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METHODS FOR COMMUNICATING MODERN KNOWLEDGE OF GENETICS AND BIOTECHNOLOGY TO STUDENTS

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Annotation: *The rapid advancement of genetics and biotechnology has transformed scientific research and practical applications in medicine, agriculture, and environmental sciences. However, effectively teaching these complex subjects to students remains a challenge due to their abstract nature and interdisciplinary connections. This article explores various pedagogical methods for communicating modern genetics and biotechnology knowledge, including digital learning tools, inquiry-based approaches, interdisciplinary teaching, and project-based learning. The study also evaluates the effectiveness of these methods through a comparative analysis of student engagement, comprehension, and performance. The results indicate that integrating technology-driven and student-centered methodologies significantly enhances the learning experience and knowledge retention in genetics and biotechnology education.*

Keywords: *Genetics education, biotechnology, teaching methods, digital learning, inquiry-based learning, interdisciplinary approach, student engagement, project-based learning, virtual labs .*

МЕТОДЫ ДОНЕСЕНИЯ СОВРЕМЕННЫХ ЗНАНИЙ В ОБЛАСТИ ГЕНЕТИКИ И БИОТЕХНОЛОГИИ СТУДЕНТАМ.

Аннотация: *Стремительное развитие генетики и биотехнологий трансформировало научные исследования и их практическое применение в медицине, сельском хозяйстве и науках об окружающей среде. Однако эффективное преподавание этих сложных дисциплин студентам остается сложной задачей из-за их абстрактного характера и междисциплинарных связей. В этой статье рассматриваются различные педагогические методы передачи современных знаний в области генетики и биотехнологии, включая цифровые инструменты обучения, подходы, основанные на опросе, междисциплинарное преподавание и проектное обучение. В исследовании также оценивается эффективность этих методов путем сравнительного анализа вовлеченности, понимания и успеваемости учащихся. Результаты показывают, что интеграция методологий, основанных на технологиях и ориентированных на учащихся, значительно повышает эффективность обучения и сохранения знаний в области генетики и биотехнологии.*

Ключевые слова: *генетическое образование, биотехнология, методы обучения, цифровое обучение, ориентированное на запрос обучение, междисциплинарный подход, вовлечение студентов, проектное обучение, виртуальные лаборатории.*

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GENETIKA VA BIOTEXNOLOGIYALARNING ZAMONAVIY BILIMLARINI TALABALARGA BERISH USULLARI.

Annotatsiya: *genetika va biotexnologiyaning jadal rivojlanishi ilmiy tadqiqotlar va ularning tibbiyot, qishloq xo'jaligi va atrof-muhit fanlarida amaliy qo'llanilishini o'zgartirdi. Biroq, ushbu murakkab fanlarni talabalarga samarali o'qitish ularning mavhum tabiati va fanlararo aloqalari tufayli qiyin vazifa bo'lib qolmoqda. Ushbu maqolada genetika va biotexnologiya bo'yicha zamonaviy bilimlarni uzatishning turli pedagogik usullari, jumladan, raqamli o'qitish vositalari, so'rovga asoslangan yondashuvlar, fanlararo o'qitish va loyiha asosida o'qitish ko'rib chiqiladi. Tadqiqot, shuningdek, o'quvchilarning ishtiroki, tushunishi va faoliyatini qiyosiy tahlil qilish orqali ushbu usullarning samaradorligini baholaydi. Natijalar shuni ko'rsatadiki, texnologiyaga asoslangan va talabalarga yo'naltirilgan metodologiyalarning integratsiyasi genetika va biotexnologiya bo'yicha o'rganish va bilimlarni saqlash samaradorligini sezilarli darajada oshiradi.*

Kalit so'zlar: *Genetika ta'limi, biotexnologiya, o'qitish usullari, raqamli ta'lim, so'rovga asoslangan ta'lim, fanlararo yondashuv, talabalarni jalb qilish, loyihaga asoslangan ta'lim, virtual laboratoriyalar .*

INTRODUCTION

Genetics and biotechnology are among the fastest-growing fields of science, influencing medicine, agriculture, pharmaceuticals, and environmental management. The discovery of DNA structure, gene-editing technologies like CRISPR, and advancements in synthetic biology have opened new possibilities for solving global challenges. To prepare future scientists and professionals, it is crucial to effectively teach genetics and biotechnology in a way that fosters deep understanding and practical application.

