	174
Number of warnings concerning the toxicness of certain substances and precautions to be taken when dealing with them	14	34
Number of illustrations	43	10
Number of episodes from the history of chemistry	27	2
Number of questions and instructions in the textbook	5	12

Both textbook comprise contents related to general, inorganic and organic chemistry. In Sima Lozanić's textbook, the contents are organised in the form of three wholes: the general chemistry section, inorganic and organic chemistry. Following a brief opening part, explaining several fundamental terms in the sphere of chemistry, the contents of Mita Petrović's textbook are organised in the form of two wholes: inorganic and organic chemistry.

These two textbooks differ when it comes to the way in which their contents are organised. Sima Lozanić's textbook first explains the basic concepts, principles and laws in the sphere of chemistry, and only then proceeds to deal with inorganic chemistry through the families of elements, and with organic chemistry through the classes of compounds and homologous series. In Mita

Petrović's textbook, the material related to inorganic chemistry, within the framework of which chemical elements are dealt with individually, is interspersed with segments of the material wherein the general chemical principles and laws are reviewed (what is referred to as "*placing the general part within the framework of a special part*").

In the general section of Sima Lozanić's textbook, what is explained are the fundamental concepts and laws in the sphere of chemistry, the division of elements into metalloids and metals, and the nomenclature of chemical compounds. The following fundamental chemical laws are dealt with: the law of constant mass ratio, the law of multiple proportions, the law of conservation of mass, Avogadro's law. The material is conceived in such a way that what is presented first are the corresponding experiments, or the results of experiments that preceded the discovery of the law in question, following which a formulation of the law is presented. At the end of the general section, the author explains to the reader how the remainder of the textbook will be organised, announcing that in it they will study the most important elements and the important compounds that they are part of, that carbon compounds are given a special emphasis because of their numerousness, that is, that the entire sphere of chemistry is divided into two parts: inorganic chemistry, within the framework of which elements and their compounds are presented, and organic chemistry, within the framework of which carbon compounds are studied.

As opposed to the general section of Sima Lozanić's textbook, which contains 28 subtitles, in the opening section of Mita Petrović's textbook there are four subtitles. In the section entitled *Things change*, various kinds of physical and chemical changes known from everyday life are presented (changes of the aggregation states of water, sliding a bow across a string, charging a resin bar with electricity, sliding a magnet across steel, the dissolution of sugar in water, the burning of wood, the fermentation of grapes). In the section entitled *Transient and essential changes*, the author describes the differences between the types of changes presented, following which he classifies them into two groups and finally defines them as physical and chemical changes. In the section entitled *The directions of chemical changes*, the author presents some experiments, following which he defines the meaning of the terms analysis and synthesis. The last section in the introductory part of the textbook is entitled *The difference between a mixture and a compound*, and in it the author explains the difference between the two.

In the section of Sima Lozanić's textbook that deals with inorganic chemistry, chemical elements are dealt with on the basis of the family of elements they belong to, in the following order: the hydrogen family (H), the halogen family (F, Cl, Br, J), the oxygen family (O, S, Se, Te), the nitrogen family (N, P, As, Sb, Bi, B; V, Nb, Ta), the carbon family (C, Si, Ge, Sn; Ti, Zr,

Th), the alkali family (Li, Na, K, Rb, Cs), the earth alkali family (Ca, Sr, Ba), the magnesium family (Be, Mg, Zn, Cd), the mercury family (Hg, Cu, Ag, Au), the lead family (Pb), the aluminium family (Al, Ga, Jn, Tl; Ce, La, Di, Sm; Y, Er, Yb, Sc), the iron family (Fe, Co, Ni, Cr, Mn), the platinum family (Pt, Pd, Jr, Rh, Ru, Os), the molybdenum family (Mo, W, Ur). A consistent manner of presentation was used to deal with each of the above families of chemical elements. First the name of the given family is presented, following which all the elements belonging to it are enumerated, along with their valences, and then the elements are studied one by one. The organisation of the presentation of material when dealing with each individual element is as follows: after the section title, which contains the name of the element in Serbian, and in most cases in Latin as well, its atomic mass, as well as molecular mass if that element occurs in nature in molecular form, the author proceeds to speak of the forms in which it occurs in nature, both in its elementary state and as part of compounds, then of the ways in which it can be obtained, its physical and chemical properties, and finally of its use, that is, its practical application. The physical properties include the state of aggregation, colour, taste, solubility in water and less polar solvents, for example, alcohol and CS_2. The chemical properties include the reactivity of the given element with some other element or compound. Concerning the use of elements, the author first of all deals with their use in everyday life, be it in their elementary state or in compounds. This order of presentation of the material is retained when dealing with the important compounds of the elements previously presented. In the case of compounds where characteristics analogous to those of previously presented compounds featuring elements of the same family can be observed, the author points out a similarity in their physical and chemical characteristics. At the beginning of the presentation of the majority of the elements, the author briefly mentions the year when a particular element was discovered and who discovered it. In the section dealing with nitrogen, he mentions the three-atom molecule of nitrogen, N_3, referred to as argon, as an allotropic modification of nitrogen, analogous with oxygen and ozone (which was deleted from the next edition of the textbook, published in 1897). The mention of N_3 as an allotropic modification of nitrogen was criticised by Marko Leko, and constitutes one of his objections contributing to his negative review of the textbook.

