https://doi.org/10.15360/1813-9779-2022-6-59-68

Competency-Based Approach in Teaching Cardiopulmonary Resuscitation

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For citation: *Svetlana A. Perepelitsa.* Competency-Based Approach in Teaching Cardiopulmonary Resuscitation. *Obshchaya Reanimatologiya = General Reanimatology.* 2022; 18 (6): 59–68. https://doi.org/10. 15360/1813-9779-2022-6-59-68 [In Russ. and Engl.]

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Summary

Aim of the study: to develop an additional professional competence «Emergency care in cardiac arrest» and to evaluate a set of tools for its development among the graduating students majoring in general medicine (code 31.05.01).

Material and methods. The study was done in two stages. During the first stage, within the framework of PC (professional competence)-11 «Readiness to participate in providing first medical aid in conditions requiring urgent medical intervention» an additional professional competence «Emergency care in cardiac arrest» was developed with the definition of performance assessment. During the second one, the scientific research was conducted at the medical institute of the Immanuel Kant Baltic Federal University during the study of Anesthesiology, resuscitation, and intensive care, which has been included in the block 1 discipline (module) list, being a basic part of the General Medicine curriculum (code 31.05.01). The study involved 140 six-year students majoring in general medicine (code 31.05.01). The students were divided into two groups. The main group included 80 students who studied in 2021 (average age 25±1.5 years), while the control group comprised 60 participants who studied in 2019 (average age 25.9±1.6 years, retrospective analysis).

Results. An additional professional competence «Emergency care in cardiac arrest» and its stratified structure have been developed. Specific elements were elaborated for each component stratum. Based on the developed elements, which were mastered by the student in the process of training, the necessary competence was developed. The novel pedagogical technologies in the curriculum contributed to more effective learning and development of the competence. The levels of development of additional professional competence «Emergency care in cardiac arrest» differed between the groups. Most students in the control group had a threshold level of competence. The basic and advanced levels of competence were significantly higher among the students in the main group compared with the control group ($P<0.05$).

Conclusion. We have shown the necessity of developing an additional professional competence «Emergency treatment in case of cardiac arrest» within the «Readiness to participate in providing first medical aid in conditions requiring urgent medical intervention» PC-11. We have successfully implemented and validated in practice the system of development of additional professional competence using pedagogical innovations, including those based on advanced information and communication technologies.

Keywords: training; cardiac arrest; competence; simulation training; mind map; animated cartoons

Conflict of interest. The authors declare no conflict of interest.

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Introduction

In recent years the doctrine of medical education has been undergoing significant changes in the Russian Federation and worldwide. The global transformations were initiated by the World Federation for Medical Education and the Association for Medical Education in Europe. Today, higher medical education should provide training of specialists with certain competencies, who will be able to carry out their professional activities adapted to the requirements of ever-changing conditions of work [1–4]. Currently, the general provisions of the competence paradigm have become the basis for the implementation of the competence approach in medical education, and the main task of higher medical education institutions is to train a physician with certain professional competencies [5–8].

The Federal State Educational Standard of Higher Education, which formulates a competency-based approach aimed at improving the quality of professional education, serves as the main document regulating the organization of the education in General Medicine (code 31.05.01) [6, 9]. According to this document a gradual development of competences occurs at all stages of education, and the section «Requirements for the results of mastering the curriculum» contains a list of competences. There are 8 core cultural, 11 core professional and 22 professional competences (PC) [9].

The PC-11, which is «Readiness to participate in the emergency medical care in conditions requiring urgent medical intervention» deserves special attention and is developed after studying many

disciplines, included in the curriculum of the student's training. Each of the clinical disciplines explores aspects of specialized emergency medical care. However, all disciplines share the section «Care in cardiac arrest», because this condition can complicate any disease. In this regard, a special emphasis should be made on the development of competence of providing emergency care in case of cardiac arrest. This competence has a direct connection with the labor function «Providing emergency or urgent medical care to the patient», which is regulated in the Professional Standard for Medical Specialists. The unified labor function specifies the labor activities, as well as details of the necessary knowledge and skills that a physician must possess in order to provide professional care to a patient with circulatory and respiratory arrest [10].