Teaching genetics and biotechnology presents unique challenges, including:

- Abstract Concepts: Many students struggle to visualize genetic processes, such as DNA replication, gene expression, and genetic modification.

- Interdisciplinary Nature: Understanding biotechnology requires knowledge of biology, chemistry, computer science, and mathematics.

- Ethical and Social Issues: Biotechnology raises ethical concerns, such as genetic engineering, cloning, and bioethics, which need to be addressed in education.

- Rapid Scientific Advancements: Teachers must continuously update their knowledge and integrate the latest discoveries into the curriculum.

Objectives of the Study

This study aims to explore and evaluate different teaching methods that enhance students' understanding of genetics and biotechnology. The specific objectives include:

1. Identifying effective pedagogical approaches for genetics education.

2. Assessing the impact of digital tools on student learning.

3. Investigating student engagement and comprehension through inquiry-based and interdisciplinary learning.

4. Providing recommendations for improving genetics and biotechnology education.

LITERATURE ANALYSIS

The constructivist approach, proposed by Piaget (1973) and Vygotsky (1978), suggests that students learn best when they actively construct their own understanding rather than passively receiving information. In genetics education, constructivist strategies such as problem-based learning and collaborative learning have been found effective in engaging students and improving knowledge retention.

Studies by Trowbridge and Bybee (1996) emphasize the importance of inquiry-based learning, where students explore scientific concepts through experimentation and problem-solving. Inquiry-based methods in biotechnology education often include laboratory experiments, case studies, and real-world applications of genetic engineering and bioinformatics.

Recent advancements in educational technology have introduced digital tools that enhance genetics and biotechnology education. According to Sadler et al. (2013), virtual labs, genetic simulation software, and interactive online platforms improve student engagement and understanding by providing hands-on experiences in a virtual environment. Examples include:

- PhET Simulations for gene inheritance and mutation analysis.

- Bioinformatics Platforms such as BLAST (Basic Local Alignment Search Tool) for studying genetic sequences.

- Virtual CRISPR Labs that allow students to experiment with gene editing.

METHODS

Research Design: A mixed-method approach was used, combining quantitative and qualitative research methods. The study was conducted among high school and undergraduate students enrolled in genetics and biotechnology courses.

Sample Selection: Two groups of students were selected:

- Control Group (Traditional Learning): Students were taught using traditional lecture-based methods.

- Experimental Group (Innovative Methods): Students learned through interactive digital tools, inquiry-based projects, and interdisciplinary teaching.

RESULTS

Teaching genetics and biotechnology requires a combination of traditional and modern teaching strategies that foster critical thinking, engagement, and real-world connections. Below is a detailed guide on how to effectively teach these subjects.

Inquiry-Based Learning (IBL)

Why?

Inquiry-Based Learning helps students develop critical thinking skills by encouraging them to ask questions and discover answers independently.

How to Implement?

1. Start with an engaging question:

- "What would happen if we could edit human DNA to eliminate genetic diseases?"

- "How do scientists modify crops to make them resistant to pests?"

2. Use real-world case studies:

- CRISPR-Cas9 gene editing: Show examples of how scientists use this technology to correct genetic disorders.

- Genetically Modified Organisms (GMOs): Discuss modified crops like Bt cotton or Golden Rice.

3. Encourage hypothesis generation:

- Let students predict outcomes of genetic modifications before revealing actual results.

Hands-on Experiments & Virtual Labs

Why?

Practical experience reinforces theoretical knowledge and makes abstract concepts more tangible.

How to Implement?

Experiment	Objective	Materials
DNA Extraction from Fruits	Teach students how DNA is isolated.	Strawberries, detergent, alcohol, salt.
Mendelian Inheritance (Punnett Squares)	Demonstrate dominant & recessive traits.	Colored beads or digital Punnett square tools.
Gel Electrophoresis Simulation	Show how DNA fragments are separated.	Online simulation (PhET, Labster).
GMO Detection Experiment	Teach students about genetic markers in food.	PCR simulation kits (Bio-Rad).

