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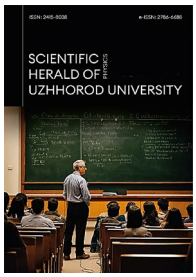

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Principles of teaching medical biophysics as a major subject

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Abstract

Relevance. The relevance of the study is conditioned by the need to form clear principles of teaching medical biophysics to students, considering the main features of teaching biology and related disciplines in higher educational institutions of Kazakhstan at the moment.

Purpose. The purpose of this study is to investigate the basic principles of teaching medical biophysics in profession-oriented areas in the system of higher educational institutions of the Republic of Kazakhstan, to identify similar teaching trends and form an assessment of the overall effectiveness of teaching this discipline in the system of educational institutions under consideration.

Methodology. The basis of the methodological approach in this study is a combination of a systematic analysis of the methodological foundations of combining the principles of teaching biology and physics in a modern higher educational institution, with an analytical investigation of the main aspects of teaching medical biophysics as a major subject of a number of modern higher educational institutions.

Results. The results obtained are a clear demonstration of the importance of the qualitative study of medical biophysics in higher educational institutions of Kazakhstan, to develop students' competencies necessary for their subsequent professional activities.

Conclusions. The findings and the conclusions formulated on their basis are of significant importance for students of medical departments of universities of Kazakhstan studying medical biophysics as a principal subject of the general training programme, and representatives of the teaching staff of these educational institutions, who, by the nature of their professional activities, are faced with the need to search for and practical implementation of effective principles of teaching this subject within the requirements of the university curriculum.

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Keywords: biology; physics; specialised medical education; specialised training; synthesis of biology and physics.

Introduction

The main features of teaching medical biophysics as a major subject in the curriculum of medical universities are its close relationship with the other subjects that make up the curriculum [1]. In this context, it is necessary to determine the main tasks of teaching the biophysics course as a major subject: consideration of the peculiarities of the vital activity of the organism as an open-type non-equilibrium system; use of the basic concepts of the biophysics course for the competent use of medical equipment and the correct interpretation of the results; mastering the physical foundations of medical devices and techniques used in various fields of medical science; research of physical phenomena to study the laws of functioning of living systems and their impact on the human body; substantiation in the theory of the influence of various physical processes on human vital activity [2].

Medical biophysics considers the human body as an open thermodynamic system, so this discipline cannot be considered in isolation from other natural sciences. In recent years, the concept of teaching medical biophysics in direct connection with biology has been adopted in the systems of higher medical educational institutions of the Republic of Kazakhstan. As a result, it is planned to impose knowledge in the field of biophysics on knowledge in the field of biology, which is quite understandable, since biology acts in this context as the basis of the entire complex of scientific knowledge obtained by students when mastering the main disciplines. Notably, the lack of knowledge in the field of biology would necessarily affect the quality of studying biophysics as an independent discipline. Such circumstances must necessarily be considered when drawing up a curriculum and planning the total number of hours of teaching Biology and Medical Biophysics in their competent ratio [3-5].

The expediency of introducing a medical biophysics course into the curriculum of higher medical education of modern educational institutions is largely determined by the trends of today, expressed in the need for high-quality satisfaction of the needs of specialised education of medical students who show a desire for the natural sciences and endowed with a certain style of thinking, with a pronounced behavioural orientation. Such an approach implies the need to form a number of special principles of teaching medical biophysics as a major subject [6-8].

Integration of the content of natural education can be implemented through the introduction of a number of natural science disciplines into the educational process. The historical development of medical biophysics suggests that this science has its own characteristics, in particular, the presence of the object of study, the scientific object of knowledge, characteristic only for this discipline, and scientific logic and the basis for experimental studies characteristic only of medical biophysics [9; 10]. All the above-mentioned factors determine the need to bring biophysics into strict compliance with the process of university education in the context of the synthesis of knowledge, both cross-curriculum and intrasubject. Obtaining such a synthesis involves the development of the main conceptual areas of generalisation of scientific knowledge and their structural relationship. All participants in the educational process receive real opportunities for the development of theoretical thinking, stemming from scientific synthesis, considering various generalisations.

In this study, the task is to consider the basic principles of teaching medical biophysics as a major subject, to form the above trends in teaching medical biophysics and create an understanding of the overall effectiveness of teaching this discipline in the system of educational institutions of the Republic of Kazakhstan. The task is planned considering the experience of past studies of the subject, which represent a qualitative theoretical basis of this study and determine the main trends of this research as a whole. The results obtained and the conclusions formulated on their basis in the future can serve as a qualitative theoretical basis for further research on the subject of this research paper.