The study of the discipline «Anesthesiology, resuscitation, and intensive care» is the final stage of development of PC-11 «Readiness to participate in the emergency medical care for conditions requiring urgent medical intervention», as it includes a full list of activities of providing advanced medical care for life-threatening conditions. However, within the framework of the discipline a need exists for in-depth training of students to provide emergency care specifically in cardiac arrest within PC-11, which, in our opinion, confirms the necessity of developing appropriate additional professional competence «Emergency care in cardiac arrest».

Aim of the study: to elaborate an additional professional competence «Emergency care in cardiac arrest» and to test a set of tools promoting its development among the graduating students of General Medicine (code 31.05.01).

Material and Methods

The study was conducted in two stages.

Stage I. Within the framework of PC-11 «Readiness to participate in the provision of emergency medical care in conditions requiring urgent medical intervention», an additional professional competence «Providing emergency care in cardiac arrest» was elaborated, and the level of its development was assessed.

Stage II. The research was carried out at the medical institute of the Immanuel Kant Baltic Federal University during the study of the «Anesthesiology, resuscitation, and intensive care» subject included into the Block 1 Core Disciplines (modules) of the General Medicine curriculum (code 31.05.01). The curriculum was based on the Federal state educational standard of higher education in General Medicine (specialist level, code 31.05.01), approved by the Ministry of Education and Science of the Russian Federation, order No. 95 dated February 9, 2016, and the syllabus approved by the Academic Council of Immanuel Kant Baltic Federal University.

The study involved 140 6th-year (graduating) students of the medical institute specializing in General Medicine (code 31.05.01). The students were divided into two groups. The study group included 80 participants with the average age of 25±1.5 years, who studied the subject in 2021. The control group included 60 physicians with the average age of 25.9±1.6 years who were trained in 2019. Their data were analyzed retrospectively.

The conditions of education were identical for both groups. Seminar classes were held in line with the schedule in the classrooms of the medical institute, practical training and simulation course took place in the simulation center. The duration of the «Anesthesiology, resuscitation, intensive care» rotation, which aims at developing the competence of emergency care in cardiac arrest, was identical in the study groups. The curriculum comprised two mandatory courses, theoretical and simulation. Figure 1 shows the set of tools used to develop competencies in the groups.

The academic course differed between the groups. In the control group, it included lectures, student's recitation, preparing a topical essay, and group discussion. In the study group, it was supplemented by novel pedagogical technologies such as mind maps, «abstract-Interview» method, and thematic animation. The criteria for assessing the level of theoretical knowledge are shown in Table 1.

Simulation training in the control group comprised two blocks including basic cardiopulmonary resuscitation/automatic external defibrillation and advanced CPR. In the study group role-play was added to the above-mentioned blocks. The clinical situation «Circulatory arrest due to cardiac causes» was used as the basic training model. Training and assessment of practical skill in the simulation training on basic cardiopulmonary resuscitation was conducted on a manikin with computer software allowing real-time training in chest compressions and ventilations.

The first session included baseline assessment of basic knowledge in the fundamental and clinical disciplines. The results of assessment are shown in Fig. 2. We found that the trainees of both groups had the same level of theoretical knowledge acquired during the training. No significant differences between the groups were found ($P>0.05$).

Most students in both groups had an advanced or basic level of knowledge, whereas 15% of students had a threshold level. The obtained results allow us to consider the groups equivalent in the experiment.

Statistical analysis of the results. Statistical analysis was performed using Statistica 10.0 software package (StatSoft Inc., USA). The groups were compared using χ^2 criterion or Fisher's exact test. Statistical results were presented as percentages. Differences were considered significant at $P\leqslant 0.05$.

