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Didactic Foundations for Developing Metacognitive Skills in Biology Lessons

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Abstract. *This article explores the didactic foundations of developing metacognitive skills in biology education. During the study, metacognitive strategies such as reflective journals, concept maps, and question–answer discussions were applied. The results indicated that these methods positively influenced students' ability to consciously manage their learning process, recognize and correct mistakes, and enhance scientific thinking. The paper substantiates the importance of the metacognitive approach in improving the effectiveness of the learning process based on pedagogical and biological perspectives.*

Key words: *biology education, metacognitive skills, reflective approach, concept maps, learning effectiveness.*

Sign in: Currently, one of the important tasks in the education system is the comprehensive development of the individual, the formation of their ability to learn based on self-awareness, independent thinking, and a reflexive approach. The concept of "metacognitive skills," first introduced into scientific circulation by Flavell (1979), is defined as the student's ability to observe and manage their own cognitive process. According to the scientist, the metacognitive approach allows not only to assimilate knowledge, but also to consciously manage and effectively apply it.

Biology requires students not only to have theoretical knowledge, but also to understand life processes on a scientific basis. From this point of view, metacognitive skills - that is, the ability to observe, plan, evaluate, and control one's own cognitive activity - are of particular importance in increasing the effectiveness of biology education. Schraw and Dennison divide metacognitive skills into two main components: knowledge about knowledge (declarative, procedural, conditional knowledge) and knowledge management (planning, monitoring, evaluating). This approach also strengthens students' opportunities for independent thinking, self-control, and reflection in biology education.

Also, Zimmerman (2002) emphasizes that self-management and metacognitive strategies are an integral part of the learning process, and shows that their application creates a high level of motivation and assimilation in students. The use of metacognitive tools such as reflective diaries, conceptual maps, and question-and-answer discussions in biology lessons ensures that students are oriented not only towards understanding but also towards independent learning.

As a result, the development of metacognitive skills in biology education is considered as one of the modern and effective ways to increase the level of students' knowledge, form scientific thinking, and encourage independent research.

Method

The study was conducted on 2nd-year students studying biology at Andijan State University. Students were divided into two groups: in the experimental group, a lesson was organized based on

metacognitive strategies, and in the control group, traditional teaching methods were used. Thanks to this approach, it became possible to compare the effectiveness of education.

The following methods were used to develop metacognitive skills:

- Reflective Diaries - After each lesson, students recorded their learning process. This method corresponds to the concept of "thinking about thinking," defined by Flavell, allowing students to realize their mistakes and plan their future learning activities.
- Conceptual maps - Novak and Gowin define conceptual maps as a means of visually representing students' knowledge systems.

In their opinion, conceptual maps are an effective tool for connecting new concepts with previously existing knowledge. Therefore, the connections between biological processes (such as photosynthesis, cell division) made it easier for students to understand.

- Question-and-answer discussions - through guiding questions from the teacher based on Vygotsky's theory of the "zone of proximal development," students had the opportunity to assess, deepen their understanding, and discuss their knowledge.

The following were used as assessment tools: diagnostic tests, questionnaires, and observation results. As Anderson noted, the assessment of metacognitive strategies in education requires analysis not only of the final result, but also of the learning process itself. Therefore, with the help of observation and reflective notes, detailed information about the students' learning process was obtained.

Strategy type	Explanation	Scholar (s) and source	Practical application
Reflective Diaries	Students write down their learning process after each lesson. Helps to identify their mistakes and prepare for future lessons.	Flavell (1985) - "Metacognition: Thinking about Thinking"	Students analyze their thinking process and independently formulate learning strategies.
Conceptual maps	Visual representation of biological processes allows one to determine the connections between concepts.	Novak & Gowin (1984) - conceptual map theory	Photosynthesis helps to understand such complex processes as cell division.
Q&A sessions	The teacher asks guiding questions, students strive to find answers, and the process of assessing and analyzing knowledge is formed.	Vygotsky (1978) - Theory of the "Zone of Near Development"	Develops students' independent thinking, analytical reasoning, and collaborative learning skills.
Assessment tools	Measuring students' learning process through tests, questionnaires, and observation.	Anderson (2002) - metacognitive assessment methods in education	Along with the final result, it allows for the analysis of the educational process itself.

