GALAXY INTERNATIONAL INTERDISCIPLINARY RESEARCH JOURNAL (GIIRJ)
ISSN (E): 2347-6915
Vol. 13, Issue 5 May (2025)

STRATEGIES FOR IMPROVING BIOLOGY EDUCATION BASED ON INNOVATIVE APPROACHES

Niyozov Qahramon Adashaliyevich,
Lecturer at the Department of Anatomy and Physiology
at Namangan State University
nambiolog@umail.uz

ABSTRACT

This article explores the role and importance of innovative approaches in biology education. The author analyzes the impact of using interactive methods, problem-based learning, the STEAM approach, digital tools, and the integration of international assessment tasks (PISA, TIMSS) on the quality of teaching and student engagement. Based on the findings, methodological recommendations are proposed for improving biology education in accordance with modern educational requirements.

Keywords: Biology education, innovative approaches, interactive methods, STEAM, ICT, international assessment, competencies, functional literacy.

INTRODUCTION

The radical reforms taking place in the education system in recent years, especially in the natural sciences, have brought to the agenda, the need to revise the education of natural sciences based on modern requirements and improve it based on innovative approaches. In order to train globally competitive personnel and achieve high results in international assessment systems, it is necessary to cultivate not only theoretical knowledge but also practical, critical and creative thinking competencies in students. In particular, the direct connection of biology with life and its role in the environmental and health sectors requires its teaching based on modern educational technologies.

Foreign experience shows that in the education systems of advanced countries, biology lessons are organized using person-centered, problem-based, project-based, and interactive methods. For example, in the United States, biology education, based on the Next Generation Science Standards (NGSS), is focused on developing design, problem-solving, scientific thinking, and reasoning skills [1]. In the Finnish education system, students are encouraged to learn independently through interdisciplinary integration, hands-on learning, and the widespread use of digital technologies [2]. At the same time, countries such as Singapore, Japan, and South Korea are achieving high results in biology based on the results of PISA and TIMSS, which are based on students' ability to think critically, solve real problems, and apply knowledge based on a competency-based approach to education [3, 4].

The Republic of Uzbekistan is also taking significant steps in this direction. The Law “On Education” (2020, ORQ-637) and Resolution No. 997 of 2018 provide for the implementation of international assessment systems and the updating of curricula based on a competency-based approach [5, 6]. In the new National Curriculum, biology is based on a combination of theoretical and practical components, which is aimed at the students’ application of the acquired knowledge in real life [7].

The role of innovative approaches in biology education is also deeply covered in the works of Uzbek scientists. For example, Tolipova J.O. places special emphasis on increasing students' interest in science through the use of interactive and digital technologies in biology lessons [8]. N.N. Azizkhojyeva justifies the need to organize the educational process in a person-oriented manner through pedagogical technologies [9]. M. Ergasheva and Q. Niyozov propose a methodology for developing scientific literacy in biology by integrating PISA and TIMSS tasks [10].

Thus, the analysis of foreign and national experience shows the importance of the following to improve the quality of biology education:

- organizing the educational process in a student-centered manner;
- teaching biology based on interdisciplinary integration;
- using ICT and digital platforms;
- consolidating knowledge through experiments and practical activities;
- using tasks that meet international assessment requirements.

This article systematically analyzes innovative approaches to improving biology education based on these factors and highlights their effectiveness on a scientific basis.

METHODS

This study aims to conduct an in-depth analysis of the scientific and pedagogical situation focused at improving biology education based on innovative approaches. Therefore, analytical, practical and comparative research methods of modern pedagogy and didactics were selected as the methodological basis. The study was carried out through the following main stages and methods:

1. Theoretical analysis method

At the initial stage, scientific, methodological, regulatory and legal literature on traditional and modern approaches to teaching biology was analyzed. At this stage, the Law of the Republic of Uzbekistan “On Education” [5], Resolution No. 997 of the Cabinet of Ministers of the Republic of Uzbekistan [6], the National Curriculum [7] and the NGSS (USA), PISA and TIMSS assessment systems based on foreign experience [1,3,4] served as the main sources.

Also, the recommendations and ideas for the use of innovative methods in biology presented by local scientists who are renowned in the field of pedagogical technologies - N.N. Azizkhojeva [9], J.O. Tolipova [8], M. Ergasheva and Q. Niyozov [10] were deeply analyzed.

2. Empirical (experimental) methods

The practical stage of the study was carried out in the 2023–2024 academic year with the participation of teachers and students in grades 6–11 of secondary schools. At this stage, the following methods were used:

Pedagogical observation - students' attitude towards biology, their activity in lessons, and their reaction to interactive methods were observed;

Questionnaire and interview - anonymous questionnaires were conducted with the participation of 40 biology teachers and 180 students on their experience of using modern methods, their level of interest, and their effectiveness;

Didactic experiment - biology lessons were conducted in one class based on traditional methods, and in the second class based on interactive, problem-based, STEAM approaches. At the end of the lesson, students' knowledge level, critical thinking skills, and interest in science were compared.

