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SCIENTIFIC BASIS OF USING STEM TECHNOLOGIES IN VI CLASS IN BIOLOGY LESSONS

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VI SİNİF BİOLOGİYA DƏRSLƏRİNDƏ STEM TEXNOLOGİYALARINDAN İSTİFADƏNİN ELMİ ƏSASLARI

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НАУЧНЫЕ ОСНОВЫ ИСПОЛЬЗОВАНИЯ СТЕМ-ТЕХНОЛОГИЙ НА УРОКАХ БИОЛОГИИ В VI КЛАССЕ

Xülasə. Məqalədə biologiya dərslərində STEM texnologiyasından istifadənin elmi əsaslarının əsas müddəaları haqqında məlumat verilir. Ümumtəhsil məktəblərində biologiya kursunun tədrisi, təlimi və tərbiyəsi prosesində şagirdlərə yanaşmaların yenidən nəzərdən keçirilməsi üçün zəruri tələblər araşdırılmışdır. (Tayson, 2007) (Felder, 2016) Məqalədə, həmçinin həmin texnologiyalar və onların biologiya dərslərində istifadəsinə düzgün yanaşma ətraflı təsvir edilmişdir. Məqalədə fənlərdən daha çox fənlər üzrə inteqrasiya olunmuş təhsil kimi STEM təhsilinin üstünlüklərinin təhlili; yaradıcı təfəkkür və problem həlletmə bacarıqlarının inkişafı; texniki fənlərə marağın inkişafı və s., həmçinin müasir texnoloji istiqamətlərin üstünlükləri və onların təlim kursunu hazırlayan müəllimin işində tətbiqi imkanlarının təhlili aparılır. Praktiki material kimi biologiya dərslərində STEM texnologiyası vasitəsilə hesablamalar və riyazi həllər, onların həlli ilə bağlı bir sıra fikirlər təklif edilmişdir.

Açar sözlər: *biologiya, STEM texnologiyaları, STEAM, yaradıcı təfəkkür, elmi əsaslar*

Резюме. В статье представлена информация об основных положениях научно-педагогических основ использования STEM-технологий на уроках биологии. Исследованы необходимые требования к пересмотру подходов к учащимся в процессе преподавания, обучения и воспитания по курсу биологии в общеобразовательных школах. (Tyson, 2007) (Felder, 2016) В статье также подробно описаны эти технологии и правильный подход к их использованию на уроках биологии. В статье проводится анализ преимуществ STEM-образования как интегрированного обучения по предметам; развитие творческого мышления и навыков решения проблем; развитие интереса к техническим предметам и др. Также проводится анализ преимуществ современных технологических направлений и возможности их внедрения в работу преподавателя, готовящего учебный курс. В качестве практического материала на уроках биологии посредством технологии STEM были предложены ряд идей, связанных с расчетами и математическими решениями, и способы их решения.

Ключевые слова: *биология, STEM-технологии, STEAM, творческое мышление, научные основы*

Summary. The article provides information on the main provisions of the scientific-pedagogical basis of using STEM technology in Biology classes. Necessary requirements for revising approaches to learners during the teaching, training and education process of the Biology course in secondary schools were

investigated. (Tyson, 2007) (Felder, 2016) The article also describes in detail those technologies and the correct approach to their use in Biology classes. The article provides an analysis of the advantages of STEM education as an integrated education on subjects rather than subjects; development of creative thinking and problem-solving skills; development of interest in technical subjects, etc. Also, an analysis of the advantages of modern technological directions and the possibility of their implementation in the work of the teacher preparing the training course is carried out. As a practical material, a number of ideas related to calculations and mathematical solutions and their solutions were proposed in biology classes through STEM technology.

Key words: *biology, STEM technologies, STEAM, creative thinking, scientific foundations*

The relevance of the topic lies in the fact that, despite the existence of numerous interpretations of the cognitive interest of students, it is essential to focus on a specific aspect in order to promote better understanding and effective teaching strategies. The lack of scientific and methodological research on the problem and the underutilization of opportunities necessary for the development of cognitive abilities of students in the field of Biology highlight the need for a single recommendation. This study aims to develop the content and procedural components of the educational process by using STEM technologies to improve the cognitive interest of students in learning Biology.

