Technological model of training of Masters in Electrical Engineering to electrical installation and commissioning

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Abstract. The article presents the technological model of training of Masters in Electrical Engineering to electrical installation and commissioning. In the structure of the model of training future electrical engineers, three basic blocks are identified: motivational-target, content-procedural and resultant. The following components act as structural elements of the motivational-target block of the model: social order, technological progress and normative base, purpose, tasks. The content-procedural block of the model includes components of the Master's readiness to electrical installation and commissioning (motivational, orientation, operational), as well as methods and tools of training. The resultant block contains a system of criteria for the formation of the Master's readiness to electrical installation and commissioning, control procedure, levels of formation, self-assessment, result, as well as elements of self-correction and correction of content and methods of education. It is noted that the practical implementation of the proposed model involves a special organization of the learning process, application of appropriate methods and learning tools that would ensure the formation of components of readiness for this activity. The obtained results of the experimental study provide an opportunity to assert that the model of training of Masters in Electrical Engineering to electrical installation and commissioning is effective.

1. Introduction

Due to socio-economic transformations in the country, there is a need for engineers who have a new type of thinking, able to successfully, creatively and quickly solve professional problem. The profession of an electrical engineer in the context of technological progress is developing rapidly due to the intensive development of machinery and technology, as well as the scale of their application and safety. The training of highly qualified specialists of the relevant profile and level, who are ready for constant professional growth, self-education and self-realization, comes to the fore. A modern university must train not just an educated specialist, but a specialist who is able to understand and navigate in the system 'nature – man – technology'. However, the existing system of training an engineer in the electrical industry does not fully meet the needs of society in the development of a competitive, competent specialist. Outdated style prevails in teaching, and innovative processes and methods are only gaining momentum. Insufficient attention is paid to the development of independence, creativity, personality of the engineer. There is a need to renovate the existing systems of training engineers in the electrical industry and their improvement. Therefore, the development of a model for training future specialists

in electrical engineering to electrical installation and commissioning in the context of modern needs is quite relevant. The novelty of the author's work is that was developed a set of means of selection and implementation of a step-by-step educational process of training Masters in Electrical Engineering on the basis of tasks using appropriate methods to obtain the result of integrated readiness for electrical installation and commissioning.

An analysis of the literature leads to the conclusion that the curriculum in electrical engineering begins with a comprehensive review of engineering mathematics and maintenance [1]. Students then receive more focused training in electrical and mechanical principles and applications such as circuits, microprocessors and motors. Rapid strides made in technological advancements call for a paradigm shift in engineering education [2]. In modern conditions, there is a need to ensure the operation of the system and take prompt measures to eliminate violations that arise in the process, to improve the knowledge of engineers and, consequently, their training methods [3] and technical tools for numerous engineering purposes [4]. In the context of technology-enhanced learning three support types are distinguished: technical tools, technical tools with predefined guidance, and technical tools with human interaction guidance [5]. The study points out the possible gaps between Software Industry and Education [6]. It is presented a statistical analysis of the views of Electrical Engineering students, regarding the knowledge formation process in a Project-Based Learning application, as a complement to classical teaching methods [7]. The American-Japanese Joint Working Group on Engineering Education (M. S. Dresselhaus, E. Baum, G. Bugliarello, S. C. Florman) determines that the key tasks of training a modern engineer should take into account the competence approach and practical experience [8]. G. Gorshkova investigated application of mathematical modelling in the training of future metallurgical engineers [9]. A. Manikandan and M. Muthumeenakshi emphasize the role of engineering education in supporting India's economic development [10]. S. Zappe, T. Litzinger and S. Hunter point out the need to improve seminars, practical classes and engineering courses [11]. From the standpoint of the European Review, C. Baillie and P. Walker [12], M. Lande [13], Z. E. Liu and D. J. Schnwetter [14], S. Morin, J.-M. Robert and L. Gabora [15] outline the directions of modern creative approach to the training of engineers in Europe. D. Schaffhauser outlines the key skills of the engineers of the future [16]. Z. Bakum and L. Tsvirkun emphasize the need to intensify the cognitive activity of future engineers during graphic training [17].

