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Forming professional thinking among future doctors while teaching physics

Abstract. The given article deals with the issue of forming professional thinking (particularly medical judgment) among future doctors. The significance of medical judgment for the professional development of doctors was noted by the founders of clinical medicine I.P. Pavlov, S.P. Botkin and G.A. Zakharyin and it remains relevant nowadays. Realizing the given necessity, the authors see the goal of their research in developing methods of teaching physics aimed at forming professional thinking. To achieve the intended goal by applying the well-known scientific-methodological approaches the authors consistently solve a number of research tasks: (1) specify the nomenclature; (2) develop the theoretical basis of forming methods of teaching physics to future doctors by using the existing algorithms, stages of professional activity of a doctor, regulations and principles of situational approach, as well as case studies; (3) implement the created model of the methods and test its efficiency applying the apparatus of mathematical statistics. Thus, while solving the first task of the research, an “operational” definition of a notion “medical judgement” was formed and it allowed to define the general strategy of the research. The result of solving the second research task was a model of the methods of teaching physics to future doctors that includes the invariant components (goals, contents, forms of education and types of control), the novelty of which lies in their forming (selection, formulation) based on doctor’s activity. For the implementation of the given methods the authors create (select) special didactic means – situational tasks, cases that allow actualizing and forming element of medical judgement (analysis, synthesis, modeling, abstract thinking, identifying the cause-and-effect relationship). The model of methods of teaching physics was implemented in the practice of teaching physics to students of medical universities. The estimation of its efficiency was implemented with the application of G-sign test and the expert evaluation method. The obtained results testify to the positive effect in forming medical judgement among future doctors while applying the given model.

Keywords: professional thinking; teaching physics to future doctors; preparation for the professional activity of medical university students

Introduction

It is well-known that the presence of a doctor's medical judgment is one of the indicators of his professionalism. Thus, according to the opinion of famous Russian clinicians M. Mudrov, I. Pavlov, S. Botkin, G. Zakharyin and others, a doctor is an expert in his field and alongside with a distinct innovative style of activity and rich professional experience he has a special type of professional thinking, the so-called medical judgment. Generalizing the experience of predecessors in the field of medicine, pedagogic psychology we can say that medical judgment as thinking upon the whole is a "socially conditioned inseparably associated with speech psychological process of independent search and discovery of the substance by a person, i.e. a process of an intermediated and a generalized reflection of reality in the form of analysis and synthesis that appeared on the basis of practical activity from knowledge of acquaintance".

This function of cerebrospinal system is manifested only in cases when a person is faced with a new task where stereotypical actions aren't enough and a new way of solving this task should be found. Speaking of medicine, the given type of mental process goes through a number of consecutive stages: comparison, when a similarity between the phenomena is revealed. Then follows analysis, that is defining separate symptoms of a disease and their assessment. Synthesis allows to reveal the interconnection of separate manifestations of a disease on the basis of theoretical knowledge. The next mental process, abstracting, is aimed at defining the characteristics significant for a certain medical case and the connection of these characteristics with each other while distracting from the insignificant manifestations of the disease. And at last, there comes the generalization stage, as result of which all the characteristics of pathology (at the identified pathogenic basis) are united into a single entity and a notion as a specific disease entity is formed.

Thus, general laws of thinking are applied to medical practice while as if transforming into the so-called "medical judgment" that excludes the randomness of a thinking process and leads to establishing the correct diagnosis, and therefore to adequate treatment. Now we get the answer to the question that is often asked: are there specific types of thinking? It appears that there are. In view of common for all the people brain cognitive function its character differs depending on the profession in which it is implemented. Specific nature of "medical judgment" first of all lies in the fact that a doctor works with sick people, who have their own world outlook, their temper and habits. It is not merely a meeting of a doctor and a patient. It is an event that isn't noticed: a doctor's psyche comes in contact with a patient's psyche. And here apart from professional actions on diagnostic and treatment, it is necessary to work out the form of communication, that would facilitate those actions.

