Creative Cards on Chemistry in the Mental Development of Students

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Abstract. The change in the professional positioning of a modern university graduate — from the narrow development of one specialty to the ability to adapt to the changing conditions of the innovation economy; reliance on creativity and mental development of an individual identified the research problem — the lack of methodological support to develop teaching aids at the university. The theory comprehension and practice of the educational process organization in the chemical direction made it possible to affirm that there are large reserves for the students’ mental development due to the completeness and depth, consistency, and logic of a high theoretical level in the chemical disciplines.

The study purpose is to develop and determine the effectiveness of the use of creative cards in the study of chemical disciplines to improve the level of students’ mental development.

The research methodology included an analysis of the essence of the concept «creative card», identification of criteria and indicators of students’ mental development, development of a set of creative cards in chemistry, determination of their influence on the mental development level, development of a methodical system of students’ mental development using creative cards, and testing the effectiveness of the system in a teaching experiment.

The basis of the chosen approach is an idea of cognitive psychology D. P. Ausubel. Presentation of new concepts and judgments through logical structures and concepts are already known; accumulated by students, identifying the main ideas of the subject, further differentiation, detailing; combining new material with previously presented information by comparing, comparing and finding connections between them is one of the effective tools to organize and present knowledge. However, the study made it possible to substantiate creative cards as means of learning that affects mental development. Developed methodological support for the use of creative cards to improve the level of students’ mental development, confirmed its effectiveness.

1. Introduction

The present stage of the world community development is characterized by the increasing role of education, which determines the basis of economic and social progress. Along with traditional methods, quality education is implemented in the search for new forms, methods, and mechanisms to obtain new information and knowledge. The need to realize the knowledge gained at the university is opposed not only to the graduate’s lack of the necessary professional experience and skill, but also the ability to think and act independently, creatively, without outside help to find a way out of problematic
situations. Developmental educational technologies, methods and means of training, individualization of students’ training are needed.

There are debatable questions about what methods and means of training are aimed at students’ mental development.

2. Materials and methods
The concept of "mental development" is one of the key in modern education. Analysis of pedagogical literature and programs of chemical disciplines shows that for the students’ mental development in the university there are large reserves, due to the completeness and depth of the chemical content, consistency, logic of its presentation, high theoretical level.

Under the mental development, we understand the complex dynamic process of quantitative and qualitative changes that occur in the student's mental activity in connection with his mastery of the knowledge system and mental skills [1].

Mental development is a multidimensional process that depends on the characteristics of the learner’s nervous system, individual personality traits, upbringing and education. It is almost impossible to offer a universal indicator of development, moreover, to talk about the results achieved only in the learning process. However, the quality of knowledge and the ability to carry them out to new learning conditions may indicate an increase in mental development. In the works of some psychologists, equality between knowledge and mental development is actually set [2]. The presence of knowledge and the ability to operate with them, to put into practice testify to mental development.

We consider it right to single out the cognitive criterion to assess the level of students’ mental development, whose indicators are the cumulative rating, the overall and qualitative performance of students. Analyzing the general laws of mental development, we consider mental skills as a special case of mental development, correlate them with the systemic organization of developing cognitive structures, cognitive schemes-representations, and also single out mental skills based on mental operations: «isolation from external influence of large elements», «mental separation from objects of their signs», «thinking abstracts, symbols» [3].

The chemistry development when learning is possible not only by means of the subject (theories and laws, chemical concepts, rules, language), but also by chemical skills specific to chemistry (analysis, synthesis, comparison, observation, abstraction, and generalization) [4].

Among the indicators of students’ mental development of chemistry we include the mental operations possession, the independence of mental skills (activity criterion). Developmental skills are considered at different levels (reproductive, productive, creative).

American psychologists have developed a theory of the man’s moral development, showing his connection with mental development. One of the main criteria for mental development is the ability to solve independently problems of different types, the ability to control their behavior, to set goals consciously, to exercise self-control. Independence and responsibility become important characteristics to develop a person.

As indicators of students’ personal development, we define the level of independence, responsibility, communication.

Cards, as a way of structuring content, are widely used, used in many subject areas and are effective to learn, organize, consolidate and summarize the material.

In addition, cards allow you to master knowledge, mental skills at any level and use them in a certain relationship with great depth and independence. Mastering knowledge and skills with the help of cards occurs at all levels of mental development: from actions by analogy to transfer to similar conditions, full mastery, i.e. the ability to carry out an independent transfer and apply knowledge and skills with sufficient depth in new learning situations and extracurricular work.

The work on the creation and application of cards is a creative process, taking into account the students’ involvement in initiative, non-stereotypical thinking, the ability to act in new ways, to move deep into the subject for a theoretical explanation of phenomena, objects, the formation of new knowledge.
The search for learning aids related to creativity, creative activity, becomes actual, because creativity allows students quickly and easily to adapt to the dynamic conditions and requirements of modern education, to learn new things, to improve themselves.

