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AUTHOR Ctrnactova, Hana
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ABSTRACT

Using interesting interactive educational tasks increases student motivation in difficult subjects such as biology, physics, and chemistry and creates more effective science instruction. This paper presents a method for developing interactive educational tasks that make science subjects easy to understand. (Contains 10 references.) (YDS)

Increasing the Effectivity of Science Education Through Interactive Tasks

Hana Čtrnáctová, Charles University of Prague
ctr@natur.cuni.cz

INTRODUCTION

In both primary and grammar schools, Science subjects are very important, both as a single Science subject or separate Biology, Physics and Chemistry. In the Czech Republic Science is taught as a stand-alone subject in the first stage of primary school (4 years) and as the subjects Biology, Physics and Chemistry in the second stage of primary school (4–3–2 years) and in grammar schools (2–3–4 years). Whereas Science is considered quite interesting by pupils, the separate subjects are taught mostly theoretically, so they are considered very demanding and difficult. The problems encountered while teaching these Science subjects are similar. They are connected with the objectives and syllabus content, methods and ways of teaching, verifying the results, increasing the pupils' motivation etc. Our main goal is to increase the education's effectivity. That is why we concentrate on one of the basic didactical ways to increase effectivity – interactive educational tasks.

One of the ways to make Science subjects easier to understand is to use interesting interactive educational tasks. That is why we have created a method for creating these tasks. If an educational task (or a set of these) is to be created, first we have to analyse the subject's curriculum, determine its goals, select basic concepts and determine their relations. Additionally we have to consider the extent of acquiring separate facts and the structure of activity which will allow them to do so at a given level.

Various questions, examples, exercises, tasks etc., overall called "educational tasks", are one of necessary parts of every lesson. This term is also often used in pedagogical, psychological and didactical literature, although a unified definition of educational task has never really been laid down. In accord with references we will define "educational task" as a demand on pupils to do some purposeful task aiming at a previously set goal. This goal requires both knowledge and action.

The educational tasks used in teaching usually come from two sources – either they are taken from textbooks and collections of exercises or they are conceived by the teachers themselves. Let's look at what types of educational tasks are the most frequently used in common practice.

We carried out an analysis of the tasks most widely used in Czech Science textbooks in basic and grammar schools. We found that the textbooks contain quite large

numbers of tasks – more than 2.5 per lesson. However, the tasks are always put at the end of each theme block. They presuppose the pupil already knows the content of the block, and that they are only required to reproduce or explain it. The very setup of those tasks suggests they are very uniform in nature. They are usually simply pedantry and don't inspire students to solve them impulsively on their own. Only 4%–80% of tasks in these textbooks are in anyway different. Very often questions cover the curricula only formally, and usually they don't even respect different levels of acquiring knowledge and other activities.

Similar results were obtained by the analysis of educational tasks in other textbooks, exercise collections and tasks created by teachers.

METHODOLOGY

From both the results of pedagogically–psychological theory of educational processes and practice it is nevertheless clear that educational tasks should be a part of the whole educational process. They must be subject to the concept of educational theory and practice. These questions should be gathered into collections, and they should definitely be not monotonous, but, on the contrary, very varied.

When we create a collection of educational tasks, we should of course start with the analysis of curriculum from which the tasks will stem. The analysis of the curriculum is based on its contents and its arrangement within the theme as a whole. For expressing such an arrangement effectively we can use, for example, matrices or oriented graphs.

This method takes in an analysis of subject matter and its structure by matrix methods and creates concept maps which pupils can become familiar with. Thus acquiring each fact is connected with a set of activities. The structure and size of this set depends on the content and complexity of the fact itself and level of acquiring it. The structure of pupil's activity follows from Bloom's taxonomy and and contains levels of knowledge, applications, observations and experimentation and competences. The formal side of educational tasks is equally important as the content side. In accordance with debate as to which parts should be included in educational tasks we may perform an analysis of the form of text and the given solutions of the educational task.

The core of an educational task is usually described by one or more sentences. Usually, the question or instructions to solve the task are given verbally. All other parts of a task can be verbal too – motivating and complementary information, advice on the solution and expressing the answer.

Those parts, however, can also be given by a variety of nonverbal means. Their use in a task has a significant motivating effect because of their nonconventional and unusual approach, as the research confirmed (see part 4).