Materials and Methods

The methodological base of this study is a combination of a systematic analysis of the methodological foundations of combining the principles of teaching biology and physics in a modern higher educational institution, with an analytical investigation of the main aspects of teaching medical biophysics as a major subject of a number of modern higher educational institutions. A qualitative combination of methods for studying the basics of teaching physics and biology in a modern medical educational institution with an analysis of the main aspects of teaching medical biophysics allows forming a complete picture of research, considering all the characteristic features of studying this discipline in the modern system of higher medical educational institutions in the Republic of Kazakhstan.

The theoretical basis is the results obtained in the study of available scientific developments on the basic principles of teaching medical biophysics in the system of modern higher educational institutions, which are important in the context of the practical application of these scientific developments in the field of teaching medical biophysics in medical educational institutions of Kazakhstan. In addition, as a theoretical basis for this study, research papers devoted to the relationship of medical biophysics with other natural sciences included in the curriculum of higher medical education were considered.

This study assumes the presence of three main stages of research.

At the first stage, a theoretical analysis of available research papers devoted to the teaching of medical biophysics in higher medical educational institutions and the relationship of this discipline with other related natural science disciplines was carried out. In addition, this stage included a systematic investigation of the methodological foundations of combining the principles of teaching biology and physics in a modern higher education institution, based on a pre-formed theoretical base.

The next stage involved an analytical investigation of the main aspects of teaching medical biophysics as a major subject of a number of modern higher educational institutions and the role of this discipline in the development of the profession-oriented literacy of a

graduate. In addition, an analytical comparison of the preliminary results obtained in the course of this study with the results and conclusions of other researchers was carried out, considering the teaching of medical biophysics within the curriculum of a medical educational institution and the relationship of this subject with other main natural science disciplines.

The final stage formed the main conclusions drawn from the findings of this study, serving as the final generalisation of the entire complex of research on the principles of teaching medical biophysics as a major subject. The results obtained and the conclusions formulated on their basis are in strict accordance with the subject of this study and can be successfully used in the future as a theoretical basis for assessment of the principles of teaching medical biophysics as a major subject in the system of modern higher medical education.

Results

The study of the basic principles of teaching medical biophysics as a major subject in modern higher medical educational institutions has yielded the following results.

Training in medical biophysics as a major subject contributes to the development of professional competencies necessary for the subsequent implementation of their professional activities among medical students [11]. It is the training of qualified medical specialists that is the main task of the medical education system in modern social realities. This task can be successfully solved only if a medical student is fully trained in various aspects of educational activities, including the learning of sciences that form the basis of modern natural science.

Medical biophysics is one of the fundamental natural science disciplines. Table 1 provides information on the role of medical biophysics in the system of modern medical education.

Table 1. The role and place of medical biophysics in the system of modern medical education

Medical biophysics in the development of professional competencies of a doctor	The essence of professional competencies in the field of medicine
Forms a system of ideas about the features of the biological structure of the human body and the essence of the physiological processes occurring in it	Basic knowledge in the field of natural and biomedical sciences, contributing to the establishment of a system of stable ideas about human interaction with the outside world
Determines the degree of readiness of a specialist to conduct medical practice using modern equipment and diagnostic tools	Skills of working with complex diagnostic equipment and the ability to correctly interpret the information received
Develops scientific logic and contributes to the development of skills for conducting independent research	The connection of medicine with related scientific disciplines, physics, biology, chemistry, expanding the range of their use in the profession
Promotes the introduction into medical practice of methods of mathematical modelling of cases of medical practice and their comprehensive analysis	The development of skills to describe the phenomena of medical practice in their dynamic manifestation, the establishment of close links between a number of observed phenomena

Modern principles of teaching medical biophysics in the profile area suggest a breakdown into several composite categories:

1. The principle of synthesis of biology and physics as fundamental from the standpoint of understanding the role and place in the system of disciplines of modern natural science.
2. The principle of synthesis of biology and physics using the chemical method of cognition of the surrounding reality.
3. The principle of synthesis of biology, physics and chemistry as a whole in the system of natural sciences, revealing the integrity of the scientific picture of the world.