Engineering education is experiencing a paradigm shift from teacher-centric to student-centric teaching and learning process, content based education to outcome based education, knowledge seeking to knowledge sharing classrooms, teachers to facilitators, traditional engineering disciplines to interdisciplinary courses, lecture based learning to technology driven learning [18]. The mechanism of collaborative education receives the most attention, while the talent ability pays more attention to the cultivation of soft skills [19]; it the transformation of traditional disciplines, and there is little construction of corresponding disciplines for certain key industries [20]. The Renewable Energy program at Holon Institute of Technology gives the students technical and practical aspects of energy use (technology and methodology of the study) and energy efficiency [21]. New ideas for engineering design and engineering education is presented by M. Zilbovicius and J.R.C. Piqueira [22]. Features of the development of training simulators for the training of future engineers are covered in the works of N. Dotsenko [23] and I. Batsurovska [24]. Skills development and training for engineers investigated by H. Tank [25]. The issue of forming competencies in engineering specialists was studied in [26–32]. Engineering student's motivation towards an engineering career was investigated by R. Kjelsberg and M. Kahrs [33]. ICT is important part in electric engineering education [34]. O. Sushchenko, I. Trunina, D. Basyuk and M. Pokolodna presented coaching as education technology on electrical engineering education [35]. The findings are experienced from practical work and student evaluations in the field of electrical engineering described T. Fuhrmann [36]. But the issue

of the model of training future specialists in electrical engineering to electrical installation and commissioning has not been sufficiently studied.

The aim of the article is development and experimental verification of the technological model of training of Masters in Electrical Engineering to electrical installation and commissioning.

2. Methods

At the first stage of the study, we used the survey method, the method of evaluation of educational activities, taking into account the quantitative and qualitative indicators of the results of professional training of Masters in Electrical Engineering to electrical installation and commissioning. The experiment involved 267 higher education applicants in electrical engineering. The division into control and experimental groups was statistically checked for homogeneity using Fisher's criterion. It is determined that the formed groups are homogeneous. In the control group, the number of higher education applicants in electrical engineering is 135, in the experimental – 132 persons. After the division into control and experimental groups, it was implemented the author's model of training future electrical engineers to electrical installation and commissioning. At the end of the experimental work, the input and output quantitative indicators of the quality of training were checked using Student's t-criterion. T-statistics is usually based on the general principle: in the numerator – a random variable with zero mathematical expectation (when performing the null hypothesis), and in the denominator – a selective standard deviation of this random variable, obtained as the square root of the unbiased estimate of variance.

3. The technological model of training of Masters in Electrical Engineering to electrical installation and commissioning

Modelling becomes the optimal method of studying specifically organized objects, and the model is a means of cognition based on analogy. The model serves as a generalized reflection of the process, is the result of an abstract generalization of practical experience [37]. Technology is a system of functioning of all components of the pedagogical process, built on a scientific basis, which ensures the achievement of the intended results [38, 39]. The technological model in education is a set of ways, means of selection of the control process from a set of possible implementations in order to generalize the sequences and achieve the result. Under the technological model of training Masters in Electrical Engineering for electrical installation and commissioning it is meant a set of methods, means of selection and implementation of step-by-step control process based on tasks using appropriate methods to obtain the result of integral readiness for electrical installation and commissioning.

Formation of readiness for activity of future specialists is based on their readiness for work [40]. The readiness of Masters in Electrical Engineering to electrical installation and commissioning is a professional quality, which includes a set of professional knowledge, skills and attitudes that determine the effectiveness of actions within the competence of the technician and lead to professional safety tasks. In order to increase the readiness of Masters in Electrical Engineering to electrical installation and commissioning, it was developed a technological model of their training. The method of modelling allows to meaningfully reveal the essence of the model and present it graphically.

In the structure of the model (figure 1) of training future specialists in electrical engineering to electrical installation and commissioning, three basic blocks are identified: motivational-target, content-procedural and resultant. The following components act as structural elements of the motivational-target block of the model: social order, technological progress and normative base, purpose, tasks. The content-procedural block of the model includes components of the Master's readiness to electrical installation and commissioning (motivational, orientation, operational), as well as methods and tools of training. The resultant block contains a system of criteria

for the formation of the Master's readiness to electrical installation and commissioning, control procedure, levels of formation, self-assessment, result, as well as elements of self-correction and correction of content and methods of education.

