

"SECRET CONCEPT" - PROBLEMS FOR KNOWLEDGE TESTING

BY COMPUTER

"CONCEPTO SECRETO" - PROBLEMAS PARA EVALUACIÓN DE LOS CONOCIMIENTOS

POR COMPUTADOR

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Abstract

In this paper, a new type of the problem "secret concept" (substance, equation, object, etc.) is presented. It is very suitable for checking the knowledge with or without a computer. A set of concepts from general, inorganic or organic chemistry was given to the students as well as the corresponding statements (the characteristics of the concepts) which were the bases for the elimination of some concepts. The remaining concept (correct solution) was the concept that included all given statements. Since the elimination was carried out in several steps, the computer was suitable because it enabled the gradual revealing of the elimination conditions. Solving of such a type of problems, students should understand the relationships among the concepts as well as differentiation, abstraction and generalisation of the concepts.

Keywords: teaching/learning, problem-based learning, computer assessment,

type of problem

RESUMEN

Un nuevo tipo de problema "el concepto confidencial" (la sustancia, ecuación, el objeto, etc.) se presenta

en este trabajo, útil para verificar los conocimientos con o sin el computador. Se presentaron a los estudiantes las declaraciones correspondientes de química general, inorgánica u orgánica con el propósito de eliminar algunos conceptos en el proceso de búsqueda de la respuesta. El concepto restante (la solución correcta) es

el que incluye todas las nociones. El computador se puede utilizar en estas tareas porque facilita el análisis gradual de las condiciones en la eliminación de los conceptos. Al resolver tal tipo de problemas, los estudiantes entienden las relaciones entre los conceptos así como la diferenciación, abstracción y generalización.

Palabras clave: preguntas, evaluación por computadores, enseñanza-aprendizaje

Introduction

Computer and software, as teaching aids, are currently used in all phases of the education process (Wood, 1988, Schibeci, 1989). Bell et al. (1998) showed the application of computer-assisted learning (CAL) in five areas of the education process (lecture, tutorial, self-assessment, laboratory and problem solving). Computers also play a significant role in knowledge testing (Davis, 1984, Bowen, 1998).

Within the celebration of the 100th anniversary of the Serbian Chemical Society a competition in chemistry for the students from age 14 to 18 was organised in Serbia (Mandic et al., 1999). For that occasion original software with database was prepared (Korolija et al., 1999).

About the software

The original software was designed to provide each student-competitor with a balanced set of problems. Software was equipped with five databases containing approximately 150 problems for each category of students (age 14-18). The problems in the bases were classified according to characteristics: contents (theme), type of a problem and the number of points. For every student who entered his/her name, school and code computer and software prepared a different set of problems. Every combination consisted of 11 problems each of them was equal in all characteristics mentioned above.

In addition to standard problems (multiple choice, true-false choice, true-false with addition, ranking, pairing, stoichiometric calculation) in each set there was also a new type of problem: "Secret concept" (substance, subject, equation, etc.). The total time for solving the set of 11 problems was 45 minutes. Fields on the screen of three problems were colored reds indicating that these problems could be entered only once. Fields of other problems were colored green and there were no limits for entering these

problems.

The software also provided complete information about each competitor: set of problems, correct answers, time needed for solving each problem and the whole test, final score, number of entering each problem, etc. These new data bases formed during the competition were used to:

- analyze the results achieved for each topic/area of chemistry, individual problems, types of problems;
- determine the time needed for solving each problem and the measuring characteristics of each problem;
- test the problems which are particularly suitable for use with a computer;
- notify the most frequent dilemmas of students (based on changes of their answers).

“Secret concept”

Beside the knowledge of facts, for solving such a new type of problem, the students should understand the relationships among the concepts as well as differentiation, abstraction and generalisation of the concepts.

