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EVALUATING THE PREPAREDNESS OF FUTURE BIOLOGY SPECIALISTS TO INTEGRATE STEM APPROACHES INTO THEIR EDUCATION AND TRAINING

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Abstract. The aim of this article is to examine the level of awareness among students in higher educational institutions regarding the STEM (science, technology, engineering, mathematics)- innovative teaching method, as well as to explore the range of activities related to STEM being conducted within universities. In today's world, there exists a wide range of modern teaching methods, among which the STEM method stands out. Based on foreign experiences, it is recognized as an integrative approach across scientific disciplines, aimed at providing students with a profound understanding of Natural Science concepts. Robotics, one of the narratives of the STEM, has seen widespread adoption in schools, but has only recently begun to be incorporated into higher education institutions. Currently, the Y. Altynsarin National Academy of Education has introduced methodological guidelines for the implementation of the STEM approach, and efforts to establish STEM-focused classrooms and numerous laboratories within schools and universities are being coordinated by the ministry.

On this foundation, an array of specialized facilities, including 3D modeling studios, robotics workshops, center, and laboratories, have been established in both schools and tertiary institutions, integrating into the educational framework. Furthermore, under the auspices of Chevron, the educational entity "Caravan of Knowledge" has embarked on the development of the methodological guides within the ambit of the "STEM Education Development Roadmap for 2021-2025". This initiative has led to the organization of STEAM-focused video lessons, thematic STEM fortnights and scholarly conferences. The undertaken research has been pivotal in assessing the preparedness levels for implementing education via STEM methodology, while also evaluating its significance.

Key words: STEM method, innovative approaches, future biology teachers, biological experiments, STEM, robotics courses, Natural Science directions, Biology

Introduction

Currently, amidst the advancements in technology and science, the demand for modern professions in the job market is on rise. A decade or two ago, we were hardly familiar with roles such as nanotechnologists, microbiologists, and artificial intelligence experts. Yet, now it's acknowledged that there's a significant shortage of these professionals, who also command high salaries. In response to

the evolving demands of the times and to address the need for specialists who meet contemporary requirements, updated educational programs are being developed.

The 21st century marks an era of unprecedented access to information and advancements in technology, offering individuals significant opportunities for learning new knowledge, acquiring skills, self-development and enhancement. Against this backdrop, a variety of innovative educational strategies have been developed globally, aimed at facilitating effective and deep understanding of knowledge. One of the most prominent responses to the global demand for skilled professionals is the expansion of the STEM (Science, Technology, Engineering, Mathematics) fields. This modern, interdisciplinary educational approach is designed to address real-world problems and meet global challenges by seamlessly integrating science, technology, engineering and mathematics, reflecting a cohesive strategy for preparing individuals to navigate and contribute to the complexities of the modern world [1].

In the past, the STEM approach may have been considered with less direct emphasis and viewed as more of a future-oriented strategy. However, nowadays, education through the STEM lens plays a pivotal role in the educational frameworks of many leading nations worldwide. Among the countries actively supporting STEM are the United States Canada, Australia, Hong Kong, Finland, Germany, the United Kingdom and Sweden. Within these countries, there exist dedicated governmental bodies and a plethora of initiatives aimed at fostering the development of STEM education [2].

In Kazakhstan, the abbreviation STEM may not be widely recognized, but it does occasionally appear in the governmental programs. For example, the Y. Altynsarin National Academy of Education offers directives on incorporating STEM education [3], and educational institutions at large may adopt guidelines to facilitate scientific inquiry among students in STEM fields [4]. These directives often pertain to curriculum development and the integration of robotics technology within the realm of STEM.

The advantages of education using the STEM approach include preparing competitive young individuals as a flexible workforce, nurturing highly skilled professionals, and enhancing the population's digital, scientific, and engineering literacy. Despite the lack of a uniform methodology for teaching STEM in schools and universities, its international recognition is undeniable. However, the general awareness of STEM education remains low. Furthermore, there are discrepancies in understanding the STEM approach and a notable shortage of qualified professionals to implement STEM education in Kazakhstan's schools.

