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Ružica S. Nikolić, Danijela A. Kostic, Nenad S. Krstic, Aleksandar Trajković, Nena Stojanović
Serbia

A Multidisciplinary Approach to Teaching Metals as Part of the Elementary School Curriculum in Serbia

Abstract

The multidisciplinary approach to the study of metals which we are proposing includes the modernization of the curricular content and its connection with everyday life. The use of additional teaching material in elementary schools in rural and urban areas in the wider region of the city of Niš has contributed to increased interest and activities on the part of the schoolchildren, which has in turn led to a significant quantitative improvement in their knowledge of chemistry in general, but also of metals in particular. All of the schoolchildren achieved a satisfactory level of knowledge (>50%) following the implementation of the expanded curriculum.

Keywords: *teaching metals, elementary school*

Introduction

Chemistry is a part of our everyday life. Knowledge of chemistry enables us to understand and explain the world around us, including both the occurrences and changes that take place in it. It offers explanations of many things from everyday life, ranging from water and food, via various products we use, to means of preserving our environment.

Educating schoolchildren about chemistry enables them to choose a job in the chemical industry and other related fields. Knowledge of chemistry is necessary for work in almost all other sciences, including biology, medicine, pharmacy, technology, environmental sciences, archaeology, geology, etc.

De Jong defines four basic tasks for chemistry: to offer knowledge that is necessary in everyday life (personal one), to help make a suitable career choices, (professional one), to enable the understanding of scientific and technological applications (technological one), and to help educate and shape socially responsible citizens (social one) (De Jong, 2006, 23).

Research Problem

Earlier pedagogical research carried out in both schools in Serbia and abroad has indicated a lack of knowledge, especially at the level of understanding, generalization, conclusion making and the ensuing responses (Šišović, 1998, 5). It is surprising that most schoolchildren finish the school year with a high grade in chemistry (both here and abroad), but only small percentage of them (7%) continue to have the same success in high school (Šišović, 2000, 263).

According to the TIMSS 2003 research results, student knowledge in natural sciences at the end of their elementary school education in Serbia, compared to the grades of their peers from 45 countries which were involved in the research, was somewhat below the established average (28 rank- 468 points, an average of 474 points) (Babić, 2009, 23).

The highest results in our population were scored in the category of factual knowledge retention, followed by the understanding of concepts, and the weakest results were scored in the category of analysis and reasoning. Another special problem is the synthesis of knowledge from various subjects, all of which take a different view of the same problem.

With the aim of overcoming these problems and improving chemistry classes in Serbia, numerous studies have been carried out.

Šišović used a cooperative approach in teaching a chemistry core topic: acids and bases. The experimental group obtained higher results on the final test by 16% at the level of reproduction, 22% at the level of understanding, and 14% at the level of application. A significantly higher number of schoolchildren from the experimental group were able to apply their theoretical knowledge and explain the changes that occurred during the demonstration of the experiment. (Šišović, 2000, 269).

A group of authors from the University of Niš proposed a computer-based method for the study of acids and bases. This concept represents a solution to the problem of the lack of conditions for experimental work, enables virtual simulation and economic rationalization. It also contributes to the active participation of schoolchildren in the teaching process and the improvement of their interests and knowledge (Kostić, 2008, 10). Similar studies and the results obtained by means

of a cooperative method indicated an improvement in the teaching method of proteins (Kostić, 2010, 172) and carbohydrates (Zarubica, 2012, 9).

More than half of the known elements are metals. Due to their good physical and chemical properties, they are widely used in various spheres of life. They are studied in elementary schools as part of the eighth-grade chemistry curriculum. It has been noticed that the knowledge acquired in the field of metals is insufficient and does not have great applicative value, and that the students are insufficiently motivated to learn.

There is only one study which deals with the teaching of metals. An alternative approach to the teaching of metals was proposed as part of a project, The Primary- LISP (P). It includes: motivating schoolchildren to ask questions regarding metals, to answer questions, consider the responses which are not correct and offer a summary in the form of discoveries that were made as a result. Although it motivates schoolchildren to ask questions, they do not possess the necessary skills and strategies for research. (Biddulph, 1983, 32)

Research Focus

The aim of the presented study was:

- on the basis of the critical view of the existing elementary school curricula and programs, to propose the expansion and modernization of the content of the chemistry core topic of metals
- to enable the application of the expanded content in elementary schools in both rural and urban areas
- to carry out the testing of schoolchildren and offer an analysis of the results
- on the basis of the obtained results, to propose future activities.

