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TEACHING GENETICS IN HIGHER EDUCATION: DEVELOPING STUDENTS' RESEARCH ACTIVITIES THROUGH SYSTEMS THINKING AND MODERN EDUCATIONAL TECHNOLOGIES

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Abstract. This article examines current challenges in teaching genetics in higher education and their potential relationship with students' interest in research activities. The study aims to identify didactic shortcomings in genetics instruction and to substantiate approaches to promoting students' research engagement through systems thinking and modern educational technologies. A theoretical and empirical approach was adopted, incorporating an analysis of scientific and pedagogical literature, regulatory documents, and survey findings from students at several higher education institutions in Bukhara, Uzbekistan. The analysis identified four major shortcomings in genetics education: fragmentation of genetic knowledge, limitations of conventional knowledge-oriented instructional approaches, insufficient integration of genetics with general professional and specialized disciplines, and inadequate development of cognitive processes required for constructing coherent genetic knowledge and fostering creative thinking. According to the reported survey results, interest in participating in research activities accounted for 7.9% of students' extracurricular activity preferences, ranking sixth. These findings indicate that research activities may have limited appeal as an extracurricular option among the surveyed students. However, the available data do not establish a causal relationship between the identified instructional shortcomings and students' research engagement. In response, the article proposes a conceptual integrative model combining systems thinking and interdisciplinary integration, modern educational technologies, and research-oriented learning tasks. The model provides a theoretical framework for integrating research activities into genetics instruction and requires subsequent empirical validation.

Keywords: genetics education; systems thinking; student research engagement; modern educational technologies; professional competence; higher education; future specialists.

1. INTRODUCTION. The modernization of contemporary education in Uzbekistan requires the systematic development of conditions that foster the creative potential of future specialists. Developing the country's future scientific and technological capacity depends, in part, on identifying, nurturing, and supporting talented young people in science and technology. Accordingly, effective mechanisms for developing students' research skills and engagement have become important issues in scientific and pedagogical scholarship [7, 9, 12].

The Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030, approved by Presidential Decree No. PF-5847 on October 8, 2019, emphasizes the wider application of innovative educational technologies and teaching methods, the qualitative improvement of curricula and academic programmes, the development of teaching staff, and the modernization of scientific and educational processes [24]. Within this framework, an important educational objective is to

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prepare individuals capable of responding to the demands of the contemporary information and educational environment by locating, acquiring, analysing, processing, and systematizing information.

Biology, particularly genetics as one of its fundamental disciplines, offers considerable potential for developing systems thinking and helping students construct an integrated understanding of the natural world [17, 19]. Nevertheless, although conventional classroom-based and extracurricular forms of student research are widely used in undergraduate education, students' interest in research activities remains a concern. Another important challenge is the fragmented acquisition of genetic knowledge and the insufficient explanation of connections between genetics and other professionally relevant disciplines [10, 14].

These challenges highlight the need for an integrated approach to genetics education that combines systems thinking, interdisciplinary connections, modern educational technologies, and research-oriented learning. The insufficient development of an instructional framework that brings these elements together constitutes the research problem addressed in this article.

The aim of the study is to identify didactic shortcomings in genetics education and to substantiate approaches to developing students' research activities through a systems-based approach and modern educational technologies.

The study addresses the following objectives:

1. To identify shortcomings in the current teaching of genetics in secondary and higher education.
2. To examine students' interest in participating in research activities.
3. To substantiate a conceptual model of integrative teaching designed to promote students' research engagement.

The study is guided by the following working hypothesis: teaching genetics through a systems-thinking approach, supported by modern educational technologies and research-oriented tasks, may increase students' interest in research activities. In this article, the hypothesis is theoretically substantiated rather than empirically tested and therefore requires verification through subsequent pedagogical experimentation.

2. MATERIALS AND METHODS

The study employed a theoretical and empirical approach and incorporated the following methods.

2.1. Methodological framework

The methodological foundation of the study was the systems approach. In the systems-thinking literature associated with Joseph O'Connor, systems thinking is understood as an approach to reasoning that emphasizes relationships among components whose interactions form an integrated whole directed towards a particular purpose.

From a didactic perspective, the study also draws on the concept of managing students' cognitive activity as a theoretical basis for moving professional education away from predominantly passive, reproductive forms of instruction towards more active learning approaches.

2.2. Analysis of the literature and regulatory documents

Scientific and pedagogical literature concerning biology and genetics education in higher education, the development of students' research activities, systems thinking, and modern educational technologies was reviewed. The provisions of Presidential Decree No. PF-5847, dated October 8, 2019, were also considered.

2.3. Comparative and analytical assessment

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The current teaching of genetics as a foundational biological discipline in secondary schools and higher education institutions was examined comparatively. The analysis focused on identifying instructional limitations, fragmentation of knowledge, insufficient interdisciplinary integration, and challenges associated with developing students' cognitive and creative capacities.

2.4. Student survey

Survey findings from students at several higher education institutions in Bukhara, Uzbekistan, were used to examine preferences regarding extracurricular activities and interest in participating in research. According to the reported results, research activities accounted for 7.9% of the stated preferences and ranked sixth.

