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Assessment of the Model of Formation of Professional Competence in the Learning Process of Medical Physics

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In modern pedagogical theory and in the practice of training future medical specialists, there is a contradiction between the need to develop a qualitatively new meth-odological system for teaching medical physics bachelors and insufficient the development of scientific and methodological support for the process of mastering the course of medical physics. The purpose of the study is to develop a model for the formation of professional competence of future medical specialists in the process of teaching medical physics and its testing. To achieve the goal of the study, we applied such methods of theoretical research as analysis and synthesis of scientific and pedagogical, methodical literature, modeling the methodological training system in medical physics, conducting a pedagogical experiment, analysis and processing of the results of the experiment. The article presents a model of the methodological sys-tem and the results of checking the effectiveness of the model, the content of the didactic conditions, the corresponding training technology.

Keywords: training, medical physics, professional competence, practical work, model

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INTRODUCTION

The development of modern medicine is largely due to the implementation of the achievements of the exact sciences, in particular, medical physics. This is due to the fact that modern methods of diagnosis, treatment and prevention of diseases are based on physical laws. A qualitative approach (Han et al., 2019) in medicine without quantitative measurements and processing of results has practically become obsolete and does not provide sufficient information about the processes and phenomena studied, and quantitative measurements are impossible without the use of modern medical equipment and electronic computer technology. In preparing future medical specialists, it is necessary to form professional competencies in them that will allow them to act competently, meaningfully, to carry out analytical, research activities and implement a systematic approach to solving professional problems. Moreover, the formation of professional competencies of a modern medical specialist should be carried out in the study of disciplines of various cycles, including the natural science cycle.

Relevance of the study

Today, the urgent task of not only Kazakh, but also world education is to improve the quality of education, both general and professional. To solve this problem, the goals and results of education are rethought, its content is changing and the concept of "professional competence" is increasingly used (Valica & Rohn,2013), which includes such concepts as "qualification", "professionalism", "professional readiness", etc. In Kazakhstan, the concept of "professional competence" has become firmly in use with the link to higher education reforms. According to the concept of modernization of Kazakh education, the main goal of vocational education is to prepare a qualified employee who can compete in the labor market, freely owns his profession, who effectively does his job, is free to navigate in related areas of his professional activity and is ready for continuous self-improvement in professional terms.

The ideas and research of psychologists of the second half of the 20th century changed the view on the processes of perception and the mechanisms of interaction between a professional and the surrounding professional and educational environments. They became a scientific platform for determining the mechanisms for creating and improving competence as the primary personal quality of a person in professional activities.

Despite the constant growth of publications devoted to the development of a competency-based approach in education (Hrich et al., 2019), the degree of development of this problem in the field of teaching natural sciences is not high. Until now, there are discrepancies in the concepts of "competence" and "competence", and there is also no single diagnostic system for the formation of certain competencies and the methodology for their formation. Despite a number of works devoted to the diagnosis of the formation of student competencies (Kaiser et al., 2015; Berestova et al., 2020), this issue is far from being resolved.

Analyzing the above, we can conclude that, despite a significant amount of research on the problem of introducing a competency-based approach in universities, there are contradictions between the need for future medical specialists who can solve new professional problems and the insufficiently developed system of preparation for their

solution. All of the above makes the topic of research relevant. The purpose of the study is to develop a model for the formation of professional competence of future medical specialists in the process of teaching medical physics and its testing.

LITERATURE REVIEW

The importance of tolerance as a professional competency acquires a special role in the formation of the educational system at a medical university. Competence is the quality of a person, which implies the possession of a certain competency, while competency itself is a combination of knowledge, skills, methods of activity, i.e. components of the content of education necessary for the effective implementation of activities in relation to a certain circle of objects and processes. The concept of competency includes not only the cognitive and operational-technological components, but also the motivational, ethical, social and behavioral, i.e. competence is always personally painted by the qualities of a particular person.

