

**BASIC PRINCIPLES OF THE SECONDARY SCHOOL SCIENCE TEXTBOOKS
DEVELOPMENT**

**PRINCIPIOS BÁSICOS PARA EL DESARROLLO DE LIBROS DE TEXTO DE
CIENCIA PARA ESCUELA SECUNDARIA**

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Abstract

One of the main concerns about teaching science at secondary school and university is the design of a new kind of textbooks with a special system and tasks for independent work for students so that they develop their self-education skills. In this work based on many decades of scientific and educational activities, the author reports his recommendations on how to design good quality textbooks on science subjects for the secondary school. The author has more than 100 million copies of his textbooks printed in several countries in 22 languages. The longitudinal pedagogical experiments were organised widely throughout many countries.

Keywords: textbooks improving, self-education, independent student's work.

Resumen.

Una de las principales preocupaciones de la enseñanza de las ciencias en escuela secundaria y universidad, es el diseño de un nuevo tipo de libros de texto con un sistema especial y tareas de trabajo independiente para estudiantes, de manera que ellos desarrollen sus propios niveles de educación. En este trabajo basado en muchas décadas de actividad científica y educativa, el autor presenta sus recomendaciones sobre como diseñar libros de texto de buena calidad en temas de ciencia para escuela secundaria. El autor tiene mas de 100 millones de copias de sus libros de texto impresos en varios países en 22 idiomas. Los experimentos pedagógicos longitudinales fueron organizados ampliamente a través de muchos países.

Introduction

The quality of textbooks is a very important part of science instruction. The textbook is the main teaching and learning tool for all levels of education. Unfortunately, in many countries we have a lot of examples of low quality science textbooks that contain many methodological and scientific mistakes (Orlik, 2000). The best examples of good textbooks have been written by authors who are big scientists and teachers.

In all his published textbooks, the author of this text paid great attention to independent student work and the introduction of learners to self-education. According to the author’s 40 year experience, the didactic materials necessary for independent work and the introduction of self-education should be included in textbooks. By following this thesis, teachers can have a real opportunity to implement one of the most important pedagogical basic requirements: the learners must acquire a considerable part of the learning material by themselves without direct participation from the teachers for reaching the highest level of independent work and self-education.

Principles of good textbook writing

To find new ways for improving textbooks all the author’s textbooks were subjected to wide experimental tests and development. Besides, in many regions, through surveying of thousands of learners, the author got to know about their wishes on future development of the textbooks. The author and his coauthors got many suggestions through meeting with the experienced educators and in personal contact with the authors of textbooks from many different countries. At the same time, an analysis of the best textbooks of the different countries was carried out. As a result of this multi-form work, the author has managed to involve the important principles of textbooks design as the structural elements of the theory of secondary school text book development (table 1) . (Rudzitis, 1977a; Rudzitis, 1977b; Rudzitis and Feldman, 1989; Rudzitis, 1990a; Rudzitis, 1990b)

Table 1. The general didactic basic principles of textbook design

1. An attractive layout for the book. That the book: 2. Provides learners with special text-instructions on how to work with the book and the	7. Arises the student interest of towards the learning process including materials on interesting historical facts, illustrations and elements of humor.
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<p>methodological recommendations for independent study, self-upbringing and for preparing students for self-education.</p> <p>3. Explains uniformity learning material under a common plan.</p> <p>4. Encourages the success of independent studies by helping students acquire consolidation and recapitulation of knowledge during lessons and consultations, as well as while preparing home tasks, through the use of tables, schemes, algorithms that facilitate perception of the essentials of learning.</p> <p>5. Guides motivations of education is its economic relation, the link f the teaching material with production and practical life through extra texts, schemes, illustrations and tasks over the entire course since it traditionally arise the interest of students toward the learning process.</p> <p>6. Differentiates the learning material, using various prints, notices on margins, and special notes.</p>	<p>8. Promotes the development of independent thinking processes and helps students to use their knowledge in new circumstances.</p> <p>9. Helps students work with questions, exercises and tasks and introduces these materials in the text-book for self-control of knowledge.</p> <p>10. Considers that it is necessary to write learning texts in easy, clear language but at the same time on a sufficient scientific level.</p> <p>11. Acknowledges that computers and Interent have become prospective additional tools for being used with modern textbooks.</p>
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1. One of the structural elements should be an attractive layout for the book. It is excellent to allow students to see the beauty of the new knowledge, the nature and the practical work of people on every page with the help of the artist. But the implementation of this structural element requires very hard work of the author and editors and a lot of money from the Publishers.