When the problem “secret concept” was used with computer, students could see on the top of the screen a general instruction for the solution of (in fact example for "secret substance" was given in Fig. 1.) the problem. The instruction was followed by concepts (formulas or names of substances, subjects or equations). The number of concepts for the Lower and Upper secondary school students were six and six or seven, respectively. After pointing at the instruction “next sentence”, four sentences (statements) defining the “secret concept” successively appeared on the screen. By deductive reasoning students had to eliminate one or more concepts which were not in agreement with the given statement. The solution of the problem is the concept, which was described in all statements, i.e., which remained after elimination.

INK70001 VREMA DO KRAJA je 42:07

The text on the screen (shaded areas) describe the "secret substance". For the each sentence, out of total four, you have to eliminate one or more substances which are not in agreement with the description and you will arrive to the "secret substance".

☐ HClO_4
☒ H_2S
☐ H_2SO_4
☒ HCl

☐ H_2SO_3
☐ H_3PO_4
☐ H_2CO_3

Statements

a) I am not a gas

The substance can be eliminated in two ways.
 1. By moving the arrowkeys to the desired answer by pressing ENTER or SPACE.
 2. By positioning the mouse arrow to the desired answer field and by pressing the mouse left button.

Next sentence

1c.

INK70001 VREMA DO KRAJA je 40:07

The text on the screen (shaded areas) describe the "secret substance". For the each sentence, out of total four, you have to eliminate one or more substances which are not in agreement with the description and you will arrive to the "secret substance".

☒ HClO_4
☒ H_2S
☐ H_2SO_4
☒ HCl

☐ H_2SO_3
☒ H_3PO_4
☐ H_2CO_3

Statements

a) I am not a gas
 b) I do not form three types of salts
 c) I am not the strongest mineral acid

The substance can be eliminated in two ways.
 1. By moving the arrowkeys to the desired answer by pressing ENTER or SPACE.
 2. By positioning the mouse arrow to the desired answer field and by pressing the mouse left button.

Next sentence

INK70001 VREMA DO KRAJA je 41:12

The text on the screen (shaded areas) describe the "secret substance". For the each sentence, out of total four, you have to eliminate one or more substances which are not in agreement with the description and you will arrive to the "secret substance".

☐ HClO_4
☒ H_2S
☐ H_2SO_4
☒ HCl

☐ H_2SO_3
☒ H_3PO_4
☐ H_2CO_3

Statements

a) I am not a gas
 b) I do not form three types of salts

The substance can be eliminated in two ways.
 1. By moving the arrowkeys to the desired answer by pressing ENTER or SPACE.
 2. By positioning the mouse arrow to the desired answer field and by pressing the mouse left button.

1d.

INK70001 VREMA DO KRAJA je 40:06

The text on the screen (shaded areas) describe the "secret substance". For the each sentence, out of total four, you have to eliminate one or more substances which are not in agreement with the description and you will arrive to the "secret substance".

☒ HClO_4
☒ H_2S
☒ H_2SO_4
☒ HCl

☐ H_2SO_3
☒ H_3PO_4
☒ H_2CO_3

Statements

a) I am not a gas
 b) I do not form three types of salts
 c) I am not the strongest mineral acid
 d) I can be both oxidizing and reducing agent

The substance can be eliminated in two ways.
 1. By moving the arrowkeys to the desired answer by pressing ENTER or SPACE.
 2. By positioning the mouse arrow to the desired answer field and by pressing the mouse left button.

Next sentence

Fig. 1a - 1d. The screen displays of the problem "secret substance" with one, two, three and four sentences (shaded areas)

The examples of the problems "secret concept" suitable for testing of the knowledge of the students (different age) in various areas of chemistry were given.

The numbers in the parentheses, which followed the statement, referred to the substances which were eliminated by a given statement. Of course, students could not see these numbers on their screens.