In 1984, the work of J. Raven, "Competence in Modern Society," was published in London. In this work, the author gives a detailed explanation of competence as a phenomenon consisting of "a large number of components, many of which are relatively independent of each other, while some components are more related to the cognitive sphere, while others are more sensitive, these components can replace each other in as components of effective behavior" (Raven, 2002). J. Raven identified 37 categories of competency relevant in modern practice.

Other researchers not only systematized the concept of competence, but emphasized that competence is the end result of training, and for different types of activity there are their own types of competence. In the works of L.J. Peter, competence is described as a condition that allows one to act. Competence is the ability and ability to perform a specific function. This is a method that leads to a certain result (Peter, 1990). The study of the foreign approach to competencies made it possible to single out its focus on determining the behavioral characteristics necessary for a person to successfully complete one or another activity. It is personal traits that are the decisive factor for success in the performance of tasks by the employee. And the competence that an employee possesses in a certain type of professional activity is the main behavioral characteristic that affects the achievement of efficiency in his work.

The need for continuous improvement of the professional competence of medical workers (Blömeke et al., 2015) is objectively determined by a number of social factors: environmentally unfavorable living conditions for people, which leads to the emergence of new diseases and an increase in morbidity, low valeological culture of people who care little about their health, the development of medicine and the emergence of new drugs, technologies, equipment, etc.

The key to understanding the learning process at a medical university is the concept of professional education, focused on the formation of students' professional competence and professional attitudes. Various forms and methods of forming professional competence are presented in the works (Mann, 2006; Hoth et al.,2016; Mayring, 2015) and others. Some problems of the formation of professional competence and readiness for the professional activities of medical specialists were investigated by N. Fernandez,

M. Whitecomb, U.Baizak, D. Bailey, H.Wijk, E.Khamitova and others (Fernandez et al., 2012; Berberat et al., 2019; Albanese et al., 2008; Baizak et al., 2015; Bailey, 2016; Wijk et al., 2019). In the publication (Ramankulov et all, 2019,2020; Ramankulov et al., 2016) discusses the formation of creativity of medical students by non-traditional methods, one of which is the creation of electronic textbooks. The study (S.Johnston, 2018) examines the issues of developing tolerance as professional competence in the process of training future doctors. And the work (Kalen et all, 2015; Nejad & Mahfoodh, 2019) examines the development of professional sustainability among students of medical universities.

The following works address the issues of the willingness of future doctors to use physical culture in their professional activities. So in the work, the process of formation of the skill of preventing morbidity by means of physical education and sports among future doctors is studied. And the work (Shektibayev et al, 2017; Sunarto et al., 2020) examines the problem of determining the organizational and pedagogical conditions for the formation of the readiness of pediatricians to implement physical culture products to maintain reproductive function in adolescent girls. The actualization of physical knowledge and the formation of professional skills in teaching medical physics to students of medical specialties is devoted to works (Martens et al., 2019).

The given analysis of literature sources on the problem of determining the professional competence of a teacher shows that professional competence is a complex characteristic that includes such elements as the possession of subject knowledge and personal qualities of a teacher.

Taking into account the above, we can offer our own formulation of professional competence of the teacher. Professional competence of a teacher is an integral characteristic of a teacher's personality, which includes all areas of pedagogical activity (possession of subject knowledge, technologies, methods and methods of teaching, the ability to expand and Supplement their knowledge, a set of personal characteristics), which form the teacher's readiness to solve professional tasks.

We have justified the choice of four main components of professional competence of future medical specialists:

- informational (the degree of understanding of the information used;)

- communication (degree of involvement in group work;)

- worldview(уровень самостоятельности в выполнении различных этапов работы;)

- organizational (statement of purpose; the level of complexity of the methods used;)

Despite the fact that the definition of professional competence is complex and ambiguous, the assessment of the level of competence formation is an even more complex task that requires more detailed consideration.