### Table 1. Types of Creative Cards.

| Types of Cards                          | Mental Operations                                                                 | Elements of Search Activity on the Formation of New Knowledge                                                                 |
|----------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| **Subject Cards (Reproductive Level of Mental Development)** |                                                                                   |                                                                                                                             |
| Card analysis (for perception, reproduction) | Selection of the main idea of the content, components that obey the main idea, the establishment of logical, associative links between them, formulation, retelling, reproduction of ready-made evidence, judgments, identification of essential and non-essential features of objects | Perform elementary search task (low level of creativity): make a card on the model; find out…; tell ...; reproduce ... |
| Synthesis card (to recreate based on recall, representation) |                                                                                   |                                                                                                                             |
| **Object-Integrated Cards (Productive Level of Mental Development)** |                                                                                   |                                                                                                                             |
| Comparison card (to identify similarities and differences) | Awareness of the structure of the studied content, drawing up a response plan, evidence on the card, awareness of the comparison structure, establishing similarities and differences of objects for a given basis, assigning single objects and their properties to the corresponding class, combining objects with common essential properties | Perform problem-finding task (medium level of creativity): encode information using images; fill in a fragment of the map with regard to its connections; rate the result ...; prove the correctness of the conclusions; think of ways to convert cards |
| Causal card (to show a cause-effect relationship) |                                                                                   |                                                                                                                             |
| **Integral Cards (Creative Level of Mental Development)** |                                                                                   |                                                                                                                             |
| Integral cards (creative level of mental development) | Awareness of the principles of organizing content from individual parts, using knowledge from different sections and areas to solve new problems, finding additional grounds for comparison, determining the name of a new generalized object, independent distribution of objects and their properties into groups | Fulfillment of a creative task (high level of creativity): think up ...; transform ...; offer a solution to the problem; use your intuition; organize work with the card; find the pattern; predict properties |
| Classification card (for classifying on a specific basis) |                                                                                   |                                                                                                                             |
By a creative card we mean the result of the transformation and visualization of chemical material based on the system of mental operations and the method of generating new knowledge in the course of search activity.

The basis of building creative cards is the idea of the knowledge structural organization, their application is a system-forming factor to build a learning process aimed at the students’ mental development [5].

Qualitative changes in the students’ mental development in chemistry with the use of creative cards are determined by the independent decision of the system of gradually complicating search tasks.

Search assignments for creative cards should be designed in such a way that it was possible to orient students to cognition, creation, transformation, using objects, situations, phenomena, increasing rates and complexity of work in a new quality (Table 1).

Activity to make a creative card can be represented as follows:
- accumulation of chemical material, need awareness and material conversion possibility;
- formulation the purpose a creative card;
- analysis of chemical material accumulated on the topic and identification of the most significant components;
- detailing the content of selected components, coding in the form of symbols, associations, images; color and font selection of key concepts;
- establishing links between components (logical, associative, causal);
- location of components in accordance with the chosen method of conversion;
- return to the appointment of a creative card, checking the possibility of «unfolding» the material based on it.

| Chemical Content | Optionally Operations |
|------------------|-----------------------|
| Invariant        | Mental                |
| Awareness of the principles of organizing content from individual parts | Using knowledge from different sections and areas to solve new problems |
| Finding additional grounds for comparison | Definition of the name of the new generalized object |
| Independent distribution of objects and their properties into groups |

| Information Coding |
|--------------------|
| use of symbols, associations, images |

| Result Visualization |
|----------------------|
| Establishment of logical, associative and causal relationships between parts to obtain the whole |

| Creative Task |
|---------------|
| Make up … |
| Transform … |
| Suggest a solution … |
| Use the intuition … |
| Solve nonstandard … |
| Organize work with the map … |
| Find the pattern … |
| Operate with images … |
| Predict properties … |

**Figure 1.** Structural and informative characteristics of the creative card on the creative level.
For example, creative reproductive-level cards are focused on the reproduction of chemical information, studied classification, identified signs of generalization and comparison. At this level, when drawing up creative cards, students have access to ways to establish associative, logical connections and work on a pattern.

Creative cards of the productive level help to realize the structure of the studied content, to vary it, to carry out a synthesis, comparison and classification of significant features. Information recovery on a creative card occurs consciously, on the basis of a mentally composed plan. Problem-search task is aimed to develop the ability to evaluate the result, to prove the correctness of the assumption, the position taken, the ability to transform the card.

The motivations for working with creative cards on a creative level (Figure 1) are the personal qualities of students - the ability to independently organize their work, discover interdisciplinary connections between different areas of knowledge, and predict the result of work in new conditions.

Creative cards can be used in a ready-made form to generalize knowledge, but mainly to organize a search and creative activity of students to solve new problems for them.