2. Another important structural element is the use of ***special texts-methodical instruction for learners*** for independent study work, for solving self-upbringing matters and for introducing self-education. These methodical instructions are given not only in the introduction, but they are meant for the rationalisation on the most significant teaching material of the course.

3. Another structural element is the ***regular explanation of similar teaching material*** (for instance, in physics, chemistry, or biology) according to common plan.

For example, material related to chemical elements in new manuals is usually printed under the following common plan:

- 1) structure of the atom.
- 2) situation in nature.
- 3) how to obtain the elements:
 - a) in laboratory.
 - b) in industry.
- 4) physical properties.
- 5) chemical properties.
- 6) practical use.
- 7) genetic association (links).

The analysis of many thousands of student answers shows that most of them wish to learn on such common plan.

4. A very important basic element is ***to provide didactic materials in structured form***, that is, ***tables, schemes, and algorithms***. It is important because the success of the learners independent study, acquiring consolidation and recapitulation of knowledge during lessons and consultations, as well as while preparing home tasks, is mainly predetermined by the use of tables, schemes, algorithms that facilitate seeing the essential information in the learning material.

Experience and practical testing have proved that to achieve the greater informative value and viscosity of the texts is advisable to use the tables specially designed for this purpose. The example of such a table is given below. It is a table for examining chemical properties of hydrochloric acid.

Table 2. Chemical properties of hydrochloric acid (Rudzitis 2000a)

Common properties for other acids	Specific properties
1. Change in dyeing of Indicators 2. Interaction with metals: $2\text{HCl} + \text{Zn} \rightarrow \text{ZnCl}_2 + \text{H}_2$ 3. Interaction with bases and Intermediate oxides: $2\text{HCl} + \text{CaO} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$ $2\text{HCl} + \text{ZnO} \rightarrow \text{ZnCl}_2 + \text{H}_2\text{O}$ 4. Interaction with bases: $2\text{HCl} + \text{Cu(OH)}_2 \rightarrow \text{CuCl}_2 + 2\text{H}_2\text{O}$ 5. Interaction with salts: $2\text{HCl} + \text{CaCO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{CaCl}_2$	1. Interaction of HCl with silver nitrate (I): $\text{HCl} + \text{AgNO}_3 \rightarrow \text{AgCl} \downarrow + \text{HNO}_3$ 2. Interaction of chlorides with silver nitrate (I): $\text{CaCl}_2 + 2\text{AgNO}_3 \rightarrow 2\text{AgCl} \downarrow + \text{Ca(NO}_3)_2$

Such tables give students new possibilities for learning. When the students open a traditional textbook, he/she starts thinking about how boring it will be to learn by heart all the formulas and equations. But if the teacher has at his/her disposal a carefully worked out table he/she would say: "Please, open your book and look at the table reflecting chemical properties of hydrochloric acid: on the left you can see the common chemical properties to all acids. Our lesson will be devoted to studying the specific properties of hydrochloric acid and its salts. Have a look at the right side of the table and there are only two equations. We shall only learn this material at this lesson. It is very easy". To make the study-process more effective and the material easily understood it is advisable to compile the tables on the principles of comparison and contraposition. (Rudzitis, 1991; Rudzitis, 1993; Rudzitis, 1997, Rudzitis, 1996; Rudzitis, 1993, 1994, 1996, 1998, 1999)

The summary tables on a whole teaching subject are very important in the text books because they help the learners to prepare for tests and examinations. For example, table 3 reflects the chemical properties of bases. Tables and schemes of various kinds help students in their independent work.

Table 3. Chemical properties of bases

Alcaline solutions	Insoluble bases
<p>1. Interaction with acids: $2 \text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2 \text{H}_2\text{O}$</p> <p>2. When heated do not decompose</p> <p>3. Decompose many organic substances</p> <p>4. Interaction with salt solutions (if metal in their composition has the ability to form an insoluble base): $\text{Fe}_2(\text{SO}_4)_3 + 6\text{KOH} \rightarrow 2 \text{Fe}(\text{OH})_3 \downarrow + 3\text{K}_2\text{SO}_4$</p> <p>5. Interaction with acid oxides: $2 \text{KOH} + \text{CO}_2 \rightarrow \text{K}_2\text{CO}_3 + \text{H}_2\text{O}$</p> <p>6. Affect indicators</p> <p>7. Combine with oils producing soap</p>	<p>1. Interaction with acids: $2 \text{Fe}(\text{OH})_3 + 3 \text{H}_2\text{SO}_4 \rightarrow \text{Fe}_2(\text{SO}_4)_3 + 6 \text{H}_2\text{O}$</p> <p>2. When heated decompose: t° $2 \text{Fe}(\text{OH})_3 \rightarrow \text{Fe}_2\text{O}_3 + 3 \text{H}_2\text{O}$</p> <p>3. Usually do not affect organic substances</p> <p>4. Reactions with salt solutions are not typical</p> <p>5. Reactions with acid oxides are not typical</p> <p>6. Do not affect indicators</p> <p>7. Do not combine with oils</p>

At the end of the Organic Chemistry Course (Rudzitis and Feldman 1989) are printed special tables for revising learning material of every chapter. Therefore, the learning process becomes easier if questions, which are difficult to understand, are given as algorithms, for example, when students must compile electronic formulas and chemical equations (molecular, ionic, oxidative-reductive, processes of hydrolysis and electrolysis).