We will focus on the formation of knowledge and skills of a student of a medical university in the study of medical physics. Since the practical skills of a student are formed to a greater extent in special disciplines and clinical departments.

Focus Research

It should be noted that scientific research on the formation of professional competencies of medical students in the study of medical physics is absent, although studying the physical foundations of the methods of diagnosis, prevention and treatment of diseases undoubtedly contributes to the formation of a future medical specialist as a professional.

The results of a stating experimental study showed that 80% of the third and fourth year students of medical specialties surveyed believe that the formation of professional competencies occurs in the study of professional cycle disciplines, and medical physics at a medical university is a general scientific discipline and is not related to professional training.

An analysis of the workshops existing in medical universities showed that most of the practical work consists of work in general physics and a very small percentage of the work that would use a biological object, in particular, the human body and other biological objects would be included in the object field of research. The results of the ascertaining experiment also indicate a weak motivation of students to study medical physics at a medical university, and older students note that it is advisable for teachers to pay more attention to improving students 'research and development work and to include materials more often in class as additional measures to improve the quality of students' professional competencies. professional content.

Thus, there are contradictions:

- between the new modern requirements for the formation of professional competencies of students of medical specialties and the lack of a holistic methodology for their formation in the process of teaching medical physics at a medical university.

These contradictions determined the relevance and topic of the study: « Assessment of the Model of Formation of Professional Competence in the learning process of medical physics» the problem of which is to find the answer to the question of how to most effectively use the capabilities of medical physics to enhance motivation, enhance students' cognitive activity medical universities.

METHOD

To solve the tasks, a set of mutually complementary research methods was used: The steps of research and development in this research were adapted from Borg and Gall (1983) which consisted of: Preliminary Research and Collection of Information, Planning, Early Product Development, Expert Validation, First Revision, Early Trial, Second Revision, Field Test, Final Product Revision, Dissemination. In our study, two tests were performed.

The experimental base of the study was the International Kazakh-Turkish University named after H.A. Yassavi and Kazakh National Medical University named after S. D. Asfendiyarov.

As a rule, a pedagogical experiment consists of several stages: ascertaining, searching and teaching. The number of participants in the ascertaining stage was 600 students and

10 teachers, and the number of participants in the search and educational stage was 170 students, 6 teachers.

The planning stage includes activities

- to identify the essence, structure and features of the professional activity competence;

- to characterize and justify the concept and didactic potential and effectiveness of network communities in the formation of professional competence;

- to develop and justify a didactic model and based on it didactic system of professional competence formation through the Foundation of personal experience;

-determine the format of training, including training devices;

-to test Experimentally the effectiveness of the didactic system of professional competence formation

At the introductory lesson of the search and training phase, an entrance survey was conducted to determine the initial level of motivation and testing to determine the initial level of knowledge in physics of students of medical specialties. Moreover, the students after the input questionnaire and testing were divided into two groups: control (CG) and experimental (EG), the number of which was 85 people in each, and the groups consisted of students of different specialties.

At the initial stage, all students were asked to answer 10 questions, which are situational proposals, each of which is aimed at determining the level of development of one of the four components of professional competence: worldview, communication, organizational and informational, and professional competence in General.

Students of the EG and CG were offered tasks of I and II types. Tasks of type I are tasks for testing knowledge in medical physics and the corresponding contribution to the formation of professional competencies. Tasks of type II are tasks for testing knowledge in the professional field, obtained by performing practical work in medical physics. Note that in tasks of types I and II, the mastery of the physical method was also tested to determine the physical quantities that characterize a person or other biological object among students of a medical university.

In each type of assignment, 10 questions were formulated and for each correct answer the student received 1 point. Thus, the student, when answering questions of tasks of each type, received a result from 0 to 10 points.

The results of students completing tasks of type I and II are presented in Figures 2 and 3. The absentee points are given by students, the ordinate axis is the number of students who receive a certain number of points.