The available study description does not specify the sample size, sampling procedure, survey dates, questionnaire structure, response rate, or statistical analysis. Consequently, the survey findings are interpreted descriptively and should not be generalized beyond the surveyed population without further evidence.

3. RESULTS.

3.1. Analysis of the current state of genetics education

The analysis of scientific and pedagogical literature and educational practice identified four major shortcomings in genetics instruction (Table 1).

Table 1.

Major shortcomings identified in genetics education

No.	Category	Description of the identified shortcoming
1	Didactic	Effective instructional strategies for overcoming the fragmentation of genetic knowledge in secondary and higher education have not been sufficiently developed.
2	Paradigmatic	Within a predominantly traditional, knowledge-transmission paradigm, ensuring that students develop a coherent body of genetic knowledge necessary for subsequent professional training remains challenging.
3	Interdisciplinary	Connections between genetics and general professional and specialized disciplines are insufficiently explored, potentially hindering the development of biological literacy and professional competence among future biologists.
4	Cognitive	Students' cognitive processes and intellectual strategies for constructing coherent genetic knowledge and developing creative abilities within an integrated understanding of biological systems remain insufficiently developed.

Taken together, these shortcomings suggest that genetics education requires more than the transmission of separate concepts and factual information. It also requires instructional strategies that help students identify relationships among genetic processes, connect theoretical knowledge with other biological disciplines, and apply their understanding to research problems.

3.2. *Survey findings on students' interest in research activities*

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According to the reported survey results, participation in research activities accounted for 7.9% of students' extracurricular activity preferences, ranking sixth.

This finding suggests that research activities occupied a relatively low position in the extracurricular preferences of the surveyed students. However, the result should be interpreted cautiously. The reported percentage reflects the distribution of stated preferences and does not, by itself, demonstrate that students lack research competence, are unwilling to conduct research, or are dissatisfied with genetics instruction.

Further investigation is needed to determine whether students' preferences are associated with instructional methods, the accessibility of research opportunities, the perceived relevance of research to future careers, or other educational and motivational factors.

4. DISCUSSION. The findings provide a basis for discussing the possible relationship between shortcomings in genetics instruction and students' engagement with research activities. When genetic knowledge is acquired as a collection of disconnected facts and the links between genetics and other professional disciplines are insufficiently emphasized, students may find it difficult to recognize research as an integral component of their professional development. Nevertheless, this proposed relationship remains a hypothesis and requires direct empirical investigation.

Systems thinking is particularly relevant to genetics education because it encourages students to identify relationships among concepts, integrate information from different sources, and apply their knowledge when investigating new problems. It can also support the selection, organization, and interpretation of scientific information in a rapidly developing field.

The pedagogical principle that knowledge is acquired through learners' own intellectual activity has a long history. Thinkers and educators such as Plato, Aristotle, Jan Amos Comenius, Johann Heinrich Pestalozzi, Adolph Diesterweg, and Konstantin Ushinsky emphasized, in different ways, the importance of learners' active participation in the educational process. From this perspective, effective teaching requires alignment between instructional activities and students' learning processes, as well as the deliberate development of reasoning, imagination, and independent inquiry.

The distinction between conventional reproductive teaching and a systems-oriented, activity-based approach is summarized in Table 2.

Table 2.

Comparative characteristics of conventional and systems-oriented, activity-based approaches

Criterion	**Conventional reproductive approach**	**Systems-oriented, activity-based approach**
Nature of knowledge	A collection of separate topics and facts	An integrated system of interconnected concepts and processes
Role of the student	Recipient of information provided by the instructor	Active learner who constructs knowledge through inquiry and problem-solving
Role of the instructor	Primary source and transmitter of information	Facilitator who guides and supports students' cognitive activity
Interdisciplinary connections	Genetics is taught primarily as a separate discipline	Genetics is integrated with general professional and specialized disciplines

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Research activities	Primarily extracurricular and optional	Integrated into learning through theoretical and empirical research tasks
Educational technologies	Mainly supplementary instructional tools	An interactive learning environment supporting systems thinking and research skills

The comparison illustrates the conceptual distinction between the two approaches. It should not, however, be interpreted as an experimentally established comparison of their effectiveness.

4.1. *A conceptual model for developing students' research activities*

To address the identified shortcomings, the article proposes a conceptual model integrating three complementary components (Figure 1).

Component 1: Systems thinking and interdisciplinary integration. Genetics concepts are connected with general professional and specialized disciplines. Students are encouraged to examine relationships among biological processes, interpret genetic phenomena in broader biological contexts, and apply knowledge across disciplinary boundaries.

Component 2: Modern educational technologies. Virtual laboratories, interactive learning platforms, and the FSMU method are proposed as tools for supporting active learning, evidence-based reasoning, argumentation, and the interpretation of scientific information. Their selection and application should correspond to specific learning objectives rather than serve as ends in themselves.

Component 3: Research-oriented learning tasks. Students undertake small-scale research projects based on locally relevant biological materials and problems. Scientific clubs and other forms of collaborative inquiry can provide additional opportunities to formulate research questions, collect and analyse data, discuss findings, and present evidence-based conclusions.