The proposed model can be considered as a structure that has a function given by the social order and personal needs of Masters in Electrical Engineering to electrical installation and commissioning. Management of such a system involves diagnostic tasks. Then it is possible to correlate the purposes and results and to draw a conclusion about efficiency of functioning depending the declared purposes and the received results.

The first structural element of the technological model is the goal, determined as the formation readiness of future electrical engineers to electrical installation and commissioning, which will lead to the successful solution of professional problems to ensure safety in the workplace. This goal is due to the social order in modern conditions, technological progress and regulatory framework.

In the educational process of the university as tasks of formation of readiness of masters in electrical engineering the formation of motivational, orientation, operational component of readiness for electrical installation and commissioning is considered. Formation of future specialists in electrical engineering of integral readiness to electrical installation and commissioning is carried out step by step, on the basis of the set tasks.

The first stage is aimed at forming motivation to electrical installation and commissioning through the formation of interests, inclinations, in the development of social and professional values, value orientations in the learning process. At this stage, the future specialist acts as a subject of value self-determination in the professional activities of the specialist. As a result, higher education applicants must have a focus on the chosen profession, it is formed a conscious motivation to electrical installation and commissioning and self-realization in the socio-economic conditions of future professional activity, as well as a positive attitude to important aspects of future professional activity.

The second stage in the formation of Masters' readiness to electrical installation and commissioning is aimed at mastering the system of functional knowledge, conscious skills, abilities and actions in the process of training. The result of the second stage is the formation of the orientation component of the integral readiness of future specialists in electrical engineering to electrical installation and commissioning.

The third stage solves the problem of improving the professional activities of the future specialist in electrical engineering, the readiness of the Masters to varying the tasks of electrical installation and commissioning; achieving a high level of operational component of readiness for professional activity through testing as a subject of this activity in the learning process. The result of the third stage is the formation of the operational component of the integral readiness of future specialists in electrical engineering to electrical installation and commissioning. The practical implementation of the model of formation readiness of future specialists in electrical engineering to electrical installation and commissioning involves a special organization of the learning process, the use of appropriate methods and learning tools that would ensure the formation of components of readiness for this activity.

There are considered the didactic methods and means of formation of readiness of Masters in Electrical Engineering for electrical installation and commissioning. Methods that attributed to the *motivational component*:

- solving problem situations and creative tasks related to the installation of wiring, grounding, repair of electricity in apartments, offices and industrial accommodations,
- discussions on electrical installation and commissioning,
- business and role-playing games in the process of work on electrical sites.