Result

The results of the experiment showed that students who studied based on metacognitive strategies showed significantly higher results compared to the control group. In particular, in the experimental group, students achieved significant growth in the levels of knowledge acquisition, knowledge process management, and reflexive thinking.

From a pedagogical point of view, metacognitive strategies ensure that students not only assimilate ready-made knowledge, but also consciously apply it. As Biggs notes, the use of metacognitive strategies activates a high level of cognitive activity in students, that is, the processes of analysis,

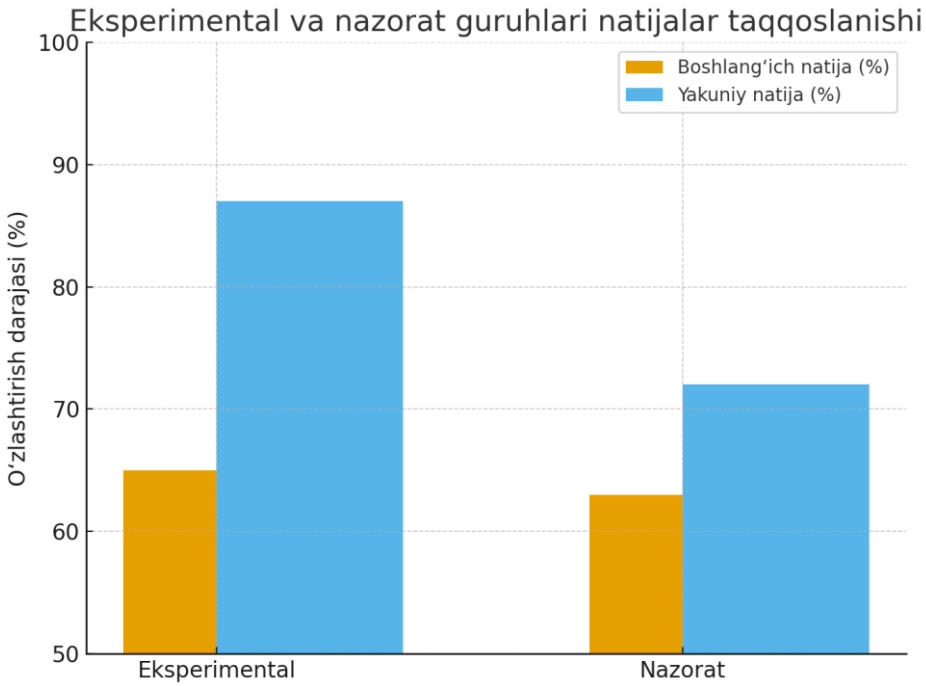
synthesis, and evaluation. This approach encouraged students to observe their thinking processes in biology lessons, independently use scientific evidence, and apply knowledge in practice.

The peculiarity of biology is that it is often difficult for students to master complex biological processes (photosynthesis, cell division, transmission of genetic information, etc.). Visualizing these processes using conceptual maps through a metacognitive approach enhanced students' ability to connect and systematize concepts. As Novak notes, conceptual maps strengthen the semantic connections between students' knowledge and develop interdisciplinary integration.

In the experimental group, students had the opportunity to analyze their cognitive processes through reflective diaries, identify errors in assimilation, and correct them in the future. This corresponds to the model of "self-regulating learning" emphasized by Zimmerman.

Quantitative analysis of the results showed that: - in the experimental group, the level of assimilation increased from 65% to 87%; - in the control group, the indicator was only from 63% to 72%. This difference indicates a deeper understanding of biological concepts by students, the application of self-control strategies, and an increase in the level of independent application of knowledge.