The reliability of the results and conclusions was also verified by us using the Kramer-Welch test. Checking the statistical hypothesis for a qualitatively determined the test was performed at the level of significance $\alpha=0.05$, the critical value of the Kramer-Welch test $T_{crit}=1.96$. We had two independent samples: the control group, which included all control classes, and the experimental group - experimental classes. We

compared the number of correctly solved tasks of students in the control and experimental groups when performing these tests and based on this assessed their level of competence. We have formulated two statistical hypotheses:

H0: no difference between the numbers of correctly solved problems in the control and experimental groups.

H1: there is a significant difference between the numbers of correctly solved problems in the control and experimental groups.

As a result, it turned out that:

Before the start of the training experiment, the empirical value of Temp is 00.7<<Tcrit. Therefore, the H0 hypothesis is accepted at a significance level of 0.05;

After the end of the training experiment, Temp = 5.7>>Tcrit, so the hypothesis H0 is accepted with a 95% confidence difference.

FINDINGS

The purpose and final results of the study of the discipline "Medical Physics"

Medical physics is one of the fundamental biological disciplines, which makes it possible, on the basis of a fruitful merger of the three sciences - physics, chemistry and biology, to understand the basics of life processes.

Knowledge of the laws of medical physics makes it possible to develop new methods of diagnosis and treatment. Currently, many physical methods are widely used in the diagnosis of various diseases, to elucidate the mechanism of action of drugs, for monitoring during treatment. Knowledge of the theoretical foundations of these methods is necessary for a conscious and objective interpretation of the data of clinical diagnostic and therapeutic measures. Diagnostic and therapeutic tactics of a doctor are largely dependent on data that can be obtained using instruments. The maximum efficiency of using various technical means in biomedical research can be achieved only when the researcher knows the physical basis of the device. The program is also aimed at developing students' scientific knowledge and practical skills on the use of modern medical equipment.

The volume of discipline and types of educational work:

Total loan amount: 3 credits

Total hours: 135 hours

Practical classes: 3 credits (45 hours)

IWST: 3 credits (45 hours)

IWS: 3 credits (45 hours)

The training course is aimed at developing the following competencies, according to the framework of the final results of training of graduates of medical specialties of the International Kazakh-Turkish University named after H.A.Yasavi.

Table 1
FinalResults of Training of Graduates

Knowledge level	Role competencies	Specific gravity
B.1.1	Scientist, researcher. application of knowledge: applies the knowledge of non-medical, biomedical, clinical, social and behavioral sciences in practice.	0,4
B.1.2	Scientist, researcher. information management: can formulate a research question, search for literature, critically evaluate literary sources, effectively present a presentation, own computer technologies.	0,3
B.3.1	Professional of its business. self-development: demonstrates the ability to continuous learning.	0,3

The purpose of the discipline: The formation of a scientific worldview and scientific methodology in medicine, as the theoretical basis of clinical, laboratory and functional research methods, molecular diagnostics and the use of modern technical means for medical research.

Learning Objective:

• Show the role of biophysics in biomedical research;

• Create a theoretical basis for biomedical and professional disciplines;

• Form the basis for the application of biophysical methods in biomedical, clinical, hygiene and epidemiological studies;

• To teach the use of physico-chemical laws to explain the processes taking place inhuman organisms;

• To form the ability of logical reasoning among students.