All creative cards are interconnected by consistently developing skills that unite them into a single whole. The system of creative cards provides for a gradual increase in the level of students’ development as it is implemented.

In addition, the system of creative cards, permeated and sealed with a structured content of chemical discipline and ensures the assimilation of the science system.

3. Results
Determining the initial data for the study began with identifying the level of bachelors’ mental development. At the first stage of the experiment, the control and students’ experimental groups in chemistry were selected by the method of simple random selection [6].

The task of the teaching stage of the pedagogical experiment was to check the effectiveness of the methodical system of students’ mental development using creative cards. For this purpose, the experimental groups organized lessons using creative cards. In the control classes the study of the material was traditional.

As the main method of research used the test of applicants’ mental development and high school students (ASTUR) [7]. The scale of the level assessment of mental development according to the results of the ASTUR test is given below. The creative level of the bachelor’s degree corresponds to 85 % or more, recruited for the performance of the entire test, to the productive level – 68 % or more, to the reproductive level - to 51 %.

According to the results of the experiment training stage, the following data were obtained. In the control groups, an increase in the level of mental development was observed, as evidenced by: a decrease in the number of students who are at the reproductive level of development from 58 to 45 %; an increase in the number of students at the productive level - from 33 to 44 %; an increase in the number of students who are at a creative level — from 9 to 14 % (Figure 2 — activity criterion).

Students in experimental groups have gained an advantage over students in control groups. Thus, the number of pupils who are at the reproductive level of development has decreased from 58 to 32 %; the number of students at the productive level increased from 33 to 50 %; the number of students at the creative level increased from 9 to 18 %.
To study the level of knowledge in chemistry at the beginning of the experiment, a test was conducted [8].

The number of points scored and the average value for the whole group was calculated. At the training stage of the experiment, there was an increase in the quality performance and average cumulative rating of students in both groups, but students in the experimental group showed an advantage (Table 2).

Table 2. Quantitative assessment of knowledge on the implementation stages of the methodical system.

| Stages of Implementation | General Performance, % | Qualitative Performance, % | Average Cumulative Rating (points) |
|--------------------------|------------------------|----------------------------|-----------------------------------|
|                          | C          | E          | C          | E          | C          | E          |
| State                    | 100        | 100        | 51         | 63         | 65         | 64         |
| Learning                 | 100        | 100        | 64         | 67         | 68         | 76         |

C - control group, E - experimental group

A level study of the students’ knowledge in the control and experimental groups after completing their chemistry studies using creative cards showed the following.

In the control groups: the number of students with knowledge corresponding to the reproductive level of mental development, decreased from 55 to 43%; productive level - increased from 35 to 45 %, creative level - increased from 10 to 12 % (Figure 2 - cognitive criterion). In experimental groups: the number of students with knowledge corresponding to the reproductive level of mental development, decreased from 55 to 30%; productive level - increased from 35 to 54 %; creative level - increased from 10 to 16 %.

To identify the quality of students’ personal characteristics, the «Diagnostics of the parameters of independent activity of students» [9], «Methods of identifying students' communicative aptitudes» [10], «Diagnosing the responsibility of teenagers» [11] were used.

The severity of communicative students with a value of up to 0.55 corresponded to a low level of mental development; within 0.55 - 0.75 - average; 0.75 and higher – to the higher level. The level of independence and responsibility was assessed on a 3-point scale: low, medium, high.

The results of the pedagogical assessment of the students’ personal characteristics are reflected in table 3, showing their qualitative increase by the end of the learning phase of the experiment.
Table 3. Dynamics of personal characteristics of students on the implementation stages of the methodical system.

| N  | Personal characteristic   | Expressiveness stage specifications |
|----|---------------------------|-------------------------------------|
|    |                           | State | Learning |
| 1  | Independence             | 1.9   | 2.2      |
| 2  | Responsibility           | 1.6   | 2.1      |
| 3  | Communication Skills     | 0.64  | 0.74     |

The results of the level study of personal characteristics are reflected in Figure 2 (personality criterion).

4. Conclusion
The state stage of the pedagogical experiment revealed the relevance of the research topic, students' interest in using creative cards in chemistry, the low level of development of students' mental skills (≈ 65 %), their inability to identify signs of classification and generalization of objects and phenomena.

The result of the methodical system implementation can be considered positive: the number of students in the experimental group who are at the reproductive level of mental development (by 26 %) has decreased, the number of students at the productive (by 17 %) and creative (by 9 %) levels has increased.

The positive influence of the methodological system on the level of students' knowledge is shown (high indicators of general and high-grade performance, increase in the cumulative rating - by 15.7 %); development of students’ personal characteristics (from medium to high).

The data obtained as a result of the experiment allow to conclude about the reasonable use of creative cards when teaching bachelors of chemical directions in order to increase the level of mental development.

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