A lot of attention is paid to ores and minerals that contain certain elements and to where they can be found, the most important mines are enumerated, both in Serbia and outside its boundaries at the time. This points to the significance of mineralogy and to the importance that was attached to it in the sphere of education in the 19th century.

As has already been pointed out, the contents of the inorganic chemistry section of the textbook *Chemistry for Secondary Schools, based on Prokop*

Prohaszka and Others were organised based on the principle of "*placing the general part within the framework of a special part*", which applied for the chemistry curriculum dating from 1881. This textbook contains separate sections for studying metals and non-metals. The section dealing with non-metals included a lot of contents from the sphere of general chemistry, alternating with segments wherein the characteristics of individual elements and their compounds were dealt with. The textbook section entitled *Metals* deals with individual metals and their characteristics. The presentation of contents related to inorganic chemistry begins with the section entitled *On air*. At the very beginning of this section, the following experiment is described – the heating of tin inside a closed vessel, along with measuring the mass of solid substances before and after the reaction, identical to the one on the basis of which Lavoisier (Antoine Laurent Lavoisier, 1743-1794) established the Law of conservation of mass. However, Lavoisier's work is not mentioned here, nor is the law that he discovered; the latter is subsequently explicitly stated within the framework of the section entitled *The quantitative ratios of compounds*. There follows a description of experiments for the purpose of obtaining nitrogen and oxygen. After this, the characteristics of oxygen and nitrogen are dealt with individually, primarily the physical ones, and when dealing with the characteristics of oxygen, the process of oxidation and the creation of oxides are explained. The next section is entitled *On water*, and it deals with hydrogen. The author expounds on the dilemma of whether hydrogen should be classified among non-metals or metals. There follows a general part again, within the framework of which the following are defined: chemical affinity, atoms and molecules. After neutralisation, there is a detailed presentation of chlorine and sulphur (the way they appear in nature, how they are obtained, their properties, use). Within the framework of the section entitled *The quantitative ratios of compounds*, for the first time an equation of a chemical reaction is presented, namely, the one depicting the creation of water, wherein the reactants are presented in their atomic form. Within the next section, entitled *The important compounds of the elements dealt with so far*, the following compounds are presented: HCl, H_2S, HNO_3 ($HO.NO_2$), NO_2, NO, H_2SO_4 ($(HO)_2SO_4$). What is described is how they occur in nature, how they are obtained, their properties and the use of those compounds. The next element to be dealt with is carbon, its allotropic modifications, and the types of coal. Particular attention is paid to the sites of coal deposits and the sources of mineral water in Serbia. Together with carbon, its compounds are dealt with alongside it, which was not the case with the preceding elements. *Valence*, as a topic belonging to the general section, is dealt with after carbon. There follows a section entitled *On flame and burning*, and the last non-metal dealt with is phosphorus. At the beginning of the section dealing with the study of metals, it is stated that metals are divided into light and heavy ones. Light metals are: K, Na,

Ca, Mg, Ba, Sr, Al. The rest are heavy metals. What is presented next is the division of metals on the basis of valence: one-valence metals (K, Na, Ag), two-valence metals (Ba, Sr, Ca, Mg, Zn, Cd, Pb, Cu, Hg), three-valence metals (Bi, Au), four-valence metals (Al, Mn, Fe, Co, Ni, Cr). It is pointed out that some metals, as well as some non-metals, have more than one valence, that they form two lines of compounds, but that it is still not known what valence depends on and how it changes, except that it often happens at high temperatures. After that, the important metals and metal compounds are studied individually, and it should be noted that the "*affinity*" of certain metals is pointed out. The section of Mita Petrović's textbook dealing with inorganic chemistry ends with an explanation of the spectral analysis method and a description of the main parts of the spectroscope. As opposed to Mita Petrović's textbook, spectral analysis is not dealt with in Sima Lozanić's textbook, even though in the general section of the textbook the author did mention the importance of this method and said that he would speak about it later.