5. In different countries **one of the most important guiding motivations of education is its economic connection, the link of the teaching material with production and practical life.** They should be considered as an obligatory structural element of the textbooks which may be implemented in the form of special texts using empty spaces in the margins as well as in the form of schemes, special exercises, tasks, and so on.

In order to deepen the investment of the school teachers in this educational sphere in the USA, Canada, the Netherlands and other developed countries in the first years of studies special teaching subjects are introduced by the faculties of humanities at the higher educational establishments, for instance, practical chemistry and practical physics (Chemcom. Chemistry in the Community. By the American chemical society. USA, Kendal, Hunt Publishing Company, 1988, p.518).

6. The differentiated approach becomes a very significant structural element in the layout of the teaching material. It should be implemented throughout the whole text book **by means of special relative signs, fonts of different size and colour** or by giving the supplementary text on the margins of pages. As in a definite teaching material we must take into consideration not only the methodical requirements of the lesson but also the necessary level of knowledge at tests and examinations.

7. The stimulation of the learners cognitive interests is equally important. It may be done to a great extent through the solving of the fourth structural element, **by means of descriptions of experiments and demonstrations of interesting, exciting historical and other facts, the inclusion of illustrations** in the textbook, using the empty margins of the pages for this purpose.

In this respect we should add that the traditional didactics acknowledges only the academic style. Only a few authors manage to resist the generally acknowledged requirements in this sphere. Such pioneers using anecdotes and other elements of humour already in the 70's were soviet authors A.Losev and B.Infantyev who prepared the textbook "Russkoje slovo" for forms V-VIII at evening schools. Every youngster using this book expressed that it was interesting to learn Russian grammar by means of anecdotes. But as soon as these authors submitted to the Academy of Pedagogical Sciences requirements and the second part of the text book was issued without these elements of humour the youngsters unanimously said that this textbook was not interesting.

The authors of the text books consider the inclusion of the elements of humour in the text book to be one of the most important means for stimulating the learners cognitive interests.

8. The textbooks should include problem questions and descriptions of problem-solving situation. It is another important structural element in the development of teaching material that serves for the gradual development of the learners independent thinking until the highest level of independent work and self-education is reached. Such materials help to teach the learners to apply the acquired knowledge in new circumstances.

9. One of the most important structural elements is the elaboration of the necessary amount of questions, exercises and tasks for independent repetition, strengthening and self-control work. Long research in various areas proved that this material needed to be supplemented by methodical advice on how to work with it independently. So, for instance, examples of solving the tasks turned out to be quite useful for the school learners lacking the skills to work independently in the initial period. The experimental work showed that the desired level of knowledge and skills was forming if the learners were solving the given questions, exercises and tasks independently.

Sometimes such textbooks are referred to as very sophisticated and difficult by many learners and also by less experienced teachers, when this structural element is observed and the necessary methodological material for independent work and for introduction of the learners in self-education is

designed.

10. The requirement that ***a school text book should be written in a simple, clearly understood language*** was stated already long ago. Nevertheless, at the same time, the text should comply with the current scientific information. These two opposite requirements are not always easily fulfilled by the authors. In this respect, we should note the thought correctly stressed by the outstanding Russian educator K.Ushinsky of XIX century that the author of school textbooks must know how to explain the scientific statements to school children in the way they are able to perceive it, but a precise interpretation of these concepts should be done by the teachers of higher educational institutions.

The most important scientific concepts and theories should be stressed in the contents of the textbook by including different descriptions of laboratory and practical experimentations.

11. Another important element of the modern textbook are the links with computerization of the teaching process and using Internet. Many modern textbooks have the complementary systems of different kinds of educational software in CD-ROMs and corresponding links with Internet. (Rudzitis, 1998; Rudzitis, 1999; Rudzitis, 2000a; Rudzitis, 2000b)

Conclusions

The design and writing of good textbook is a very difficult process. The authors of these textbooks have to be not only experts but truly artists of science and education. We believe that the advice and recommendations written in this work can help authors to improve the quality of textbooks for rising the quality of science education.

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