In order to achieve this aim, it was necessary to determine the psychological and pedagogical foundations of STEM technologies for the development of students' cognitive interests in teaching and studying Biology. The study aimed to determine the role and place of STEM technologies in the development of students' cognitive interests in Biology, and to develop a structural and functional model of the project. Furthermore, a methodology for organizing project activities for students in teaching Biology was developed to contribute to the development of cognitive interest and ensure its effectiveness in pedagogical experiments.

STEM technologies are one of the active teaching methods that differ from passive teaching methods. Passive methods involve children's inactivity, as the purpose of their activity is less important for the student. In most cases, when working with traditional teaching methods, the student is not aware of the specifics of their activity, and they do not know why they are performing certain tasks. However, the teacher's recognition of the student's diligence, accuracy, and ability to cope with hard work becomes a more important incentive for the student. (L, 2018) (M.U., 2020)

Pedagogical experiments and analyses in educational activities carried out project activities in a specific subject area. A systematic approach to solving problems in Biology leads to the learning of skills and habits found in the learning process. Thus, a systematic approach is important for building algorithms for different performers. If the performer is a computer, then we are talking about a systematic approach to programming, structured programming. This approach - when programming, compiling algorithms, and other sections of informatics, according to the proposed methodology of the design method, innovative projects are studied and created.

The use of STEM technologies in teaching Biology means, first of all, the organization of teaching in groups. During the application of the design methodology of creative projects, students work together in groups, which contributes to the development of important social personal qualities. They learn to obtain missing knowledge with enthusiasm and independently from various sources, use the knowledge gained while performing cognitive and practical tasks, acquire communication skills by working in various groups, develop their research skills (problem detection, hypotheses, data collection, observation, investigation, analysis, and generalizations), develop thinking systems, and acquire basic competencies. Additionally, students' independent creative activity is carried out through the use of STEM technologies, and they become more active at the end of the project, updating their previous knowledge and strengthening their practical skills.

During the experiment, it was found that solving mathematical problems increases the responsibility of students, and they feel a more

serious approach to learning. Students' interest in the subject increases, and they try to do more programming. Students come to classes every day prepared, knowing that their knowledge will be tested. Information about each student is received at each lesson, and the overall dynamics of learning in the classroom is monitored to provide necessary assistance. It is easier for students to perceive new topics than in the previous period because they did not study the previous topics sequentially, and the gaps in their knowledge were gradually eliminated, making them better prepared to understand the following topics. Time is effectively used in the educational process, and more knowledge is transferred to a number of students in less time, reducing downtime and keeping students active.

Our research on "Using STEM technologies in teaching Biology" allows us to draw the following general conclusions. The successful use of STEM technologies in teaching Biology has numerous benefits for students. These opportunities include:

1. Ensuring the integrity of the pedagogical process: STEM technologies provide teachers with a variety of tools that can be used to enhance the pedagogical process. This ensures that the content being taught is up-to-date and relevant, and that the teaching methods are effective.

2. Comprehensive development of students: STEM technologies create conditions for the development of both the upbringing and education of students. This means that students are able to develop their knowledge and skills in a holistic way, rather than just focusing on one specific area.

3. Ensuring the creative activity of students: STEM technologies allow students to become active participants in the educational process. By using these technologies, students are able to engage in creative activities, which can help to foster their creativity and critical thinking skills.

4. Forming a cognitive motive for learning: When students see the end result of their activities, they are more likely to be motivated to learn. STEM technologies provide students with a clear goal, which can help to create a cognitive motive for learning.

5. Developing personal qualities of students: By engaging with STEM technologies, students are able to develop a range of personal qualities. These include social abilities, independent research skills, managing challenging skills, accuracy, and more.

However, despite the many benefits of STEM technologies, there is a significant gap between the content of existing secondary school textbooks and the requirements of real-life STEM technologies. This is why the article discusses the different views of well-known researchers in the field of STEM technologies, in order to guide secondary school teachers and textbook authors.