International research indicates that the STEM approach to teaching science subjects significantly boosts students' theoretical understanding and practical skills, leading to improved academic performance and increased interest [5-6]. Schools and universities are now incorporating cutting-edge

facilities like 3D modeling and robotics, creating labs and centers to enhance the educational experience. Furthermore, under Chevron's sponsorship, the "Caravan of Knowledge" initiative has developed a strategic roadmap for STEAM education for 2021-2025. This includes the preparation of methodical guides and the organization of STEAM-focused video lessons, thematic weeks, and conferences. Additionally, initiatives like "Tanym" and "Jana Talap" aim to support teacher development in this area. Despite these efforts, Kazakhstan lacks a formal curriculum for preparing future educators to deliver STEM-based education effectively. As a result, there's a notable shortage of qualified teachers who can apply the STEM approach in educational settings. This highlights the urgent need for research to assess the readiness and attitudes of future teachers towards STEM education, to address this gap efficiently.

Materials and Methods

The study's objective was to uncover the level of knowledge and attitudes towards the STEM approach among future teachers (senior year students) at the Kazakh National Women's Pedagogical University. To achieve this, methodologies such as questionnaires and detailed analysis were employed. The survey involved 27 students from the "Natural Sciences" faculty following the 6B01509 Biology Education program and 20 students pursuing the 6B05101 Biology (Scientific) Educational program. The collected data from these respondents underwent an extensive analysis (Table 1).

Results and Discussion

The Kazakh National Women's Pedagogical University hosts 98.7% of the survey respondents, comprising 47 students.

Table 1 - Question directed towards the students:

	Which institution are you studying in?
1. Are you familiar with the concept of "STEM"?	6. Have you ever integrated knowledge from other fields during biology classes?
2. How do you understand the term of "STEM"?	7. Are the materials and technical resources at your educational institution sufficient?
3. How laboratory classes are conducted at your educational institution?	8. What do you think is necessary to enhance your understanding of biology?
4. Which format of teaching would make natural science subjects (biology) more understandable to you?	9. Does your educational institution offer courses in robotics?
5. What courses related to your field would you like to see offered by the institution?	10. Are you satisfied with the knowledge and teaching methods of your instructors?

Responses to the following questions are illustrated in different types of diagrams.

In response to the first question, 54.3% of students (as depicted in the first diagram) are moderately aware of the STEM concept, but lack full understanding. Thus, it is apparent that there is a general need for students to have a better grasp of STEM, highlighting the requirement for specific educational materials or introduction exercises (Figure 1).

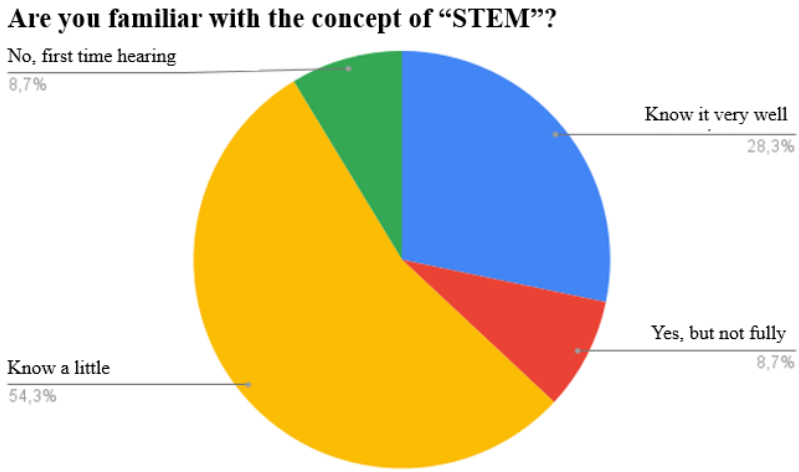

Figure 1 - Students' General Familiarity with the STEM Concept

Diagram 2 presents information on how students most commonly understand the concept of STEM education (Figure 2).