The construction of learning in the context of any single principle involves the development of a special approach based on the features of a particular learning principle. In general, high-quality teaching of medical biophysics in the system of medical higher educational institutions assumes compliance with all these teaching principles, considering the individual characteristics of students of each particular university [12].

Table 2 presents the main professional competencies that are formed by medical students when they study natural sciences within the framework of the programme of specialised higher education of the Republic of Kazakhstan. The connection of biophysics with a number of other natural science disciplines and the principles of the development of the competencies of the future doctor is revealed.

Table 2. The main professional competencies that are formed by medical students when they study natural sciences within the framework of the curriculum of specialised higher education of the Republic of Kazakhstan

Professional competencies acquired by a future doctor in the study of disciplines related to the field of natural science	The natural science disciplines included in the curriculum of medical students in higher educational institutions of Kazakhstan
The ability to determine the essence and meaning of emerging problems based on the practical application of physical, mathematical, and chemical methods	Biology, Mathematics, Physics, Chemistry.

Practical ability to build a systematic approach to the processing of available medical information, and to make decisions based on the mastered theoretical and practical developments	Fundamentals of Computer Science, Mathematical Statistics
Practical skills in analysing the results of laboratory studies and forming correct conclusions based on them	Biophysics, Physics, Chemistry, Biology, Mathematical Statistics
The ability to determine the patterns of functioning of human body systems based on the processed analytical information	Biophysics, Mathematical Statistics, Fundamentals of Physiology
The ability to freely navigate the international systems of units used in the processing of analytical information	Mathematical Statistics, Physics, Chemistry, Biology
Readiness for the rapid development of modern methods of experimental research and their practical application in everyday scientific activities	Mathematical Statistics, Physics, Chemistry, Biology

The qualitative combination of Biophysics with other natural science disciplines, in particular, Biology, Physics, Chemistry, Computer Science and Mathematical Statistics ensures the fullest possible development of the necessary professional competencies of future doctors. The skills and abilities to understand the essence of physiological processes occurring in the human body are formed, and the skills of working with modern diagnostic equipment necessary for the qualitative interpretation of the results of a survey of the current state of the patient with the formulation of correct conclusions based on them. At the same time, knowledge of the nature of phenomena occurring in the human body, and the physical foundations of external influences on the body is necessary for proper diagnosis and determination of the necessary degree of medical influence to resolve a specific situation of medical practice [13]. This determines the importance of a high-quality combination of teaching medical biophysics with related natural science disciplines to form high-quality competencies of future specialists in the medical field, necessary for them to carry out their professional activities in the future.

Figure 1 below shows the main stages of mastering medical biophysics by students of higher educational institutions, for which it is one of the principal subjects of the curriculum.

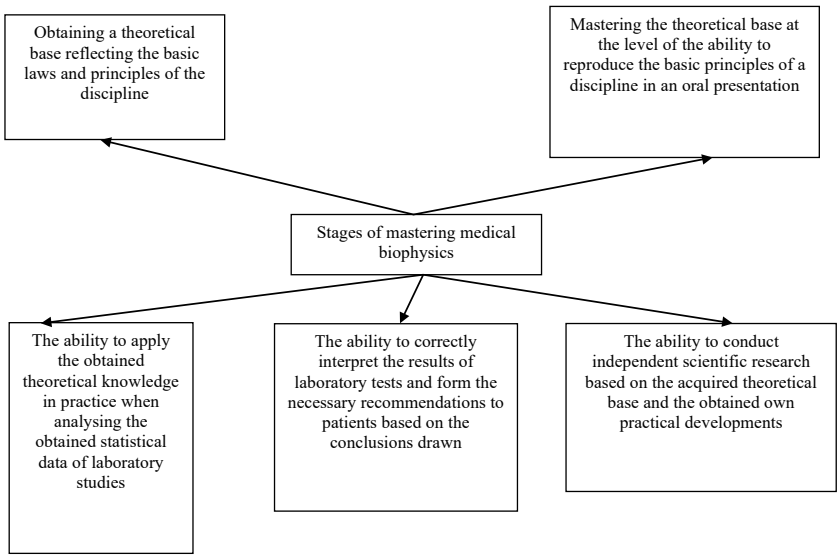

Figure 1. The main stages of mastering medical biophysics by students of medical specialities of higher educational institutions

The practical implementation of the above-mentioned principles of teaching medical biophysics as the main subject of a student of medical specialities of higher educational institutions of the Republic of Kazakhstan should contribute to the gradual development of their full set of competencies necessary to achieve a degree of professionalism sufficient for high-quality laboratory research, whose task is to obtain an accurate picture of the patient's condition, and the correct interpretation of the results obtained during such studies. In addition, the development of such competencies in the future should contribute to the practical development of skills sufficient for the independent formulation of scientific research in any of the areas of activity in the field of medicine and obtaining based on completed research results that reflect the essence of the research and solve the main tasks set during its development.