Besides, taking into consideration the fact that it is necessary to discourse of some issue only with the application of theoretical knowledge, it is possible to talk about theoretical thinking. At the same time on these bases, thinking practically, a doctor develops a strategy of distant search and the best option of helping the patient. It turns out that "medical judgment" is a unity of its theoretical and practical elements.

Research Focus

There is no doubt that it is early to mention the presence of medical judgment among medical university students of the first and the second years of study. At the given stage only a base for studying medical disciplines is created, where students step by step guided by their teachers, accumulating knowledge and experience, form their opportunities in the future. After all it is the present (forming

the ability of medical judgment) that defines the future (ability to establish a diagnosis correctly). Thus, teaching academic disciplines must be implemented from the viewpoint of theoretical knowledge base as well as from forming elements of medical judgment.

One of the academic disciplines in a medical university is traditionally a course of physics (medical physics, biophysics) and nowadays there are many works by researchers – educators devoted to the issues of teaching physics to medical university students. Analyzing these works we established that there are the following unrevealed issues:

Research Aim and Research Issues

Thus, the goal of our research was developing original methods of teaching physics to future doctors. Application of these methods would allow forming elements of medical judgment among medical university students. For the implementation of the given goal we sequentially solved the following tasks: (1) specifying the content of the term, “medical judgment” and singling out elements (it is reasonable to form their content while teaching physics); (2) develop a model of methods of teaching physics to students of medical universities; (3) introduce it into the educational process and estimate the efficiency using methods of mathematical statistics.

Research Methodology

General Background

Various well-known scientific-research methods were applied for solving each of the research tasks. Thus, for solving the first research tasks the following methods were used: comparative analysis, generalization and classification of the obtained results, simulation and idealization. A monitoring (lesson observation) of students and teachers of specialized departments was implemented at the stage of introducing the developed methods. The efficiency evaluation of methods of teaching physics was implemented by methods quantitative and qualitative analysis. The experiment was participated by 30 employees of physics departments with work experience from 2 to 15 years, holding positions of assistants, head teachers, associate professors and professors, as well as over 400 students of the 1st and the 2nd year.

Instrument and Procedures

Initially we regarded important to make sure that before the experiment students of control and experimental groups have the same level of knowledge of physics and that they in equal measure possess or don't possess mental activity (analysis, synthesis, abstract thinking, identification of cause-effect relations). For this we organized special tests evaluated on a five-grade scale (table. 1).

Table 1

Distribution of frequencies for the experimental and control groups. P

Grades	Experimental group	Control group	Σ
2	88	96	184
3	120	125	245
4	182	180	365
5	30	36	66
Σ	430	430	840

Evaluating the empiric value χ_{emp}^2 – criterion ($\chi_{emp}^2 = 0,88$) obtained as a result of calculation, when the number of degrees of freedom equals 2 and χ_{crit}^2 defined according to statistic tables

($\chi_{\text{emp}}^2 = 5,99$ at $p \leq 0,05$), we came to a conclusion that students of experimental and control groups have the same level of preparation ($\chi_{\text{emp}}^2 = 0,88 < 5,99$), i.e. it can be considered that groups don't differ from each other.

G-sign test was calculated for the evaluation of the results authenticity. It allows to prove that the introduction of the developed methods has positive effects, while for the quality analysis of the developed didactic means method of expert assessments was applied.