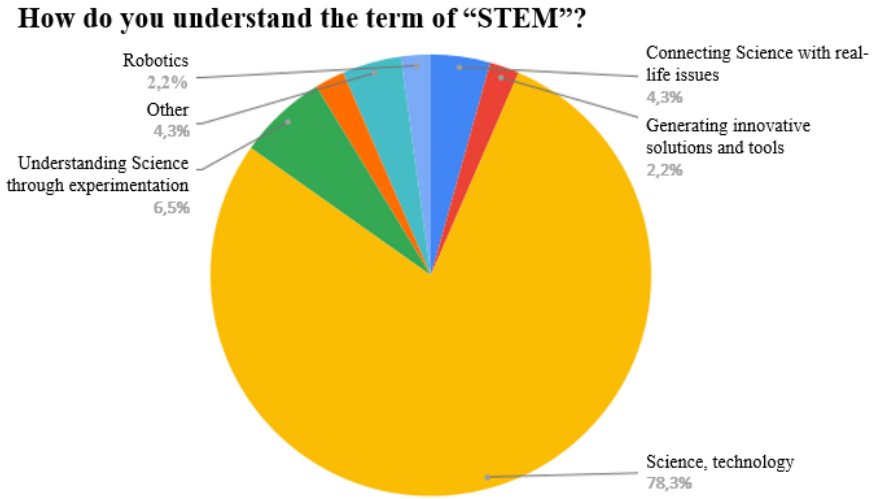

Figure 2 - Indicators Regarding the Understanding of the STEM Concept

According to the diagram, 78.3% of students understand the STEM approach as solving real-life problems with the help of science, technology, engineering, and mathematics, while 6.5% associate it with understanding science through experimentation. This suggests that the definition of the STEM concept remains unclear and is not yet fully established in higher education institutions.

Taking into account the unique and important role that laboratory classes play in the mastery of natural science subjects, we posed the next question to determine how laboratory classes are conducted in their educational institutions (Figure 3).

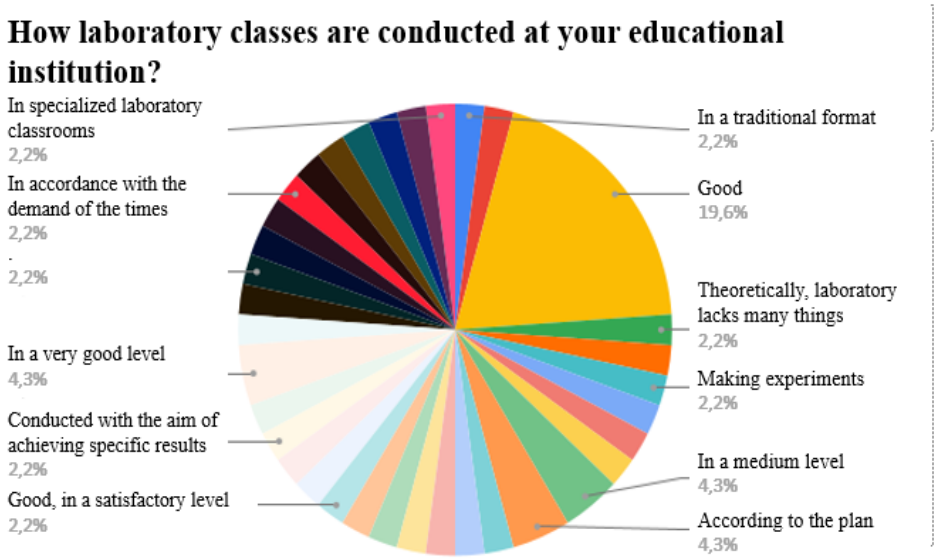

Figure 3 - Methods of Conducting Laboratory Classes

The findings suggest that most students engage in laboratory activities following conventional methods, although there is a subset capable of more innovative work. This indicates a diverse range of methods and proficiency levels in conducting laboratory tasks. Such insights are significant as creativity is a foundational element the STEM methodology.

The fourth diagram identifies the most efficient teaching methods that lead students to achieve the educational objectives by enhancing their active participation in classes and facilitating a deeper understanding of the topics (Figure 4).