Table 2
The General Framework of the End Results of Training in the Curriculum

Level	Role competencies	Learning Outcomes
B.1.1	Research scientist. Application of knowledge.	Knowledge (cognitive) domain: Remembers: - biophysical processes taking place in the human body at the molecular and cellular level, positive and negative effects of physical factors on the human body; - physico-chemical structural features of membrane structures and the mechanisms of their functioning. Understands: - The theoretical basis of biophysics, the emergence and distribution of biopotentials; - biophysical mechanisms of transport of substances through the membrane, mechanisms of electrogenesis; - Einthoven theory, the basis of hemodynamics, the principle of photocolorimetry, spectrophotometry, etc., the mechanism of action of physical factors (electric current, EM fields, low frequency, high frequency, microwave currents); - biophysical laws of the cardiovascular system, muscle and respiratory systems. Applies: - Biophysical laws for determining the coefficient of surface tension, the concentration of a solution using a photocolorimeter. - safety regulations for laboratory work in biophysics.
B.1.2	Scientist, researcher. Information management.	Skills (psychomotor) domain: Accuracy: - organizes the main group of medical equipment and apparatus for the study of biological systems. - organizes computer technology for building diagrams, graphs, charts, presentations based on literary sources. Attitude / behavior (affective) domain:

		Empowerment: - Students on the topics of each lesson independently prepare diagrams, schedules, recognizing the importance of knowledge of medical biophysics for future doctors.
B.3.1	Professional of its business. self-development.	Attitude / behavior (affective) domain: Empowerment: - demonstrates the ability of knowledge obtained from previous information.

The structure and content of the model for the formation of professional competence of future medical specialists.

In order to form the professional competence of a future medical specialist in the process of teaching medical physics in this study, we developed a substantive-procedural model (Figure 1). A prerequisite for the formation of this model was the analysis of works devoted to the study of the theory and methodology of vocational education (Baizak, 2017).

The presented model consists of five main interconnected components: target, diagnostic, substantive, procedural and effective. The goal of our study, which is the development of students studying in the direction of preparation 5B130100- "General Medicine" and 5B130200- "Dentistry", acts as a system-forming element in our model.

The target component of the model is focused on identifying and formulating the goals of student learning. Thus, the target component of the given model is aimed at creating professional readiness, so that in the future the formed competencies will help the future medical specialist to implement the requirements of the state educational standard of basic education.

The substantial component of the model we developed is the content of education, which acts as a means of developing the professional competence of a future medical specialist. Normative documents, such as state standards and qualification requirements for the training of future medical specialists, are responsible for the content of education.

The next element of the model for the formation of professional readiness of a doctor is the procedural component. This component includes a didactic system aimed at the formation of the four components of professional competence: worldview, organizational, communicative, organizational.

The diagnostic component of the model is aimed at determining the level of professional competence at the initial and final stages of student learning using a diagnostic card. This map consists of 11 situational proposals, each of which is associated with one or two components of professional competence.

The final component of the presented model is effective. It examines the final development and dynamics of the student's professional competence after the verification experiment put forward in the study of the hypothesis, gives an analysis of the degree of formation of the components of the teacher's professional competence, and allows us to judge the further development of professional skills.