Research Results

We successively reveal the solution and the results of each of the research tasks. Solving the first research task and specifying the notion "medical judgment" considered the analysis of the possible approaches to forming the given notion, developed in the practice of doctors' training and the practical experience of famous clinicians. As a rule, the content base of the notion "medical judgment" is the approach that relies upon the consideration (description) of practical activity of outstanding clinicians with patients. G. Zakjarian is considered to be the founder of clinical pedagogics. He believed that the goal of medical education was training educated, independently thinking doctors that possess medical judgment. G. Zakjarian introduced changes into the system of higher medical education, improved the training of practice doctors and introduced the notion "medical judgment" into the medicine. It is necessary to note that the content of the given notion was revealed on the basis of the task-oriented analysis of a doctor's practical situations on developing measures of prevention of forming inconvertible medical conditions as well as on the analysis of professional tasks aimed at the development of medicine as a labor area. The disadvantages of this approach include understanding the term "medical judgment" as an archetypical image of a doctor endowed with infinite wisdom and capturing a person's dreams [1]. Thus, for example, elements of specifically personalized, strictly individual character are always present in the "medical judgment". Moreover, the manifestation and implementation of personal origin acts as a strictly qualitative indicator of thinking [2].

Still, in spite of its advantages, to our mind the given approach has currently lost its relevancy according to the following reason: (1) huge range of clinical situations in the professional activity of a doctor; (2) the need to apply the results of usage of evidence-based medicine. Nowadays evidence-based medicine represents an integral part of the system of medical knowledge and is the most important base for clinical practice bringing its own editions into the content of a doctor's medical judgment [3].

Besides, there exists an approach in the formation of the term "medical judgment" based on the incredible intuitive ability of a clinician. For example, Yu. Abaev [4] in his research points out the special role of intuition in establishing the diagnosis as well as forming diagnostic thinking and medical judgment. The author thinks that the "first form of a doctor's diagnostic thinking was intuition. Intuition is an unconscious mind that gives knowledge avoiding reasoning and speculations, immediate understanding or realization without rational thinking" [5, p. 127]. Supporters of the given approach T. Novikova, O. Vorobeichikova [6] consider that "medical judgment" is defined as a doctor's ability to "embrace the entire clinical picture as something integral intuitively as if with inner sight and link it to the similar earlier observations. Medical judgment allows an experienced doctor to diagnose some diseases merely by the outer appearance of a person, especially characteristics of a sick person, without getting acquainted with the medical background and the following examination" [6, p. 19]. After all, to our mind intuitive approach to "medical judgment" isn't always concretized and doesn't always have strict frameworks, which in turn caused a lot of controversies.

In the given work we revealed far from all the possible approaches to understanding "medical judgment". Unfortunately, generalization of these approaches doesn't let us develop a theoretical concept of the research: its content and structure remain unrevealed, there is no analysis of the system

of characteristics and principles of medical style of judgment, ways and means of forming bases of medical style of judgment as a unity haven't been developed.

For revealing the conceptual idea of our research, it is necessary to formulate the so-called tentative definition. With this in mind we applied the rules of forming the definitions of notions formulated in the science "Logics". Thus, according to Aristotle's rules the following should be reflected in the definitions of notions: (1) genius of the notion; (2) "specific features distinguishing the notion from the number of similar notions"; (3) features peculiar to "all the things of the given class, that aren't among the specific features, but that can be inferred from them" [7]. The given rules allowed us to formulate the tentative definition on the basis of analysis of a great number of definitions of the notion "medical judgment": medical judgment is the thinking aimed at solving professional tasks of a clinician (medical, medical and preventive, scientific-research), the goal of which is revealing signs of disease from the initial syncretic form of ailment and defining their specific relations in the biosocial and spiritual context, which shows the individual clinical picture of the disease.

According to the definition of "medical judgment", it is possible to make a conclusion on the main stages of thinking that characterize it as medical judgment. The stage "creating the initial syncretic form of ailment" corresponds to the type of activity on the comparison of the given data on the disease with the healthy image; "revealing signs" corresponds to the differentiating, analysis, synthesis; while "defining specific relations" corresponds to the individualization of the disease as an object of the research.