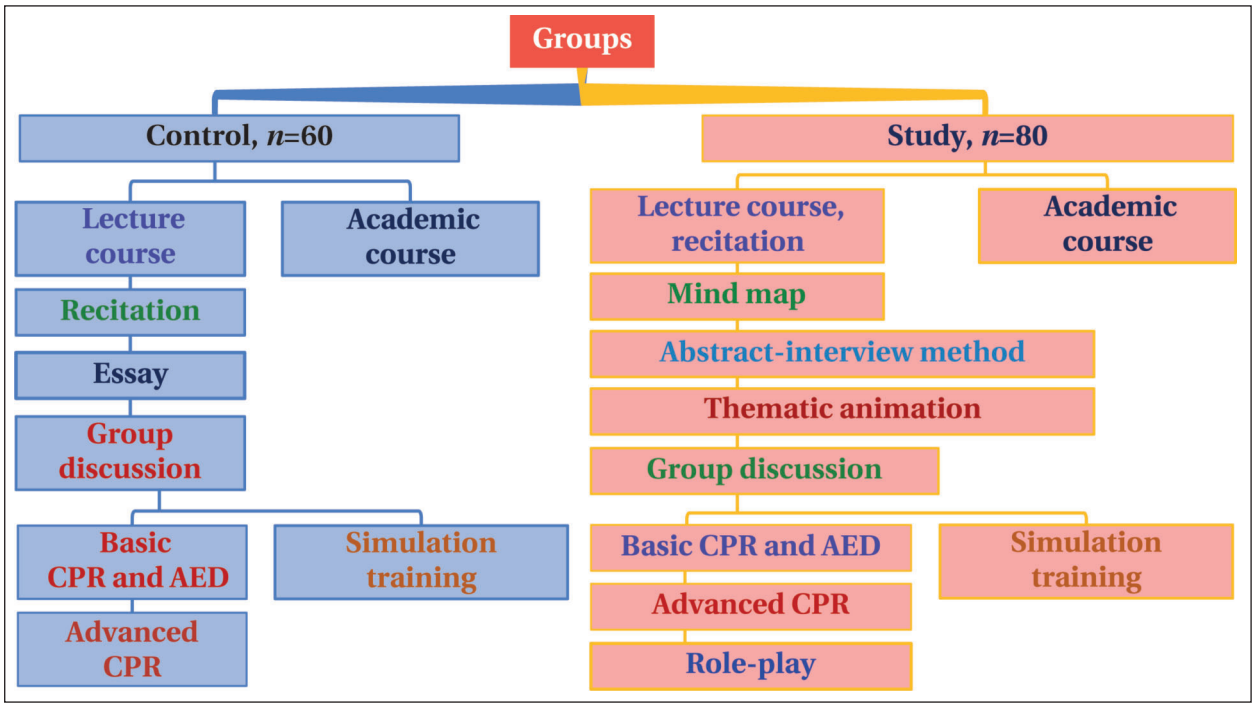

Fig. 1. Groups and set of tools used to develop competencies.

Table 1. Assessment of the level of basic and novel theoretical knowledge (adapted from the curriculum of the «Anesthesiology, resuscitation, intensive care» discipline).

Criteria	Assessment scale, points
The answer is logical, the student shows knowledge of professional terms, concepts, categories, and theories. He/she argues extensively and gives convincing examples. Demonstrates analytical approach in covering various concepts. Draws meaningful conclusions. Demonstrates confident knowledge of regulatory legal acts and special literature. Speech is competent and professional vocabulary is used.	Advanced level — 5
The answer presents various approaches to the problem, but their rationale is not complete enough. The conclusions are correct. Arguments and examples of law enforcement practice, but there is inconsistency in the analysis. Demonstrates knowledge of regulatory legal acts and special literature. Speech is competent, predominantly professional vocabulary is used.	Basic level — 4
The answer is not logically structured enough. The student reveals poor disclosure of professional concepts. The points made are declared, but not supported by evidence. The answer is mostly theoretical, no examples are given. There is only a general idea about regulatory legal acts. Knowledge of special literature is missing. Professional vocabulary is used sporadically.	Threshold level — 3

Results and Discussion

Development of the model of competence development in emergency care in cardiac arrest. For successful development of the competence of providing emergency care in cardiac arrest, we developed a model, which provides a detailed elaboration of all supposed stages of training medical students (Fig. 3.).