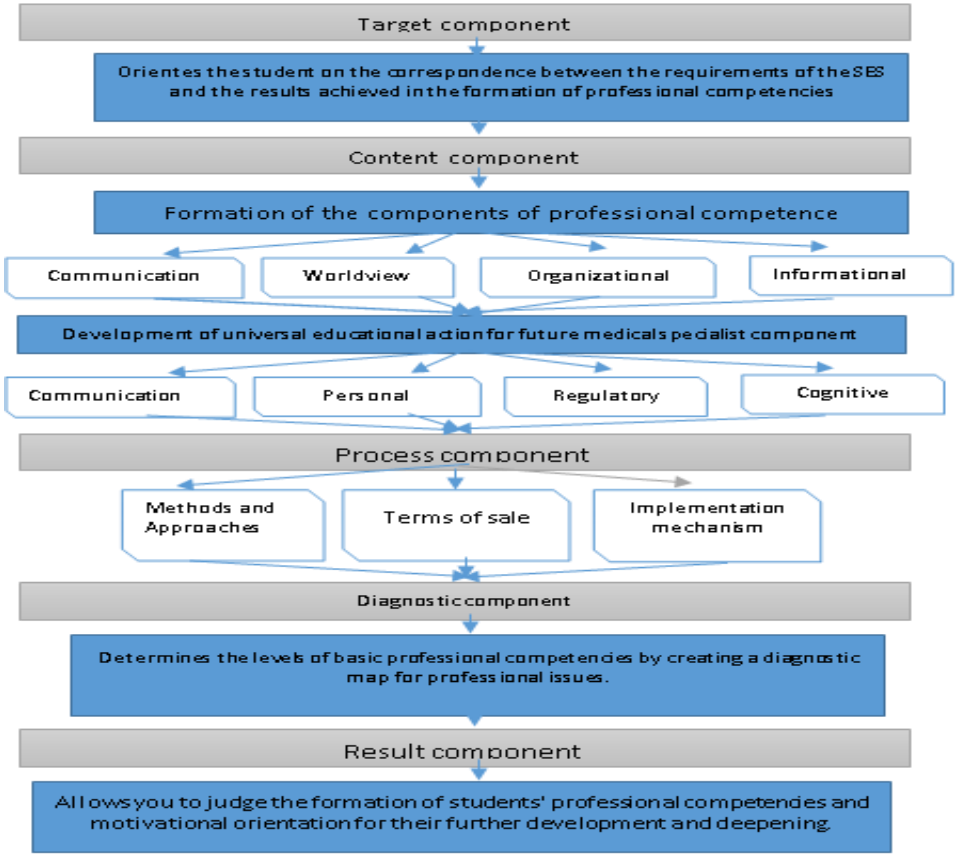

Figure 1
Model for the Formation of Professional Competence of Future Medical Specialists

Stages of formation and development of professional competence of future medical specialists.

We can distinguish the following sequence of formation and development of professional competencies among students:

Stage 1: assessment of the level of formation of the components of professional competence at the initial stage;

Stage 2: the development of the components of professional competence in the process of laboratory and practical work in the framework of the proposed didactic system;

Stage 3: assessment of the level of formation of the components of professional competence in students (after laboratory and practical work);

Stage 4: checking the effectiveness of the methodological knowledge and skills of students in practice in the formation and development of competence.

Didactic conditions for the formation of professional competence of future medical specialists.

The first condition assumes that the successful preparation of a bachelor is in many respects determined by the awareness of the importance of his profession.

The second condition is that independent work leads to the development of skills and abilities that in the future will allow you to set your own goals for yourself, independently solve professional problems, choosing the appropriate methods and methods.

Fulfillment of the following condition should allow the future specialist to become involved in the professional process.

The fourth condition is the use of modern educational and professional tasks aimed at the formation of professional competence of the future medical specialist.

Thus, we have defined the basic stages of formation of professional competence of the student to the development of universal educational actions in the lessons of medical physics, goals and methods of formation of professional competence developed a relatively simple diagnostic system, which allows to assess the level of formation of professional competence, and identified pedagogical conditions of formation professional competence of future health professionals.

Experimental verification of the effectiveness of the model for the formation of professional competence of future medical specialists.

To test the effectiveness of the model, a pedagogical experiment was conducted on the basis of the International Kazakh-Turkish University named after H.A. Yassavi and the Kazakh National Medical University named after S.D. Asfendiyarov.

The first group consisted of 85 people and was the control (CG). The lessons were held in it according to the traditional method. The second group also consisted of 85 people and was experimental (EG). Students included in this group performed practical work according to the methodology described in this article.

We defined the professional competencies of future doctors as given social requirements (norms) for the educational preparation of a medical university student, which is necessary for his high-quality productive activities in the professional field. In itself, the concept of competence means knowledge, skills, and personal qualities of a person.

Therefore, at this stage of testing the hypothesis of the study, we tested knowledge in medical physics, professional knowledge and skills that can be formed by a student of a medical university on practical work in physics.