At the beginning of the section dealing with organic chemistry, Sima Lozanić states that organic chemistry studies carbon compounds, whether those in the "*kingdom of life*" or those artificially produced in laboratories. Then he presents a classification of organic compounds on the basis of their composition into: *hydrocarbons, halogen derivatives of hydrocarbons, alcohols, aldehydes, acids, carbohydrates, nitro compounds, amines, amides, nitriles, unstudied compounds (terpenes, camphors, resins and caoutchouc, natural colours and the like, alkaloids, proteins)*. When speaking of a class of compounds, it is stated whether a particular compound exists in nature, whether it is extracted from certain plants and animals, and how this is done, whether such compounds exist in the human body and what sort of function they perform. Along with homologous series of carbohydrates, the text presents the boiling and melting temperatures of various elements of the series, on the basis of which one may draw conclusions about their state of aggregation under the same conditions. The importance that was attached to fuel is evident from the amount of space dedicated to oil, the way it is obtained, its refining and various fractions. When dealing with proteins, when the molecular formulas of albumin, haematin and haemoglobin are presented ($C_{72}H_{112}N_{18}SO_{22}$, $C_{68}H_{70}N_8Fe_2O_{10}$, $C_{600}H_{960}N_{154}FeS_3O_{17}$), it is pointed out that those are their presumed formulas, and that it is still not known what the exact composition of those compounds is, except for the fact that they are characterised by a great molecular mass. The ensuing section contains a detailed description of various types of fermentation that contribute to many important processes unfolding in nature, and to the processes of producing various compounds. Within the framework of the section entitled *The processes inside an animal organism*, there is a description of the composition of blood and urine, of the process of breathing and digestion. This

chapter also contains advice for healthy eating and presents information on the daily needs of the human organism for various kinds of food in order to function properly.

In Mita Petrović's textbook, the first section dealing with organic chemistry, entitled *The ingredients of organic compounds*, contains an explanation of the elements that are part of the composition of organic compounds, while organic chemistry is determined in the following way: *"If we heat wood, a feather, paper, cotton, egg-white, etc. in a glass tube which is heated at one end, after a while they will all turn black and turn into coal. All organic matter contains carbon without exception. An object that does not contain carbon is not organic. We can therefore say that organic chemistry is the chemistry of carbon compounds." Paraffins* are dealt with first, of which methane is presented in some detail, as are its halogen derivatives, along with four equations depicting chemical reactions for its gradual chlorination. After that, *cyan compounds, alcohols, ethers, aldehydes* and *acids* are dealt with. Not much attention is dedicated to aldehydes, while acids are dealt with individually and in more detail within the framework of two sections. As regards carbohydrates, the following are dealt with individually: *plant fibre (cellulose), starch, dextrin, grape sugar, cane sugar (sucrose), milk sugar*. It is described how they occur in nature, the method of extracting them from natural products, and an experimental way of distinguishing between reducing and non-reducing sugars (Fehling's test) is presented. Within the section entitled *Alcohol fermentation*, there is a detailed description of the processes of producing wine, beer and various kinds of brandy. A significant amount of attention is dedicated to tannin, in order to point out its use for tanning leather, making ink, etc. Next to be dealt with are aromatic compounds, that is, how to obtain benzene and its nitro and amino derivatives, and their characteristics. Several alkaloids are enumerated, and their physiological effect on man is pointed out. The next to last section is dedicated to natural colours, and the last one to proteins.

Sima Lozanić's textbook contains descriptions of 13 experiments, while that of Mita Petrović contains 29 of them. A list of experiments featured in both textbooks is featured in Table III. Some of the experiments are featured in both textbooks. The experiments are not individually marked and separated from the main text. From the manner of the presentation of the material, it can be concluded that the authors intended them for demonstration in class, and having presented them, both authors subsequently referred to the experiments already presented when dealing with new material.

