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OPTIMIZATION OF THE TECHNOLOGY OF MASTERING COMPETENCE COMPLEX FOR PROFESSIONAL ACTIVITY OF ELECTROMECHANICAL ENGINEERS

Future professionals have poor knowledge of both hardware and its types, technology, organization and research, prefer reproductive activities, following their teachers' instructions without understanding the purpose of certain actions of theory in practice. Based on the exploration of training future electromechanical engineers it has been revealed that the students' mastering of research skills requires the development of competence-focused teaching technologies and consideration of complex pedagogical conditions of its effective use. There has been designed a competence-focused technology which involves creating a single experimental environment within the complex of technical disciplines by unifying methodological tools (target benchmarks, principles and approaches), component characteristics of the learning process (subject-activity, functional-content, organizational-activity), as well as technological components (methods, means, conditions, etc.). It has been implemented in the educational process of the experimental group of students. The control group was taught according to the traditional system. As a result of the experiment it has been found that the experimental group students' reseach skills have significantly improved as compared to the control group students, which is indicative of the efficiency of the designed technique.

Keywords: *experimental research, skills-oriented, technology training, technical disciplines, electromechanical engineers.*

Introduction

The analysis of the trainees' and graduates' activity at industrial enterprises shows that they have adequate knowledge of modern equipment and innovative technologies, job organization, economics and management, but are not prepared for real practical activity. Future professionals have poor knowledge of both hardware and its types, technology of organization and conducting of researches, prefer reproductive activities, and choose to follow the teacher's instruction and guidance, without understanding the purpose of certain actions in practice. It should be noted that young professionals are not always ready for rational planning and organization processes, analyzing work situations and making effective decisions. They rarely use a creative approach to solving traditional professional tasks. Experts and scientists in the technical field state that capacity for creativity in intellectual, design, organizational practice requires the development of engineering thinking skills in order to be good at design and technological documentation, systems and principles of design; to use specialized computer tools and information systems of a universal purpose effectively, as well as organize and conduct experimental researches if necessary.

A culture of experimentation has arisen around the lesson study model [1]. It allows both rapid adoption of new curricula and continual refinement of existing content and teaching methods.

There is an urgent need to train competent electromechanical specialists, which means to form a set of competencies in them necessary for professional work in a real production or educational process, as well as to develop relevant scientific and reasonable optimal technology of conducting experimental researches when mastering technical disciplines for the solution of practical tasks of electromechanical nature.

A significant number of works from different research areas and levels, from program articles to dissertations and tutorials [2; 3; 4; 5; 6] deal with the experimental activities in the curricula of electromechanical profile and related issues of engineering activity. This led to the transformation of the methodological support of experimental researches to the use of the results and experimental recommendations unsuitable for application in the educational process. In this regard we believe that the issue of the experimental research mastering by electromechanical engineers in the process of technical subjects studying is not properly investigated and requires further exploration.

Aim and tasks

The paper aims to present, theoretically substantiate and experimentally check the efficiency of the designed technology of mastering the competence complex for the professional activity of electromechanical engineers.

Based on the competence focus of professional training of future specialists in electromechanical field the following tasks were set:

– distinguishing pedagogical conditions of the organization of experimental studies;

– highlighting the content training of future electromechanical engineers in the field of experimental studies;

– optimization of mastering the technology of competence complex for professional activity of electromechanical engineers.

Research Methods

To achieve the goal and test the effectiveness of the developed training technology we used a set of methods reflecting the dialectical unity of theoretical and empirical levels of knowledge. The following ones were applied:

1. A specially designed set of tasks for determining the level of research skills of the students majoring in electromechanics.

It involves specially selected tasks for assessing the maturity of skills to distinguish concepts (objects, processes), understanding the nature of relations between them, the retrieval of objects, processes, or some of their characteristics.

Distinction of concepts (objects, processes) provides such a form of a response when a student chooses one or more variants from the list given, for example: “Choose the right order of the engineering experiment”.

The task to ascertain the nature of relationships involves setting common characteristics or differences in objects provided that comparable properties or certain parameters are displayed in the task. For instance: “Which DC-motor parameters are referenced to the primary ones and which ones are calculated analytically?”.

Tasks for retrieval require from students the ability to recall information and to perform much more complex information tasks. For example: “Can you explain what the requirement to make adjustment of the electric drive system means?”.

A typical example of the tasks involving the sequence of the engineering experiment or its stages is as follows: “Specify the correct order to perform operations for debugging the thyristor converter-motor system”.

2. The survey in a form of a questioning was used in the pedagogical experiment for:

– students’ self-assessment concerning their research skills;

– comparing the results of self-assessment with a teacher’s evaluation in order to improve the reliability of the results;

– identifying difficulties which students face at certain stages of an engineering experiment, namely adjusting and testing systems;

– evaluation of maturity of the individual components the students’ research skills in the process of studying technical subjects.