3. Comparative analysis

Based on the empirical data obtained in the study, the effectiveness of innovative and traditional methods was compared. Differences and similarities between methodological approaches to biology education in international experiences (Finland, USA, South Korea) [2,3] and local approaches (Uzbek National Curriculum, new textbooks) [7,8] were identified, and practical recommendations were developed based on them.

4. Statistical analysis

In order to ensure the reliability of the research results, the collected data were processed using Microsoft Excel, and percentages and relative growth rates were calculated. It was found that the level of mastery of students taught using interactive methods was 17–24% higher, which confirms the effectiveness of innovative approaches.

5. Modeling and development of recommendations

At the end of the research, a methodological model was developed for designing biology lessons based on innovative technologies. This model incorporates a combination of person-oriented, competency-based and integrative approaches, and includes modern pedagogical technologies. These methodological approaches have laid the foundation for making clear, scientifically sound decisions to improve biology education. Since the research methodology was based on multi-stage, comprehensive, and systematic approaches, the results are considered reliable and of practical importance.

RESULTS

The study investigated the impact of innovative approaches in biology education on students' knowledge, interest in the subject, and practical skills based on empirical data. The analysis was conducted in three stages: diagnostic (initial), experimental (during the process), and final assessment.

1. Initial diagnostic results

At the beginning of the study, tests conducted among students in grades 6–11 of secondary schools (n=180) showed that the average biological literacy level of students was 57 points out of 100. Also, 73% of 40 biology teachers reported that they use innovative methods in their lessons only in some cases.

In the questionnaires, 64% of students rated biology as a "difficult" subject, and 58% as a "dry theoretical" subject. This showed a decrease in interest due to a lack of practice and interactivity in science.

2. Results of experimental lessons

In the main phase of the study, two groups were formed:

Control group - a class that was taught based on traditional teaching (n=90);

Experimental group - a class that was taught based on problem-based, person-centered, interactive methods, STEAM elements (n=90).

While the curricula were the same, the methods used in the experimental group consisted of:

– problematic questions;
– interactive games and tests (through Kahoot, Quizizz, Genially);
– virtual laboratories and biological simulations (PhyloGen, BioRender);
– group project work and mini-research.

Students began to actively participate in these lessons, and independent research, experimentation, and thinking skills began to develop. Over the course of 6 weeks, in the experimental group:

– the average level of mastery increased from 57 to 78 points (an increase of 37%);
– the number of students who expressed interest in biology increased from 42% to 85%;
– the number of students who expressed independent opinions increased from 31% to 70%.

These results showed that innovative approaches increase not only the level of knowledge, but also motivation in science, the level of thinking and practical skills.

3. Final evaluation and comparative analysis

Based on the general tests, project work and oral assessment criteria at the end of the study, the following differences were identified:

Results	Control group	Experimental group
Average test score	61	83
Performing practical tasks	54%	88%
Positive attitude towards science	49%	90%
Indeoendent reserch skills	40%	76%

The results are consistent with the scientific conclusions presented in domestic and foreign literature. For example, the NGSS (USA) standards emphasize the increase in biological literacy of students through progressive thinking and a problem-based approach [1]. Tolipova J.O. and Azizkhojyeva N.N. also proved that person-centered and interactive methods in biology increase student performance [8,9].

Also, in the high-performing countries in the PISA 2018 and TIMSS 2019 studies (Singapore, Finland), it is precisely experience-based, competency-based and interdisciplinary teaching that is noted as a key factor [3,4].

The facts, observations and analyses collected at this stage clearly demonstrated the high effectiveness of innovative approaches in biology education. With their help, students not only

gain knowledge, but also learn to apply it in real life, acquire the skills of scientific thinking, analysis and independent decision-making.

DISCUSSION

During the study, it was found that teaching biology based on innovative approaches has a significant positive impact not only on the level of knowledge of students, but also on their independent thinking, interest in science, and practical skills. These results directly correspond with modern pedagogical theories and international research.

In particular, through interactive, problem-based, person-centered, and STEAM-based lessons used in the experimental group, students were encouraged to actively participate, ask questions, and think scientifically. These aspects are consistent with the model of pedagogical technologies put forward by N.N. Azizkhojyeva. According to her, the educational process should be person-centered, activate student activity, and be result-oriented [9].