There is no doubt that it is impossible to form medical judgment on a full scale while studying academic disciplines. However, we are convinced that it is possible and reasonable to form its elements at teaching physics by preparing students to a doctor's practical activity. The given theoretical concept allowed us to develop a model of methods of teaching physics aimed at forming elements of medical judgment among students (fig. 1). The models includes traditional elements: (1) goals of the first level setting the global strategy of teaching physics to students of medical universities; (2) goals of the second level that particularize a student's and a doctor's activity at the lessons of physics; (3) the content of educational material and the content of activity of the participants of learning process; (4) forms of interaction of a teacher and students; (5) didactic means for the organization of learning activity and control.

We should additionally mention the peculiarities of the model of teaching physics to medical university students, developed by us:

I. The fundamental theoretical base of the methods is first of all a doctor's activity, particularly its structural components. Thus, a doctor while interacting with a patient finds himself in a situation of choice, open situation [8], the following algorithm may be considered the generalized scheme of solving the given problem situation [9; 10].

1. Acknowledging the problem:

- a) problem origin;
- b) understanding of the present factors;
- c) formulating the issue.

2. Solving the problem:

- a) developing a hypothesis;
- b) developing a solution;
- c) disclosing a principle;
- d) working out a judgment that fixes the solution.

3. Assessing the solution.

A doctor's activity is determinative for forming the content of education and the activity of a teacher and students. It is also a base for developing requirements to didactic means of teaching physics to future doctors.

II. The structure of the theoretical basis includes situational approach and case study that are well-known in pedagogics. As is shown by literature analysis, the given pedagogic technologies are seldom used for teaching physics to students of medical universities. However, their application for teaching clinical specialties proves their efficiency. That is why we chose situational approach and case study as the theoretical basis for the model of the methods of teaching physics to students of medical universities.