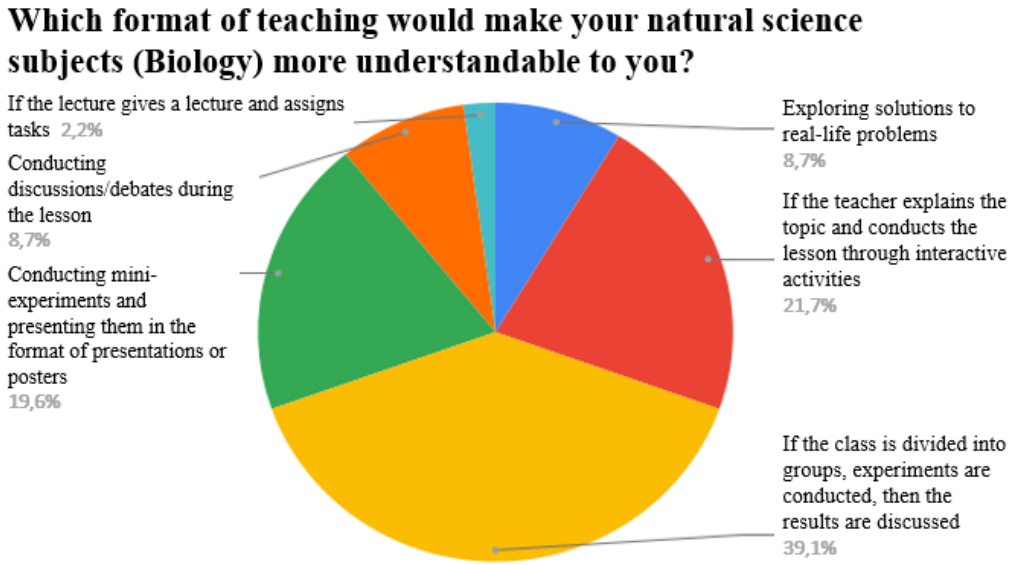

Figure 4 - Students' View on the Methods of Mastering the Subject

The diagram illustrates that a significant portion of students (39.1%) believe that learning is enhanced when the class is divided into groups and teachers dissect experiments, leading to a deeper understanding of the subject matter. Additionally, 21.7% of students feel that their engagement and knowledge increase when instructors incorporate problem-solving based on real-life scenarios into their teaching. The main conclusion drawn from these responses in the diagram is that the most efficient teaching methods involve thoroughly addressing topics through various activities or tackling real-life issues, thereby enhancing critical thinking and problem-solving skills. This indicator is crucial as it underscores the essence of the STEM approach, which involves breaking down disciplinary barriers and addressing societal issues.

The fifth diagram presents insights into the kinds of courses students desire to see offered at their educational institutions based on their chosen fields. Present-day students exhibit adeptness in utilizing smartphones and computers, facilitating their ease of operation with installed applications [7, 8]. As a result, a notable portion of students (32.6%) expresses interest in courses that delve into cutting-edge technologies like 3D modeling, IT applications, MatLab, AutoCAD software suites, programming languages, and robotics. However, the inclination towards courses centered on robotics remains relatively modest (8.7%) due to its recent emergence and students' potential lack of awareness or hands-on experience in the field (Figure 5).

