A THREE-STAGE STRATEGY FOR TEACHING BIOPHYSICS IN HIGHER MEDICAL EDUCATION INSTITUTIONS: A BIOMEDICAL PROBLEM-SOLVING APPROACH AND ITS IMPACT ON LEARNING OUTCOMES"

Bobur T. Rakhimov,
https://orcid.org/0000-0002-6810-360X
Assistant, Department of Biomedical Engineering, Computer Science and Biophysics, Tashkent State Medical University, Farobiy 2, Tashkent, 100109, Uzbekistan,
E-mail: bobur_rakhimov@inbox.ru

Sevara Z.Alikulova,
Student of Biomedical Engineering, Tashkent State Medical University, Farobiy 2, Tashkent, 100109, Uzbekistan,
E-mail: sevaraalikulova431@gmail.com

Makhbuba T.Abdurasulova
Student of Biomedical Engineering, Tashkent State Medical University, Farobiy 2, Tashkent, 100109, Uzbekistan,
E-mail: mahbubaabdurasulova027@gmail.com

Gulsevar O. Begmatova,
Student of Biomedical Engineering, Tashkent State Medical University, Farobiy 2, Tashkent, 100109, Uzbekistan,
E-mail: begmatovagulsevar76@gmail.com

Ruhshona K. Buriyeva ,
Student of Biomedical Engineering, Tashkent State Medical University, Farobiy 2, Tashkent, 100109, Uzbekistan,
E-mail: norakamoliddinovna@gmail.com

Mukammalkhon A.Turg'unboyeva,
Student of Biomedical Engineering, Tashkent State Medical University, Farobiy 2, Tashkent, 100109, Uzbekistan,
E-mail: mukammalxonabdumominova@gmail.com

Annotation. "Reforming the modern system of medical education is aimed at increasing the efficiency of training future doctors who not only have knowledge and skills, but are also ready to apply them in solving problems of professional activity. The authors show the need for biophysics in the future professional activity of a future specialist doctor in solving professional problems".

Key words: "biophysics, medicine, methodology, integration, contextual learning".

Introduction. Biophysics is one of six year-long core modules designed to enable underprivileged students from disadvantaged schools, especially in rural areas, to access a medical degree program. It is assumed that after successfully completing a medical degree, they are more likely to work in their disadvantaged communities. The same applies to other South African universities. They all require excellent completion of grade 12 in math and physics as prerequisites. In addition, there is a limited number of places for students who intend to pursue medicine as a career.

Three-step strategy for solving physical problems. "Strategic design is a key aspect of problem-solving. The ability to solve biophysics-related problems plays a crucial role in deeply understanding the concepts of biophysics."A student who develops from a beginner biophysical problem solver to a full-fledged problem solver achieves a higher degree of conceptual assimilation as well as a good ability to visually analyze the abstract phenomena of biophysics. This section presents a three-stage strategy for solving problems in biophysics. Before a detailed description of the proposed three-stage strategy for solving biophysical problems, some important and useful definitions are given below.

Problem definition and problem solving. "Physics problems have been analyzed based on Resnick's work, where he describes a 'problem' as a scenario in which an individual encounters an unfamiliar challenge and must determine a solution without a clearly defined method to follow." Such a task must be new to the person, although already existing processes or knowledge may be involved in the solution. A problem can exist whenever there is a gap between where you are now and where you want to be, and you don't know how to find a way to bridge that gap. He pointed out that not all tasks or situations constitute a "problem". It is the skills and knowledge that a person brings to the interaction process that determines whether a task or situation is a problem or not. For an expert, the path or solution to a problem is obvious; the expert sees the "problem" only as an exercise. According to Maloney, a "problem" should essentially be a problem characterized by three components, namely: "initial state; target state and procedures to bridge the gap between them. In addition to the above definitions, several others can be found in the literature, but they all have common elements. "Fundamentally, researchers agree that a problem emerges when addressing a challenge of a certain complexity for which an immediate solution is unavailable. In this study, our interpretation of a 'problem' aligns with key elements already recognized in existing literature. Therefore, we shape our understanding of the problem's essence by considering the nature of assigned tasks or situations, along with the knowledge and experience required to solve them."The tasks/situations that make up the problem are very broad and can usually be attributed to a specific field of knowledge such as chemistry, biology and physics. In this study, we decided to narrow the problems/situations to cover the field of biophysics, so we classify as a problem in biophysics a problem of a certain degree of complexity, the answer to which is unknown. It can be obtained through a process that involves the application of concepts from biophysics. A problem classified as a biophysics problem can be solved using already existing knowledge in the field of biophysics, following a certain procedure, called in this study a three-stage strategy for solving a biophysics problem. **"An individual capable of effectively resolving issues is considered to possess problem-solving skills. However, defining what exactly constitutes a 'problem-solving skill' and assessing its transferability can be highly challenging, which falls outside the scope of this discussion.