All the experiments featured in Sima Lozanić's textbook pertain to the contents relating to general and inorganic chemistry, whereas in Mita Petrović's textbook two of the experiments belong to the sphere of organic chemistry.

TABLE III. The experiments described in the textbooks analysed

The experiments featured in Sima Lozanić's textbook	The experiments featured in Mita Petrović's textbook
Making a mixture of iron and sulphur	Anhydrating copper sulphate and then hydrating it anew
Heating a mixture of iron and sulphur	Making a mixture of iron and sulphur and separating its ingredients from each other
Electrolysis of water, gases collected together	Heating a mixture of iron and sulphur
Dissolving salt in water and subsequent evaporation of the solution	Heating tin (lead, zinc, mercury) and measuring the mass of the substance before and after the reaction
A reaction between sodium and water	Heating tin and paraffin, and measuring the mass of the substances before and after heating
Analysis of "red dust" (HgO)	Burning phosphorus inside a bell jar, investigating the characteristics of the gas left in the bell jar
Electrolysis of water, gases collected separately	Obtaining oxygen from red HgO, investigating the characteristics of oxygen
Synthesis of water	Making a mixture of nitrogen and oxygen
Obtaining hydrogen from zinc and sulphuric acid	Burning sulphur in oxygen
Obtaining chlorine from HCl and MnO_2	Burning pieces of coal on a spiral wire in oxygen
Obtaining oxygen from $KClO_3$	Electrolysis of water and investigating the characteristics of the gases obtained
Retention of nitrogen after burning phosphorus in the air inside a bell jar	Obtaining hydrogen from zinc and sulphuric acid (prescribing the exact masses of the reactants)
Obtaining NH_3 from NH_4Cl and $Ca(OH)_2$	Burning hydrogen, covering the flame and obtaining water (chemical harmonica)
	Creating explosive gas in soap suds
	Obtaining NH_3 from NH_4Cl and $Ca(OH)_2$ (prescribing the exact masses of the reactants)
	Obtaining hydrogen from KOH (prescribing the exact masses of the reactants) and nitrogen from KNO_3 and iron (prescribing the masses of the reactants) and their reaction
	The neutralising reaction of ammonia and sulphuric acid
	Obtaining chlorine from HCl and MnO_2, and investigating its characteristics
	Obtaining HCl from table salt, water and sulphuric acid
	Obtaining HFl from $CaFl_2$ and H_2SO_4
	Obtaining H_2S from FeS and HCl in Woulfe bottle
	Sedimentation of Ag_2S, PbS, As_2S_3
	Obtaining HNO_3 from KNO_3 and H_2SO_4
	Obtaining NO from copper and nitric acid
	Obtaining CO_2 from $CaCO_3$ and HCl, and investigating its characteristics
	Decomposition of $CaCO_3$ and the reaction of its product with water
	Obtaining KOH by boiling K_2CO_3 with $Ca(OH)_2$
	Reactions of various sugars with NaOH in $CuSO_4$
	Making colour from indigo, $FeSO_4$ and NaOH (prescribing the exact masses)

In both textbooks, one can observe the connection between the textbook material and everyday life outside school, be it when it comes to the practical application of certain elements and compounds, or the occurrence and function of organic molecules in the human organism, plants or animals. There are 158 such examples in Sima Lozanić's textbook, and 174 examples in Mita Petrović's textbook.

In both textbooks, apart from pointing out the practical use of various substances, the author stresses that certain substances have a toxic effect on man's health. Those include not only substances that can be found in a chemical laboratory, but also substances that are encountered in everyday life, or those that easily occur as a result of processes unfolding in our surroundings (such as the carbon monoxide gas). In Sima Lozanić's textbook, there are 14 examples testifying to the toxicness of certain substances and their harmful effects on man, but there is no direct reference to precautions that should be taken or first-aid measures to be applied if any accidents happen, which is a shortcoming of this textbook. In Mita Petrović's textbook, there are 34 such examples, and in some cases the author points to precautions that should be taken when dealing with such substances, as well as first-aid measures to be applied.