The developed questionnaires allowed to standardize the obtaining of information about the impact of engineering experiments on the formation of ideology, knowledge and practical skills of future specialists, reduce the time of the survey and statistical processing of the results, increase the number and regularity of assessments in the groups of the participants.

The predetermined binary (“yes-no”) or ternary (“yes-no-undecided”) variation of the answers is due to semantic unambiguity of the interpretation of the questions and maximum informativeness of the results according to personal characteristics and academic achievements of the participants.

3. The observation was used as an independent method of obtaining and accumulating information concerning the process of mastering technical disciplines and conducting engineering experiments. In the process of observation, the individual components of training of future specialists for research activity were assessed from the standpoint of educational and professional requirements to specialists of the electromechanical field.

4. Evaluation of the process of teaching future engineers to perform electro-profile experimental research.

We used two indicators: a complex one that was calculated by the formula (1), and a performance coefficient, which was defined as the ratio of the final result to initial one by the formula (2).

The coefficient C_C of the maturity of the components of the training system is calculated as follows

$$C_C = \frac{\sum n_i}{n}, \tag{1}$$

where n_i – number of patters mastered by the student (patterns are considered to be indicators of knowledge of different types of educational and professional activities);

n – maximum number of patterns to be mastered.

The coefficient of teaching effectiveness C_{te} (the criterion of the effectiveness of the developed technology) was determined as the ratio of coefficients of volume of mastering before and after the introduction of the developed technology:

$$C_{le} = \frac{C_{after}}{C_{before}} \tag{2}$$

where C_{after} and C_{before} – coefficients of the answers completeness before and after the introduction of the developed technology.

The effectiveness of the training was assessed by the four-interval scale:

– optimal if $C_{after} > 0.85$,

– sufficient if $0.71 \le C_{after} \le 0.85$,

– low if $0.51 \le C_{after} \le 0.70$

– not effective, if $C_{after} < 0.51$.

According to this scale the future electromechanical specialists' research skills in the process of studying technical disciplines were valued as optimal, acceptable, critical and unacceptable.

5. Statistical methods of processing the results of the pedagogical experiment to evaluate the effectiveness of the designed technology of teaching future engineers conduct researches in the process of studying technical subjects.

6. Graphical interpretation of the results of the pedagogical experiment for visual presentation of the research results and visual comparisons.

Research results

As a result of reviewing the issue studied it has been found that experimental studies are an integral part of almost all technical subjects; play a leading role in the formation of professional competence, sufficient for professional activity under conditions of real production or educational process.

A searching experiment was conducted in order to obtain the original (source) data about the level the respondents' research skills in the process of mastering technical disciplines, as well as in order to check the necessity of designing teaching techniques of conducting experimental researches at a higher education institution. Besides, initial data assessment was necessary due to the need for monitoring and assessing changes in the students' research skills. The searching experiment involved the determination of the effectiveness of the competence-focused technology for teaching students to conduct experimental researches in the process of studying technical subjects.

Considering the fact that technical disciplines are planned to be learnt starting from the 3rd year of studying, the period of the 3rd-4th years was chosen to start the experiment and the data obtained in it was regarded as original (initial).

Taking into account that standardized (normalized) indicators of research skills of the students majoring in the electromechanical field in the process of mastering technical subjects are missing, the primary objective of the pedagogical experiment was to determine empirically some indicators of this type within the chosen experimental education environment. For this purpose, the assessment was organized and conducted and it was based on subjective and objective evaluation of the respondents' academic achievements.

The subjective evaluation involved all the students who participated in the pedagogical experiment. The participants basing on their own ideas and experience for performing certain tasks (operations) had to assess their own capabilities on various aspects of experimental researching in the process of mastering technical disciplines.

The subjective evaluation lasted for 2016-2017. It covered a range of key questions that reflect the order of events held during an engineer experiment and are practiced in the course of study. There were 16 questions of this type (listed below), and the answers to them were used for statistical processing of the results.

The proposed questions consisted of two parts, the first of which contained the main question and the second contained its variable detail:

"Can you identify:

1) ... what "exploring the characteristics of the drive" means?

2) ... the correct procedure for the engineering experiment?

3) ... which drive parameters are original and which ones are calculated?

4) ... the right order of the experiment preparation circuit?

5) ... the order of the test switching on after installation?

6) ... the order of the operations for establishing the electric system?

7) ... the order of the emergency shutdown procedure in the case of the system failure?

8) ... which parameters can be measured in the scheme of the experiment?

9) ... which characteristics can be got during the engineering experiment?

10) ... which electric modes are available on the experimental installation?

11) ... which types of protection are carried out in this scheme?

12) ... what kinds of experiments can be used to get the static characteristics of the engine?

13) ... what kinds of errors present in the system during the regression experiment?