These components are intended to function as an integrated instructional framework. Interdisciplinary integration provides the conceptual foundation, educational technologies support learning and investigation, and research-oriented tasks enable students to apply their knowledge in practical and inquiry-based contexts.

4.2. Study limitations and directions for future research

Several limitations should be acknowledged.

First, the survey covered students from several higher education institutions in Bukhara, Uzbekistan. The available information does not establish whether the sample is representative of students in the region or elsewhere.

Second, the reported survey result concerns a single indicator: interest in research activities as an extracurricular preference. It does not directly measure research competence, actual participation in research, academic achievement, or changes in students' motivation over time.

Third, the conceptual model has not yet been tested through a pedagogical experiment. Therefore, its effectiveness in improving students' research engagement and professional competence remains to be established.

Future research should employ a structured pedagogical intervention involving experimental and comparison groups, clearly defined assessment criteria, and appropriate quantitative and qualitative methods. Relevant outcome measures could include students' research motivation, systems-thinking skills, ability to formulate research questions, data-analysis skills, and academic performance. Baseline and post-intervention measurements would help determine whether observed changes can reasonably be attributed to the instructional intervention.

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Where feasible, future studies should also document the sample size, sampling procedure, survey instrument, reliability of measurement tools, and statistical methods used. Such measures would strengthen the validity, transparency, and reproducibility of the findings.

5. CONCLUSION. The analysis of genetics education identified four major shortcomings: fragmentation of genetic knowledge, limitations associated with conventional knowledge-transmission approaches, insufficient integration between genetics and general professional and specialized disciplines, and inadequate development of the cognitive processes required for coherent knowledge construction and creative thinking.

The reported survey findings indicate that research activities accounted for 7.9% of students' extracurricular activity preferences, ranking sixth. This result suggests that research activities may have limited relative appeal within the extracurricular preferences of the surveyed students, although the available data do not establish the causes of this pattern.

To address the identified challenges, the article proposes a conceptual integrative model combining systems thinking and interdisciplinary integration, modern educational technologies, and research-oriented learning tasks. The model provides a theoretical basis for embedding research activities more systematically into genetics education and for supporting the development of students' research skills and professional competence.

The model's effectiveness has not yet been empirically established. Its validation through a controlled pedagogical intervention, using clearly defined indicators of research engagement, systems thinking, and academic achievement, is therefore a necessary next step.

REFERENCES:

1. Republic of Uzbekistan. (2019, October 8). *Decree No. PF-5847 on approval of the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030*. [Official regulatory document; complete publication details should be provided.]
2. Mirzoeva, M. A. (2021). Sovremennye trebovaniya k professionalu [Modern requirements for a professional]. *Zhurnal estestvennykh nauk*, 1(1). [Further bibliographic details should be verified.]
3. Mirzoyeva, M. A. (2026). Improving genetics education through methodological support. *Ekonomika i sotsium*, (2-1(141)), 246–249.
4. Kosimov, Z., Bussmann, R. V., Beshko, N., Naralieva, N., Xudjanazarov, U., Mirzoeva, M., & Kuzieva, S. (2026). Traditsionnye znaniya o lekarstvennykh rasteniyakh pod antropogennym davleniem: dannye iz botaniko-geograficheskogo rayona Sredney Syrdari, Uzbekistan [Traditional knowledge of medicinal plants under anthropogenic pressure: Data from the Middle Syr Darya botanical-geographical region, Uzbekistan]. *Ethnobotany Research and Applications*, 34, 1–9. [The original publication details should be checked.]
5. Mirzoyeva, M. A. (2026). Teaching the subject "Genetics" in the system of higher education based on the STEM education approach. *Ekonomika i sotsium*, (2-2(141)), 236–240.
6. Bazarova, F., Abduvaliyev, Z., Kenjaev, I., Mukhitdinova, M., Mukhammadkhuja, S., Mirzoyeva, M., & Jumaniyazova, S. (n.d.). *Investing and generating income from urban waste management*. [Publication year, journal or publisher, volume, issue, and page numbers are required.]
7. Mirzoyeva, M. A. (2026). Applying the case study method in teaching genetics as a factor in enhancing professional competence. *Ekonomika i sotsium*, (2-1(141)), 241–245.
8. Mirzoeva, M. (2022). Improving the professional competence of future biology teachers as a pedagogical problem. *Science and Innovation*, 1(4), 293–296.

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9. Akhtamovna, M. M. (2023). Digitalization—Development. *Web of Synergy: International Interdisciplinary Research Journal*, 2(2), 128–130.
10. Mirzoeva, M. A. (2023). Oliy ta'lim tizimida genetikani o'qitishning tizimli tahlili [A systematic analysis of genetics teaching in higher education]. *Amaliy va tibbiyot fanlari ilmiy jurnali*, 2(11), 302–307.
11. Mirzoeva, M. A. (2023). Teaching genetics: Past, present and future. *Best Journal of Innovation in Science, Research and Development*, 2(10), 246–251.

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