Problem-solving can be described as a cognitive process directed toward reaching a goal when no immediate solution is apparent to the problem solver (Meyer, 1992)."**This definition takes into account the ability of an expert and a beginner. The student in most cases is a novice problem solver, knows little of the subject area in the area under study. On the other hand, senior undergraduate students in their last year of specialization, graduate students and experienced university professors can be experts. Biophysical problem solving skills involve formulating strategies that formulate a sequence of events or steps leading to an answer, steps that can be learned. Solving problems in biophysics can be learned in the same way as solving problems in physics. Gordon emphasizes that once practiced over and over again, physical problems are internalized within the person to the point where they become secondary. The same can be said about the problems of biophysics.

In this article, we present a three-stage strategy (method) for solving biophysical problems, which consists of three main stages, namely: strategy development, strategy implementation and evaluation of the results obtained. A student who succeeds in successfully completing the steps described above for solving problems in biophysics will find solving problems in biophysics enjoyable and exciting. Approached with a spirit of exploration, these challenges will certainly never disappoint. The ability to solve problems in biophysics improves the cognitive skills of students and, ultimately, improves the acquisition of concepts.[1].

Strategy design. Strategy development is the most important part of the decision process, and if it fails, the whole process will fail. Developing a strategy begins with reading and analyzing the issue. Here the problem solver generates a representation of the internal model of the problem/situation. This process is critical, it allows the problem solver to understand as well as visualize the physical system, with particular attention to its behavior. **"This process aligns closely with the fundamental concepts and principles of biophysics (Maloney, 2009). An inaccurate internal representation can impede progress, often resulting in difficulties when solving biophysics-related problems. However, this challenge can be addressed through re-introduction—an essential skill that helps problem solvers recognize key obstacles.

Beyond internal representation, external representation also plays a crucial role. It outlines the tasks and methodologies used in problem-solving."**

Key aspects of external representation include:

• Enhancing understanding of the problem by providing a qualitative explanation through visual aids and descriptive language."**

• Drawing relevant diagrams where possible and listing the data provided.

• Write down what the question requires to keep the target in view.

• Recording the necessary corresponding mathematical formulas.

• Rewrite the formula, causing the unknown variable to be calculated (this procedure is applicable to all problems of a quantitative nature).

The average student is encouraged to read the question at least three times. A rushed approach often leads to a lack of understanding of what the task requires, often resulting in lost grades. In addition, a hasty approach regularly leads to poor interpretation of the relevant concepts of biophysics, which in turn leads to poor academic performance on the part of the student.[3].

Implementation of the strategy. Implementation and implementation of the strategy is the second most important stage on the way to solving the biophysical problem. This requires a well-organized work from the person, which will allow the examiner to easily follow the work. Most of the grades are given at this stage, so great care and accuracy is required.

Execution tactics include:

• Analysis and interpretation of the physical concept used to justify the procedure to be adopted.

• Substitution of data into the corresponding equations.

• Simplify equations to get the final solution.

During execution, you need to make sure that the data substituted into the formula has the appropriate units of measure. If the units indicated are not SI units, they should be converted to SI units.

Many students tend to overlook the meaning of SI units and in most cases confuse regular units with SI units, resulting in incorrect answers.