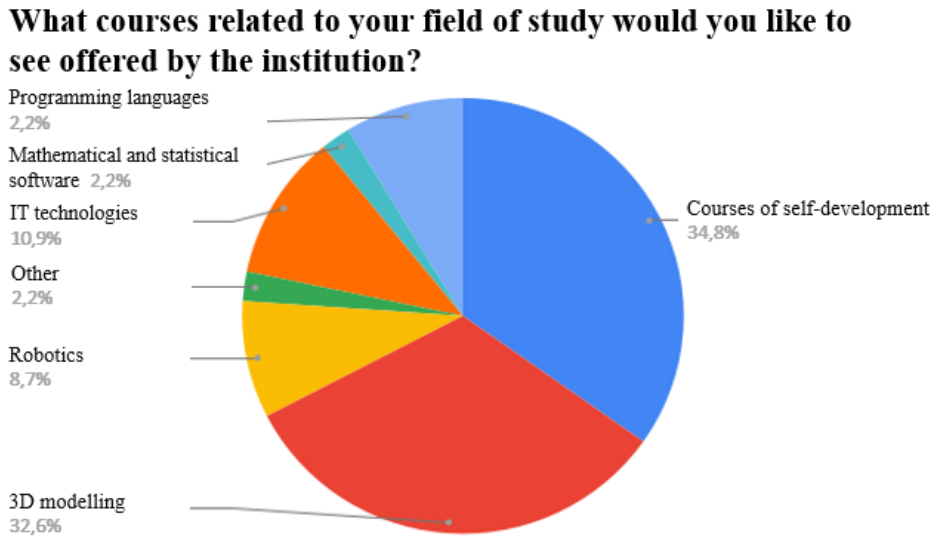

Figure 5 - Strategies for Advancing Students' Educational Proficiencies

Presently, it is widely recognized that a comprehensive grasp of biological concepts necessitates a solid foundation in disciplines such as chemistry, physics, mathematics, and programming languages. This understanding is affirmed by over 78.3% of educators. Moreover, the observation of students engaging in integrated approaches during practical sessions at advanced educational institutions serves as further evidence of their exposure to this pedagogical strategy. This information indicates educators' awareness of the widespread utilization of integrated teaching methods (Figure 6).

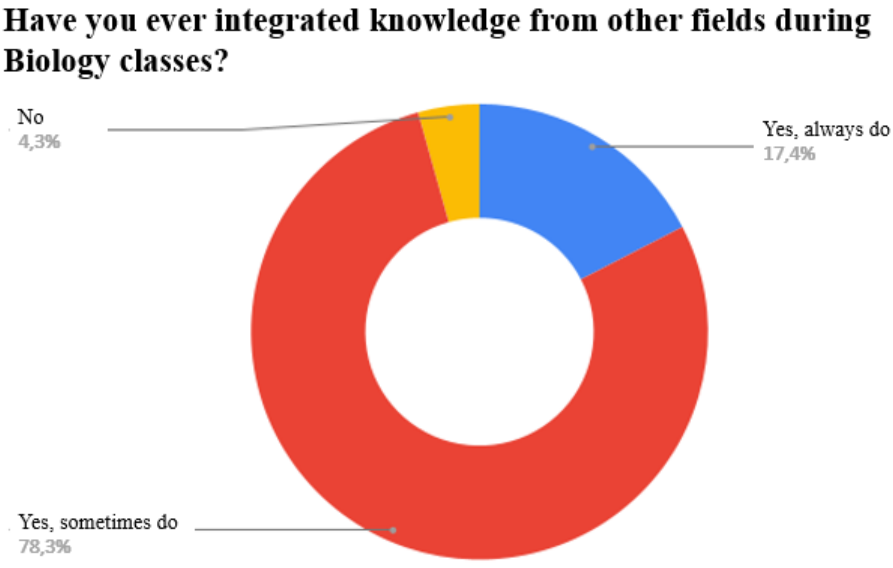

Figure 6 - Level of Application of the Interdisciplinary Linkages

Enhancing the quality of education undoubtedly requires a well-equipped material and technical base. Where such infrastructure is well-established, learners benefit from expanded possibilities and attain higher levels of knowledge, facilitating research endeavors. The subsequent seventh diagram illustrates responses pertaining to this matter. It elucidates that while higher education institutions possess material and technical foundations, there's a discernible necessity for their enhancement or modernization (Figure 7).

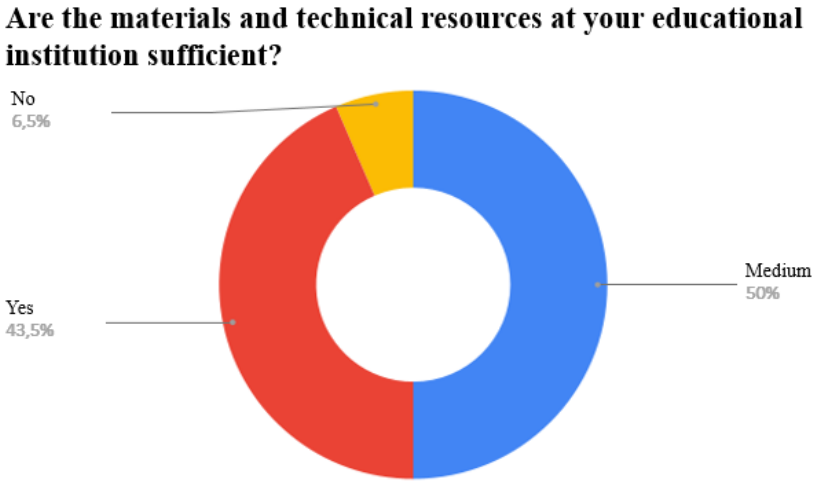

Figure 7 - Sufficiency of Material-Technical Base

The following diagram displays responses from students to a crucial question in our study, emphasizing its relevance to the quality of education. The majority of students (over 70%) believe that the most effective method to deepen their knowledge is by reinforcing what they have learned through practical experiments. This outcome affirms the indispensable role of integrating theory with practice in the educational process (Figure 8).