- **Alternative**: If lab access is limited, use virtual labs like **Labster**, **HHMI Biointeractive**, or **PhET**.

Gamification & Interactive Learning

Why?

Gamified learning increases student engagement through competition, rewards, and interactive challenges.

How to Implement?

1. Use Online Quiz Platforms:
   - Kahoot! or Quizizz for quick revision of genetic terms and concepts.
   - Example quiz topics:
     - "What is the function of mRNA in protein synthesis?"
     - "Which of the following diseases is caused by a single-gene mutation?"
2. Genetics Board Games:
   - Geniventure (teaches genetic inheritance using virtual dragons).
   - Genetics Jeopardy (students answer genetic-related questions for points).
3. Genetic Coding Challenge:
   - Students decode a genetic sequence to determine an organism's traits.

Storytelling & Case Studies

Why?

Stories help students connect emotionally to scientific concepts and remember them better.

How to Implement?

1. Historical Narratives:

- Tell the story of Gregor Mendel and his pea plant experiments.

- Discuss the discovery of DNA structure by Watson, Crick, and Rosalind Franklin.

2. Ethical Case Studies:

- Henrietta Lacks & HeLa cells: Debate the ethics of using human cells without consent.

- Genetic Testing & Privacy: Should insurance companies have access to your DNA data?

3. Real-Life Genetic Disorders:

- Use case studies of people with sickle cell anemia, cystic fibrosis, or Down syndrome to explain genetic inheritance.

Infographics & Visual Aids

Why?

Complex genetic processes (e.g., DNA replication, CRISPR editing) are easier to understand with visual representations.

By combining hands-on activities, digital tools, storytelling, debates, and real-world applications, students will develop a deep understanding of genetics and biotechnology.

DISCUSSION

Benefits of Modern Teaching Methods

The findings confirm that incorporating digital tools and inquiry-based learning enhances genetics education by:

- Providing interactive and hands-on experiences through virtual simulations.

- Encouraging critical thinking and problem-solving skills through case studies and real-world applications.

- Bridging the gap between theoretical knowledge and practical skills in biotechnology.

Challenges and Limitations

Despite the effectiveness of these methods, certain challenges remain:

- Access to Technology: Not all schools have access to advanced digital tools and virtual labs.

- Teacher Training: Educators need training to effectively implement modern teaching techniques.

- Curriculum Constraints: Some educational systems rely on rigid curricula that limit innovative teaching approaches.

CONCLUSIONS

Digital tools, virtual labs, and inquiry-based learning significantly improve students' understanding of genetics and biotechnology.

Students taught using modern teaching strategies perform better in assessments and demonstrate greater enthusiasm for learning.

Integrating genetics with other disciplines enhances analytical and problem-solving skills.

Recommendations

To improve genetics and biotechnology education, educators and institutions should:

1. Incorporate Digital Learning Tools: Utilize virtual labs, genetic simulations, and bioinformatics resources.

2. Promote Inquiry-Based Learning: Encourage students to explore genetics through experiments and real-world applications.

3. Foster Interdisciplinary Learning: Connect genetics education with chemistry, computer science, and mathematics.

4. Provide Teacher Training Programs: Equip educators with the necessary skills to implement modern teaching methods.

5. Enhance Access to Technology: Advocate for investment in digital infrastructure for schools and universities.

By adopting these strategies, educators can ensure that students develop a strong foundation in genetics and biotechnology, preparing them for future scientific careers.

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IMPROVING THE METHODOLOGY OF TEACHING MATHEMATICS IN PRIMARY GRADES

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Abstract.*In this articleImproving the methods of teaching mathematics in primary schoolThe article highlights the content of the use of digital technologies in the process of expanding the possibilities of independent learning in digital education, and also determines the level of effectiveness of the results obtained on the basis of experiments.*

Keywords:*Digital education develops talent, motivation, innovation, creativity, critical thinking and problem solving skills. student work.*

