SCIENTIFIC COMPETENCE BASED ON COGNITIVE ACTIVITIES, THE ICAP MODEL, AND RESEARCH-BASED LEARNING.

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Abstract: *This article presents a methodological analysis of the ICAP model and inquiry-based learning (IBL), advanced educational approaches and their advantages used to enhance students' cognitive activity in the modern educational process, develop independent research skills and scientific thinking, and identify methodological foundations for developing research competencies in biology students at higher education institutions.*

Keywords: *ICAP model, inquiry-based learning (IBL), research, research competencies, cognitive activity.*

Аннотация: *В данной статье представлен методологический анализ модели ICAP и обучения на основе исследовательского подхода (IBL), передовых образовательных подходов и их преимуществ, используемых для повышения когнитивной активности студентов в современном образовательном процессе, развития навыков самостоятельной исследовательской работы и научного мышления, а также для определения методологических основ развития исследовательских компетенций у студентов-биологов в высших учебных заведениях.*

Ключевые слова: *модель ICAP, обучение на основе исследовательского подхода (IBL), исследования, исследовательские компетенции, когнитивная активность.*

Annotatsiya: *Mazkur maqola Oliy ta'lim muassasalarining biologiya yo'nalishi talabalarida tadqiqotchilik kompetensiyasilarini shakllantirish zamonaviy ta'lim jarayonida talabaning kognitiv faolligini oshirishga, mustaqil izlanish va ilmiy fikrlash ko'nikmalarini rivojlantirish, metodologik asoslarini belgilash ICAP modeli va Inquiry-Based Learning (IBL) kabi ilg'or ta'lim yondashuvlar va uning afzalliklari metodik jihatdan tahlil qilinadi.*

Kalit so'zlar: *ICAP modeli, Inquiry-Based Learning (IBL), tadqiqotchilik, tadqiqotchilik kompetensiyalari, kognitiv faoliyat.*

Developing research competence in students is a key objective of modern education. Effective development of this competence is directly linked to enhancing students' cognitive engagement in the educational process, developing independent research skills, and fostering scientific thinking. Therefore, when defining the methodological foundations of this study, we relied on such advanced educational approaches as the ICAP model and inquiry-based learning (IBL).

The ICAP model is a cognitive taxonomic model that identifies qualitative levels of students' cognitive activity, developed in 2013 by American scholar Michelene T. H. Chi.

The ICAP model (Chi, 2013) is one of the most effective concepts in modern pedagogy for classifying students' learning activities according to their level of cognitive engagement. This model includes a four-level taxonomy that helps define how students acquire knowledge: passive (P), active (A), constructive (C), and interactive (I).

Each level reflects the student's attitude toward the learning activity, that is, how they acquire knowledge, process it, or create something new. Here:

1. Passive level - indicates the student's participation in the learning process only as a listener or observer (e.g., listening to a lecture, watching a video, reading a text);

2. Active level - encompasses activities such as working with knowledge, highlighting it, marking it, and writing it down;

3. Constructive level - the student demonstrates the ability to create new knowledge based on existing knowledge, draw personal conclusions, and analyze it;

4. Interactive level – students communicate with each other and actively participate in discussions, leading to the co-creation of knowledge.

Thus, the ICAP model serves as an important criterion for determining the depth of student cognitive activity, as well as for the scientific evaluation of the effectiveness of educational methods[1].

The ICAP framework has been adopted for curriculum development in various disciplines and at different levels. For example, in school education (Morris and Chi, 2020), higher education (Wekerle et al., 2022), health care (Lim et al., 2019), and science and technology (Wiggins et al., 2017), the impact of different ICAP modes has been studied pedagogically and psychologically across several empirical research topics: student engagement (Wekerle et al., 2022) and perceived effort (Lim et al., 2019), subjective learning outcomes and self-assessment of learning (Wekerle et al., 2022), and assessment through objective learning outcomes (knowledge tests or certifications) (Morris and Chi, 2020)[2].

A step-by-step assessment of cognitive activity based on the ICAP model:

The ICAP model is widely used to determine the cognitive levels of students. This model consists of four stages: passive, active, constructive, and interactive. Each stage represents

the student's level of activity in the learning process, and by identifying it, the effectiveness of pedagogical interventions can be assessed.

In this study, student activity was analyzed using the ICAP model according to the following criteria:

1. Passive stage: The student only receives information (listens, reads);
2. Active stage: The student works with the material (draws, takes notes, reads);
3. Constructive stage: The student forms their own opinion, explains, and draws conclusions;
4. Interactive stage: The student analyzes, exchanges ideas, and argues in collaboration with other students. This model allowed us to analyze each stage of the learning process and determine the relationship between the student's cognitive level and his research competence.

Inquiry-Based Learning (IBL) is a form of active learning that begins with posing questions, problems, or scenarios. It differs from traditional teaching, which typically relies on the teacher presenting facts and knowledge about the subject matter. Inquiry-Based Learning is often led by a facilitator (a facilitator who leads the discussion at a summit) rather than a lecturer. Inquiry-Based Learning identifies and explores problems and issues with the goal of developing knowledge or solutions. Inquiry-Based Learning incorporates problem-based learning and is typically used in small-scale studies and projects, as well as in scientific research.[3] Inquiry-Based Learning is typically closely linked to the development and practice of thinking and problem-solving skills.[4]

Inquiry-based learning (IBL) is the methodological foundation of inquiry-based education.

IBL is a methodology that transforms students from passive participants in the learning process to active participants in research. Within the IBL approach, the learning process was organized into the following stages:

1. Problem formulation – student interest was aroused through questions on the topic
2. Hypothesis formulation – a scientific hypothesis was developed based on existing knowledge;
3. Research process – the hypothesis is tested through laboratory work, observations, and experiments;
4. Analysis and conclusions based on the results;
5. Presentation – the information obtained is presented orally or in writing.

The inquiry-based learning approach (IBL) develops the following student cognitive skills:

- asking questions,
- searching for information,

- identifying cause-and-effect relationships,
- logical thinking,
- forming scientific hypotheses,
- formulating conclusions.

The IBL methodology also served as the primary research tool as an approach activating the two highest levels of the ICAP model—constructive and interactive.

The ICAP model helps in assessing and determining student activity levels.

The IBL methodology enables the organization of interactive, research-based practical and laboratory lessons in zoology.

When used together, a cognitively grounded, experimentally proven methodology was created.

Methods that activate cognitive activity during the learning process are important for developing students' research competence. To this end, a model of learning activity methodology based on the ICAP model and the inquiry-based learning approach (IBL) was developed.

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