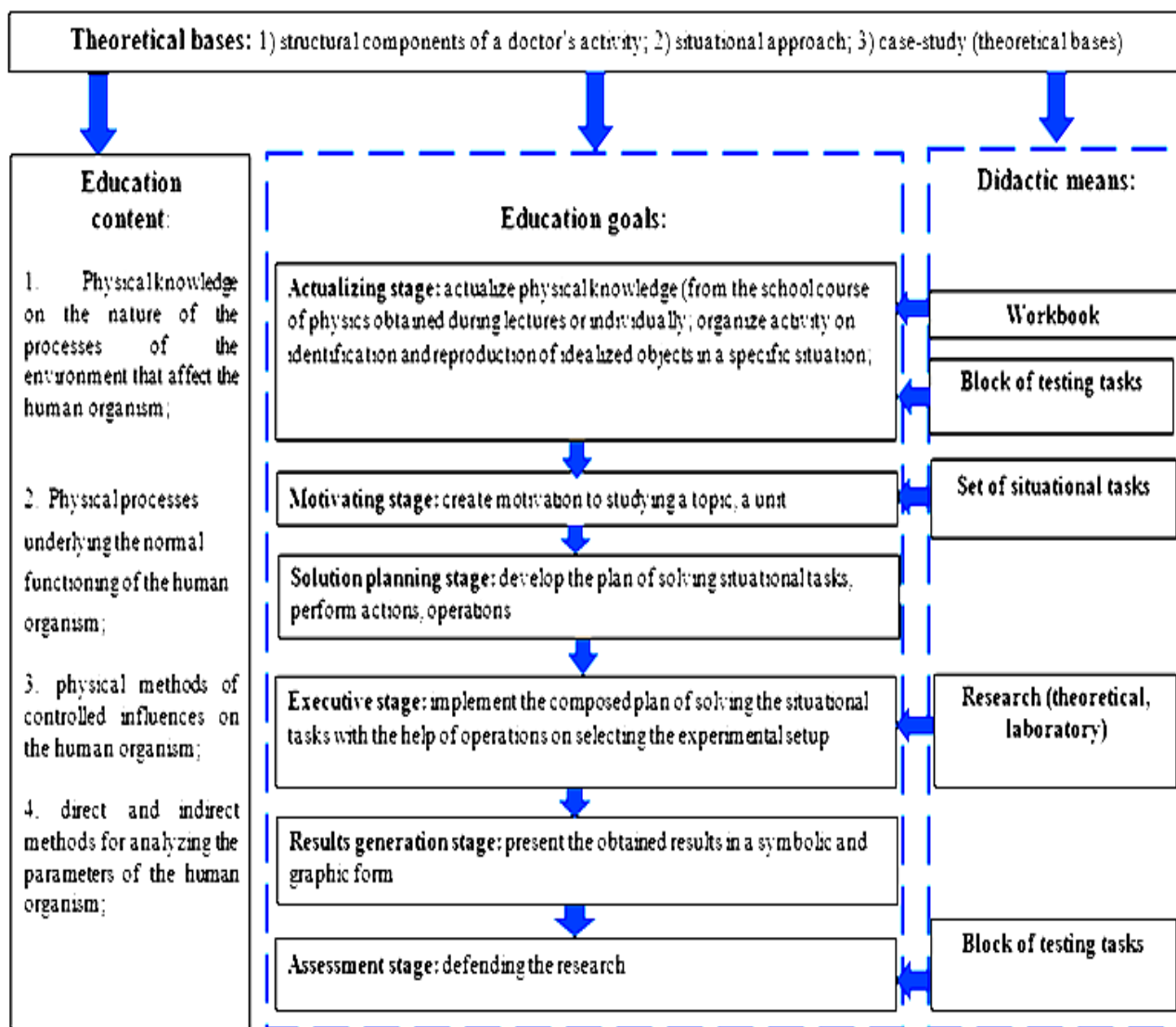


Figure 1. Model of teaching physics to medical university students aimed at forming medical judgment

III. For the organization of each stage of the methods, special didactic means for teaching physics in the form of situational tasks were developed. Different types of activity are organized with the help of these tasks. Speaking of situational tasks as of didactic means of teaching physics, it is necessary to note that teachers of special departments have particular difficulties while creating situational tasks. Thus, the results of questionnaire survey of physics teachers of medical universities allow to speak about difficulties: (1) in choosing theoretical material according to timelessness,

fundamentality, understandability (68 % of the respondents); (2) in establishing intersubject communications, physics and clinical specialties (48 % of the respondents); in developing (composing) a model of professional task, solving of which lies in the area of physical knowledge (52,3 % of the respondents). Moreover, the analysis of the present didactic means of teaching physics to future doctors, showed an extremely insignificant base of situational tasks composed by the authors of a number of works and allowing to apply them at physics lessons.

Therefore, we initially analyzed situational tasks of the 2019 examinational base presented for the accreditation of medical field specialists. It was determined that most of the tasks are aimed at the reasoned diagnosis establishing, option of the methods of examination and diagnostics, as well as to the interpretation of its result. Understanding the fact that hardly all the activity of a doctor may be reflected in the situational tasks that are offered to medical university graduates during the accreditation and registered in the case management records, we held a poll of the practicing doctors with different work experience and professional specialization. The obtained results were generalized and classified (tab. 1).

Table 1

Classification of the types of situational models

#	Type of a situational model	Characteristics of this phenomenon (basis of the classification)	Prevailing factors in the formation of the situation
1	Need	Lack of data for establishing the diagnosis	Identifying the need of additional examination
		Lack of means for prescribing treatment	Applying analogue means
2	Option	The need to choose one of several alternatives while implementing goals on establishing the diagnosis, choosing the treatment method, etc.	Establishing diagnosis according to the given data, choosing the treatment method
3	Crisis	Condition at which means and methods used while treating become inadequate and as a result, there happens an unpredictable situation and problems conditioned by external factors	External interference (patient's self-treatment, refusal from the therapy measures protocol) Treatment at misdiagnosis Discrepancy to the stage of the disease progress
4	Conflict	The most subtle way of solving contradictions in interests, goals, views that appear in the processes of treatment prevention. It consists of the counteraction of the conflict participants and the accompanying negative emotions	An emotionally loaded type of a situational model that is used for the consideration of problem situations that appear while holding preventive measures of vaccination, impossibility of medical intervention because of religious views or other types of beliefs
5	Fight	A confrontation of a doctor and a patient that happens in the process of medical protocol, with the application of a specific ways for maintaining one's opinion	The same as in point 4 as well as attracting proof of one's own opinion on a matter of argument
6	Innovation	Innovations that fundamentally change methods of maintaining medical protocol	Introduction of a new element and the analysis of its influence on the constituent parts of the process