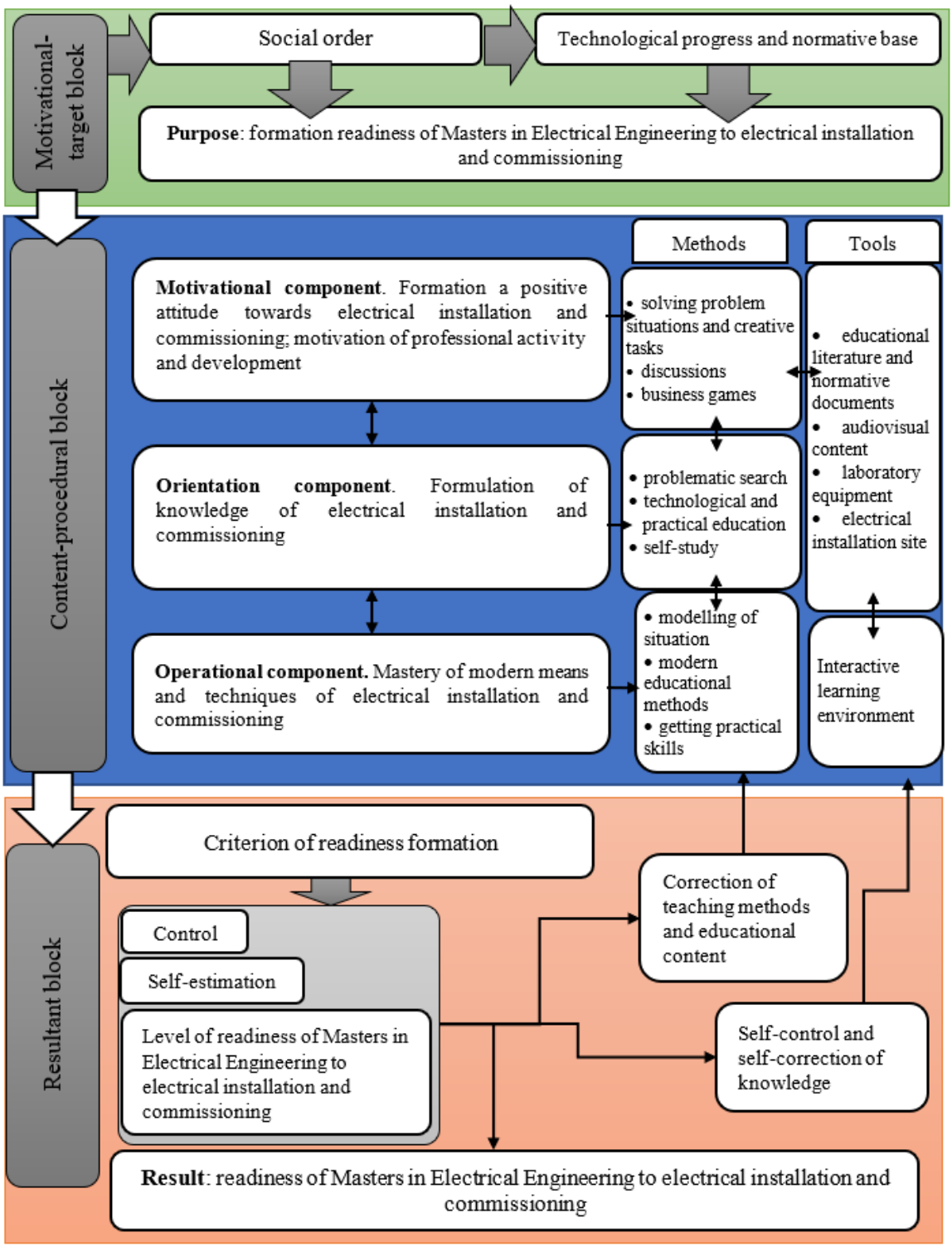

Figure 1. The technological model of training of Masters in Electrical Engineering to electrical installation and commissioning

The methods involve work in laboratories and on experimental electrical sites. Methods that attributed to the *orientation component*:

- problem-searching method (provides for the creation of problem situations of electrical installation and commissioning, active reflection and on this basis their independent promotion in the acquisition of new knowledge),
- technological method (provides an orderly set and sequence of methods and processes that ensure the implementation of the project of the didactic process and the achievement of the diagnosed result of electrical installation and commissioning),
- method of practical training (determines the conduct of joint tests and electrical installation and commissioning),
- method of self-learning (provides opportunities for self-improvement).

Methods that can be attributed to the *operational component*:

- modelling of situations of the process of installation of cable power lines,
- active methods of teaching elements of automation of technological processes,
- acquisition of practical skills.

The means of forming the readiness of Masters in Electrical Engineering for electrical installation and commissioning include the following:

- educational literature and normative documents (lay the basis for the study of key theoretical provisions, laws and regulations and relations in power companies),
- audiovisual content (helping to expand the perception of debugging processes),
- laboratory equipment (is the basis of work with electrical appliances and electrical systems based on training models and simulators),
- electrical installation site (lays the foundation for the operation of commissioning systems for street lighting of residential areas).

Interactive learning environment is one of the key aspects of training Masters in Electrical Engineering based on interactive, visual and audio content.

Criteria and indicators. A key element of the model is a system of criteria and indicators of the level of formation of the components of readiness of future professionals to electrical installation and commissioning. Among the criteria for the formation of Master's readiness to electrical installation and commissioning, there are included:

- awareness of the importance and necessity of the electrical installation and commissioning,
- possession of a system of special knowledge necessary for the activities of the electrical installation and commissioning,
- possession of methods and techniques of necessary actions of the electrical installation and commissioning,
- performance, ability to apply the acquired knowledge and skills in terms of production activities.