The elaborated model of developing competence in emergency care of cardiac arrest makes it possible to move the project forward as quickly and successfully as possible. Detailed elaboration allows to exclude ineffective methods and to choose technologies with high efficiency of training.

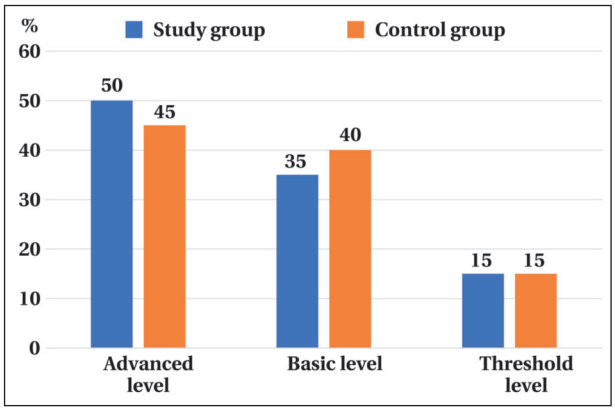

Fig. 2. The results of baseline assessment.

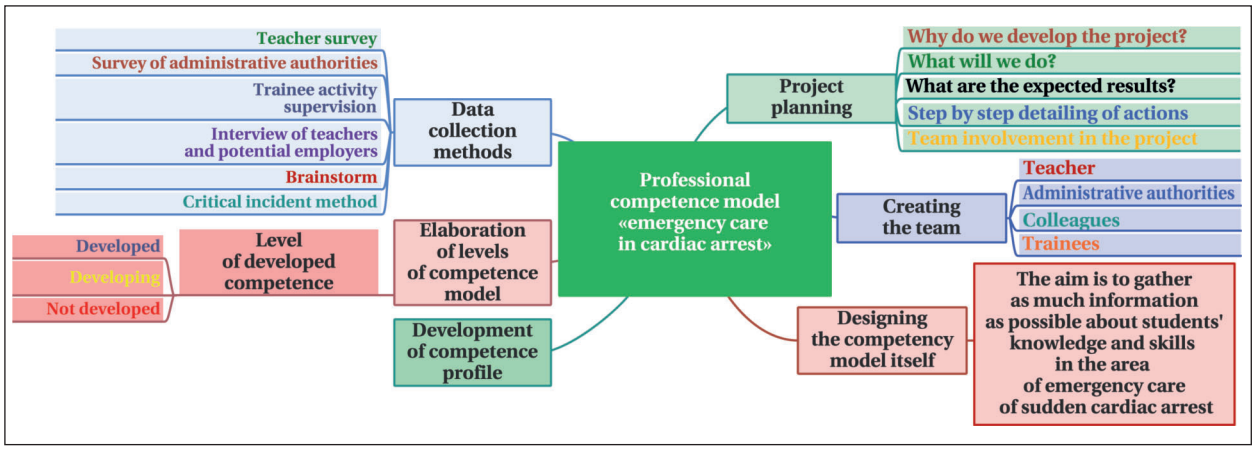

Fig. 3. Model of developing the competence of emergency care in cardiac arrest.

Sources of information at the planning stage are Federal State Educational Standard of Higher Professional Education for General Medicine, survey of fellow teachers, administrative staff, employers, who may have participated in this type of training, have experience in teaching and have an opinion on the project being developed. Interviewing the trainees themselves is quite important for obtaining their opinion on the level of their own training and the experience of previous students.

The critical incidents method makes it possible to anticipate unusual psychological and physical reactions, in response to a certain «critical situation», which cardiac arrest is. Conducting a structured interview enables the instructor to identify trainees who have already had positive or negative experiences with CPR in real-life situations. Any information obtained by the instructor during the training phase can contribute to the success of the project.