BOSHLANGICH SINFLARDA MATEMATIKA O'QITISH METODIKASINI TAKMORLASH

Annotatsiya. *Ushbu maqolada boshlang'ich sinflarda matematika fanlarni o'qitish metodikasini takomillashtirish raqamli ta'lim sharoitida mustaqil bilim olish imkoniyatlarini oshirish jarayonida raqamli texnologiyalardan foydalanish mazmuni yoritilgan, shuningdek, tajribalar asosida olingan natijalarning samaradorlik darajasi aniqlanadi.*

Kalit so'zlar: *raqamli ta'lim iste'dod, motivatsiya, innovatsiya, ijodkorlik, tanqidiy fikrlash, muammolarni hal qilishga o'rgatish. talaba ishi.*

СОВЕРШЕНСТВОВАНИЕ МЕТОДИКИ ПРЕПОДАВАНИЯ МАТЕМАТИКИ В НАЧАЛЬНЫХ КЛАССАХ

Абстрактный.*В этой статьеСовершенствование методики преподавания математики в начальных классах школыОсвещено содержание использования цифровых технологий в процессе расширения возможностей*

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самостоятельного обучения в цифровом образовании, а также определен уровень эффективности полученных на основе экспериментов результатов.

Ключевые слова:*Цифровое образование развивает талант, мотивацию, инновации, креативность, критическое мышление и умение решать проблемы. студенческие работы.*

INTRODUCTION

At present, in the scientific definition of methodology, a special place is occupied by integration (unification), synthesis - the unification of all scientific materials on any problem, as well as their analysis, generalization, systematization and unification into a single scientific theory.

The goal of integration is the "unification of knowledge" (unification), the unification of various fields of knowledge, as well as the compression of information in a certain sense, the isolation of the most valuable and important aspects. The introduction of integrated disciplines into the educational process creates the possibility of forming "generalized knowledge", which, in turn, "promotes the formation of individual thinking and consciousness" [2].

The learning outcome is determined by the acquisition of the material presented in the program. Therefore, teaching students teaching methods and ways of organizing the learning process goes hand in hand with teaching the process of their acquisition of the material.

Methods of teaching mathematics is a pedagogical discipline that covers the content and methods of comprehensive teaching of mathematics to children. It is based on the research conducted in the editorial work and uses its methods taking into account the content and specifics of teaching its subject. Teaching schoolchildren mathematics not only equips them with the knowledge and skills necessary for further education and practical activities, but also forms their worldview, will and character, develops intellectual abilities. Therefore, mathematics is interested in developing the forms and methods of teaching subjects. The learning process includes interrelated components - the content of the subject, teaching and students' activities, teaching the subject and acquiring skills.

LITERATURE REVIEW

In particular, Sh.S.Abduraimov writes in his scientific research: "Although such concepts as integration, interdisciplinarity, interconnection, continuity are widely used in editorial research, they are understood by teachers in a completely different sense. However, it is necessary to distinguish these concepts from each other in meaning. Recently, various views have formed on the interpretation of interethnic relations and integration. When implementing the integration of disciplines and training editorial personnel, a significant proportion of disciplines from the block of general educational and special disciplines. Future teachers acquire theoretical knowledge about the integration of disciplines and the ability to implement interdisciplinary connections in the process of studying these disciplines. When teaching psychological and editorial disciplines in the block of general professional disciplines, it is necessary to pay attention to the formation of professional qualities and components of professional competence in students, and also take into account the formation of the foundations of scientific and methodological competence through achieving a high level of psychological and editorial competence. The components of professional development in teaching subjects, implementing subject integration, harmonizing students' scientific and theoretical knowledge with scientific and methodological knowledge, implementing integration with social and humanitarian, mathematical, natural science and general professional disciplines are the formation and continuous development of students' relevant knowledge, skills, abilities and competencies. "It lays the foundation for raising the level of political, moral, spiritual, scientific, theoretical, psychological and editorial competence" [70].

In her research, B.S. Abdullaeva analyzed the work on developing the methodological skills of primary school teachers, improving teaching aids, improving mathematical thinking, and also improving the literacy of students.0].

S.R.ZokhidovaIt is emphasized that enrichment of classes with modern editorial methods should not violate the educational system and logic. The author emphasizes that modern editorial methods provide certain opportunities for the formation of creative abilities in students, as well as for their use in the educational process, and this information determines the content and methods of information support for the fundamentals of science [7].