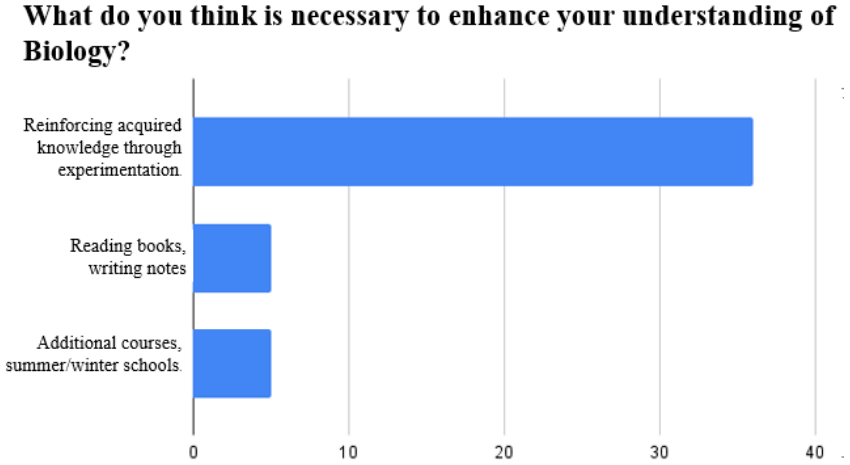

Figure 8 - Strategies to Enhance Knowledge

As indicated above, the implementation of robotics courses in schools has been widespread, with robotics laboratories established in 16 pedagogical universities across our country. It's noteworthy that one of the primary aims of these endeavors is to bolster the professional preparedness of prospective educators. This affords students the chance to incorporate elements of STEM education into their learning. By engaging with robotics, students not only deepen their comprehension of the subject matter but also cultivate practical skills in conducting contemporary scientific investigations [10]. Consequently, awareness regarding the availability of robotics-related courses in higher education institutions attended by aspiring educators has been studied. The breakdown of responses to this inquiry is depicted in the ninth figure. Merely 21.7% of students (those specializing in computer science) are aware of the existence of robotics courses and their availability for enrollment. This indicator clarifies the lack of awareness among the majority of students regarding robotics-related topics (Figure 9).

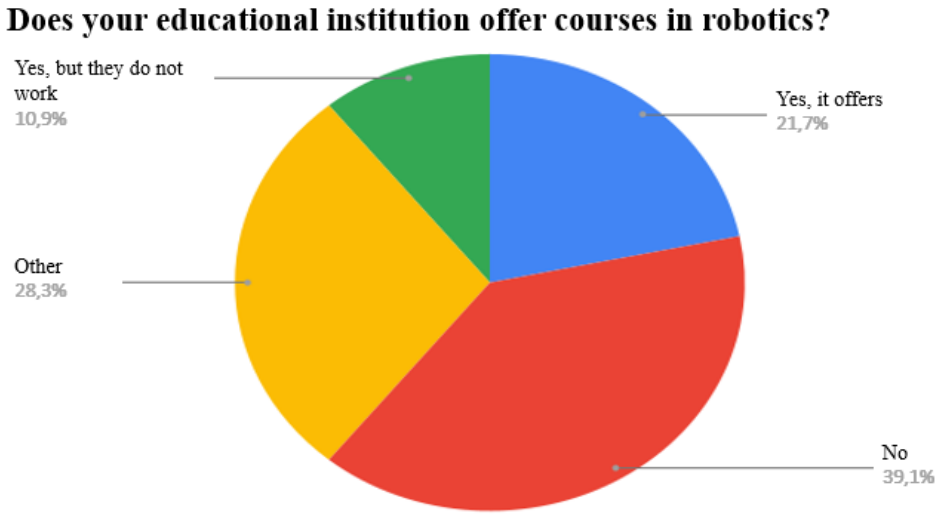

Figure 9 - Indicators Regarding the "Robotics" Courses

The proficiency of the teacher has a considerable impact on students' acquisition of knowledge, it is a fact that cannot be overlooked by anyone. Therefore, today's educators undergo national or international professional development programs with the aim of improving their skills.