Sima Lozanić's textbook contains 43 illustrations, whereas that of Mita Petrović contains 10 of them. All the illustrations featured in both textbooks analysed follow the main text and contribute to a better understanding of chemical concepts and processes. The illustrations in both textbooks are numerically marked, but contain no captions explaining their contents. The main text contains references pointing to a particular illustration through its number. In Sima Lozanić's textbook, illustrations are used to present apparatuses (ten illustrations), experiments (two illustrations), industrial plants or its segments (nine illustrations), various types of furnaces (eight illustrations), crystallographic structures (two illustrations), structures seen under a microscope (two illustrations), certain processes or parts of them (seven illustrations), chemical vessels and equipment (three illustrations). The first four illustrations are featured in the general section of the textbook, 36 illustrations are to be found within the framework of the inorganic chemistry section, whereas only three illustrations are included in the section of the textbook dealing with organic chemistry. In Mita Petrović's textbook, illustrations are used to present apparatuses (two illustrations), experiments (four illustrations), processes (two illustrations), laboratory vessels (one illustration), instruments (one illustration). All the illustrations are included in the textbook section dedicated to inorganic chemistry, specifically, in the part dedicated to studying non-metals.

Contents pertaining to the history of chemistry, mention of essential discoveries in the sphere of chemistry and names of great chemists are to be found in Sima Lozanić's textbook, 27 cases in all, whereas in Mita Petrović's

textbook there are only two references to the historical development of chemistry. In his textbook, Sima Lozanić points to the turning points in the development of the science of chemistry (disproving the phlogiston theory, disproving the vitalist theory by means of Wöhler's synthesis of urea), and also to the development of certain production processes that have a broad scope of practical usefulness (the production of ceramic dishes, the production of glass), from time immemorial to the period when the textbook was written, on the basis of which one can draw conclusions about the development of science through history and its beneficial effect on mankind.

When it comes to the structural components that we monitored in the textbook analysed, both of them contain: the main text, illustrations and questions; apart from the above components, Mita Petrović's textbook also contains instructions and references to other parts of the text. Concerning the organisational components, the following were observed in both textbooks: a table of contents, an introductory explanation of the textbook structure as part of the preface, an index of terms arranged in alphabetical order, tables of chemical elements. In Mita Petrović's textbook, there is a brief note on the author, consisting of a few sentences included on the title page. When it comes to providing a list of the literature used in compiling the textbook, this component is not presented separately in the textbooks analysed, but in their prefaces both authors refer to the authors on whose books they relied when writing their textbooks. Sima Lozanić states that, when writing the present textbook, he relied on his own textbooks of inorganic and organic chemistry which he had previously written for the High School, while Mita Petrović explains in the introductory section that his role model for writing the present textbook was the book written by Prokop Prohaszka, professor of the Czech High School in Prague, entitled *Chemie učebna kniha pro čtvrtu tridu škol realnih, založena na pokuseh*, and that he also relied on Sima Lozanić's inorganic and organic chemistry textbooks for the High School.

Indicators of the didactic organisation of a textbook, such as explanations of scientific terms, a functional use of illustrative means of expression and variety of the examples used are for the most part similar in these two textbooks. In both of them, when a term is mentioned for the first time, it is printed in bold letters, and immediately next to it there is an explanation. In both textbooks, definitions of a certain concept, process or phenomenon are supported by diverse specific examples, before or after the formulation of the definition.

In the general section of Sima Lozanić's textbook, there are five questions, followed by answers, whereas in Mita Petrović's textbook, in the course of studying inorganic chemistry, 12 questions are posed, but no specific answers are provided to them afterwards. The questions and instructions found in both textbooks analysed are presented in Table IV.

TABLE IV. Questions and instructions found in Sima Lozanić's and Mita Petrović's textbooks under analysis