Thus, for example, module "Option" presupposes that a professional situation where a doctor finds himself is a situation with lack of information. It may be filled from the variety of alternatives ($\sum X$ is the sum of treatment means, $\sum Y$ is a sum of diagnostic methods alternatives) establishing the cause-effect relations between the element of the alternative (x_i is an element of a variety of similar treatment means, while y_i is an element of a variety of diagnostics methods) and the situation as a whole estimating the efficiency, optimality and reasonability according to the conditions of a professional situation (fig. 2).

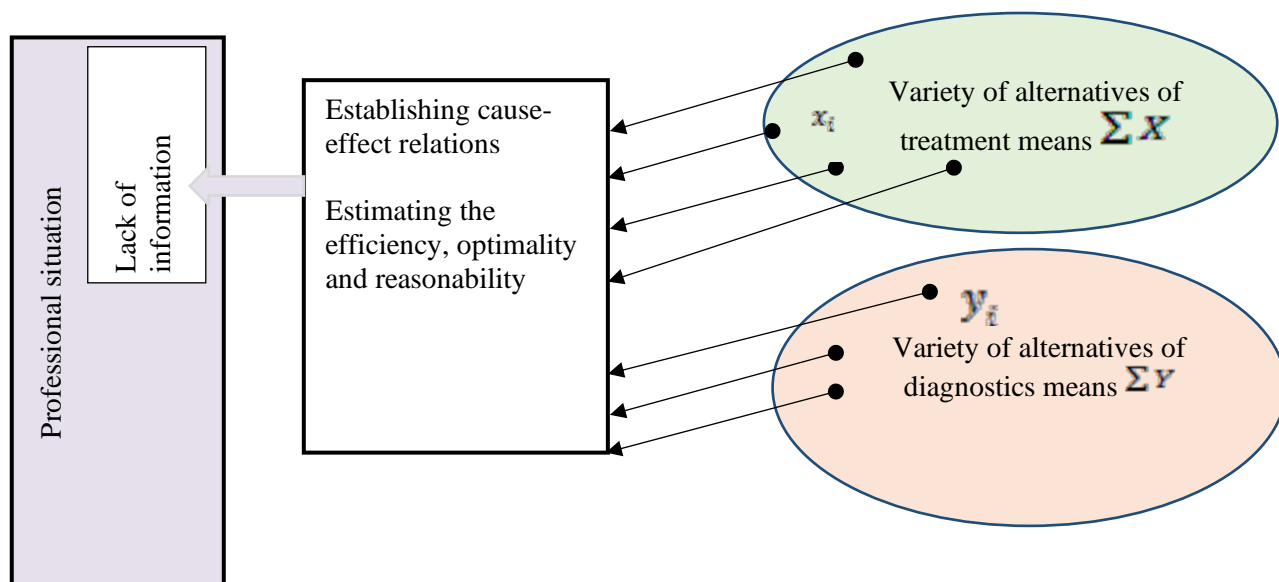


Figure 2. Model of a professional situation “Option”

Thus, we reveal models of professional situations and their constructive components which allowed furthermore to design (develop, select) situational tasks as didactic means of teaching physics to future doctors. The didactic means formed this way: (1) have a vividly expressed motivational potential in consequence of its connection with the future professional activity of a doctor; (2) helpful in solving in consequence of the teacher’s awareness on the initial level of knowledge of the students; (3) have the terminology and reference material of professional and general professional disciplines; (4) have parameters of a person that characterize him as a system in a normal condition.