Of the 32 professional competencies that should be formed for students of medical specialties in the learning process, we identified 6 professional competencies, the impact on the formation of which, provides training for medical students in medical physics:

1) the ability and willingness to identify the natural science essence of the problems; use the physico-chemical and mathematical apparatus;

2) the ability and willingness to form a systematic approach to the analysis of medical information based on the search for solutions using theoretical knowledge and practical skills;

3) the ability and willingness to analyze the results of modern laboratory instrumental studies;

4) the ability and willingness to analyze the patterns of functioning of organs and systems;

5) the ability and willingness to use international unit systems;6) the ability and willingness to participate in the development of modern theoretical and experimental research methods.

Table 3
Results of Students Completing Assignments of Type I and II

Assignments	Levels	before the experiment		after the experiment	
		CG	EG	CG	EG
Tasks of the 1st type	High	20	18	22	28
	Medium	48	50	50	51
	Low	17	17	13	6
Tasks of the 2nd type	High	16	17	18	30
	Medium	40	38	41	35
	Low	29	30	26	10

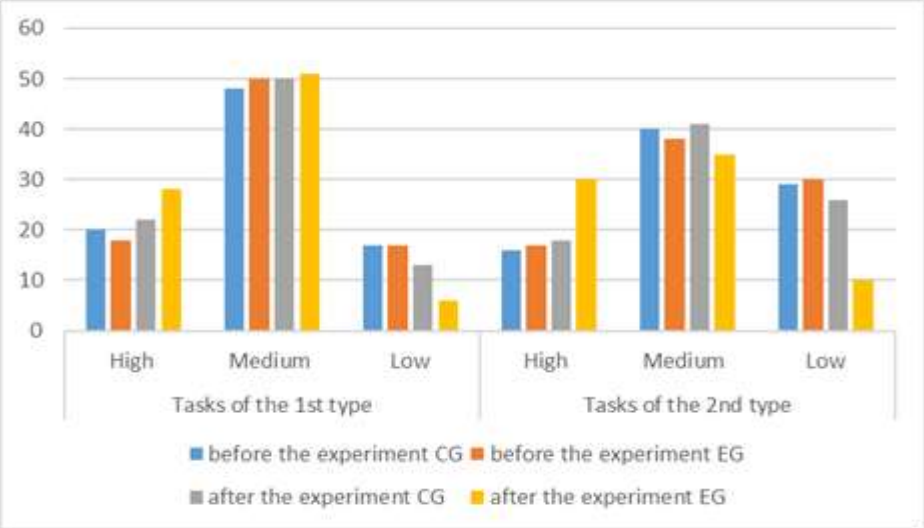

Figure 2
Results of Students Completing Assignments of Type I and II

In the conclusion of the pedagogical experiment, the examination grades of students in the EG and CG were analyzed. Moreover, the teachers who took the exam did not know which group a particular student belonged to.

To establish the presence or absence of differences in the control and experimental groups, the Pearson criterion- χ^2 was also used. Exam results were better in the EG.