Our goal was to characterize the nonverbal means useful for the construction of educational tasks and expressing the presence of both verbal and nonverbal parts of educational tasks in a synoptic form, useful for analysing vast collection of tasks. After

studying various ways of processing large data files, we determined the table form to be the best for our purpose. Every row of the table corresponds to one educational task. The presence of various verbal and nonverbal parts of a task are marked in the columns. The parts of a task are arranged in the order of increasing motivational levels.

Symbol	Meaning	Marking
V	verbal part, i.e. text which contains advice or a question	+
I	additional information – either necessary data for answering the question or motivational text	+, ++
T	table – the legend contains two groups of elements, and their relation is explained in the table	+, ++
S	scheme – the elements of scheme are given by words or formulas and they are connected by lines or arrows	+, ++
G	graph – relation of two or more elements, where the elements – nodes of graph are only given by symbols and they are connected by lines – edges	+, ++
M	model or a picture of a model	+, ++
R	reality or a picture of a reality – illustration, photography etc.	+, ++

These 7 forms inform us about the educational task.

The presence of a form in task is marked by +. If it is also used for motivation, it is marked by ++.

Here is an example of a table for a group of 6 educational tasks.

Task	V	I	T	S	G	M	R
I-1-1	+						
I-1-2	+	++					
I-1-3	+						
I-1-4	+						
I-1-5	+	++					
I-1-6	+						

All these tasks are just verbal, but tasks 2–5 also use some motivational information.

Task	V	I	T	S	G	M	R
I-1-1	+	++					
I-1-2	+		++				
I-1-3	+			+			
I-1-4	+		+			+	
I-1-5	+	+					
I-1-6	+			+			++

These tasks use various nonverbal means.

Symbol	Meaning	Marking
P	the task does not contain any advice for a solution	
P	the task does contain some advice for solution	+

Task	V	I	T	S	G	M	R	P
I-10-1	+	+					++	+
I-10-2	+	+	+					
I-10-3	+	++		+				+
I-10-4	+					++		+
I-10-5	+	+		++				
I-10-6	+		+					+

These tasks are very various – there are tasks with many nonverbal parts.
Tasks 1, 3, 4 and 6 contain information about the method of solving the problem.

Therefore, if we want to create a collection of various educational tasks, the formulation of the task must contain as many different verbal and nonverbal parts of both assignment and solution as possible. The overview of the character of such a file can be obtained in the form of a table containing all 8 entries as we see.

APPLICATION

These theoretical results were gradually confirmed in practice. We created six collections of educational tasks for curricula of general, inorganic and organic chemistry and biochemistry in primary and secondary schools in the form of workbooks containing more than 800 educational tasks.

We now show an example of determining the contents and degree of acquiring of knowledge in separate tasks for the *Composition of Atom* theme.

Theme: **Composition of Atom**

The level of acquiring: **Understanding and application of knowledge**

In the basic school, the pupils have to have a basic idea about the elementary building block of matter – atoms; they have to know the make up of an atom and understand it. They should be able to apply knowledge about the composition of atoms and determine a composition for a given atom. The activity leading to the final goal (i.e. understanding the term at the required level) has this structure:

Final Goal To use the knowledge about the composition of atom in solving given tasks.	**Activity** To determine the composition of a given chemical element's atom.
Intermediate Goal 3 To understand the knowledge about the composition of an atom.	**Operation 3** To explain the composition of an atom.
Intermediate Goal 2 To acquire the knowledge about the composition of an atom.	**Operation 2** To remember the knowledge about the composition of an atom.
Intermediate Goal 1 To get the idea of atom as a basic building block of the matter.	**Operation 1** To imagine matter being built up of many small particles – atoms.

Therefore, for the acquiring of the term at the required level, at least four educational tasks need to be solved: task 1 (Intermediate goal 1 – Operation 1), task 2 (Intermediate Goal 2 – Operation 2), task 3 (Intermediate Goal 3 – Operation 3), task 4 (Final Goal – Activity).

Task 1: The matter is made up of very small particles – atoms. You can get the idea about atoms' tiny size by completing the graph for picture 1. Assign letters A to I to the values in graph.

A – The diameter of Earth
B – Red blood cell
C – The highest mountain on Earth
D – Macromolecule
E – The distance Earth–Sun
F – Atom
G – Three–storey house
H – The diameter of Aspirin tablet
I – The atom nucleus

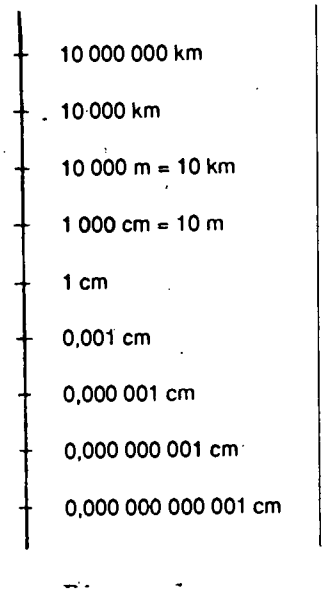
Task 2: Fill in the missing words:

An atom is made up of ..... and .....

