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Using didactic enclosures as teaching methods and social forms for active learning in chemical education

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ABSTRACT

Innovative teaching and learning can be defined as the effective use of various didactic materials combined with the methods and social forms of active learning. We carried out an evaluation of didactic enclosures as the initial stage in the methodology of our scientific strategy for researching the project "Didactic Redevelopment of Chemical Education in Slovenian Elementary Education". To obtain the results of our evaluation of didactic enclosures we concentrated on the innovative approach of using enclosures for just games and video. These types of enclosures are used in didactic game methods and video methods, as well as various problem-solving sheets (individual and group) that are typically used for individualised group work. We put special emphasis on furthering the development of programmed sequences, which are essential in effectively utilizing the well-known teaching aid called the "Periodic Table in Cube".

Key words: didactic game method, didactic enclosures for games; didactic video method, didactic enclosures for video; teaching aids, "Periodic Table in Cube", programmed sequences; individualised group learning, group learning sheet, individualised learning sheets

Nekateri didaktični sklopi učnih metod/socialnih oblik aktivnega učenja pri predmetu kemija

POVZETEK

Inovativno poučevanje/učenje predstavlja učinkovito uporabo metod in oblik aktivnega učenja ter učnih sredstev (učil in didaktičnega gradiva), ki so potrebna za uspešno izvajanje načrtovanih aktivnosti. Začetno fazo v metodologiji dela v raziskovalni nalogi Didaktična prenova kemijskega izobraževanja v osnovni šoli sta predstavljali empirična in racionalna evalvacija didaktičnega gradiva kot sestavini »metodne« opreme, uporabljeni v času izvajanja načrtovanih strategij učnega dela. Izhajajoč iz evalvacijskih ugotovitev, so bili med inovacijskimi elementi prednostno opredeljeni igrne in video didaktične priloge, ki so potrebne za učinkovito uporabo metode didaktičnih iger, video metode, pa tudi skupinski in individualizirani učni listi, uporabni pri izvajanju individualiziranega skupinskega dela. Posebna skrb je bila namenjena tudi gradivu – programirane sekvence, ki omogoča bolj smotrno uporabo učila Periodni sistem v kockah.

Ključne besede: metoda didaktičnih iger, igrne didaktične priloge, video metoda, video didaktična gradiva, učila, Periodni sistem v kockah, programirane sekvence, individualizirano skupinsko delo, skupinski učni list, individualizirani učni listi

Introduction

One of key aims of our research "Didactic Redevelopment of Chemical Education in Slovenian Elementary Education" was determined as an innovative development of didactic material. It provides more effective using of selected method and social form for teacher's role in learner's more active learning. For stimulating the learners' higher activity and consecutive learning effectiveness the teachers should use suitable teaching aids and proper didactic enclosures (learning sheets used by particular method or social form or teaching aid).

Realization of planned learners' activities is carried out using different methods of active learning, such as problem solving method, where learners are introduced to a specific problem-solving strategies and asked to use their chemical knowledge and in such a manner develop problem-solving skills (Janiuk, 1993; Hanson and Wolfskill, 2000). By Howlett (1989) and Gordon (2008) the emphasis is on learner, using a planned approach to tackle a learning problem. The learners are delineating the problem firstly, then deciding on what an appropriate solution might be and deriving possible solution.

For realizing competence-oriented activities a teacher offers some topical accompanying methods generally which must be supported by suitable didactic material (teaching aids and didactic enclosures). The literature gives some cases of using such didactic enclosures. For example, Tiberius (1999) suggests to encourage co-operation and trust among group members what is happening during individualised group working. For successful performing I suggest this social form to my students-teachers to articulate the topical didactic enclosures, such as group and individualised working sheets. According to Towns, Kreke and Fields (2000) learning in small groups is one way to enhance different learning styles. Moreover, in the case of individualised group learning, each learner involved in group activities has his/her own task what means to notice the notorious principle of individualisation and differentiation in full. However, in such kind of group learning they can work cooperatively or collaboratively depending on the type of task and teacher's constructional approach.

In the present study we examine closely an elected teaching aid, e.g. "Periodic Table in Cube" (PTC in advance, authorized by M. Golob, a retired elementary school teacher from Maribor).