Results of solving the third research task was the introduction of the developed model of methods of teaching physics to future doctors aimed at forming elements of diagnostic activity of a doctor, estimating its efficiency. The introduction was implemented on the bases of Astrakhan state medical academy. The efficiency estimation was implemented in two main directions: in the accumulation of quantitative and qualitative data. Thus, quantitative data (fig. 3) reflected the information on the number of students correct/incorrect: 1 – those who solved the situational task using physical knowledge; 2 – those who defined and justified actions on solving a situational task; 3 – those who defined the necessary and sufficient features in situations that simulate professional activity; 4 – those who performed tasks on establishing cause-effect relations between physics and medicine.

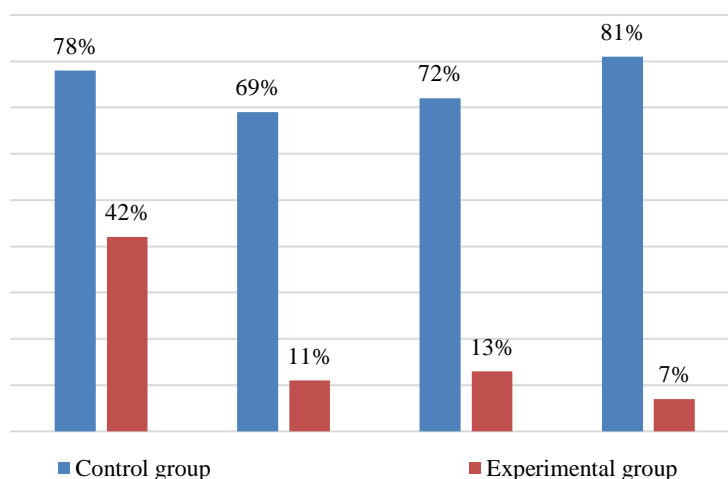


Figure 3. Results of qualitative analysis

G-sign test was calculated for the estimation of the results authenticity. It allows to prove that the introduction of the methods that we developed, has positive effects on the indicators that we selected. Statistical hypotheses were formulated in the following way:

1. H_0 : changing the selected factors in a positive direction in the experimental group is not accidental; H_1 – alternative hypothesis.
2. H_0 : changing the selected factors in a positive direction in the experimental group is accidental; H_1 – alternative hypothesis.

Qualitative data on the empiric value G_{emp} -criterion and critical G_{cr} -criterion for each indicator are presented in table 2.

Table 2

G-sign tests values for the experimental and control groups

G-criterion ($p \leq 0,05$)	1	2	3	4
Experimental group				
G_{emp} -criterion	12	54	35	67
G_{cr} -criterion	78	78	64	87
Control group				
G_{emp} -criterion	148	176	154	104
G_{cr} -criterion	133	106	83	93

1 – those who solved the situational task using physical knowledge; 2 – those who defined and justified actions on solving a situational task; 3 – those who defined the necessary and sufficient features in situations that simulate professional activity; 4 – those who performed tasks on establishing cause-effect relations between physics and medicine

During the comparison of the results it was noted that in two other groups there is a typical shift towards positive changes, however, for the experimental group $G_{emp} < G_{cr}$, which indicates validity of the hypothesis H_1 . Therefore, for the control group $G_{emp} > G_{cr}$, hypothesis H_0 is accepted. Thus, while comparing the results, it can be seen that the changes in the experimental group are in fact authentic. This testifies to the fact that the developed methods of teaching physics to medical university students aimed at forming diagnostic activity among future doctors, is effective.