Research Methodology

Research General Background

The main goal of the pedagogical experiment is for the schoolchildren to achieve better results on the final evaluation/test. It was expected that the proposed expansion of the curriculum could enable better transfer of information and knowledge and facilitate the acquisition of usable and permanent knowledge

The modification of the curriculum: The existing curricula include the recovery, physical and chemical properties of metals, their extraction and application. The

additions to the curricula were prepared based on a multidisciplinary approach so as to enable schoolchildren to acquire all-encompassing knowledge of metals.

The expansion of the curricular content includes: the identification of metals in groceries, daily metal requirements, food quality, illnesses that result from metal deficiency in one's diet (the biological aspect of life), metal toxicity, metal contamination of the earth, water, food and air, as well as preventive measures (the ecological aspect) and the application of metals (the technological aspect).

The proposed expansion was prepared in accordance with the pedagogical, psychological, and methodological requirements (Rančić & Anđelković, 2007).

Research Sample

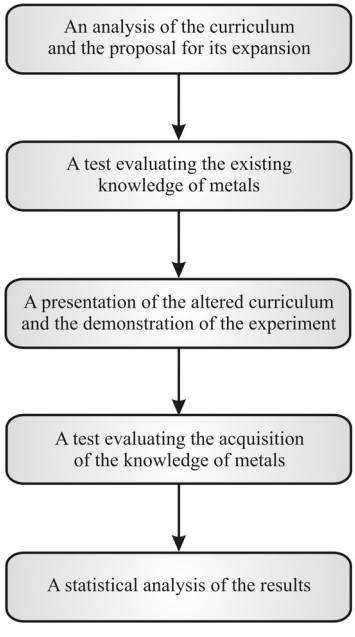
The pedagogical experiment was realized in the following elementary schools in the wider region of the city of Niš, including:

- Vožd Karađorđe Elementary – an elementary school within the city limits
- Vojislav Ilić Mlađi – Hum Elementary – a village elementary school.

Procedures

Figure 1shows the structure of the pedagogical experiment:

Figure 1. A schematic representation of the pedagogical experiment



The aforementioned tests were designed in accordance with the pedagogical, psychological, and methodological requirements so that the relevant questions referred to the entire core topic of metals. The questions were age-appropriate and unambiguous.

Data Analysis

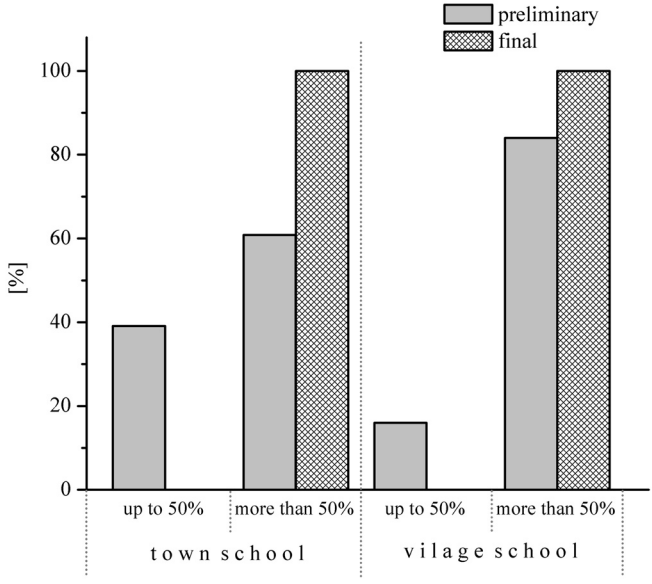
The results of the tests were processed for statistical significance. The statistical analyses were based on the means, standard deviation, degree of freedom, significance (t-test), and analysis of variance (ANOVA). Statistical Analysis and Reporting System, user Guide, version 1.0, 1MB, 1999.

Research Results

In order to gain insight into the level of knowledge which the schoolchildren possess, a test for the evaluation of existing knowledge (the preliminary test) was given, which contained questions from the core topic of metals as covered in the existing curriculum. What followed was the presentation of the expanded curriculum with the performance of demonstration experiments. This was followed by another test meant to evaluate the acquired knowledge from the core chemistry topic of metals (the final test). The test consisted of questions which referred to the overall expected level of knowledge from the field of metals.

Figure 2 shows the results of the success rate of curriculum acquisition in the elementary schools, in percentage.

Figure 2. The percentage of the success rate at the Vožd Karađorđe Elementary (a school inside the city limits), (n=23) and Ilić Mlađi-Hum Elementary, a village elementary school (n=25)



The results of the preliminary and final test for the village and city elementary schoolchildren in terms of descriptive statistics are shown in Table 1.