Determining the formation of the components of readiness of future electrical engineers to electrical installation and commissioning has three levels: modelling, adaptive and reproductive. The level of formation of the components of readiness is determined by the results of the control procedure. If the control procedure reveals a discrepancy between the level of readiness of the student to some criterion of readiness of the future specialist, the system provides a set of corrective actions: self-correction of higher education applicants by developing an interactive learning environment, or correction by tutors of content and methods of education. If all the components of future specialists in electrical engineering are formed in accordance with the criteria, it can be concluded that their integral readiness to electrical installation and commissioning has been formed.

4. Results

The results of the study of the level of formation of the components of readiness of future specialists to electrical installation and commissioning in the experimental (EG) and control groups (CG) is presented in the table below. The reliability of the data obtained at the beginning and after the experiment was verified using Student's statistical T-criterion [41] (table 1).

Table 1. The results of the study of the level of formation of the components of readiness of Masters in Electrical Engineering to electrical installation and commissioning.

Level	Before the experiment				After the experiment			
	EG	EG, %	CG	CG, %	EG	EG, %	CG	CG, %
Reproductive	2	1.52	4	2.69	24	18.18	14	10.37
Adaptive	44	33.33	47	34.81	92	69.70	68	50.37
Modelling	86	65.15	84	62.22	16	12.12	53	39.26
Total	132	100	135	100	132	100	135	100

At the beginning of the experiment, the deviation from the mean value does not exceed a difference of 5 units. The calculated squares of deviations provide an opportunity to determine $t_{emp.}$=1.27. The critical values are the following: $t_{crit.}$=2.78 ($\rho \leq 0.05$); $t_{crit.}$=4.6 ($\rho \leq 0.01$).

So, $t_{emp.}$ is more than $t_{crit.}$ The empirical value of t is in the zone of significance, and therefore the indicators at the end of the experiment according to the modelling, adaptive and reproductive levels differ significantly.

At the beginning of the experiment $t_{emp.}$=18.27. and falls into the zone of significance. So, $t_{emp.}$ is more than $t_{crit.}$ The empirical value of t is in the zone of significance, and therefore the indicators at the end of the experiment according to the modelling, adaptive and reproductive levels differ significantly.

At the beginning of the experiment, quantitative indicators at high, sufficient and initial levels do not differ in quantitative ratio. Figure 2 shows the results obtained as a percentage according to the levels.

The figure in the form of histograms shows the increase in quality indicators at the adaptive and reproductive level after the introduction of the model of formation readiness of Masters in Electrical Engineering to electrical installation and commissioning. At the end of the experiment in the experimental groups at the reproductive level there is an increase of more than 15%, at the adaptive level – more than 30%. At the modelling level, there is a reduction of more than 50%. The existing increase in indicators provides an opportunity to argue about the effectiveness of the proposed methods.

Figure 3 presents a graphical comparison of data relative to the three levels in the experimental and control groups before and after the experiment.

Figure 3 shows the dynamics of each level. Indicators increase significantly in the experimental groups at the end of the experiment at the adaptive and reproductive levels.

5. Conclusion

Therefore, a technological model has been developed to prepare Masters in Electrical Engineering to electrical installation and commissioning. There are three basic blocks in the structure of the model: motivational-target,content-procedural and resultant. The following components act as structural elements of the motivational-target block of the model: social order, technological progress and normative base, purpose, tasks. The content-procedural block of the model includes components of the Master's readiness to electrical installation and commissioning (motivational, orientation, operational), as well as methods and tools of training. The resultant block contains