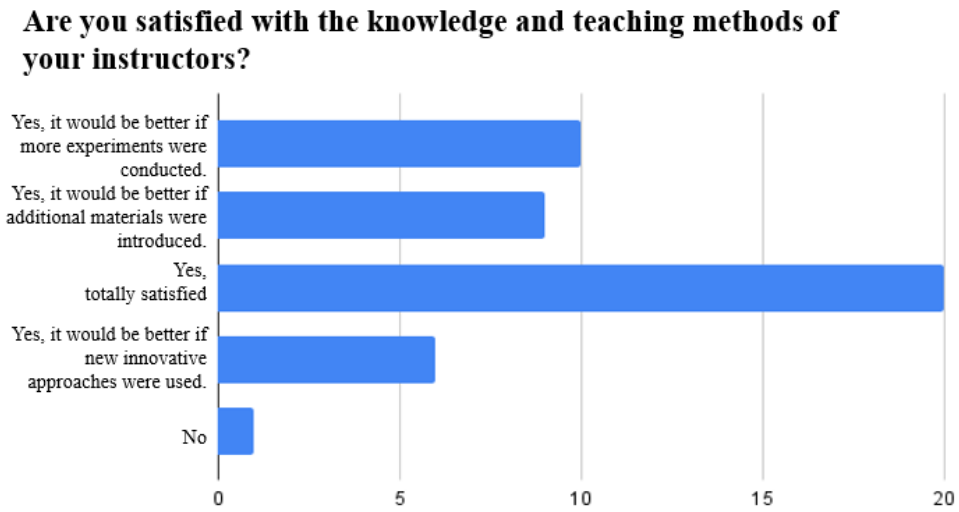

Figure 10 - The level of competence and knowledge of educators

However, according to the tenth diagram, only 45% of students express complete satisfaction with the teaching methods and the competence and knowledge of the educators in higher education institutions. The rest of the students recommend that the incorporation of innovative strategies by educators, an increase in practical activities, and the introduction of additional resources could significantly improve their educational experience (Figure 10).

Conclusion

The following conclusions were drawn from the conducted research:

- The concept of STEM is not clearly defined and has not been adequately developed within higher educational settings.
- While most students perform laboratory work following established conventional methods, a significant portion has the capacity to undertake tasks at a creative level. This indicates that laboratory exercises are conducted through a variety of approaches and cater to different skill levels.
- Students suggest that the most efficient teaching strategies include enhancing topics with diverse exercises or practical examples from real life, encouraging analytical thinking and problem-solving.
- A substantial majority of students, about 70%, express the need for their disciplines to incorporate innovative technologies such as 3D modeling, information technology, MatLab, AutoCAD, various programming languages, and robotics.
- Most students are aware of integrated teaching methods.
- Higher education institutions possess material and technical bases, yet there is a need for their enhancement and modernization.

• Over 70% of students believe that the most effective way to deepen their knowledge is through reinforcing what they have learned with practical experiment and exercises.

• Only 32% of students are aware of robotics courses, indicating a significant lack of information about robotics among students.

• Students suggest that educators to employ innovative teaching methods, which offer opportunities for them to become acquainted with both experiments and informational resources.

Based on the analysis results, we have come to the following conclusion:

1. To implement the STEM approach in the educational process, it is first necessary to clearly define what STEM is.

2. Within the scope of this definition, it is essential to develop an educational and methodological complex by integrating the STEM approach into the training program for future biology teachers.