Table 4
Results of Students Completing Assignments of Type I and II

Levels	Number of students, %	
	CG	EG
High	25	38
Medium	37	40
Low	38	22

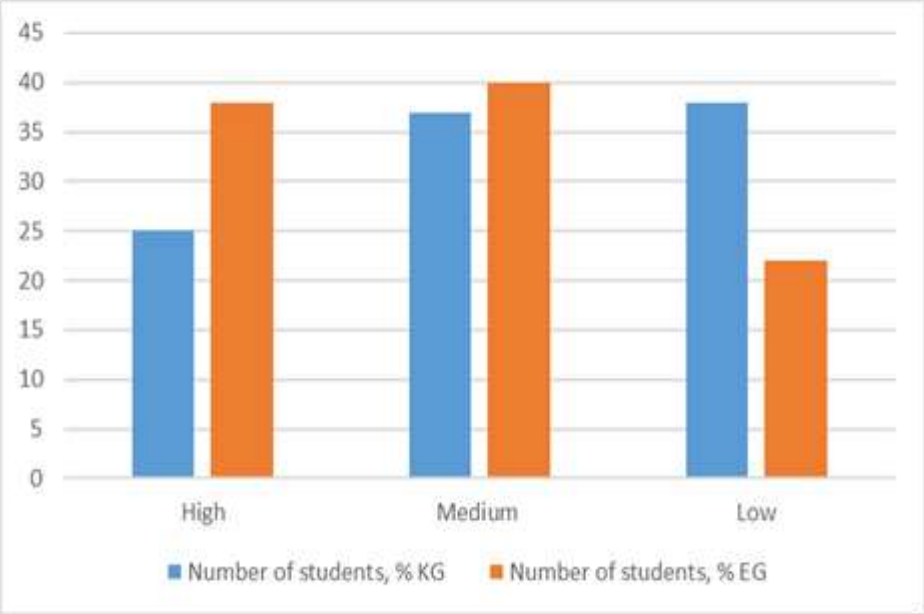

Figure 3
Results of Students Completing Assignments of Type I and II

Thus, the application of the model we have developed for the formation of professional readiness of future medical specialists in medical physics increases the number of students with an average and high level of professional competence as compared to students who performed the traditional version of practical work.

DISCUSSION

The formation and development of professional competence cannot be carried out to the extent that a diagnostic apparatus has not been developed with which it would be possible to assess the level of formation of the studied competence. Diagnostics is primarily aimed at identifying the strengths and weaknesses in the professional activity of a future medical specialist, his potential opportunities and needs, and allows us to predict possible difficulties in the implementation of the training process. A large number of researchers are involved in the development of assessment systems(Adolf, 2011), but universal methods for diagnosing the level of competence formation have not yet been proposed. As a rule, assessment apparatuses are created to assess certain competencies in a specific area of human activity (education, business, etc.). This problem is relevant not only for Kazakhstan researchers, but also for Western ones.

In the work of K.M. Grabchuk and E.V. Filatova proposed a system for diagnosing professional competence of a future specialist in social work on the basis of a graduate's self-assessment, expert assessment of a teacher, and assessment of clients of institutions of the social protection system.

The article (Romanova, 2010; Zorina et al., 2018) proposed an assessment of the level of formation of professional competence of university students enrolled in the field of "Information Security". The essence of this assessment was to determine the level of development of a graduate of each competency from the federal state educational standard of higher professional education, and then the competence of the graduate in general was assessed.

Thus, any chosen or developed methodology for diagnosing the level of competency formation should have a scientific justification, a clear organization, and an open procedure.

The considered examples show the complexity and ambiguity of the methods for assessing the level of competency formation. Despite the difference in the calculation of quantitative characteristics, showing the level of competency, most methods mainly use testing, questionnaires and expert evaluation.

Our analysis shows that not every researcher can use these methods because of the complexity of the procedure for their implementation and calculation of the studied competencies, because of the narrow focus, i.e. the formation of competence in a particular academic discipline, therefore, work to create a relatively simple way of assessing the level of formation of professional competence should continue.

CONCLUSION

Our study allows us to draw the following conclusions:

A model for the formation of the professional competence in medical physics lessons has been developed and implemented, consisting of a target component that defines the purpose of training and orientates the student to the correspondence between the

requirements of the state educational standards and the results achieved in the formation of professional competencies; a diagnostic component that determines the levels of mastery of the teacher's core professional competencies by creating a diagnostic card for professional issues; a substantial component that is responsible for the formation of professional competence, consisting of a set of four competencies: worldview, organizational, communicative and informational; a procedural component that considers the main methods, conditions and mechanisms for the implementation of the formation of professional competence; an effective component that allows us to judge the formation of students' professional competencies. It is shown that the use of this model contributes to the formation of professional competence of a future medical specialist.

It has been experimentally confirmed that solving situational problems and performing short-term practical work (materials prepared by students participating in the experiment) leads to a more effective formation of the ECM in the lessons of medical physics.

Thus, the results of theoretical analysis and the conducted experiment confirm the main points of the hypothesis put forward in this study and suggest that the main goal of the study has been achieved.

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