Implementation of the strategy. Implementation and implementation of the strategy is the second most important stage on the way to solving the biophysical problem. This requires a well-organized work from the person, which will allow the examiner to easily follow the work. Most of the grades are given at this stage, so great care and accuracy is required.

Execution tactics include:

• Analysis and interpretation of the physical concept used to justify the procedure to be adopted.

• Substitution of data into the corresponding equations.

• Simplify equations to get the final solution

During execution, you need to make sure that the data substituted into the formula has the appropriate units of measure. If the units indicated are not SI units, they should be converted to SI units. Many students tend to overlook the meaning of SI units and in most cases confuse regular units with SI units, resulting in incorrect answers.[4].

"Assessment process. Evaluation of the obtained results is the final stage. This step is always often overlooked by most inexperienced biophysics students, but it can be inferred from it whether the student has understood the biophysics concepts involved. The final result gives the student the opportunity to check if the answer is within a "reasonable range".”

Thus, the evaluation process includes checking:

- Size Consistency
- The significance of the results.

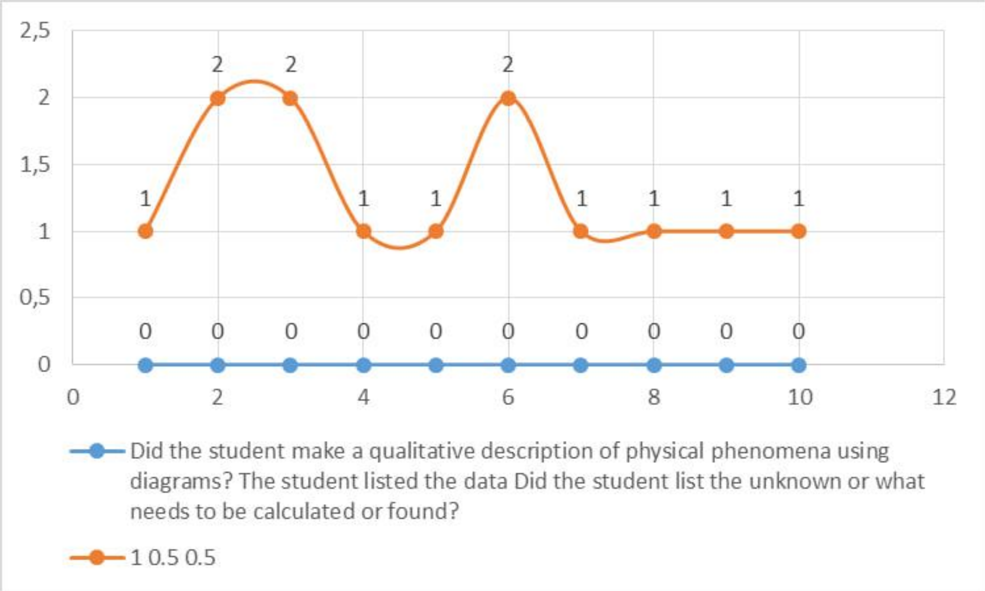
Here the student checks the answer to see if it is numerically reasonable. You should also check the meaning of its sign. For example, when calculating acceleration, a negative value would mean deceleration.

- If the appropriate number of significant digits is used in the final answer. This study sought to answer the following research question:
- Is it possible to improve the performance of students from disadvantaged communities by providing them with appropriate conditions and a good support system in the basic module of biophysics and numeracy?

Materials and methods. This study is a retrospective analysis of semester tests and final exam scores for three 2010, 2012, and 2013 cohorts enrolled in the basic biophysics and numeracy course at SMU. This paper reports on the performance of these cohorts. Most of these students were recruited from disadvantaged schools, mostly characterized by a lack of resources. Most of them achieved adequate results (50-59%) in mathematics and physics in the 12th grade exams. A small part had significant achievements (60-69%). These results were far below the grades that would have guaranteed them a place in the medicine program at SMU. All students completed the same grade 12 curriculum as in public schools. Based on their average scores in grade 12, students were assumed to be enrolled in the core biophysics and numeracy module with the same cognitive characteristics. This module is one of the six core modules offered by SMU in the Basic Medicine Program. Successful completion of a course with a passing score of 50% or higher in all core modules (Biochemistry, Biology, Biophysics and Accounting, Study Skills, English for Medicine and Anatomy & Physiology) ensures students are eligible for entry into the first year of medical education programs offered by the university.[2].