This aid consists of 60 cubes (arranged along the shelves on the special stand), which represent the main groups of The Periodic Table. Naturally, each cube has six squares where we can find vital piece of information for individual element from its atomic structure (three squares: a period, a group, a size of an atom / ion) to well designed other information (the other three squares: its metal / non-metal

properties, natural occurrence, its use (Črešnjevec, 1994). Indeed, for successful using this teaching / learning aid at elementary, as well as vocational level of chemical education, some didactic enclosures are needed.

Methodology

Aims

This study-contribution is aimed: (a) to develop method-related didactic enclosures for teaching and learning by game or video method; (b) to design the programmed sequences for pupils' motivated and effective learning by using PTC aid; (c) to prepare topical learning sheets for pupils' individual engagements in group work by demonstrating PTC aid.

This paper outlines each of the three aims, providing the practical guidelines which key methodological parameters can be used in articulating the active method-related didactic enclosures, respectively individualised group form social learning.

Approach

Empirical evaluation was flowing for estimation what is real situation on provisions with the needed didactic enclosures used for successful teaching and learning various chemical concepts by using above mentioned methods and individualised group work. We were interested if our teachers articulate such enclosures, what are their possibilities and techniques of using them in a real class situation. For gathering these items of information some questionnaires (Črešnjevec, 1994; Kojc Fišer, 1994; Maguša, 1995) were used consisting of the following questionnaire sections:

a) Technical equipment and teaching aids (how an individual school, especially chemical class-room is equipped, what can be obtained and offered to them);
b) Didactic enclosures (obtainment / using, source of, using by macro-didactic components and learning methods / social forms);
c) Teaching aids and didactic enclosures (how both are used together by various teaching methods / learning social forms, e.g. teaching and learning by PSC aid supported by problem solving method and individualised group working).

Sample Participants

The selected in-service teachers from several programmes of compulsory secondary school (20 teachers), as well as vocational or vocational-technical and professional (25 teachers) of chemistry education took an active part in this research project. But as research assistants being in action also four graduate students were included, who under author's mentorship have been developing the methodology of articulating the above mentioned method- and social form-related didactic enclosures as their schoolteacher's training certificate thesis.

Instruments

Involved in-service chemistry teachers were asked to answer on aim-loaded questionnaire called "Teaching aids and didactic enclosures". Other essential part of research instruments were the following method- and social forms-related didactic enclosures elaborated by graduate students: *Game's didactic enclosures* (Kitek, 1994), *Video's didactic enclosures* (Kojc-Fišer ,1994); *Programmed sequences* (Črešnjevec, 1994); and *Social forms enclosures* (Maguša, 1995).

Evaluations and Conclusions

About teaching aids and didactic enclosures included in our research project "Didactic Redevelopment of Chemical Education in Slovenian Elementary Education" using the above mentioned questionnaire we have gathered a following feedback from the above mentioned in service-teachers of chemistry:

(1) PTC as one of the best recommended teaching aids for didactic application is often used only by 25 % respondents. The same percentage of these answers is also valid for using the programmed sequences as didactic enclosures, needed for teaching / learning by using this teaching aid.

(2) Another further conclusion is about preferential using of PTC by the methods of explanation and discussion compared with the others, e.g. the text method.

(3) An outstanding using of PTC by individualized group work without programmed sequences is also surprising. Percentage regarding the origin of programmed sequences is the same for both of these purchased or self-made.

On the other side, there are some conclusions of professional evaluation performed by graduate students regarding to easier learning assurance by greater understanding and students motivation. For the teaching aids the following predetermined criteria were taken into consideration: level clearness / abstraction / motivation, application value for teaching methods / learning social forms, colourfulness and static / moving. We can put out the following conclusions:

(a) Analyses' results for PTC indicate, that this teaching aid is valued by its: (1) high level of clearness and motivation and schematic illustration; (2) greatest methods / forms of application; (3) three colours, but only one static demonstration what is actually a bad point.

(b) For professional evaluation of didactic enclosures two afore mentioned criteria (learning methods / social forms) were used, as well as an application value for individual macro-didactic component and the attainability (market purchase or self-making).

In compliance with the empirical and professional evaluation results our further interest was focused on innovative approach of creating didactic enclosures. Considerable efforts were concentrated to the development of didactic enclosures as an essential component of "The Teacher's Preparation for the Learning Unit". Therefore, numerous different enclosures for teaching chemistry, appropriated for application by Didactic Game Method, Video-method and Method of

Programming Chemical Learning Contents, as well as Individualized Group Work, i.e. the preferred learning social form, were created.