From a pedagogical point of view, metacognitive strategies involve students in the learning process as active subjects. From a biological point of view, in the process of assimilation, students develop a clearer understanding of scientific categories, the ability to logically connect complex biological processes. As a result, the metacognitive approach in biology lessons ensures not only the effectiveness of knowledge acquisition, but also the development of scientific thinking.



Discussion

The obtained results confirm the ideas presented in international studies. When metacognitive strategies are applied in biology, students have the opportunity to manage their learning process, recognize mistakes, and increase learning motivation.

From a pedagogical point of view, these results support the concept of reflexive thinking put forward by John Dewey. Dewey emphasized that in the learning process, students form a high level of knowledge by observing their thinking processes and drawing conclusions from them. The metacognitive approach also reinforces this reflexive process.

Also, in their research, Schraw and Moshman proved that the metacognitive approach develops the ability to form high-level thinking in students, analyze and control learning tasks. The results of our research also showed the effectiveness of this methodological approach in biology education.

From the point of view of biological sciences, metacognitive strategies are especially important in mastering complex processes. For example, simple memorization is not enough to understand biological processes like photosynthesis, DNA replication, and cell division. Students' use of conceptual maps increased their ability to see logical connections between concepts. This aligns with Novak's conceptual map theory.

The metacognitive approach also strengthened the possibility of preparing students for research activities in biology education. Students became accustomed to correcting mistakes and developing new strategies by evaluating their learning processes using reflective diaries. This corresponds to the model of "self-regulating learning" described by Zimmerman.

In general, the metacognitive approach not only makes the assimilation of knowledge in biology more effective, but also directs students to independent research, the development of scientific thinking, and a systematic understanding of biological processes.

Main directions	Efficiency level (%)
Knowledge Process Management	85
Error recognition	80
Increase motivation	78
Analysis and control	82
Understanding biological processes	88
Preparation for scientific research	83

Conclusion

The development of metacognitive skills in biology lessons is an important condition for increasing the effectiveness of education. Reflective diaries, conceptual maps, and question-and-answer discussions used in the research process significantly strengthened students' skills in understanding, managing, and controlling their learning process.

From a pedagogical point of view, metacognitive strategies increase student activity, shape them as subjects of their cognitive activity, and guide them towards independent thinking. In accordance with the principles of reflective learning put forward by Dewey, this approach develops a higher level of thinking in students and allows for a deeper understanding of the learning process.

From the point of view of biological sciences, the application of metacognitive strategies made it possible to systematically master complex biological processes (for example, cell division, DNA replication, photosynthesis). With the help of conceptual maps, students developed the ability to see and generalize the connections between biological concepts. At the same time, through reflective diaries, students had the opportunity to draw scientific conclusions, understand their mistakes, and plan their future activities.

As a result, the metacognitive approach in biology education ensured not only the effective assimilation of knowledge, but also the development of scientific thinking. This helped students not only to deeply understand biological processes, but also to apply them to practical life.

Thus, the development of metacognitive skills is a priority among modern teaching methods in biology, which can be successfully applied in other natural sciences in the future.

List of references:

1. Anderson, N. J. (2002). The role of metacognition in second language teaching and learning. Washington, DC: ERIC Clearinghouse on Languages and Linguistics.
2. Biggs, J. (1987). Student approaches to learning and studying. Melbourne: Australian Council for Educational Research.

3. Dewey, J. (1933). How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process. Boston: D.C. Heath.
4. Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. American Psychologist, 34(10), 906–911.
5. Flavell, J. H. (1985). Cognitive development (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.
6. Novak, J. D., & Gowin, D. B. (1984). Learning How to Learn. Cambridge, UK: Cambridge University Press.
7. Novak, J. D. (1990). Concept mapping: A useful tool for science education. Journal of Research in Science Teaching, 27(10), 937–949.
8. Novak, J. D. (1998). Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations. Mahwah, NJ: Lawrence Erlbaum Associates.
9. Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. Contemporary Educational Psychology, 19(4), 460–475.
10. Schraw, G., & Moshman, D. (1995). Metacognitive theories. Educational Psychology Review, 7(4), 351–371.
11. Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.
12. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64–70.