The main lecturer has always been the author. Tutors (graduate students) change every two years. In the 2010 and 2011 academic years, the same teachers were retained. Two new teachers were hired for the 2012 and 2013 academic years. The Biophysics and Counting module was designed as a hands-on physics course that introduces students to the interaction between physics and the human body through relevant experiments with an emphasis on problem solving. The first quarter of the semester covers basic mathematics and elementary statistics. The rest of the first semester is devoted to force and energy acting on anatomical structures, and then finally to temperature, pressure, fluid movement and their effect on the body. The second semester covers the characteristics of materials, electromagnetism and its applications in biological systems, the fundamentals of sound and optics and their applications. Finally, radioactivity, the generation of X-rays and their interaction with the body are considered. The course is structured in such a way that there is one lecture per week of 40 minutes, a study session per week of 140 minutes and a practical session once a week of 240 minutes.

ActaCAMU
№ 2.1 (14) 2026
ISSN: 2181-4155



Lectures for the 2010 cohort used the traditional approach, with the lecturer doing most of the talking and students taking notes. Students were previously given a textbook and a laboratory manual. During the lessons, the teachers would solve a few problems for the students on the board and then give them a series of biophysics problems to work on. At the end of each training session, students wrote a learning test. Three semester tests and a final exam were written. After realizing the challenges faced by the 2010 cohort, the 2011, 2012, and 2013 cohorts an intervention mechanism was applied (a three-stage strategy for solving biophysical problems). Further support included providing students with study notes, lecture slides and study guides with clearly defined learning objectives and expected outcomes. Feedback was provided to students either face-to-face or via the board immediately after they completed assignments or tests. Learning and teaching relied on the use of a combination of student and teacher oriented activities.

"Student performance and the impact of the three-stage biophysics problem solving strategy, as well as its role in facilitating students' conceptual understanding, were assessed using a pre-intervention test, a post-intervention test, a biophysics textbook, semester tests, and a final exam."

The pre-test measured students' skills in solving problems in biophysics and their level of assimilation of the concepts of force in relation to biological systems.[4].

Selection of participants. The study group consisted of 50 students registered in 2010; 45 students registered in 2012 and 50 students registered in 2013 for the Basic Medicine Program (MBChB-ECP) offered at SMU. These students entered the university with a limited functional understanding of some of the basic concepts of mathematics and physical sciences, so the aim of the study was to demonstrate that:

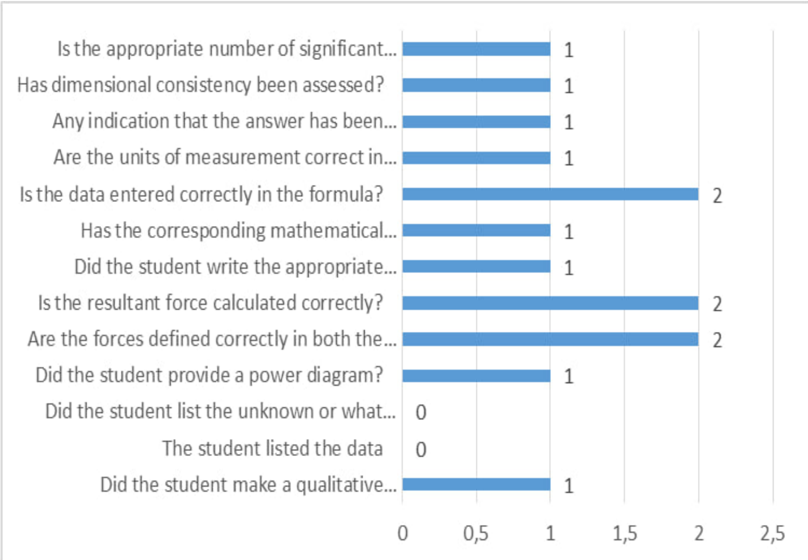
Training the brain of students is possible by instilling in them the skills to solve problems in biophysics. Skills include mastering problem solving strategies as well as logical reasoning.