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БОЛАШАҚ БИОЛОГИЯ МАМАНДАРЫНЫҢ STEAM ӘДІСТЕРІН ОЛАРДЫҢ БІЛІМІ МЕН ОҚУЫНА БІРІКТІРУГЕ ДАЙЫНДЫҒЫН БАҒАЛАУ

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Аңдатпа. Бұл мақала жоғары оқу орындарының студенттерінің STEM (ғылым, технология, инженерия, математика) инновациялық оқыту әдісі туралы хабардарлық деңгейін зерттеуге, сондай-ақ университеттерде STEM бағытында жүргізіліп жатқан іс-шараларды зерттеуге арналған. Қазіргі таңда заманауи оқыту әдістерінің кең спектрі бар, оның ішінде STEM әдісі ерекшеленеді. Шетелдік тәжірибеге негізделген бұл әдіс ғылыми пәндер арасындағы интеграциялық тәсіл ретінде танылады және студенттерге табиғи ғылымдар концепцияларын терең түсінуді қамтамасыз етуге бағытталған. Робототехника, STEM құрамының бір бөлігі ретінде, мектептерде кеңінен таралған, бірақ ол тек жақында ғана жоғары оқу орындарына енгізіле бастады. Қазіргі уақытта Ы. Алтынсарин атындағы Ұлттық білім академиясы STEM әдісін енгізуге арналған әдістемелік нұсқауларды әзірледі, сонымен қатар білім министрлігі мектептер мен университеттерде STEM бағытындағы сыныптар мен көптеген зертханаларды құру бойынша шараларды үйлестіріп отыр.

Осы негізде, 3D модельдеу студиялары, робототехника шеберханалары, орталықтар мен зертханалар сияқты арнайы объектілер құрылып, білім беру құрылымына мектептер мен жоғары оқу орындарында енгізілуде. Сонымен қатар, Chevron компаниясының қолдауымен «Күндер керуені» білім беру ұйымы «2021-2025 жылдарға арналған STEM білімін дамыту Жол картасы» аясында әдістемелік нұсқаулықтарды әзірлеуді бастады. Бұл бастама STEAM бағытындағы бейнемазмұнды сабақтарды, тақырыптық STEM апталықтарын және ғылыми конференцияларды ұйымдастыруға әкелді. Жүргізілген зерттеу STEM әдісін енгізуге дайындық деңгейін бағалауда және оның маңыздылығын анықтауда шешуші рөл атқарды.

Тірек сөздер: STEM әдісі, инновациялық тәсілдер, болашақ биология мұғалімдері, биологиялық эксперименттер, STEM, робототехника курстары, табиғи ғылымдар бағыттары, биология

ОЦЕНКА ГОТОВНОСТИ БУДУЩИХ СПЕЦИАЛИСТОВ В ОБЛАСТИ БИОЛОГИИ К ИНТЕГРАЦИИ STEM-ПОДХОДОВ В ИХ ОБРАЗОВАНИЕ И ОБУЧЕНИЕ

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Аннотация. Целью данной статьи является изучение уровня осведомленности студентов высших учебных заведений о методе

инновационного обучения STEM (наука, технологии, инженерия, математика), а также исследование спектра деятельности, связанной с STEM, проводимой в университетах. В современном мире существует широкий выбор современных методов обучения, среди которых метод STEM выделяется. На основе зарубежного опыта этот метод признан интегративным подходом между научными дисциплинами, направленным на предоставление студентам глубокого понимания концепций естественных наук. Робототехника, являющаяся одной из составляющих STEM, получила широкое распространение в школах, но только недавно начала внедряться в высшие учебные заведения. В настоящее время Национальная академия образования имени Ы. Алтынсарина разработала методические рекомендации по внедрению STEM-подхода, а также координируются усилия по созданию STEM-ориентированных классов и многочисленных лабораторий в школах и университетах министерством образования.

На этой основе были созданы специализированные объекты, такие как студии 3D-моделирования, мастерские робототехники, центры и лаборатории, которые интегрированы в образовательную структуру как в школах, так и в вузах. Кроме того, при поддержке компании Chevron образовательное учреждение «Караван Знаний» начало разработку методических пособий в рамках «Дорожной карты развития STEM-образования на 2021-2025 годы». Эта инициатива привела к организации видеоуроков, ориентированных на STEAM, тематических STEM-двухнедельников и научных конференций. Проведенное исследование сыграло ключевую роль в оценке готовности к внедрению образования с использованием методологии STEM, а также в оценке его значимости.

Ключевые слова: метод STEM, инновационные подходы, будущие учителя биологии, биологические эксперименты, STEM, курсы робототехники, направления естественных наук, биология

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