Table 1. A comparative statistical analysis of the results of the tests given in the city and village elementary school

	School	Min	Max	Mean	St.dev.	Diff.	z-test	t-test	p-val.
Preliminary test	City	15	80	53.7	15.89	-7.28	-3.507	-3.507	0.002
	Village	30	80	60.65	11.48				
Final test	City	70	100	88.70	9.91	8.07	2.472	2.472	0.022
	Village	65	95	80.77	9.87				

Number of points 0-100 points, zcritic.= 1.96, tcritic.=2.08, α=0.05

Table 2 shows the results of the paired tests for the village and city school.

TABLE 2. The results of the paired samples test which can be used for checking the differences between the number of obtained points on the preliminary and final tests in the city and village school

	t-test (observed)	t-test (critical)	z-observed	z-critical	p-value	Difference
Village	12.06	2.06	9.81	1.96	0.0001	22.54
City	10.383	2.07	9.68	1.96	0.0001	25.04

Discussion

Fifty percent of the points awarded on the test were designated as the criterion for the successful acquisition of the program, and represented the viewpoint from which the data were analyzed. Figure 2 shows the results of the success rate of curriculum acquisition in the elementary schools, in percentage. The results showed that the village school had a greater percentage of schoolchildren who possessed a satisfactory level of knowledge (more than 50%). In addition, the minimum number of points was higher in the village school. This could be the result of greater contact of the village schoolchildren with nature and the physical aspects of life. The scores on the final test were higher in both schools. The results of the city elementary schoolchildren were better on the final test, which indicates their potential for the acquisition of new knowledge. (Figure 2)

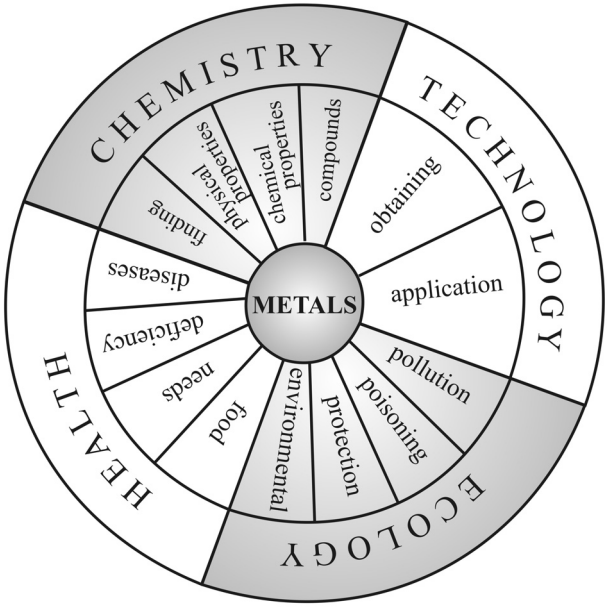
The results of the preliminary and final tests for the village and city elementary schoolchildren in terms of descriptive statistics are shown in Table 1.

The experimental values of the t-test are greater than the critical values of the t-test in both schools, which indicates that the numbers of obtained points on the preliminary and final tests differ in a statistically significant manner.

The results of the paired samples test which can be used for checking the differences between the number of obtained points on the preliminary and final tests in the city and village school are shown in Table 2. The difference in the number of obtained points is greater in the city elementary school. The P-values also indicate a statistically significant difference between the preliminary and final tests (Table 2).

The structure of the expanded curriculum related to the core chemistry topic of metals is shown in Figure 3. It reflects the multidisciplinary approach to studying metals.

Figure 3. The structure of the curriculum within the core chemistry topic of metals



Thus, it follows that the proposal for the expansion of the curriculum was well-accepted, that it raised interest among the schoolchildren and that it would be beneficial to make corrections of a similar type in other elementary school curricula. The greatest improvement was noted among the schoolchildren with the poorest grades, which is linked to the application of the proposed changes and demonstrated experiments.

Conclusions

By applying a multidisciplinary approach to the study of metals and the improvement of the curriculum in terms of the core topic of metals, we have obtained qualitative and statistically significant differences in the success rate on the preliminary and final tests in a village and city school. The attempt to modernize the curriculum had the greatest influence on the schoolchildren with the smallest and greatest number of points on the preliminary test, which may mean that the program can be realized not only in regular, but also additional and advanced classes, in the appropriate form. The modernized concept of education contributes to making teaching more dynamic, interesting and suitable for schoolchildren. It contributes to the acquisition of permanent knowledge at the level of understanding and generalization and allows for the synthesis of knowledge from various scientific fields. New research will focus on the application of the expanded and optimized content and its application in the reformed teaching process of chemistry, which is of national strategic interest. An analogous study of the chemistry classes involving the core topic of metals in high schools will also be carried out.

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