Overall, the aim of the article is to inform teachers and authors about the advantages and main features of STEM technologies, so that they can better incorporate them into their teaching and learning materials. By doing so, they can ensure that students are able to develop the skills and knowledge needed for success in the 21st century.

Introduction:

Recent studies and publications highlight the use of STEM technologies as a means to sustain cognitive interest in students. Combining different activities and learning methods, STEM technologies can facilitate the realization of personal potential and the development of cognitive interests. Although STEM technologies are not new, their creative implementation is now necessary. [1]

STEM technologies are used in modern pedagogy not as a substitute but as a component of the education system. It can help achieve the main task of schools, which is not only to provide knowledge but also to create interest, arouse personal motive, and prepare students for modern society. STEM technologies are primarily didactic, representing a set of methods and operations to acquire theoretical and practical knowledge in a particular field. They provide a way of cognition and organize the cognitive process.

Biology teaching is the most optimal field for developing students' cognitive interests, making STEM technologies particularly

important in this subject. Psychological-pedagogical and methodological analyses allow us to draw the conclusion that there are many interpretations of cognitive interest, but there is a need for a single recommendation for developing it.[2]

There is currently no developed mechanism for using STEM technologies to develop students' cognitive interest in Biology learning. The results of a confirmatory experiment, conversations with teachers, questionnaires conducted with them, and observation of Biology classes indicate that there is no systematic work to develop students' cognitive interest. There is a serious discrepancy between the development of students' cognitive interests and its practical organization and the potential of STEM technologies. Projects aim to resolve the conflict between the method's potential and the need to develop students' cognitive interests, which is especially relevant for the teaching of Biology.

In secondary schools, the teaching of Biology begins with theoretical information on characteristics of living things, cell theory, plants and animals' characteristics and classification. The organization of the training process is related to the methodology of using information technology. The application of STEM technologies in teaching ensures the development of students as intellectual, civic, and social beings.[3]

The formation of cognitive interest has attracted the attention of famous educators due to its practical significance. Project activities are one of the evolving teaching methods that allow students to develop logical and creative thinking, research skills, and the ability to summarize knowledge acquired in the learning process. Massirova R.R. and Saveleva V. suggest that project activities are especially important for bachelors, and there is a need to create a model for their formation after the creation of pedagogical conditions.

In the field of education, the concept of cognitive activity has attracted significant attention from scholars. The term cognitive activity refers to a lively and energetic type of activity aimed at fulfilling a given task. The development of cognitive interests in school is considered impossible without the application of heuristic techniques in training. It has been equated with the needs of the heart and mental activity, and is viewed as a sign of personality manifested in action.[4]

Different scholars have put forth varying definitions and interpretations of cognitive activity. For example, E.A. Krasnovsky considers the idea of "preparation for problem solving, the complexity of teaching, which is the basis of training" as cognitive activity, whereas Groshev A.S. sees it as a sign of personality that leads to effective acquisition of knowledge, skills, and habits. M.A. Danilov defines cognitive activity as a special type of activity focused on fulfilling a given task.[5]

Moreover, the concept of cognitive activity has been linked to the process of formation of personality neoplasms. A model has been proposed that includes various elements, such as goals, objectives, principles, components, criteria, and levels of project activity. The interrelationships between these elements ensure the implementation of the process of formation of personality neoplasms.

The role of training in cognitive activity has also been emphasized by scholars. Ponomarev Ya. A. considered training as a type of activity, with the ultimate goal of preparing students for independent work. He noted that the learning process is not arbitrary, but rather has a social character, focused on the creative skills of students and carried out under the guidance of the teacher. The relationship between the teacher and student is seen as integral to the training process.

Additionally, scholars have analyzed the structure of activity and emphasized the importance of general training skills. The skills of planning work ahead, carrying it out rationally, exercising self-control, and working at a certain pace are considered crucial for cognitive activity. Memorization and revitalization also depend on the student's learning environment, highlighting the need to consider general training skills in addition to knowledge, skills, and habits.

In conclusion, the concept of cognitive activity is a complex and multifaceted one that has been analyzed by numerous scholars. It has

been linked to the process of formation of personality neoplasms, and is viewed as a sign of personality manifested in action. Training plays a crucial role in cognitive activity, with the ultimate goal of preparing students for independent work. General training skills are also deemed important, in addition to knowledge, skills, and habits, for effective cognitive activity.