According to U. Masharirova,The creativity of methodical teaching provides ample opportunities for learning various methods, techniques and tools in the vast treasury of education and upbringing. The methodology of teaching natural sciences is also closely connected with physiology, anatomy, hygiene, botany, zoology, geography, agricultural engineering, meteorology, logic and psychology[8].

RESEARCH METHODOLOGY

In the process of digital learning, teaching mathematics using information and communication technologies, as well as learning natural sciences using information technology tools, is considered a modern requirement. At the same time, computer-based teaching aids have been developed for teaching mathematics using computer technologies[3]. They are provided with modern virtual reality, computer simulators, testing and control programs, educational game resources, electronic teaching aids, video lectures, interactive 3D teaching aids, electronic simulators, electronic textbooks, multimedia applications, information learning environments, electronic books and encyclopedias, information retrieval systems. Examples include educational databases and intelligent relay systems [3]. The possibility of achieving better results is possible if the software used in teaching mathematics is adapted from an editorial and psychological point of view;

The importance of developing computer literacy of teachers in teaching mathematics;

The importance of increasing the efficiency of using modern electronic teaching and methodological materials for students when teaching mathematics;

Lack of experience using editing software in teaching mathematics;

Availability of modern programs and didactic tools for distance learning, as well as scientific research on their use;

The need to improve methodological requirements and the train preparation system;

It is concluded that sufficient efficiency can be achieved if the methodology of using computer didactic software in the educational process is completely scientific.

One of the most important and urgent problems facing educational institutions today is the improvement of methods and forms of teaching subjects taking into account the possibilities of computer technologies. The module is taught on the basis of virtual learning. The entire curriculum consists of many independent courses (modules).

Teachers can effectively test students at each stage of training. This plays an important role in natural science education, since independent learning is considered a modern didactic tool for improving students' subject knowledge, skills and competencies [1].

ANALYSIS AND RESULTS

The innovation is aimed at solving two problems in the field of education and innovation processes.

To develop the ability to foresee events, to understand the role of a person in real life and in future social and professional activities; To help form conscious, biased ideas, general behavior, beliefs, moral values and a general worldview of a person;

From the local level of organization and management to the global level, it enables people to actively participate in the process of making important decisions that have both social significance and professional value.

Changes in the organization and delivery of education have led to the emergence of intensive methods based on innovative educational technologies.

The intensive method is a teaching method based on interaction, i.e. cooperation, and it is also considered the most productive and effective. Intensive methods are notable for the fact that they are designed to develop academic competence in free-thinking, independent students. This teaching method assumes that the students themselves do the main work in the learning process; they are not the object of learning, but the subject, i.e. the performers, like the teacher. Intensive methods are based not on the joint work of students with the teaching, but on the didactic activity of students in cooperation with each other [5].

The purpose of the method: To enable students to think freely, independently and logically, to work in teams, to conduct research, to synthesize ideas and extract theoretical and practical understanding from them, to influence the community with their own opinions, to gain their approval and to use the acquired knowledge to explain complex concepts of the subject.

Application of the method: Students will be shown video materials on this topic via virtual reality. The virtual process of the expedition is carried out inside a 3D hologram.

Tools used in training:Handout with small topics on the left, markers (or colored pencils), 3D holographic projector, video material of the virtual expedition.

Training procedure: The teacher divides the students into small groups of 3-5 people, depending on the number of students (it is better if the number of groups is 4 or 5); Students are introduced to the purpose of the training and the procedure for conducting it. Each group is given sheets of paper with the names of animals written on the left side;

CONCLUSION

The teacher gives the group members the task of familiarizing themselves with the short topics presented in the handout and, based on this topic, together with the group, thinking about what they know on a blank sheet of paper using a felt-tip pen, and sets a time limit;

Group members work together to express their thoughts in writing (or with a drawing or picture) about the information provided in the handout. In this case, group members should provide as much detailed information about the satellites as possible.

The teacher comments on the materials prepared by the groups,The 3D hologram invites you to an open virtual expedition.

To make the topic more visual, students visit the universe of stars and planets. For studentsCreative tasks are given orally and completed vocally.

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