The participants of the model of developing additional professional competence are the students and the instructor. The main condition for achieving the set goal is the student's active attitude towards the education. The student acts as a consumer of knowledge, abilities and skills required to develop the competence, he/she is a conscious participant of learning. An instructor organizes and coordinates the educational process, serves as a source of information, technical and other resources. The set goal is achieved by creating certain pedagogical conditions, which are implemented in this model.

The model of competence development consists of three blocks.

1. The goal-oriented block is necessary to develop a bank of learning materials and manuals for the discipline of Anesthesiology, Resuscitation, and Intensive Care which include mind maps, the «Abstract-Interview» methodology, thematic animation, set of clinical cases for simulation training, preparing dummies and highly realistic robots to work, as well as development of assessment tools.

2. Activity block includes practical classes in «Anesthesiology, resuscitation, intensive care» with the use of mind maps, «abstract-interview», thematic animation, set of clinical cases for simulation training.

3. Reflexive block includes assessment of the level of competence development, stratified structure of additional professional competence «Emergency care of cardiac arrest» and levels of its development.

Thus, the additional professional competence «Emergency care of cardiac arrest» and its stratified structure have been produced (Fig. 4).

In the starting stratum a specific property of an individual, his/her capabilities for purposeful professional activity, were determined. In the second stratum the two most important aspects of competence development were pointed out, i. e., ability and readiness to carry out professional activity. Two components were distinguished in the «Ability» stratum: cognitive («I know», knowledge) and functional («I know how», skill). In the «Readiness» stratum two components were also distinguished: motivational («I want», willingness) and personal («I can», capability) [1]. Specific elements were developed for each component stratum. Based on the designed elements, which the student learns in the process of training, the development of the necessary competence occurred.

The proposed structure of the competence of medical students for emergency care in cardiac arrest corresponded to the content requirements of the Federal State Educational Standards of Higher Education and the list of labor functions of a medical specialist, as defined by the professional standard «General medicine».