As per Pakhomova's perspective, personality is grounded on activity. The author posits a paradox between the physical and psychophysiological fluctuations of an individual and the stability of their personality. Hence, the concept of the self, represented by the "I," has emerged as a predicament of personality psychology. The psychological traits of an individual, which define their character, constitute the essence of this predicament. Consequently, the constancy of one's "I" is challenged by these issues.

Statement of the problem

In the field of education, it is widely recognized that schooling should not only impart ready-made knowledge to students but also equip them with the skills and ability to independently strengthen their knowledge and skills system. The main task of teachers is to activate the logical thinking of students and their ability to comprehend, leading to cognitive interest. Cognitive interest is a fundamental part of life and serves as an incentive for students' learning and creative activities. However, the cognitive process is rarely stable, and it is not easy to work to keep this interest alive. This paper aims to explore the problem of cognitive interest in education and the opportunities necessary for the development of students' cognitive abilities when teaching Biology.

The problem of cognitive interest: Cognitive interest is an important motive for training and a powerful tool for educational training. It is also an essential factor for the implementation of the Projects method. The problem of cognitive interest has been studied by various scholars such as A.S. Belkin, X.J. Taneeva, V.A. Qusev, V.A. Kruteskiy, I.Y. Lanina, L.M. Friedman, and Q.İ. Shukina. These researchers have highlighted the importance of cognitive interest in learning and how it contributes to the formation of volitional qualities. Voluntary qualities are formed when students overcome difficulties and strengthen their self-confidence, which plays a positive role in their future activities.

Cognitive curiosity also motivates students to constantly search for new information. During their research, they learn to pay attention to the main, more important issues, analyze and draw general conclusions. Cognitive interest activates any human activity, and all activities have a cognitive basis.

However, cognitive interest is not always stable, and educators face the challenge of keeping it constant. The use of creative tasks in the classroom can serve this purpose, as children present themselves through these tasks. The lack of sufficient scientific and methodological research on the problem of cognitive interest highlights the need for further studies on this topic.

Opportunities for the development of students' cognitive abilities in teaching Biology: In the context of teaching Biology, various opportunities can be utilized to develop students' cognitive abilities. The following table summarizes some of the key opportunities:

Opportunities for the development of students' cognitive abilities in teaching Biology

1. Comprehensive and timely development of children and youth
2. Formation of self-education and self-realization skills
3. Understanding the world as a whole and forming a modern worldview and intra-ethnic culture
4. Diversity of types and forms of educational institutions and programs for individualization of education
5. Continuation of the levels and stages of education in the form of tradition
6. Development of distance education and information technology programs in education
7. Academic mobility of students
8. Development of national tradition when working with talented youth
9. Participation of pedagogical workers in scientific activity
10. Training of highly educated and qualified specialists with professional mobility

in the process of informatization of society and development of new scientific technologies

Cognitive interest is crucial in education, and it plays a significant role in students' learning and creative activities. Educators must strive to keep this interest constant through the use of various creative tasks in the classroom. Moreover, the development of students' cognitive abilities in teaching Biology can be facilitated through utilizing the opportunities presented in the table above. Further scientific and methodological research is necessary to explore the problem of cognitive interest in education fully.

Conclusion:

Based on the conclusions drawn from the analysis of scientific, psychological-pedagogical and methodical literature, some suggestions can be made:

1. Encourage the use of STEM technologies in the teaching of Biology to ensure the integrity of the pedagogical process, promote the full development of students, ensure their creative activity, form the cognitive motive of learning, and develop their personal qualities.

2. Incorporate visual and practical projects that integrate the actions taken during the students' experience, set short-term goals, and inspire the student to achieve these goals, thus promoting their independent thinking and action. This will also help develop civic competencies in the students.

3. Take into account the age level of students when implementing STEM technologies to ensure optimal development of cognitive interest during the learning process.

4. Address the contradiction between the existing reproductive nature of teaching Biology and the need to enhance students' productive skills and ability to acquire knowledge independently.