In our opinion several examples of method- and social forms related to didactic enclosures are classified into the following groups:

- ⇨ *Game's didactic enclosures:* (i) Game Sheet, (ii) Introduction for a Teacher;
- ⇨ *Video's didactic enclosures:* (i) Video Introducing Writing Sheet, (ii) Video Acquiring Writing Sheet; (iii) Video Practice Sheet, (iv); Video Repeated Sheet;
- ⇨ *Programmed sequences* which can be successfully used by PTC for:

(i) Acquiring new contents, (ii) Differentiated Repeating with Self-Evaluation;

- ⇨ *Social forms enclosures:* (i) Group-Learning Sheet, (ii) Individualised-Learning Sheet.

These enclosures are needed for successful performing the Individualized Group Work, particularly at concurrent application the combination of methods&social forms, such as: Problem Solving Method or Didactic Game Method using Group- as well as Individualised Problem Solving Sheets. In continuation (see table) a concise and general description of Video Repeated Sheet, then Group Problem Solving&Game Sheet and Individualised Problem Solving Sheets follow. But one example of Programmed Sequence is described as a combination of key words form and the original text.

Table: Examples of optimal method&social forms learning sheets

Didactic Enclosure / *Heading*	**Didactic Parameter**	**Key Words Description**
Video Repeated Sheet / *Call for Help* (Kojc Fišer 1994)	✓ Instruction ✓ Problem	➡ Observing chemistry video, solving given problem; ➡ Incomplete label with chemical, method of identification –suggestion;
Group Problem Solving&Game Sheet *Jig-Saw Puzzle of the Voltaic Cell* (Maguša 1995, Kitek 1994)	✓ Problem /Group Task ✓ Guidelines ✓ The plan for Realization ✓ Playing Rules	➡ Daniel Voltaic Cell, jig-saw puzzle elements (learners selfmade): compose, name cell's components, explain ! ➡ Group-, individual tasks / individual Problem Solving Sheet, group game playing; ➡ individualised (group) task/progress of the work; ➡ instruction for beginning, group playing, plenary demonstration (each group's jig-saw puzzle picture (see page 8), group manager), rang order criteria (time, quality of composed picture and explanation);
Individual Problem Solving Sheet *Redox Leaflet* (Maguša 1995)	✓ Task ✓ Guidelines ✓ Problem solving method stages ✓ Problem Solving Method stages ✓ Requirements	➡ concept's item, recognising yourself item in group problem, not known knowledge consciousness; ➡ problem solving method stages, jig-saw puzzle element plan (Redox Leaflet); ➡ questions/put, needed information/find, answers/put down, Redox Leaflet /make; "What am I interested in … ? Do you know that …? ➡ reminder;

Programmed Sequence/ *The Periodic table* (Črešnjevec, 1994)
Didactic Parameters: ✓ **To the student,** ✓ **e.g. Step 6,** ✓ **An Additional step;**

✓ **To the student**

➡ Concepts: Element (definition), Periodic Table (definition, arranging the elements/key);

➡Instructions for programmed learning:
(1) each learning contents is divided into several steps; (2) each step doesn't only explain to you the concepts clearly, but it also consists of some answers or tasks for practising your acquired knowledge; (3) for your current self-evaluation about the quantity and quality of your new knowledge the right answers and solutions in front of each next step on the other paper's side are waiting for you; (4) if your answers / solutions are incorrect, you have to go back to earlier steps and to improve your knowledge. Remember: "The Periodic Table in Cube" will help you much at learning! Instructions for using it are enclosed.

✓ **e.g. Step 6**

➡ descriptions for changing some characteristics of elements, e.g. properties, atomic radii, formation of cations and anions;

➡ Your task is on turn: (1) Find out (write in arrows of Periodic Table Scheme using the "Table of Elements in Cube"(see enclosed photo 1 a,b) how the individual afore mentioned parameters of elements in any of the period as well as in group are changing !