Sima Lozanić's textbook	Mita Petrović's textbook
1) Does the matter of water change when it freezes and when it evaporates? 2) Is it possible to decompose mercury, hydrogen and oxygen into even simpler components? 3) Do these elements of ours make up other cosmic bodies as well? 4) Is the composition of compounds permanent, that is to say, do they always contain the same elements, joined in the same ratio? 5) What keeps molecules and atoms bound together?	1) In what order shall we arrange the halogen elements based on the strength of their affinity? 2) What is the molecular weight of H_2O, NH_3? 3) What is the molecular weight of oxygen, hydrogen? 4) Thus the volume weight of steam equals 9, as we have seen before. Why? 5) What is the volume weight of HCl, NH_3? 6) Thus all chlorides, iodides, bromides, fluorides and sulphides are salts. What acids are they created from? How shall we explain that process? Which of those salts are already familiar to us? Write their chemical formulas, along with the formulas of their acids. 7) Sulphuric carbon burns with a bluish flame. What are the products of its burning? 8) According to this, in how many ways could we put out the fire? 9) Sodium occurs in compounds only, and is obtained artificially in the same way as potassium is obtained from its carbonate. What is the chemical equation of this process? 10) $BaCl_2$ and $Ba(NO_3)_2$ are important as reagents to H_2SO_4 and sulphates, with which they produce a heavy white sediment. What is the composition of that sediment? 11) When aluminium sulphate is mixed with sodium sulphate or ammonia sulphate, what is created is sodium or ammonia alum. Write their formulas. 12) Galenite is melted with iron particles, which extract sulphur from it through the greater intensity of affinity. Equation?

In Sima Lozanić's textbook, one can observe a uniform way of presenting the textbook material, consistently applied almost throughout the book (the only exception being the section entitled *Unstudied compounds*, which encompasses terpenes, camphors, resins and caoutchouc, natural colours, alkaloids and proteins), which is not the case with Mita Petrović's textbook.

The contents of both textbooks to a large degree cover the chemistry curriculum of 1881. Both authors observed the recommendation from the curriculum on what should be taught about an element: *how it is obtained, its physical and chemical properties, how it occurs in nature, its use*. Even though Sima Lozanić's textbook covers the contents relating to inorganic chemistry prescribed by the curriculum, there is a difference between the textbook and the curriculum when it comes to the organisation of contents. Mita Petrović's textbook follows the organisation of contents prescribed by the curriculum more closely ("*placing the general part within the framework of a special part*"). The essential difference between the 1881 curriculum and the organisation of contents in both textbooks lies in the way organic compounds are systematised. The curriculum, which actually was based on Sima Lozanić's textbook for the High School, systematised organic compounds according to the number of carbon atoms they contain, whereas in the textbooks the compounds were systematised in accordance with homologous series. In Sima Lozanić's textbook, a lot of emphasis was laid on that particular way of systematising compounds, whereas in Mita Petrović's textbook compounds are systematised in this way without defining the notion of *homologous series*.

One characteristic of textbooks is the translations from the language in a scientific discipline into the local or national language[7]. A difference was observed when it comes to the terminology used between the curriculum and Sima Lozanić's textbook, whereas the terminology used in Mita Petrović's textbook is in keeping with the curriculum. In Mita Petrović's textbook, the scientific terms used are adjusted to the Serbian language, that is to say, they are "serbianised". In Sima Lozanić's textbook, the scientific terminology corresponds to the terminology that we still use today, with minor changes. The names of compounds in Sima Lozanić's textbook are mainly in the nominative case (for example, potassium chloride), while in Mita Petrović's textbook the names of compounds are given in the genitive case (for example, chloride of potassium).[24] At the time, the discussion between scientists (not exclusively chemists) was ongoing – should the science terminology be "serbienisied" or not.

Sima Lozanić's textbook also contains topics that go beyond the curriculum contents, mainly related to organic chemistry, whereas Mita Petrović's textbook does not cover several topics from the sphere of inorganic chemistry, nor does it cover the topics contained in the curriculum supplement relating to: *the chemical difference between plants and animals, breathing and life-giving heat, and the feeding of plants*; also, it contains no topic beyond those prescribed by the curriculum.

In the major part of both textbooks, the knowledge available at the time is accurately presented, with the exception of the valences of some elements, the symbol of fluorine, the formulas of certain compounds and the equations of

chemical reactions in Mita Petrović's textbook, and the controversial allotropic modification of nitrogen in Sima Lozanić's textbook. Neither textbook mentions Arrhenius's theory of electrolytic dissociation or Mendeleev's periodical system of the elements. Arrhenius's theory of electrolytic dissociation was posited in 1884, and the textbooks analysed were published in 1892 and 1895 respectively. The leaving out of this theory may be explained by the fact that, for a number of years, Arrhenius's theory was called into question among the scientific public. Neither of the textbooks analysed mentions the periodical system of the elements that Mendeleev published in 1869. That is not the case with the second edition of Sima Lozanić's textbook, dating from 1897. It is surprising that Sima Lozanić did not include the periodical system of the elements in his secondary-school textbook, in view of the fact that he had done so in his previously published inorganic chemistry textbook for the High School.

