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The Role of Developing Cause-And-Effect Relationship Skills in Solving Didactic and Educational Tasks

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A B S T R A C T
This article analyzes the didactic significance of developing students' dialectical and logical thinking through the formation of cause-and-effect relationship skills in general secondary education, particularly in the process of teaching chemistry. The paper provides a detailed description of teaching methods based on algorithmic cards and demonstrates their effectiveness in the learning process through practical examples. In particular, using the topic of oxygen as an example, a system of micro-operations aimed at step-by-step identification of cause-and-effect relationships is described.

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Introduction

The establishment of cause-and-effect relationships is one of the key universal educational activities, which is gradually formed in school students across various subjects. The problem of developing the skill of identifying cause-and-effect relationships has been reflected in the research of scholars such as Tatyachenko D., Tirinova O.I., Usova A.B.[1], Chepikov V.T and Talyzina N.F. Initially, this method of logical thinking serves as a subject of special assimilation; later, it becomes a tool for establishing connections between objects and phenomena, and eventually, it functions as a universal learning practice that students need to master at the elementary level in order to achieve success in intellectual development in higher grades. E.N. Boyko, in the methodological guide *"Practice of Overcoming Typical Mistakes in Primary School"*, particularly in the section *"Main Difficulties of Students in Establishing Cause-and-Effect Relationships Between Natural Objects"*, recommends the development of algorithmic cards that are highly effective for students [2]. In addition, the author of the textbook *"The World Around Us"*, A.A. Pleshakov [3], as well as O.N. Fedotova and G.V. Trofimova in the *"Promising Primary School"* educational complex, discuss the use of algorithmic cards for establishing cause-and-effect relationships [4].

Main Part. Algorithmic cards can be structured as follows.

Why is oxygen, an element of Group VI, studied before other elements in chemistry education?

1. Identify the effect stated in the question:
   a) oxygen is studied first as a deductive basis for other elements [5];
   b) oxygen is studied before all elements except hydrogen;
   c) elements are studied according to their atomic number.
2. Determine the object of analysis within the effect, i.e., the object, process, or phenomenon resulting from certain causes:
   a) the study of oxygen and its compounds;
   b) the study of chemical elements;
   c) the study of chemical substances.
3. Describe the qualitative characteristics of the components of the analysis object, i.e., determine what defines the identified components:
   a) widely distributed in the environment and nature;
   b) more familiar to students;
   c) forms numerous compounds.
4. Identify additional conditions of the effect (not explicitly stated):
   a) studying oxygen first facilitates the study of oxygen-containing compounds of other elements;
   b) studying oxygen first expands the possibilities for comparative study of other elements' properties;
   c) oxygen and its compounds (oxides, water) are of great importance in nature and human life.
5. Reformulate the question by replacing the "object" with the combination "object + object property."
6. Compare with the following question and explain the difference, if any:
   Which element, other than oxygen, can systematically form compounds (similar to oxides) with almost all other elements?
7. Refine the question by adding additional conditions.
8. Compare with the following question and explain the difference:
   What opportunities does studying oxygen and its compounds before other chemical elements provide?
9. Formulate your answer and compare it with the following:
   Oxygen is more familiar to students than other elements, is widespread in nature, plays a crucial role in human life, and forms compounds with almost all elements. Therefore, its structure and properties serve as a theoretical basis for studying other elements and facilitate their comparative analysis.

This card includes a question containing cause-and-effect relationships and an algorithm of micro-operations aimed at establishing these relationships to reach the correct answer. To determine the cause of a phenomenon, the learner must first identify the cause and then logically proceed to the effect[6].

The first step of the algorithm is to identify the effect presented in the question. The effect is embedded in the question itself: why is oxygen studied first? (The cause is later revealed in the conclusion: oxygen is more familiar to students, widely distributed, essential in nature and human life, and forms compounds with almost all elements; therefore, its structure and properties provide a theoretical basis for studying other elements.)

To aid memory retention, the correct answer is marked as option "b." The card provides multiple options for selecting the correct answer (prepared by the teacher):