14) ... which methods can be used for calculating the results of the experimental research?

15) ... at which stage of the experiment the rapid processing of the experimental research is used?

16) …if you can conduct the engineering experiment?

The participants of the pedagogical experiment could give the only one of the three answers to every question: yes (2 points), rather yes than no (1 point) or no (0 points).

The mean values for each of the questions were calculated by the formula:

$$m_i = \frac{1}{k}\sum_{j=1}^{k} n_j \qquad (3)$$

where m_i – the mean value calculated for the i-th question ($1 \leq$ and ≤ 16);

k – the number of the respondents;

n – one of the values {0; 1; 2}, which is matched to the selected option response;

j – current number of the respondent.

The objective assessment was calculated by the results of the pedagogical experiment participants performing the series of the specially designed tasks which used the deontological modality. For example:

1) Determine the order of the operations for establishing electric system ...

2) Select the desired option plan of the engineering experiment to determine the static characteristics of the DC motor with independent excitation ...

3) Specify the DC motor settings with independent excitation referring to the initial ones or calculated analytically ... and so on.

Based on the procedures described by the formula 1, the objective assessment of the level of the participants' research skills was calculated.

It was found that from the total number of the tested participants the optimal level of subjective evaluation was recorded in 65% of the respondents, acceptable – in 30%, and the critical level – in 5%.

But according to the results of the objective assessment the acceptable level was observed in 6%, the critical one – in 88% and the unacceptable one was found in 6%. None of the respondents provided such answers that would allow to refer him/her to the group of people with an optimal level of research skills.

The essential difference between the subjective and objective kinds of assessment demonstrates that the participants inadequately assess their own engineering research skills and substantially overestimate it.

The next step in the pedagogical experiment was identifying difficulties students face in the process of mastering technical subjects when preparing for conducting experiments. For this purpose, we designed and suggested a questionnaire with the following question to the respondents: "Do you face difficulties in establishing electric DC, namely in ..." and after that a list of measures taken in the commissioning work was provided with two variants of reply: yes, or no.

For example:

1) checking the electric drive, information of its parts

2) validation of installation

3) control of insulation resistance, etc.

For each of these statements (according to the list of the routine maintenance) every participant of the pedagogical experiment had to give one of the answers:

– "Yes" if he/she believed that there were difficulties (0 points)

– "No" if he/she believed that he/she faced no difficulties (1 point).

For calculating the mean values obtained for each of the measures the Formula 3 (as in previous similar cases) was used.

According to the answers, most of the students had difficulties in setting up a pulse-phase system control, adjustment of the tacho-generator circuit, switching the converter to the engine with stopped position and setting up the speed regulators and devices.

Final analysis of the results obtained in the summative assessment allowed to make the following conclusions:

– the training system of the electromechanical specialty students requires an effective technology for the future specialists to be able to conduct the experimental studies;

– teaching future professionals to conduct experimental research in the process of mastering technical subjects requires regular monitoring aiming to detect and timely correct difficulties the students face when carrying out of the experiment procedures.

The first stage of the carried out experiment has shown that the future professionals in the electromechanical field are not quite familiar with the equipment, technology, organization of the research. They also have difficulties in setting and debugging electromechanical devices.

The students prefer reproductive activities and to follow the instructions of the teacher without understanding the purpose of certain actions of theory in practice. It should be noted that they have underdeveloped divergent thinking [7].

It has been determined that in the process of training one should take into account a set of pedagogical conditions [8] and facilitation [9].

Based on the competency approach we designed a guiding model of the formation of professionally important skills of future engineers of the electromechanical profile for the experimental studies in the process of mastering technical subjects [8]. The structural components of this model are as follows: methodological tools (targets, principles and approaches), theoretical and methodological elements (subject and activity, functional content, organization and activity) and technological ones (methods, tools, provided the organizational framework), including directly the stage of forming skills and assessing academic success, which allows to determine the level of skills.

The competence-based technology for teaching students to conduct experimental researches was tested during 2016-2017 academic year and involved control (CG) and experimental (EG) groups of students who had almost the same level of academic success.

It is known that traditional teaching technology in the field of experimental researches (which was used in CG) is characterized by the following things:

1) there is no "Experimental studies" unit in the content of the discipline "Electric Machinery and Electric Drive";

2) the workshop on this subject does not include the tasks related to the planning and conducting engineering experiments and choosing the experimental complex structure.

The situation is similar in the content of other technical disciplines, preventing fulfilment of the principle of the through implementation of a conceptually monistic system of teaching students conducting experimental researches into the process of technical disciplines studying. For these reasons we limit ourselves to the discipline "Electric Machinery and Electric Drive".

The suggested competence-based technology was used in the EG. The results obtained at the summative stage of the pedagogical experiment compared with the results for CG are demonstrated in the Figure 1.