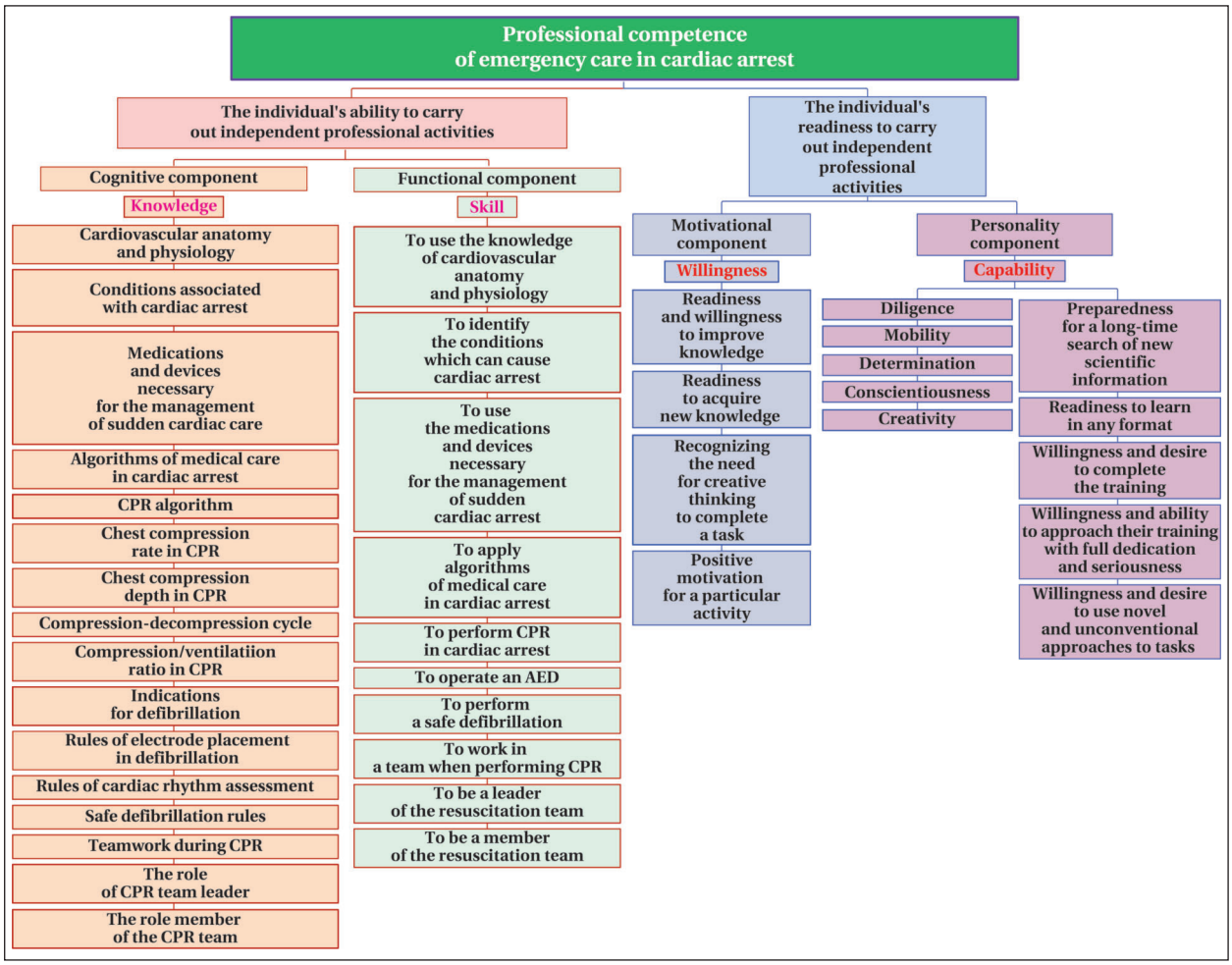

Fig. 4. Stratified structure of professional competence «Emergency care in cardiac arrest».

Assessment of competence completion was the final stage and took place at the end of mastering the discipline, when all theoretical aspects were studied, the simulation course on cardiopulmonary resuscitation and automatic external defibrillation was completed, game training with practicing the role of the leader of the resuscitation team was conducted. All stages of mastering theoretical knowledge and practical skills were taken into account.

Three levels were determined to assess the development of competence.

Threshold level was minimally sufficient to carry out professional activities.

Basic level implied fully developed components of professional competence, allowing both independent performance of certain activities and interdisciplinary interaction, and readiness to actively expand one's labor functions.

Advanced level comprised confident possession of all components of professional competence, allowing to actively use in practice both standard and innovative methods (see Table 2).

Assessment of academic knowledge of the new topics. Assessment of the level of mastering the new academic knowledge necessary to develop a competence is demonstrated in Fig. 5. In the study group, 80% of students had an advanced and

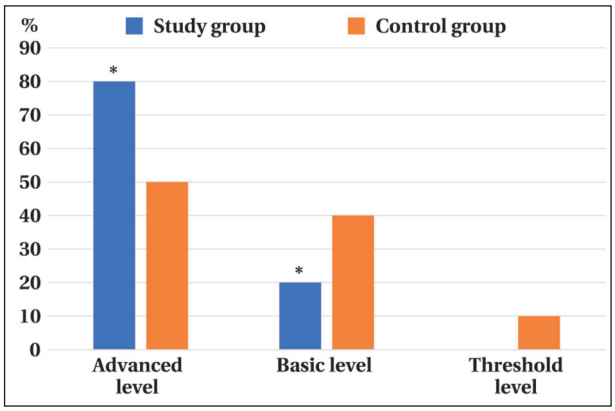

Fig. 5. Results of the current assessment of theoretical knowledge on the new subjects.
Note. * — $P<0.05$ — significant differences between the groups.

Table 2. Levels of development of professional competence «Emergency care in cardiac arrest».