In general, the outlined principles of teaching medical biophysics as the main subject of the curriculum for students of medical specialities of higher educational institutions of the Republic of Kazakhstan fully meet modern requirements put forward to the quality of training of future doctors and determine the features of building a curriculum for specialists in the field of medicine, capable

in the future to successfully solve numerous complex tasks directly related to their professional activities.

Discussion

Every student of a medical educational institution in the process of obtaining higher medical education is faced with the need to solve the problem in understanding the basic physical characteristics and properties of living systems, and the physics of the human body. They will be able to implement such opportunities qualitatively in the Biophysics course. Notably, this course forms numerous general cultural competencies, such as the development of logical thinking skills, the ability to qualitatively formulate tasks, and find the right ways to solve a wide range of professional problems [14].

In modern conditions of the development of specialised education, special importance should be given to the issues of the correct definition of the content of education in the appropriate area, which could satisfy the cognitive needs of a particular individual or group of such. In general, this will ensure that students maintain the proper level of training they need in the future when solving a wide range of tasks in their professional activities [15].

The close ties between biophysics and biology in the field of research of physiological processes occurring in the human body are explained by the significant influence of these processes on the entire human life activity as a whole. Modern physiology investigates the functional capabilities of the body in various aspects of its vital activity, while to understand the main features of the flow of these processes, qualitative knowledge of the nature of physical and chemical phenomena occurring in the body is required. This fact predetermines the main task of teaching medical biophysics within the framework of the curriculum, as an exposition to students of the basic principles of understanding the essence of the connection of Biophysics with related natural science disciplines, which in principle is necessary for mastering the professional competence of a doctor, with the subsequent possibility of conducting practical activities within the mastered speciality [16]. Since knowledge of the biophysical processes occurring in a human cell and throughout the entire body allows forming a holistic impression of the subtleties of the functioning of the main systems of the human body. Medical students who started studying Physiology immediately after mastering Biophysics are provided with all the necessary knowledge, understanding, and skills necessary for a full study and mastering of the Physiology course [17-19].

The process of teaching medical biophysics in the system of higher educational institutions involves a mandatory visual demonstration of the connection of this scientific discipline with other disciplines taught in various courses of study at a medical educational institution. In the process of studying in educational institutions of this kind, students face a real need for the consistent development of a large number of diverse competencies that are important from the standpoint of their subsequent professional activity. At the same time, the development of such competencies requires students to study and understand the basics of medical biophysics, which leads to an increase in the total number of academic hours of teaching this discipline in the curriculum. This often leads to the introduction of additional disciplines into the curriculum, such as Medical Diagnostics, designed to teach future doctors in-depth knowledge in the field of the theory of the functioning of the human body and the practical use of individual devices to determine the characteristics of the state of their body at specific intervals [20-23]. In addition, in the process of studying this subject, students gain skills in the practical application of biophysics knowledge in the practical application of equipment for diagnostics and interpretation of the results obtained to determine the real state of the patient's health and methods of treatment of detected pathologies.

The synthesis of knowledge in the field of medical biophysics and the connection of this discipline with other related disciplines studied within the framework of the curriculum must be carried out in accordance with the logical principles of a holistic representation of the system of scientific concepts, within the framework of knowledge of a specific discipline. Synthesis can be applied when creating a qualitative model of the content of knowledge within a specific scientific discipline, through a modular approach in education [24-26].

The synthesis of biology and physics is carried out through the study of fundamental objects of cognition that are similar in nature and structure and is conducted in parallel along the line of articulation of individual scientific theories. The synthesis of individual disciplines as a sign of integrity is carried out in two main areas: through a comprehensive relationship between individual disciplines and through the harmonisation of the relationship between disciplines of a general scientific nature and highly specialised, fundamental, and applied spheres of scientific knowledge. The manifestation of synthesis between the disciplines of the curriculum is a methodological basis for the didactic synthesis of the content of biophysical education. Synthesised subjects form integral scientific areas of branch knowledge, thereby ensuring an overall increase in the level of integrity of natural science knowledge [27].