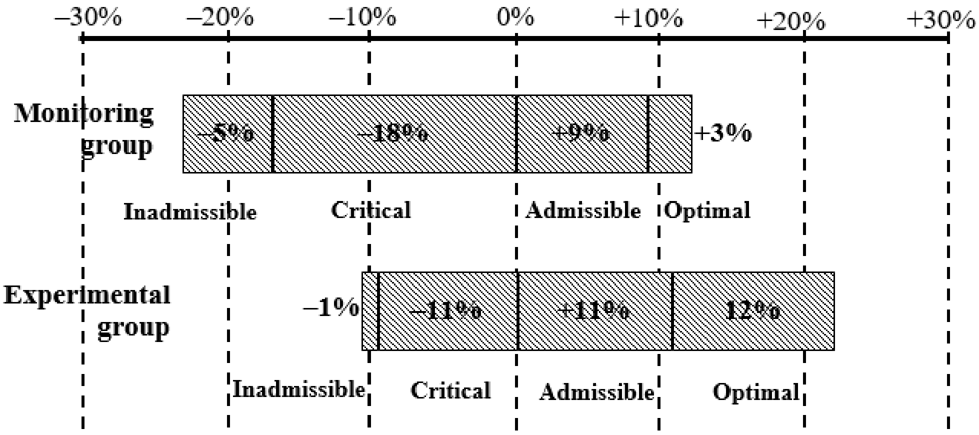

Fig. 1. Comparison of the Indicators of Research Skills in the Control and Experimental Groups at the Final Stage of the Experiment

The comparison of the resulting indicators, calculated for the experimental and control groups, gives a possibility for making a conclusion about the increase of the number of the participants with optimal and acceptable levels of research skills by 11% in the experimental group with a simultaneous decrease (by 11%) of the number of the respondents with critical and unacceptable levels.

The final results are statistically significant, which gave us grounds to conclude about the effectiveness of the proposed education technology and to recommend it for the widespread using.

Conclusion

On the basis of studying practical training of future experts in the electromechanical field and taking into account the peculiarities of the educational process organization under modern conditions we have designed, theoretically grounded and experimentally tested the efficiency of the technology of developing research skills of the above mentioned category of specialists.

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ОПТИМІЗАЦІЯ ТЕХНОЛОГІЇ ОПАНУВАННЯ КОМПЕТЕНТНІСТНИМ КОМПЛЕКСОМ ДЛЯ ПРОФЕСІЙНОЇ ДІЯЛЬНОСТІ ІНЖЕНЕРІВ-ЕЛЕКТРОМЕХАНІКІВ

У роботі встановлено, що майбутні фахівці погано знають як обладнання, так і види, технологію організації й проведення досліджень, віддають перевагу репродуктивним видам діяльності, воліючи дотримуватись вказівок викладача та методичних рекомендацій, не розуміючи призначення певних дій теорії на практиці наукових досліджень. На основі студіювання практики підготовки майбутніх інженерів електромеханічного профілю з'ясовано, що опанування студентами експериментальними дослідженнями потребує розробки компетентнісно-зорієнтованої технології навчання та врахування комплексу педагогічних умов її ефективного застосування. Спроектована компетентністно зорієнтована технологія опанування майбутніх інженерів електромеханічного профілю експериментальних досліджень передбачає створення єдиного експериментального середовища в межах комплексу технічних дисциплін шляхом уніфікації методологічного інструментарію (цільових орієнтирів, принципів і підходів), компонентних характеристик процесу навчання (суб'єктно-діяльнісних, функціонально-змістових, організаційно-діяльнісних), а також технологічних складників (методів, засобів, умов та ін.). Обґрунтовано, що основою змісту в компетентнісно зорієнтованих програмах підготовки майбутніх фахівців електромеханічного профілю доцільно позиціонувати експериментальні дослідження як універсальний, міжпредметний вид практико зорієнтованої діяльності, що дозволяє прилучати майбутніх фахівців до інженерного експериментування з метою формування нових знань і практичних умінь як необхідних результатів засвоєння технічних дисциплін. Зміст технічних дисциплін, що передбачають проведення експериментальних досліджень, орієнтується в руслі розробленої технології на формування в майбутніх інженерів електромеханічного профілю фахово значущих умінь, які лежать в основі дослідницької компетентності. У результаті її застосування відбулося суттєве зростання якісних характеристик рівня підготовки до проведення експериментальних досліджень, що характеризувалося зменшенням у вибірці кількості осіб з неприпустимим рівнем і зменшенням осіб з критичним рівнем підготовленості при одночасному значному зростанні числа студентів із допустимим і оптимальним рівнями підготовки до проведення експериментальних досліджень, що говорить про її дієвість.

Ключові слова: експериментальні дослідження, компетентністно зорієнтована, технології навчання, технічні дисципліни, інженери-електромеханіки.

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