Criteria	Assessment scale, points
The answer is logical, the student shows knowledge of professional terms, concepts, categories, and theories. He/she argues extensively and gives convincing examples. Demonstrates analytical approach in covering various concepts. Draws meaningful conclusions. Demonstrates confident knowledge of fundamental and related clinical disciplines. Speech is competent and professional vocabulary is used. Demonstrates an algorithm of care of sudden cardiac arrest during the cardiopulmonary resuscitation simulation. Confidently plays the role of «Leader» of the resuscitation team. Knows the roles of team members and creates effective communication to achieve the global goal of providing expert medical care in sudden cardiac arrest. Consistently manages patient care, prioritizes, encourages and supports the team.	Advanced — 5
The answer contains various approaches to the problem, but their rationale is not complete enough. The conclusions are correct. Arguments are supported by examples of law enforcement practice, but analysis is inconsistent. Demonstrates knowledge of basic and related clinical disciplines. Speech is competent, using predominantly professional vocabulary. Demonstrates the algorithm of care in sudden cardiac arrest during the cardiopulmonary resuscitation simulation. Confidently plays the role of «Leader» of the resuscitation team. Knows the roles of team members and creates effective communication to achieve the global goal of providing expert medical care of sudden cardiac arrest. Consistently manages patient care, prioritizes, encourages and supports the team.	Basic — 4
The answer is not logically structured enough. The student demonstrates uncertainty in the disclosure of professional concepts. The points made are declared, but not argued. The answer is mostly theoretical, no examples are given. Has basic knowledge of fundamental and related clinical disciplines. Knowledge of special literature is missing. Professional vocabulary is used sporadically. During CPR simulation, demonstrates the algorithm of care in sudden cardiac arrest. Is unsure of the role of the «Leader» of the CPR team. Does not fully know the roles of team members, partially creates effective communication to achieve the global goal of providing expert medical care in sudden cardiac arrest. Consistently manages patient care, fails to prioritize, does not always encourage and support team.	Threshold — 3

20% had a basic level of mastering the new material ($P<0.05$ vs the control group), which favored the development of the necessary competence.

Assessment of practical skills development. After completing the academic course, the classes continued in the simulation center, where during the simulation course on basic CPR and AED the students consistently mastered the necessary practical skills and developed the additional professional competence of emergency care in cardiac arrest. During the simulation the student will demonstrate his or her knowledge of the algorithm of care in sudden cardiac arrest, perform quality chest compressions and ventilations, and operate the automatic external defibrillator.

Objective assessment of the studied parameters with the help of dummy computer software is an important component. It accurately determines the hand position, each cycle of compressions and decompressions, calculates the frequency and depth of compressions, i. e., shows an objective view of what is happening. The instructor sees all data online. An exam card is created for each trainee, where all the parameters of the trainee and total score are automatically displayed (Fig. 6). After completing an assignment, the instructor individually reviews the trainee's score. They discuss the reasons for possible failures and develop an individual learning plan. This method of reading the results increases the motivation to learn, because it eliminates any bias in the assessment.

The list of skills and results of training in basic cardiopulmonary resuscitation and automatic external defibrillation are shown in Table 3.

During training all students in the study group developed the necessary skills. In the control group, the skill of correctly positioning the hands to perform chest compressions, performing compressions and breathing in a 30:2 ratio was fully developed. The remaining practical skills were fully developed in 90% of the trainees in this group and were in the process of developing in 10% of the trainees. All identified differences were significant ($P<0.05$). The skill of safe handling of automatic external defibrillator was developed in 100% of students in the study group and in 80% in the control group ($P<0.05$).

Thus, the study results showed significant differences in the degree of development of cardiopulmonary resuscitation skills between the groups. The students in the study group with good academic background showed high results of ac-

Fig. 6. An exam card of a trainee in simulation training on basic cardiopulmonary resuscitation.

Table 3. Assessment of practical skills in cardiopulmonary resuscitation.