Academically disadvantaged students, once given "artificial thinking," the intellectual equivalent of artificial respiration, can produce extraordinary results.

The three-step strategy for solving biophysics problems improves students' understanding of biophysics concepts.

Did the student make a qualitative description of physical phenomena using diagrams?	1
The student listed the data	0.5

Did the student list the unknown or what needs to be calculated or found?	0.5
Did the student provide a power diagram?	1
Are the forces defined correctly in both the Y and X directions?	2
Is the resultant force calculated correctly?	2
Did the student write the appropriate mathematical formula?	1
Has the corresponding mathematical formula been rewritten, as a result of which the unknown variable must be calculated?	1
Is the data entered correctly in the formula?	2
Are the units of measurement correct in the final answer?	1
Any indication that the answer has been checked to see if it is numerically sound.	1
Has dimensional consistency been assessed?	1
Is the appropriate number of significant digits used?	1



A three-step strategy for solving biophysics problems (intervention mechanism) was presented to the students during their lecture period after the pre-intervention test. Then the students were given the opportunity to consolidate the studied strategy for solving problems in biophysics during the training session. At the end of the training session, a post-intervention test was performed. This was scored based on the criteria in Table 1. However, this test was not included in the final score. It was used as a barometer to measure the impact of near-introduced intervention mechanisms (three-step biophysics solution strategy).

The students worked in small groups of three or four during the study sessions. These groups were kept for a year during training. Small groups gave students the opportunity to participate effectively in group activities and discussions, thus engaging in ideas while improving their communication skills. During the training sessions, at least two different groups were assigned to the same tasks. Other groups solved other problems, but the same level of complexity. All groups used a three-stage strategy for solving biophysical problems. The students presented their answers on the board, while the rest reviewed the answers and compared them with their own. This gave them the opportunity to change and internalize the strategy. A modification of the strategy has been made to tailor its application to specific problems. Tutor and lecturer intervened when students encountered difficulties.[5].

Discussion. The results and experience with the 2010 MBCS-EKP cohort showed that students in previously disadvantaged schools experienced difficulties in mastering traditional methods of teaching biophysics, as well as in acquiring skills in solving biophysical problems. The scores achieved by this group in the module were mostly marginal, however throughput was achieved at 100%. To help new entrants deal with the complex concepts of biophysics, an intervention mechanism was developed and successfully implemented across three biophysics cohorts. The majority of students 69% of the 2012 cohort failed the pre-intervention test compared to 100% who passed the post-intervention test. In the 2013 group, 30% failed the pre-intervention test compared to 4% who failed the post-intervention test, while a majority of 96% (48 out of 50) passed the post-intervention test. The student test scenarios before the intervention showed that in both groups, the majority of students solved the biophysics problems without following the steps in Table 1. Many important steps were omitted. Those who managed to arrive at the correct final answer lost most of their grades because they missed vital steps. It was also seen from their response scripts that they were simply plugging their data into the math formula without putting into perspective what they needed to calculate. Few have tried to change the mathematical formula to make the subject an unknown quantity. As a rule, students could not correctly manipulate the units of measurement. In most cases, their answers had the wrong units of measurement.[2].