The electronic shell is made up of .....

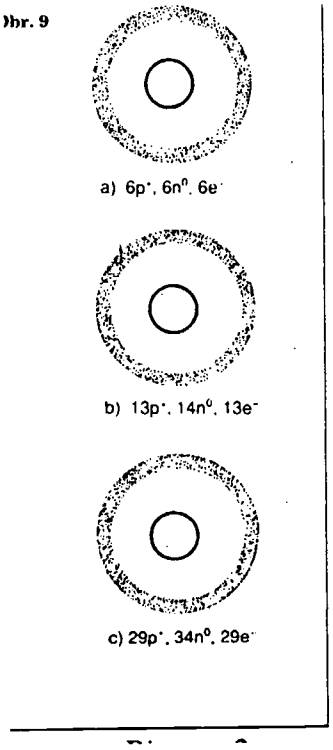
The nucleus is made of ..... and .....

)br. 8



Picture 1

)br. 9



Picture 2

Task 3: In the picture 2 you can see three atoms. According to the descriptions a} to c} fill in the number of protons, electrons and neutrons in those atoms.

a) $6p^+$, $6n^0$, $6e^-$ b) $13p^+$, $14n^0$, $13e^-$ c) $29p^+$, $34n^0$, $29e^-$

Task 4: Fill in the missing data in the table:

Z - proton number	A - Nuclear number	Number of electrons	Number of protons	Number of neutrons	Name of element	Symbol of element
	20			10		
12	26					
		16		16		
35	79					
			47	60		
82				126		

EVALUATION

For confirming our results we used several methods: Objective tests and comparative analysis and results of education with and without using the use of tasks, as well as subjective methods – anonymous surveys amongst pupils.

110 pupils who used the workbook in their chemistry lessons participated in the survey. They were asked two questions:

1. Explain where the workbook helps you and what are its advantages.
2. Explain where the workbook does not suit you and what are its disadvantages.

The very fact that number of advantages given were twice as large than the number of disadvantages, tells how popular these workbooks are.

The pupils themselves evaluated workbooks as textbooks which are nice to work with (33%), full of interesting information, pictures, tables, graphs, schemes and crosswords (73%), comprehensive, synoptic and easy to learn (49%). Incomplete pictures, tables, graphs and schemes assist pupils to solve a task.

164 pupils of both control and experimental classes participated in the verification of the level of acquired curriculum with the use of didactic tests. In the experimental classes, workbooks were used during lessons along with textbooks. Pupils were solving the tasks from workbook now only while (studying?) the curriculum, as usual, but also during the acquisition of new facts. In the comparative classes pupils only worked with the textbook and solved only tasks contained in it. To evaluate, both qualitatively and quantitatively, differences in the level of acquisition, we created a didactic test, made pupils in all classes do it and statistically processed the results. The test contained 20 questions about quite difficult theoretical matters concerning the structure of substances. The results of the tests confirmed that with the use of the collection of educational tasks, more pupils acquired the knowledge than did those who were not using the educational tasks.

CONCLUSION

In the conclusion, we can say that results from creating this collection and its verification in practice, confirm the adequacy and usability of our theoretical process of creating the tasks. Both the ways of determining the content of various tasks and their (collecting together?) with the accent on the degree of acquisition of knowledge of the curriculum and methods for constructing these tasks with the accent on their (formalisation?) seem sound.

Through application of these ways and criteria within specific parts of the educational process, we can create sets of educational tasks which can increase the interest in Science subjects and acquisition of knowledge at a given level by more pupils then solely with the standard educational methods pertaining previously.

The current method was applied to writing six workbooks (they include more then

800 varied tasks) for the subject of Chemistry in our department of Chemical Education, both for primary schools and grammar schools. The learning by means of chemical educational tasks doesn't make only for knowledge acquisition but also for competence in students' education. They are widely used now in both primary and grammar schools in Czech Republic. The tasks are interesting for pupils. They help them to understand the subject matter and they ensure its better grasp. Research, using performance tests, was carried out with pupils who used, or didn't use, the method of interactive tasks. Statistical results show a significant increase in effectivity of education when using this interactive educational method.

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