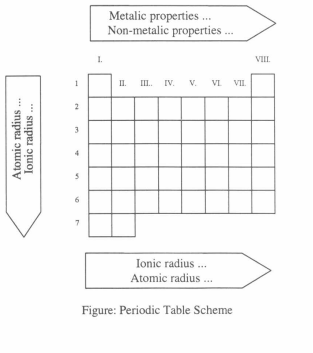

Figure: Periodic Table Scheme

Figure: Periodic table Scheme

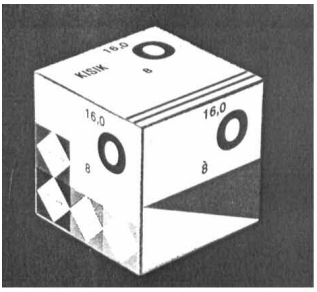

Photo 1a: "Oxgen Cube"

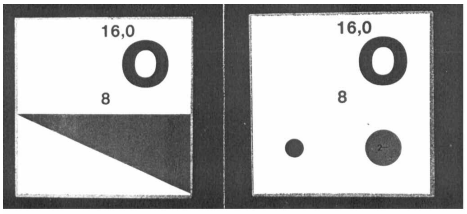

Photo 1b: "Oxgen Cube Squares" (Acd/Base properties, Atomic/Ionic radius)

(2) Explain how an oxide anion is formed, compare the sizes of oxygen atom and oxide anion and sketch their structures !
(3) Write the symbols for following cations and anions: potassium, beryllium, aluminium as well as nitride, sulphide and bromide ions.
➡ Answers:
To question **1**) change of properties: (i) metal →metal&non-metal →non-metal properties of elements for each period; (ii) change of atomic radii: →ı fall down from left to right; for each group: ↧ increase up to down; (iii) ionic radii decreases and increases for some elements along the period.
To question **2**) oxygen atom O + 2 electrons → oxide anion O^{-2}; ⇨ ionic radium >> atomic radium
To question **3**) the symbols for (i) cations: K^{+}, Be^{+2}, Al^{+3}; (ii) anions: N^{-3}, S^{-2}, Br^{-};

✓ **An Additional step**
"Tell me something about the alkali metals, e.g. lithium, sodium and potassium!, we are asked. "Well", we all agreed, "but we have a special task for you. Listen very carefully what each of us is saying about some of them. Then you will draw up (using the selected cubes of Periodic Table in Cube) their "identity cards"! At the end you will pick up all the cards and arrange them into "Periodic Table Catalogue". Let's begin with our reports for individual elements!
Be careful! Start "Catalogue File" with empty "Cards. For each presented element (considering the counted points) you have to fullfil its own card. But the point state of matter is missed. This one you will sign (using enclosed colour's legend) covering the whole "identity card" with the accurate colour.

"Element's Identity Card"

Name/Symbol Year of discovery: Atomic number: Relative atomic mass: Row/Group: Electronic configuration of:	Cation/Anion: Metal/Nonmetal: Occurrence of: Uses of: Warning notice (toxic/nontoxic, order of reactivity):	*State of Matter* *(legend) :* *Solid → grey* *Liquid → blue* *Gas → yellow*

Teaching and learning application

The "purpose" of teaching and learning "The Periodic Table" as the "families" of elements by using "The Periodic Table in Cube" as the teaching aid with the support of Programmed sequences as the didactic enclosure is the aim that steers teachers' and learners' actions. In general, didactic enclosures, as the vital part of Teacher's Preparation for anyone learning unit can be used at performing the active methods or learning social forms and at all macro-didactic components.

With regard to the method's criteria such enclosures are preferentially applied for the method of explanation, demonstration method and, of course, video method. From the point of using programmed sequences at self-learning progressing just the text method in reference to problem solving method can be suggested. Necessity of successful application of proper didactic enclosures in any of macro-didactic components is evident without any further explanation. Surely, from the point of teacher's professional development the teachers' self-made didactic enclosures are preferred, related to those made by a professional team. By elaborating didactic enclosures aimed to the optimum learning process, teachers must realize some competences related to the chemical contents and teaching strategies especially. Let's not forget three didactic imperatives: Rationalization, Differentiation and Individualization ! by using teaching aids and methods as well as social forms and all should be supported by didactic enclosures that make chemical knowledge

structure more interesting and easier for earners. Not to forget, just an inner satisfaction for both teachers and learners as study partners is the main aim of educational process in general.

It can be stated that studies on the elaborating of didactic enclosures are opened and some answers originate the new methodological questions. Both questions and answers are of great importance so for the theory of articulation of didactic enclosures, as well as for learning implications. Knowing the conclusions and suggestions of such studies helps teachers to methodological elaboration of learners' activities by acquiring several teaching contents in accordance with the learners intellectual possibilities, likewise personal perceptions and emotional profile. Teaching approach by using the appropriate didactic enclosures certainly simplifies and facilitates the learning (acquiring, revising and testing) of chemical knowledge and makes it more effective.

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