a) oxygen is not studied before other elements;
b) oxygen is studied before all elements except hydrogen;
c) elements are studied according to their atomic number.
The second step involves micro-operations: selecting the object of analysis within the effect, i.e., identifying the object, process, or phenomenon caused by underlying factors. Students are guided to understand that the object answers the question "what?" or "who?"
a) distribution and significance of oxygen;
b) compounds and properties of oxygen;
c) identifying elements similar to oxygen that form systematic compounds with all elements[7].
The third step is to provide qualitative characteristics of the components of the analysis object, i.e., determining what defines them:
a) widely distributed in nature;
b) familiar to students;
c) forms many compounds.
The fourth step – micro-operations: identifying additional conditions of the effect that are not explicitly stated: under what conditions did the phenomenon occur? Where? When? How? For what reason? Students select the correct options or eliminate incorrect ones.
a) studying oxygen first, which is more familiar and widespread, expands the opportunities for comparative study of the properties of other elements[8].
The fifth and sixth steps of the algorithm. After conducting verification and analysis, and clarifying the properties of the object along with additional conditions, it is necessary to reformulate the question. That is, the "object" in the question should be replaced with the combination "object + object property."
If the "object" in the question is replaced with "object + object property," the following question arises: Which element, other than oxygen, can systematically form compounds (similar to oxides) with almost all other elements?[9]
In the seventh and eighth steps, the question is refined, and students compare it with the following question, explaining any differences:
What opportunities does studying oxygen and its compounds before other chemical elements provide?
At the final step, students compare their answers with the given one and draw conclusions.
Cause-and-effect relationships can be simple or complex. In simple relationships, one effect results from a single cause. In complex relationships, cause-and-effect connections are more diverse and therefore more complicated[10].
Constructing questions for algorithmic cards aimed at establishing cause-and-effect relationships. An algorithmic card designed to establish cause-and-effect relationships primarily requires careful attention to the content of the question. First of all, it is important to learn how to correctly formulate questions—both in terms of content and structure—that incorporate cause-and-effect relationships[11].
When searching for questions in textbooks that begin with the word "Why," it may initially seem that such questions are absent or very limited. Therefore, it is advisable to paraphrase the questions provided in textbooks. In some cases, textbooks contain only minimal information, which may not be sufficient to answer such questions. Particularly at the third step—identifying additional characteristics—students may need to consult dictionaries, atlases, encyclopedias, textbooks from other grades, and online resources.
Often, questions may appear to be well-constructed, but difficulties arise when trying to fit them into the algorithmic structure; such questions cannot be transformed because they are incorrectly formulated. In subjects like chemistry and biology, it is relatively easier to construct cause-and-effect questions, as terms and concepts are clearly defined, relationships between phenomena are scientifically grounded, and these disciplines are rich in reliable sources. However, when designing an algorithmic card (for cause-and-effect analysis), the author's objective should be to clearly present a specific topic, explain its concepts and laws, and adhere to the principles of consistency and systematicity[12].
Questions included in algorithmic cards for establishing cause-and-effect relationships should have a guiding nature and consist of step-by-step instructions (a set of questions) that lead to the final result.
Organizing students' work with algorithmic cards.
At the first stage of teaching students to work with algorithmic cards, it is necessary to analyze the concepts of "cause" and "effect" with them and help them understand their essence.
At the second stage, students are introduced to the remaining concepts: what an object is, its components, its characteristics, and additional features. In order for students to learn to identify such questions in educational texts, they are trained to formulate questions beginning with the word "Why" (questions that require an

answer).
At the third stage, the main activity is focused on developing micro-skills, during which the algorithm is constructed. To determine the main actions, agreements are made with students regarding conventions: they are given instructions on how to select correct answers and mark them. In the first step of the algorithm, the student identifies a positive result and explains what actions or reasoning led to this result. Low-performing students may face difficulties; therefore, alternative approaches are suggested. For example, the word "Why" in a sentence is covered with a sticker, and the remaining part of the sentence represents the effect[13]t.
For instance, in the sentence: "To supply energy for life processes in organisms, organic substances must be oxidized with oxygen; therefore, breathing oxygen is very important for organisms, otherwise they will die,"the cause part is replaced with the question "Why," leaving the effect: "Why is breathing oxygen very important for organisms, otherwise they will die?"
The correct answer is the cause: "To supply energy for life processes in organisms, organic substances must be oxidized with oxygen."
In some cases, the cause is given and the effect is asked in the question:
"Where does the energy necessary for life processes in organisms come from?"
At the initial stages, the content of the cards is limited to the topic being studied. Later, students with higher learning abilities are encouraged to use additional sources such as dictionaries, encyclopedias, textbooks from other grades, and internet resources.
At the first stage, activities based on algorithmic cards are organized in small groups (no more than three or four students). One participant reads the question from their card and selects the correct answer at the first step, explaining to their partner why the other options are incorrect. Then they work with the partner's card. If both students find it difficult to explain, the teacher identifies the cause of the difficulty through guiding questions: "What do you not understand in the task? What information is missing to complete it?" These difficulties may arise from an inability to establish cause-and-effect relationships, challenges in working with the text, inability to find information, or insufficient knowledge of the material.
If students successfully complete the tasks, reflective discussion is organized through questions such as: "What actions did you perform? How did you manage to complete the task?" Later, depending on the lesson objectives, tasks, and expected outcomes, both group and individual work with the cards is organized. The sequence of actions must be followed by the student, while the teacher creates conditions for their effective implementation[14].
At the third stage, group discussions are organized around possible answers to the main question. To monitor and assess the development of micro-skills in establishing cause-and-effect relationships, it is advisable to use assessment sheets. During the first two lessons, students complete these sheets together with the teacher; later, they independently record their progress. During group work, difficulties in developing micro-skills are identified, analyzed, and corrected collaboratively.
The study of the dependence of chemical reaction rates on catalysts can serve as an example of applying statistical methods. By proposing a hypothesis about the relationship between certain process parameters, it is possible to represent their functional relationship graphically. Functional relationships correspond to the process mechanism when each value of variable x corresponds to one and only one value of y.
When identifying deviations from normal conditions, it is possible to trace consequences based on changes in related parameters. The selection of variables and the calculation of expected deviations should be determined for each specific technical scheme, taking into account the inertia of cause-and-effect relationships. Relationships, their coefficients, and the designation of vertical and horizontal axes can be analyzed and verified to reflect their interactions.
In some cases, based on the technological compatibility of certain parameters, it is necessary to consider that, within diagnostic algorithms, disturbances may spread along parallel (branched) cause-and-effect channels, leading to changes in one or several distant effect variables. If there is a high probability of serious deviations, it is important to detect signals and determine the time required to reach a critical state.
Each vertex of a graph represents the state of a parameter at a given moment. The dynamics of processes determine transitions between vertices under the influence of various factors. A key vertex represents a general parameter. Directed graphs of cause-and-effect relationships between system states can be used as diagnostic models.

Conclusion.
To represent cause-and-effect relationships between processes and objects, the method of iconographic modeling using structural block diagrams can also be applied[15].

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