CONCLUSION

Towards the end of the 19th century, general, inorganic and organic chemistry in secondary schools in Serbia were studied based on the textbooks *Chemistry for Secondary Schools* by Sima Lozanić and *Chemistry for Secondary Schools, based on Prokop Prohaszka and Others* by Mita Petrović. In these two textbooks one can see the difference when it comes to approaching the organisation of textbook contents. The discussion was ongoing for years – should general chemistry be presented under the inorganic chemistry or the special section of the textbooks. In the former, general chemistry, with the basic chemical concepts, principles, theories and laws, is dealt with in the opening section, thus forming a basis for inorganic and organic chemistry in the remainder of the textbook. In the latter textbook, the two largest sections are taken up by inorganic and organic chemistry and contents related to general chemistry are presented within the inorganic chemistry section, in those places that the author considered to be the most convenient for the students' understanding of the said contents. On the basis of the authors' introductory statements, one gets the impression that both approaches are the result of their thinking and assessment of what kind of organisation of the textbook contents would contribute to the students' better understanding of chemistry. The latter author's approach followed more closely the organisation of the then chemistry curriculum, but the former author's approach has been retained in today's chemistry curricula. It may be assumed that the said approach was developed during the course of Sima Lozanić's studies under Wislicenus and Hofmann. However, the approach applied by Sima Lozanić was criticised by Marko Leko, the reviewer of the *Chemistry for Secondary Schools* textbook. The only justification for criticising Sima Lozanić's textbook, based on our analysis of it, lies in the fact that he mentioned a controversial allotropic modification of

nitrogen. It may be assumed that this was done out of a wish to make the textbook's contents as up-to-date as possible, but in this case the said piece of scientific information was insufficiently verified. In the second edition of the textbook, Sima Lozanić already left out the controversial allotropic modification of nitrogen.

The textbooks analysed differ in terms of the scope of their contents, Sima Lozanić's textbook being the more voluminous of the two. As regards the accuracy of the textbooks' contents, several segments of Mita Petrović's textbook were assessed to be inaccurate.

Both textbooks link theoretical contents with corresponding experiments, and the experiments presented in Sima Lozanić's textbook are better suited to the lesson at hand, thus providing a better grounding for understanding theoretical contents. Both textbooks contain examples that point out the practical significance of chemistry and its connection with everyday life. Also, in both textbooks the authors point out the toxicness of certain substances. Sima Lozanić's textbook, compared to that of Mita Petrović, to a greater extent includes contents related to the history of chemistry which, at the time, could acquaint young people with the nature of science and scientific/research work, the essential turning points in science and the contribution of science to the development of society.

When it comes to the structural components, both textbooks contain: the main text, with in-built descriptions of experiments and their results, illustrations, questions. Apart from the above components, Mita Petrović's textbook also contains instructions and references to other parts of the text. As regards the organisational components, both textbooks contain: a table of contents, an introductory explanation of the structure of the textbook within the framework of the preface, index of alphabetically arranged terms, tables of the elements.

In the final analysis, it can be concluded that Sima Lozanić's textbook is of a better quality compared to that of Mita Petrović, not so much in terms of the choice of contents as in the way the contents are presented and the order of presentation.

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И З В О Д

УЏБЕНИЦИ ХЕМИЈЕ ЗА СРЕДЊУ ШКОЛУ У 19. ВЕКУ

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Настава хемије, као самостални предмет у Србији, датира од 1874. године. Први уџбеници хемије за средњу школу појавили су се у другој половини 19. века. Циљ овог рада јесте да се кроз анализу два средњошколска уџбеника из хемије, аутора Симе Лозанића (1895) и Мите Петровића (1892), сагледа шта се од научних знања из хемије презентовало ученицима у средњим школама у другој половини 19. века и према којим принципима су тада писани уџбеници. У оквиру истраживања дефинисани су критеријуми за праћење квалитета средњошколских уџбеника хемије у контексту времена у коме су настали. Најбитнија нађена разлика између два анализирана уџбеника односи се на организацију садржаја. Уџбеник Симе Лозанића карактерише већа систематичност у излагању садржаја и доследност у приступу кроз цео уџбеник. У оба уџбеника видљива су настојања да се садржаји хемије повежу са свакодневним животом, као и да се поред практичног значаја супстанци укаже на њихову токсичност.

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