The steady improvement of the quality of modern higher medical education, provided that its fundamentality is maintained, is one of the main conditions for the qualitative modernisation of the system of modern higher education. The various approaches used by researchers when considering the development of methods of teaching medical biophysics have something in common with the awareness of the urgent need for a unified understanding of the quality of higher education in terms of the quality of reflection in it of fundamental scientific disciplines. In this context, the content of modern higher professional medical education implies the need to pay great attention to the development of a unified understanding of the existing system of knowledge about the structure of a living organism, as a single integral system capable of autonomous operation. The integration of scientific knowledge, which has taken place in various forms over the past few decades, has led to the development of a wide variety of synthetic disciplines that combine the fullness of scientific views inherent in various individual disciplines. Biophysics is one of such sciences formed by the direct merger of two basic scientific disciplines (in this case biology and physics) [28]. Moreover, this discipline has deep traditions, but it received its main development only

in the last century, gradually gaining a worthy place in the general system of natural science scientific disciplines.

A consistent consideration of the methodological foundations of the synthesis of biology and physics within the educational space of a modern higher medical educational institution leads to an understanding of the fact that modern professional medical education includes a number of trends that determine the synthesis of the content of this education. These include the personal interest of the student in the high quality of the professional knowledge they receive, the public interest in training specialists in the field of medicine with high professional qualifications, and the humanisation of the entire process of higher medical education, with the development of an individual approach to teaching students [29-31]. An individual approach in the modern system of higher medical education is not applicable in all situations, however, in combination with a competently built teaching model and the personal interest of the students themselves in obtaining high results in training, it is possible to achieve high results in terms of forming a high level of professional competencies of future doctors.

The foundations of the didactic synthesis of biology and physics in the system of modern higher professional medical education are: ideas about the integrity of a living organism as an object of cognition of medical students, the interaction of scientific approaches to the issues of cognition of the vital activity of a living organism, peculiar to biology and physics as separate scientific disciplines, and the historical context of interaction and interpenetration of biology and physics in the process of professional training of a future specialist in the medical field. Subjective factors should be considered the ability of students to reflect the content of education at the level of combining the requirements of the labour market, social tasks and needs, and the qualifications of a medical specialist obtained in the process of studying at an educational institution.

The needs of students and social needs are fundamental factors in the development of an educational concept at the level of didactic synthesis of biology and physics. By themselves, the factors of scientific, fundamental education, and the quality of knowledge obtained by students in the medical biophysics course are the most important components of the development of professional competence of future graduates of higher medical educational institutions. At the same time, the professional orientation of medical education can be qualitatively implemented only through the maximum information saturation of the educational process, and through the direct activity of the pedagogical link of the educational institution, expressed in maintaining the quality of teaching medical biophysics at a high level and the introduction of an objective system for assessing students' knowledge at any stage of their training [32-36].

It is practically possible to implement the integrity of scientific knowledge in the modern education system simultaneously at several levels: synthesis of knowledge within a specific scientific discipline, connections between individual disciplines that make up the curriculum of an educational institution, and connections between these disciplines at the level of integrative connection.

The first of the presented types of integrity can be practically implemented through the synthesis of knowledge of an intra-subject nature that does not extend to related disciplines or a group of such. This can be the creation of special courses by connecting separate educational modules, the connection of which forms a single logic of cognition within a single discipline. The connections between specific scientific disciplines constitute the next level of integrity, and the consistent relationship of knowledge of individual scientific disciplines characterises the essence of such a relationship and the level of mutual penetration of these disciplines. In this context, integrity can be implemented as the definition of the main areas of this relationship and the statement of scientific facts, concepts and positions of scientific interest from the standpoint of the synthesis of two separate disciplines [37-39].

The highest level of integrity of perception of the principles of teaching biophysics as a major subject is to achieve the necessary level of integrative integrity, which is characterised by the most complete connection, interpenetration and interconnection, and the qualitative ordering of knowledge that make up the scientific baggage of any medical student. Moreover, considering the real needs of the student in terms of obtaining the necessary information from the standpoint of their subsequent professional self-realisation, and its qualitative assimilation, is put at the forefront in this context [40].