Also, J.O. Tolipova emphasizes in her research that when innovative methods are used in teaching biology, students' attitude towards science changes positively, they try to understand and apply knowledge in practice, not just memorize it [8]. In our experiment, the level of mastery increased by 37%, and the number of students who expressed interest in science almost doubled, confirming this idea.

The results of the study are also fully consistent with international experience. For example, according to the requirements of the Next Generation Science Standards (NGSS) used in the USA, biology education should, rather than imparting knowledge, direct students to scientific and creative activities, and encourage them to analyze real-life problems through experiments [1]. Practical and project-based training in the experimental group, as well as direct participation of students in laboratory processes, served to form these competencies in them.

In countries that score high in the PISA and TIMSS assessment systems, such as Finland, Singapore, and South Korea, interactive, interdisciplinary, and critical thinking-developing methods are also emphasized in biology teaching [2,3,4]. Uzbekistan's participation in international assessment systems since 2018 is an impetus for reforms in this direction [5,6]. The national curriculum also provides for the organization of biology lessons based on a competency-based approach and priority given to laboratory exercises [7].

Based on local experience, the methodological approaches developed by Ergasheva M. and Niyozov K. for integrating PISA and TIMSS tasks into the teaching process also show that they play an important role in developing students' skills in logical thinking, analyzing graphical data, and solving real problems on a scientific basis [10].

Based on the above, the following scientific and theoretical conclusions can be drawn:

- ✓ Innovative approaches to teaching biology (interactive methods, problem-based learning, ICT, STEAM) activate students' activities, encourage them to make decisions independently within the subject, and conduct scientific research;
- ✓ International assessment systems (PISA, TIMSS) pay special attention to the formation of real-life competencies in biology, therefore, the integration of these methods into the educational process is a requirement of the modern world;
- ✓ Although innovative approaches are used in local practice to a limited extent, their potential is high and their systematic implementation increases the quality of education.

The results of the study indicate that the Uzbek education system is open to reforms and has methodological, technological, and organizational resources for the development of biology. Most importantly, through innovative education, students acquire not only knowledge, but also competencies, which are skills that are useful in real life.

CONCLUSION

The results of the study proved the relevance and high efficiency of innovative approaches to teaching biology. The introduction of pedagogical technologies that meet the requirements of modern education into the educational process serves to form in-depth knowledge, independent thinking, analytical thinking and practical skills in students. Biology, due to its nature of being directly related to life, especially when taught on the basis of experiments and problem situations, develops the ability to solve real-life problems in students.

During the study, it was found that the main factors affecting the level of knowledge and interest in science among students are:

– use of interactive and problem-based methods in the educational process;
– teaching biology in an integrated manner with other subjects (STEAM approach);
– application of theoretical knowledge in practice through laboratory and virtual experimental work;
– organization of individual educational areas based on a person-centered approach;
– use of digital technologies, test platforms and multimedia resources.

The increase in mastery indicators determined on the basis of experience, the active participation of students in lessons, and the increase in the level of independent expression of opinions indicate that teaching biology based on innovative approaches is much more effective than traditional methods. Such approaches develop not only the level of knowledge, but also the positive attitude of students to science, and the potential for creative thinking.

Through the systematic use of high-quality biology education and modern methods, the following achievements can be achieved:

– formation of functional and natural-scientific literacy in education;
– orientation of students to scientific research, development of biological thinking;
– strengthening professional orientation in environmental, health care, and biotechnology areas.

Based on the above conclusions, the following practical recommendations can be put forward:

1. Implement at least one interactive or experimental method in each biology lesson;
2. Establish ongoing professional development courses for teachers on the basics of ICT and STEAM;
3. Use PISA and TIMSS-format tasks in the lesson, adapted to the grade level;
4. Deepen student knowledge by linking each topic with real-life examples and problem questions;
5. Expand practical experience activities through the use of virtual laboratories and simulation programs.

In conclusion, teaching biology based on innovative approaches is an important tool not only in mastering the subject, but also developing a modern worldview, analytical thinking, and the ability to solve life problems in a person. These approaches create broad opportunities for

improving the quality of education, achieving success in international assessment systems, and cultivating competitive knowledge holders.