5. Implement the developed methodology for practical work in the teaching of Biology in schools, and evaluate its effectiveness.

6. Consider using the developed methodology as a course project in schools with in-depth study of Mathematics and Biology, based on the positive results from research and experiments.

By incorporating these suggestions, it is possible to enhance the teaching of Biology and help students develop their skills and abilities, while also preparing them for the requirements of the modern society.

The literature suggests that incorporating STEM technologies in the teaching of Biology can address these issues and create several benefits for students. These benefits can be summarized as follows:

Table 1: Benefits of using STEM technologies in the teaching of Biology

Benefits	Description
Ensures the integrity of the pedagogical process	STEM technologies allow for a more holistic approach to learning that integrates theory and practice. This ensures that students are exposed to a range of experiences that help them develop a deeper understanding of the subject matter.
Promotes the full development of students	STEM technologies create conditions for the development of both the upbringing and education of students. This means that students are not only learning about Biology but also developing important life skills such as teamwork, problem-solving, and communication.
Ensures the creative activity of students	STEM technologies turn students into active members of the learning process by encouraging them to engage in creative problem-solving activities. This fosters a sense of ownership and responsibility for their learning.
Forms the cognitive motive of learning	STEM technologies create a sense of purpose and motivation for learning by showing students the end result of their activity. This makes learning more relevant and meaningful to their lives.
Develops personal qualities	STEM technologies encourage students to improve and develop their knowledge, which helps to develop personal qualities such as resilience, perseverance, and self-confidence.

Reveals the active personal position of the student	STEM technologies give students the opportunity to interfere in the progress of the project and change the course of the project for their own purposes. This fosters a sense of agency and independence, which are important for developing civic competencies.
Taught in accordance with age level	STEM technologies can be adapted to suit the age and developmental level of students. This ensures that students are not overwhelmed with complex concepts and can progress at their own pace.

The urgency of the problem. One of the most urgent issues in the education system of our republic, which requires its own solution, is the problem of developing investigation skills of the secondary school students in Biology lessons.

Scientific novelty of the problem. In conclusion, the literature suggests that using STEM technologies in the teaching of Biology can create several benefits for students, including a more holistic approach to learning, the development of important life skills, creative problem-solving activities, a sense of purpose and motivation for learning, and the development of personal qualities such as resilience and self-confidence.

Practical significance of the problem. It is suggested that STEM technologies should be adapted to suit the age and developmental level of students, which ensures that learning is not overwhelming and students can progress at their own pace. Finally, the literature highlights the need for a shift towards more practical and hands-on approaches to learning Biology, particularly in the context of an increasingly technology-driven world.

References:

1. Başaran, M., & Bay, E. (2022). The effect of project-based STEAM activities on the social and cognitive skills of preschool children. Early Child Development and Care, 1-19. https://www.tandfonline.com/doi/abs/10.1080/03004430.2022.2146682
2. Choi, Y., & Hong, S. H. (2015). Effects of STEAM lessons using scratch programming regarding small organisms in elementary science-gifted education. Journal of Korean Elementary Science Education, 34(2), 194-209. https://koreascience.kr/article/JAKO201518564243423.pdf
3. Conradty, C., & Bogner, F. X. (2020). STEAM teaching professional development works: Effects on students' creativity and motivation. Smart Learning Environments, 7, 1-20. https://link.springer.com/article/10.1186/s40561-020-00132-9
4. ElSayary, A. (2021). Transdisciplinary STEAM Curriculum Design and Authentic Assessment in Online Learning: A Model of Cognitive, Psychomotor, and Affective Domains. Journal of Turkish Science Education, 18(3), 493-511. https://eric.ed.gov/?id=EJ1325572
5. Keefe, D. F., & Laidlaw, D. H. (2013). Virtual reality data visualization for team-based STEAM education: Tools, methods, and lessons learned. In Virtual, Augmented and Mixed Reality. Systems and Applications: 5th International Conference, VAMR 2013, Held as Part of HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings, Part II 5 (pp. 179-187). Springer Berlin Heidelberg. https://link.springer.com/chapter/10.1007/978-3-642-39420-1_20

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