I The problem from general and inorganic chemistry (for the students age 14) suitable to check the understanding of the concept of non-metals (structure of the substance, composition, physical properties) was:

"Secret substance":

- 1) P_4 2) N_2 3) H_2 4) O_2 5) S_8 6) Cl_2

Statements:

- a) My molecule contains neutrons. (3)
- b) I am not a constituent of water. (4)
- c) At room temperature I am a solid substance. (2,6)
- d) I am yellow in color. (1)

Solution: S₈ (5)

II: The problem from organic chemistry (for the students age 15) suitable to check the understanding of the concept of organic compound (nomenclature, molecular formula, functional groups, reactions) was:

“Secret substance”:

- 1) Ethanol 2) Ethanal 3) Ethane 4) Ethyl-ethanoate 5) Ethyne 6) Ethene

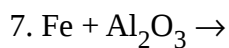
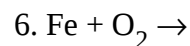
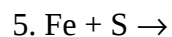
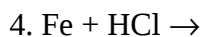
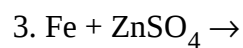
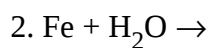
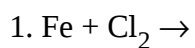
Statements:

- a) I have more than six atoms in my molecule. (5)
- b) I contain oxygen. (3,6)
- c) Water can not decompose me. (4)
- d) I have the carbonyl group. (1)

Solution : Ethanal (2)

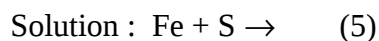
III The problem from general and inorganic chemistry (for the students age 16 and 17) suitable to check the understanding of the concept of chemical reaction (redox reaction, oxidation mean, oxidation state, salt, acid) was:

“Secret equation”:



Statements:

- a) My reaction is possible. (3,7)
- b) During the reaction the oxidation mean goes to negative oxidation state. (4)
- c) My product is salt. (2,6)
- d) My product is the salt of a weak acid. (1)



It could be seen from the examples that the "secret concept" represented the type of problem suitable for checking:

- Ability of students for deductive reasoning
- To what extent the student acquired some concept, its content and scope
- To what extent the student acquired concepts differing in the scope and complexity (e.g. single, special and general concepts)
- Understanding of the relationships among concepts
- Knowledge from one or more teaching themes in a single problem
- Acquisition of the concepts at the level of reproduction, understanding and application.

Considering the mentioned possibilities and advantages, this type of problem was more suitable for valid knowledge testing than those which were usually used. In addition, this type of problem could contribute to the scientific literacy of the students and give some elements to measure it. The problem "secret concept" also enabled the teacher to choose the way of setting the problem according to previously defined goals for understanding of specific concepts. In this paper "the way of setting the problem" could be:

- Possibility for variation

- Number of concepts
- Number of statements for elimination of concepts
- Number and order of affirmative and negative sentences

- Possibility that software allows or limits changes of student's answers.

If this type of problems is used for competition in chemistry they could be made more difficult by increasing the number of negative statements (sentences) or with alternate sequence of affirmative and negative statements.

Example : The problem from organic chemistry (for the students age 18) suitable to check the understanding of the concepts derivatives of carboxylic acids (anhydrides, amides, esters, chlorides, hydrolysis, electrolytic dissociation, salts, reactivity) was:

“Secret substance”:

1. $\text{CH}_3\text{CH}_2\text{COOCH}_3$ 2. $\text{CH}_3\text{CH}_2\text{COONa}$ 3. $\text{CH}_3\text{CH}_2\text{COCl}$
4. $\text{CH}_3\text{CONHCH}_3$ 5. $(\text{CH}_3\text{CO})_2\text{O}$ 6. $\text{CH}_3\text{CON}(\text{CH}_3)_2$

Statements:

- a) In hydrolysis, I do not yield organic acid only (5)

- b) I do not conduct electricity (2)
- c) In hydrolysis, I do not yield the derivatives of the same compound (4,6)
- d) I am the most reactive derivative of the carboxylic acid (1)

Solution : $\text{CH}_3\text{CH}_2\text{COCl}$ (3)

On the basis of the presented examples, considerations and our experience, this new type of problems “secret concept” was very suitable for checking the knowledge by computer. It was also successfully used without computer, as “paper version”, during regular school lessons and quizzes (school or TV). By means of such a type of problem the students could gradually master different abstract operations which influenced the development of their intellectual abilities. These activities contributed to the scientific literacy of the students.

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