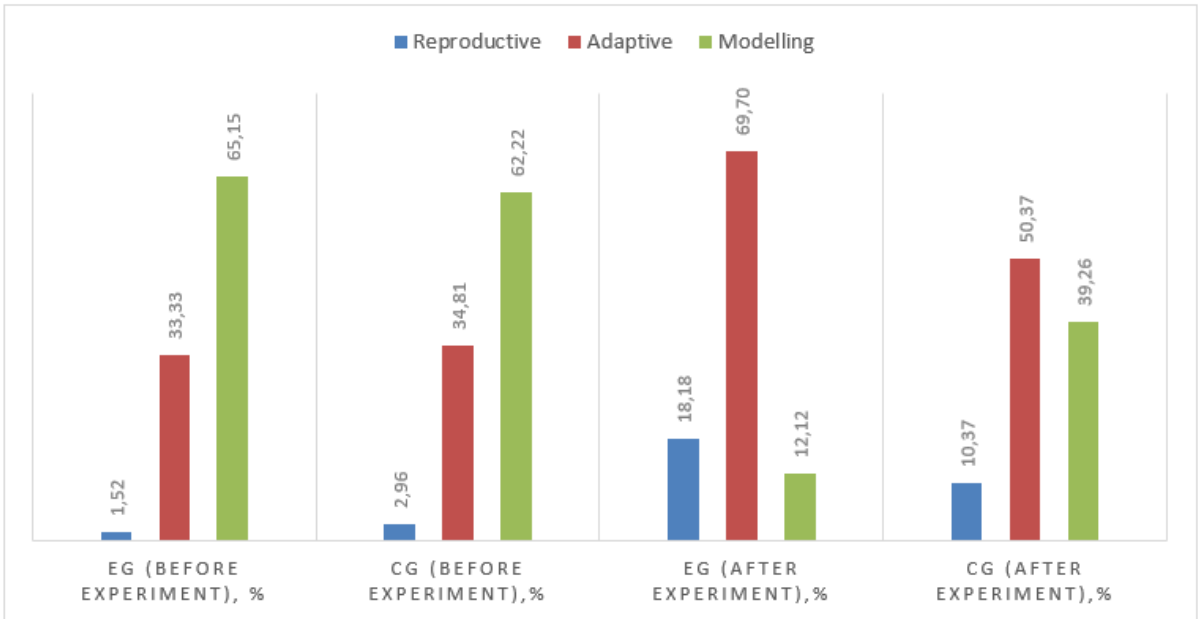

Figure 2. The study of the level of formation readiness of Masters in Electrical Engineering to electrical installation and commissioning.

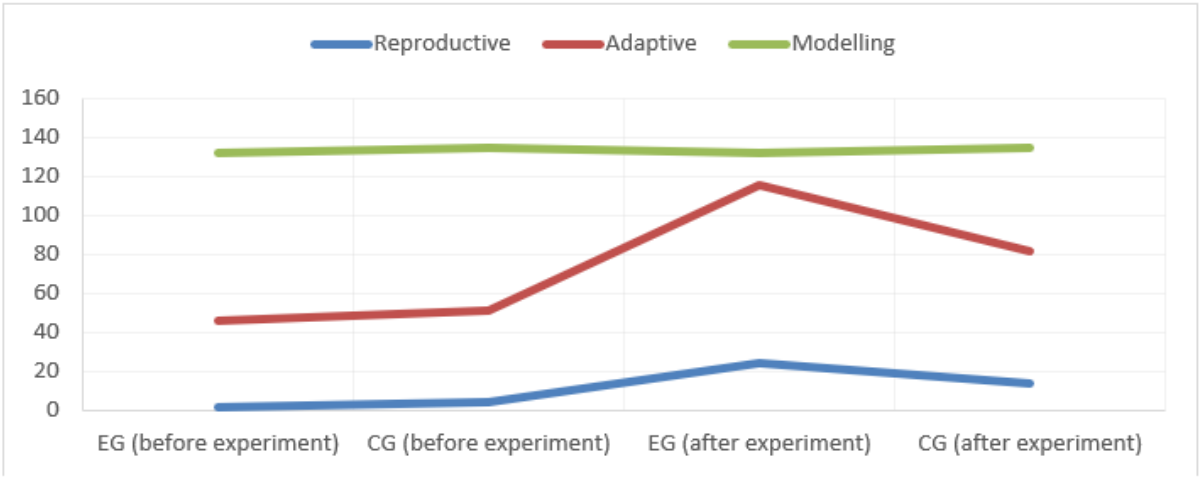

Figure 3. Dynamics of indicators according to the level of formation readiness of Masters in Electrical Engineering to electrical installation and commissioning.

a system of criteria for the formation of the Master's readiness to electrical installation and commissioning, control procedure, levels of formation, self-assessment, result, as well as elements of self-correction and correction of content and methods of education. The proposed model can be considered as a structure that has a function given by the social order and personal needs of Masters in Electrical Engineering to electrical installation and commissioning. The efficiency of the model was experimentally tested. The obtained results of the experimental study provide an opportunity to state that the model of training future specialists in electrical engineering to electrical installation and commissioning is effective.

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