REFERENCES

1. NGSS Lead States. Next Generation Science Standards: For States, By States. – Washington, DC: The National Academies Press, 2013.
2. Sahlberg P. Finnish Lessons: What Can the World Learn from Educational Change in Finland? – New York: Teachers College Press, 2015.
3. OECD. PISA 2018 Results: Combined Executive Summaries. – Paris: OECD Publishing, 2019. – URL: https://www.oecd.org/pisa/
4. Mullis I.V.S., Martin M.O., Foy P. et al. TIMSS 2019 International Results in Science. – Boston: TIMSS & PIRLS International Study Center, Boston College, 2020.
5. O‘zbekiston Respublikasi. “Ta’lim to‘g‘risida”gi Qonun. – T.: O‘zbekiston Respublikasi Adliya vazirligi, 2020. – 23-sentabr, O‘RQ-637.
6. O‘zbekiston Respublikasi Vazirlar Mahkamasi. Xalq ta’limi tizimida xalqaro tadqiqotlarni joriy etish to‘g‘risida qaror. – T.: VM qarori, 2018. – 8-dekabr, № 997.
7. O‘zbekiston Respublikasi Xalq ta’limi vazirligi. Milliy o‘quv dasturi: Biologiya fani. – T.: Maorif, 2022.
8. Tolipova J.O. Biologiyani o‘qitishda innovatsion texnologiyalar. – T.: Cho‘lpon nomidagi nashriyot-matbaa ijodiy uyi, 2011.
9. Azizxo‘jayeva N.N. Pedagogik texnologiyalar va pedagogik mahorat. O‘quv qo‘llanma. -T.: O‘zbekiston Yozuvchilar uyushmasi Adabiyot jamg‘armasi nashriyoti. 2006.
10. https://www.researchgate.net/publication/381473087_O'quvchilarning_tabiiy-ilmiy_savodxonligi_monitoringida_baholash_dasturlari_va_topshiriqlaridan_foydalanish_metodikasi.
11. Niyozov Q. Biologiya ta’limi jarayonida o‘quvchilarda kompetensiyalarning shakllanishida innovason texnologiyalarning o‘rni //Toshkent shahar XTXQTMOIda tashkil etilgan «Xalq ta’limi tizimidagi «Mahorat maktablari» faoliyatini tashkil qilishning ilmiy-nazariy va metodologik asoslari» mavzusidagi Respublika ilmiy-amaliy anjumani materiallar to‘plami.–T.:«Fan va texnologiyalar. – 2017.
12. Niyozov Q. A. Biologiya fanini o ‘qitishda pedagogik texnologiyalar. – 2017.
13. Niyozov Q. A. O‘QUVCHILARNI TIMSS XALQARO BAHOLASH DASTURIDA KELTIRILGAN TOPSHIRIQLARNI BAJARISHGA TAYYORLASHDAGI MUAMMOLAR VA ULARNING YECHIMLARI //Educational Research in Universal Sciences. – 2023. – T. 2. – №. 4 SPECIAL. – C. 1005-1010.
14. Adashaliyevich N. Q. Methodology For Developing the Skills Of Working With The Pisa In Future Biology Teachers //Pedagogical Cluster-Journal of Pedagogical Developments. – 2024. – T. 2. – №. 5. – C. 402-406.
15. Adashaliyevich N. Q. et al. TEACHING HUMAN ANATOMY AND PHYSIOLOGY BASED ON MODERN EDUCATIONAL APPROACHES //International journal of artificial intelligence. – 2024. – T. 4. – №. 04. – C. 45-47.

16. Adashaliyevich N. Q. et al. Biologiya Ta'limida O'quvchilarda Mustaqil Va Ijodiy Faoliyatlarini Rivojlantirishdagi Muammolar Va Ularning Yechimlari //Progress Annals: Journal of Progressive Research. – 2024. – T. 2. – №. 6. – C. 7-10.
17. Niyozov Q.A., "Talabalarni PISA xalqaro baholash dasturida keltirilgan topshiriqlarni bajarishga tayyorlashdagi muammolar va ularningyechimlari". Surxondaryo viloyat pedagoglarni yangi metodikalargao'rgatish milliy markazida 2023-yilning 30-may kuni "Aniq va tabiiyfanlarni o'qitishda zamonaviy yondashuv: muammo va yechimlar"mavzusida xalqaro ilmiy-amaliy anjumani materiallari to'plami.
18. Niyozov Q.A. "Bo'lajak biologiya fani o'qituvchilarda xalqaro baholash dasturlaridan foydalanish malakalarini rivojlantirishda multimedia vositalaridan foydalanish". Namangan davlat universiteti ilmiy axborotnomasi. 2025-yil 3-soni.
19. Niyozov Q.A. "Genetik va metabolik kasalliklar misolida biokimyoviy tushunchalarni o'qitish metodikasi". "Ta'lim va taraqqiyot" ilmiy-uslubiy jurnali. 2025-yil 2-soni. https://journal.namspi.uz/articleview/115
20. Niyozov Q.A., Pulatov O.R. "Yosh fiziologiyasi fanini o'qitishda amaliy tajribalarni integratsiyalash". "Ta'lim va taraqqiyot" ilmiy-uslubiy jurnali. 2025-yil 2-soni. https://journal.namspi.uz/articleview/139