We implemented the qualitative evaluation in relation to the developed didactic means in the form of thematic laboratory practice as a set of situational tasks of a different level of complexity. For this we used method of expert assessments. It is well-known that a group of experts must include specialists in the given subject area, but we thought it necessary to take into account the opinions of medical students as well. For two groups of experts (the teaching staff of physics departments of medical universities and students) special questionnaires were created, where the participants were to estimate the significance of the suggested statements according to a five-grade scale. After that the answers were ranged and a concordance coefficient (W) was calculated, that indicated the coherence of experts. For the expert group of teachers, the concordance coefficient $W = 0,87$ (χ^2 calculated 76,89 > table (54,1275)), for the group of students $W = 0,92$ (χ^2 calculated 85,63 > table (67,4657)) shows a high level of experts coherence of opinions on the efficiency of the didactic means of teaching physics in the form of situational tasks developed by us.

Discussion of the results

In the course of our research while discussing with experienced clinicians the possibility of forming medical judgment among future doctors while teaching physics, we noted a skeptical point of view. Most practicing doctors are of opinion that medical judgment is in a greater extent formed by a process conditioned by a doctor's intuition and his many years of experience. Still, they noted the importance of such constituents of medical judgment as analyzing, that is finding cause-effect relations

between symptoms, results of diagnostic examination and final diagnosis. Undoubtedly, a medical university graduate will acquire medical judgment in its full understanding, by solving many clinical cases and only the long-term experience will allow to master this type of thinking through trial and error, but there is a patient's life behind each of these errors. That is why in our opinion it is extremely to prepare a future doctor within the walls of the university, including while teaching physics. The structure of medical judgment is complicated, but it is possible and reasonable to form its elements at the lessons of physics.

Thus, to our mind methods of teaching physics to future doctors developed by us allows to include physics as an academic discipline in the system of medical personnel training to professional activity as its active participants. The process of teaching is re-oriented from static knowledge to their application in professionally significant situations.

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Формирование профессионального мышления будущих врачей при обучении физике

Аннотация. В данной статье рассматривается проблема формирования у будущих врачей профессионального мышления, в частности клинического мышления. Значимость клинического мышления для профессионального становления врачей отмечалась еще основателями клинической медицины И.П. Павловым, С.П. Боткиным, Г.А. Захарьиным и остается актуальной и сегодня. Понимая данную необходимость, авторы видят целью своего исследования разработать методику обучения физике, направленную на формирование профессионального мышления. Для достижения поставленной цели, применяя известные научно-методологические подходы и методы, авторы последовательно решают ряд исследовательских задач: (1) уточняют терминологический аппарат; (2) разрабатывают теоретическую основу построения методики обучения физике будущих врачей, используя известные алгоритмы, этапы профессиональной деятельности врача, положения и принципы ситуационного подхода и кейс-стади; (3) внедряют созданную модель методики и проверяют ее эффективность, применяя аппарат математической статистики. Так, при решении первой задачи исследования было сформулировано «рабочее» определение понятия «клиническое мышление», которое позволило определить общую стратегию исследования. Результатом решения второй задачи исследования стала модель методики обучения физике будущих врачей, которая включает в себя инвариантные компоненты (цели, содержание, формы обучения и виды контроля), новизной которых является их формирование (выбор, формулирование), основанное на деятельности врача. Для реализации данной методики авторами создаются (подбираются) специальные дидактические средства – ситуационные задачи, кейсы, позволяющие актуализировать, формировать элементы клинического мышления (анализ, синтез, моделирование, абстрактное мышление, выявление причинно-следственных связей). Модель методики обучения физике была внедрена в практику обучения студентов медицинских вузов физике. Оценка ее эффективности осуществлялась с применением G-критерия знаков и методом экспертных оценок. Полученные результаты свидетельствуют о полученном положительном эффекте в формировании клинического мышления у будущих врачей при ее внедрении.

Ключевые слова: профессиональное мышление; обучение будущих врачей физике; подготовка к профессиональной деятельности студента медицинского вуза

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