The training course of medical biophysics has its own structure, scientific logic, object and methods of scientific research. All these aspects make up the specifics of medical biophysics as an independent scientific discipline, and as a specialised scientific course, medical biophysics contributes to the creation of a fundamental knowledge base of the future doctor, through the creation of a knowledge system and their generalisation at the level of knowledge of the basics of the vital activity of living organisms in theoretical terms. At the heart of this process is the interrelation and interaction of biological concepts, and the reflection of the cognition of a naturalist engaged in cognitive activity.

Assessing the prospects of mastering the Biophysics course by medical students, it is necessary to highlight the principle of qualitative irreducibility as a methodological generalisation between ideas about various aspects of the physical activity of organisms and a number of biological patterns. The principles and laws of control of living matter are irreducible with specific physical interactions, which explain the appearance of such laws and principles. The essence lies in the discrepancy between the theoretical aspects of the interaction described by the laws of physics and mathematics, the real state of affairs in a living organism, which is often unpredictable. Thus, only a thorough study of the laws of physics and biology can be the key to mastering the principles of biophysics and the practical application of the acquired knowledge in the professional activity of a modern doctor who studied this discipline as the main one in a higher professional medical educational institution.

Conclusions

The conducted study of the basic principles of teaching medical biophysics as a principal subject in the system of

modern higher medical education led to the following conclusions.

The principles of teaching medical biophysics as one of the main disciplines of the curriculum of modern higher educational institutions of Kazakhstan are based on the fundamental aspects of the synthesis of biology and physics as the principal subjects of the system of training future medical specialists. Consistent consideration of these principles in the preparation of the curriculum involves consideration of biophysics as a discipline that synthesises the fundamental principles of biology and physics and is in close relationship with other specialised disciplines that make up the training programme for future doctors. The development of competencies of future specialists in the medical field presupposes the need for consistent study of disciplines in direct relationship with biophysics, complementing each other in the context of their consistent presentation within the curriculum. As a rule, physics is not perceived by students of medical specialities of universities as one of the core disciplines, the study of which is necessary for the qualitative mastery of the profession, which cannot be said about biology. In the process of drawing up the curriculum, it is necessary to emphasise the existence of a clear relationship between a number of scientific concepts of physics and biology, which are important from the standpoint of the synthesis of the two sciences and the establishment of medical biophysics as an independent scientific area, synthesising the principles of these two disciplines. Thus, it can be stated that the principles of teaching medical biophysics as one of the major subjects of the higher medical education programme are a reflection of the set of principles of the programme presentation of a number of related disciplines, which together determine the necessary level of knowledge of a student of the medical department of a modern university of Kazakhstan, faced with the need to form the proper level of competence, which is required for the qualitative implementation of their professional duties as a doctor already during the period of independent professional activity.

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Conflict of Interest

None.

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Принципи викладання медичної біофізики як профільної дисципліни

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Анотація

Актуальність. Актуальність дослідження обумовлена необхідністю формування чітких принципів викладання медичної біофізики студентам з урахуванням основних особливостей викладання біології та суміжних дисциплін у вищих навчальних закладах Казахстану на сучасному етапі.

Мета. Метою даного дослідження є вивчення основних принципів викладання медичної біофізики за професійно-орієнтованими напрямами в системі вищих навчальних закладів Республіки Казахстан, виявлення подібних тенденцій викладання та формування оцінки загальної ефективності викладання даної дисципліни в системі навчальних закладів, що розглядаються.

Методологія. Основою методологічного підходу в даному дослідженні є поєднання системного аналізу методологічних основ поєднання принципів викладання біології та фізики в сучасному вищому навчальному закладі з аналітичним дослідженням основних аспектів викладання медичної біофізики як профілюючої дисципліни ряду сучасних вищих навчальних закладів.

Результати. Отримані результати є наочною демонстрацією важливості якісного вивчення медичної біофізики у вищих навчальних закладах Казахстану для формування у студентів компетентностей, необхідних для їх подальшої професійної діяльності.

Висновки. Отримані результати та сформульовані на їх основі висновки мають важливе значення для студентів медичних факультетів університетів Казахстану, які вивчають медичну біофізику як основний предмет загальної програми підготовки, а також для представників професорсько-викладацького складу цих навчальних закладів, які за родом своєї професійної діяльності стикаються з необхідністю пошуку та практичної реалізації ефективних принципів викладання цього предмета в межах вимог університетської навчальної програми.

Ключові слова: біологія; фізика; профільна медична освіта; профільне навчання; синтез біології та фізики.