The results of post-intervention tests conducted in the 2012 and 2013 cohorts showed a significant improvement in the ability to solve biophysics problems. The same concept of strength was examined as in the pre-intervention test. The questions asked were very similar, despite varying degrees of difficulty. Figures 1 and 2 compare pre- and post-intervention outcomes for the 2012 and 2013 cohorts. From the two bar graphs, it can be seen that the students' biophysics problem solving skills improved significantly after they were taught the three-step strategy for solving biophysics problems. The students were able to clearly identify the given data, wrote down the unknown value, and drew the corresponding force diagrams. In addition, they carried out a proper analysis of the phenomenon of biophysics and wrote down the corresponding mathematical formulas. The unknown quantity was also included in the formula in almost all response scenarios. Data substitution done correctly. However, a few steps were skipped here and there, resulting in a loss of scores. Their concern was their ignorance of the importance of units. The three-step strategy for solving biophysical problems played a significant role in developing their analytical skills and, ultimately, in improving their ability to understand abstract biophysics. This is evidenced by worthy achievements in tests 2, 3 and 4 for the 2012 and 2013 cohorts.[8].

Among these three cohorts, only the 2010 cohort was not introduced to the three-stage strategy for solving physical problems. This explains why the quality of their grades is second-rate compared to the other two groups. Figure 3 shows that the 2012 group received the best marks for the textbook on biophysics, while all students received marks in the range from 74 to 100%. The differences in outcomes between 2010 and the other two cohorts are certainly related to the successful adoption of the three-step biophysical problem solving strategy learned and applied by the two groups. However, the performance differences between the 2012 and 2013 cohorts can be explained by individual cognitive abilities, as they had the same lecturer and the same mentors.

Graphical analysis of Figure 4 leads to the conclusion that the three-stage strategy for solving biophysical problems improved the performance of the 2012 and 2013 cohorts. However, despite registering passing scores in the same assessments, the quality of the assessments received by the 2010 group was low. The achievements of the 2012 and 2013 cohorts in the biophysics module indicate that indeed students from disadvantaged communities have a great potential that remains untapped. They fail to do well in secondary school simply because of a lack of resources and insufficient preparation.. This allowed the students to have a good understanding of the principles and concepts of biophysics.[3].

References:

1. Balakhonov A.B. Fundamentalization of higher medical education on the basis of systematic natural science knowledge: Ph.D. diss. ... doctor of pedagogical sciences. St. Petersburg, 2017. 52 p.
2. Balachevskaya O.V. Preparation for professional activities of students of the Faculty of Pharmacy in the process of studying the course of physical and colloidal chemistry based on the integrated-modular approach: author. diss. ... Candidate of Pedagogical Sciences. Krasnodar, 2017. 26 p.
3. B.T. Rakhimov. The role of innovative educational technologies in teaching biophysics. research and education. 2023. issn: 2181-3191 volume 2 | issue 3 | 202 91-99.
4. B.T. Rakhimov, X.A. Muxitdinov, Z.R. Jo‘raeva. Алгоритм обучения биофизике с использованием инновационных образовательных технологий. 30.03.2023 Innovative Development in Educational Activities issn: 2181-3523 volume 2 issue 6 2023. 191-200.
5. M.I. Bazarbaev, D.I. Sayfullaeva, B.T.Rakhimov, Z.R. Joraeva Роль информационных технологий в медицине и биомедицинской инженерии в подготовке будущих специалистов в период цифровой трансформации в образовании. 10.10.2022. Т.Т.А. Ахборотномаси. 8-13.
6. B.T.Rakhimov. Современное состояние биофизики и особенности преподавания биофизики в медицинском вузе. Formation of psychology and pedagogy as interdisciplinary sciences. Italia © Sp. z o. o. "CAN", 2021 © Authors, 18-27.
7. B.T.Rakhimov, M.I. Bazarbaev, A.Z. Sobirjonov Состояние проблемы подготовки студентов-медиков к решению профессиональных задач в обучении биофизике. New Day in Meditcina. www.bsmi.uz https://newdaymedicine.com E: ndmuz@mail.ru. 4/54/200-207
8. M.I.Bazarbayev, B.T.Rakhimov, A.Z.Sobirjonov, D.I.Sayfullayeva, Z.R.Jurayeva, S.I.Ixrorova The Importance of Digital Technologies in the Teaching of Fundamental Sciences in Medical Universities. American Journal of Medicine and Medical Sciences. American Journal of Medicine and Medical Sciences 2023, 13(6): 814-820 DOI: 0.5923/j.ajmms.2023.13.06.09