Skills	Frequency of developed skills				*P*-value
	1 Developed		2 Not fully developed		
	Study, *n*=80	Control, *n*=60	Study, *n*=80	Control, *n*=60	
Cardiopulmonary Resuscitation Algorithm					
Knowledge of cardiopulmonary resuscitation algorithm	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Safety assessment	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Assessment of consciousness	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Airway patency and assessment of normal breathing	64 (80%)	54 (90%)	16 (20%*)	6 (10%)	0.108
Correct hand positioning	80 (100%)	60 (100%)	0 (0%)	0 (0%)	1.0
Compression depth 5–6 cm	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Compression rate 100–120 per minute	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Equal compression–decompression	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Performing 2 ventilations	80 (100%)*	54 (90%)	0 (0%)*	6 (10%)	0.004
Compression/ventilation ratio 30:2	80 (100%)	60 (100%)	0 (0%)	0 (0%)	1.0
Handling of automatic external defibrillator					
Safety when analyzing rhythm	80 (100%)*	48 (80%)	0 (0%)*	12 (20%)	<0.001
Safety during defibrillation	80 (100%)*	48 (80%)	0 (0%)*	12 (20%)	<0.001

Note. * — $P<0,05$ — significant differences between the groups.

quiring the skill of qualified medical care in sudden cardiac arrest.

Assessment of development of additional professional competence in emergency care of cardiac arrest. The final stage of the research was the assessment of the level of development of additional professional competence of emergency care in cardiac arrest. The summarized assessment of theory section and practical skills for the development of the necessary competence was performed. We found that the levels of development of additional professional competence differed between the groups (Fig. 7).

In the control group, the threshold level prevailed, 60% of students in this group had minimally sufficient knowledge and skills to perform inde-

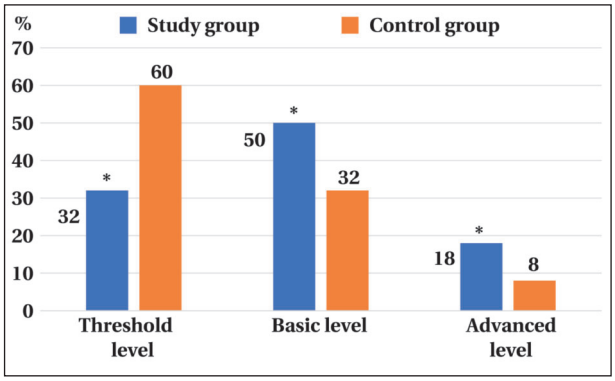

Fig. 7. Results of the development of additional professional competence.
Note. * — $P<0.05$ — significant differences between the groups.

pendent work activities in cardiac arrest. In the study group the threshold level was achieved in 32% of students ($P<0.05$). The basic level was observed in 32% of students in the control group and 50% in the study group ($P<0.05$), which confirms the confident mastery of all elements of the competence not only to carry out purposeful activity, but also to develop new types of labor functions and interdisciplinary interaction. The advanced level, confirming the creative mastery of all elements of the competence, was achieved by 18% of students in the study group and 8% in the control group ($P<0.05$).

Development of additional competence of emergency care of cardiac arrest and training of students on its basis have shown positive results. The level of development of cardiopulmonary resuscitation skill, team organization and mastery of the leadership role determine the physician's readiness for his/her professional activity. A specialist with the basic and advanced levels of competence is competent not only for independent work, but also for interprofessional communication [12–14], as well as in management of the resuscitation team. This person has a global perspective of treatment for a patient with cardiac arrest, and is able to diagnose and manage it using state-of-the-art techniques.

Making changes in the training curriculum, the use of new pedagogical technologies allowed to improve the results of training in the study group. After conducting a retrospective analysis of the training of the control group, we decided to develop a competence of emergency care in cardiac arrest, and to introduce new pedagogical technologies in the curriculum of the «Anesthesiology, resuscitation, intensive care» discipline, both in the academic section and in simulation training. The study group studied in an upgraded «Anesthesiology, resuscitation, intensive care» rotation.

Conclusion

This study supports the necessity of developing additional professional competence of emergency care in cardiac arrest within the framework of PC-11 «Readiness to participate in the emergency medical care in conditions requiring urgent medical intervention». We have successfully implemented and validated in practice the system of developing additional professional competence using new pedagogical tools, including those based on modern information and communication technologies.

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Received 20.06.2022
Online First 23.11.2022