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Modular Training as Technology of Professional Skills Development of Mechanical Engineers

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Abstract: There are main provisions of modular training program by "Theory of Automatic Control" (ACT) for students of technical universities is treating. Analysis of the advantages and disadvantages of a modular training system compared to traditional system in the formation of future engineer's professional skills. Detection of changes in the level of learning, basic skills and motivational sphere of students enrolled in the modular training program. The main conclusion of the research that the modular training exists: the development of basic skills in the future engineer. Improve educational success in mastering the subject. Increase student's motivation.

Key words: Modular training, professional skills, individual cumulative index, disadvantages, traditional system, ACT

INTRODUCTION

A formation and development professional skill of future expert is one of the main tendencies of modern higher education development. On the other hand, development of professional skills among students of technical universities presents one of low-developed but especially, important directions in the increase of educational process efficiency and quality of specialists training. We made an attempt to substantiate theoretically and experimentally prove possibility of the most important professional abilities development in future mechanical engineers in the conditions of modular training.

MATERIALS AND METHODS

Theoretical principles: The general conceptual basis of research is approach to training as to process of management of mental development of the person to process which efficiency is defined by personal precedence rules of the trainee, formation of his reflexive mechanisms among which the crucial role belongs to a self-assessment.

We consider activity of the engineer as creative, i.e., the engineer should have creative skills, the essence of which lies in finding modern, unique (from a set of alternative options), the solution of a task (project) which isn't contradicting conditions of production on the basis of modern knowledge.

There are three steps of creative abilities: the basic, we understand such abilities which make a technical aspect of creative activity of the engineer, for example, ability correctly group and systematize data of supervision, to define reliability of measurements, correctly to execute and estimate calculation accuracy, quickly to find reference data in literature, work at the personal computer, etc.

The professional skills directly related to the professional activity of engineer. For mechanical engineer example of such skills can serve as design, construction, operation and setting up processing equipment of various industries.

The highest creative skills of higher stages associated primarily with the nature of thinking and its most general laws, usually lying outside the scope of professional activity. For the representatives of technical specialties these include such skills as to invent, to formulate and test a hypothesis, pose new questions or see new problems in the traditional situation, find alternative solutions, synthesizing systems, etc.

List of basic skills necessary for the work of a mechanical engineer is quite diverse. Based on questionnaire related to professional activities conducted among professionals who have experience of 4-40 years, we have allocated four most important of them: the ability to articulate the goal of work, the ability to find the missing data and convert units of measurement, the ability to calculate, evaluate the result and find a "dropping out" digits, the ability to synthesize the system and is technically competent to explain the result.

Ascertaining stage of the experiment: To diagnose the initial level of professional skills for 102 students-mechanics proposed to perform calculation and

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graphic assignment on the main subjects which assessment was made by Bespalko's criteria: the 1st level- recognition, the 2nd level-reproduction the 3rd level application. On the basis of this task's performance results students were divided into three conditional groups. The 1st group students with the low level of basic abilities formation.

Student performs the task with the help of moving the process of solving the algorithm as a whole or its individual operations which shows the awareness of the student in the learning material but insufficient preparation for independent professional activity. He can't assess the results, find the numbers, "dropping out" of the general type of holistic solutions. Difficulty in choosing the scale of the construction schedules. He is confused with the unit conversion from one system to another. He gets difficulties in work with reference books. His knowledge of technical language is poor. The 2nd group students have the average level of basic abilities formation.

The student not clearly sees the goal of the work. He solves typical problems in the specialty at the level of literal reproduction by memory of algorithm solution and application in the given conditions. He can to evaluate the results, to find the numbers that adversely affect the general solution. His skills to work with reference books, translation units from one system to another are well enough. He easy produces the standard graph. The speech is technically competent, though isn't deprived of stylistic mistakes. The 3rd group students have high level of basic abilities formation.

The student clearly formulates goals of the work. He performs atypical, real tasks, complicated by deficiency of conditions necessary for the decision. It is capable to find alternative versions of decisions to estimate positive and negative results to build the most difficult schedules, freely uses reference books. Have perfect knowledge of technical language. Table 1 shows the results of expert assessment of the basic skills of the students.

Thus, clearly make goals of work could only 21 students (20.59%), 39 (38.24%) didn't understand task clearly and 42 students (41.18%) did not have any idea about what is it required from them. Possess ability to find missing data and to translate units of measure at the highand low level on 24 persons (23.53%) on an average 54 (52.94%). To make calculation, to estimate the received result and find the "dropping-out" digits on high levels could only 9 students (8.82%) on an average 39 people (38.24%) on low 54 (52.94%).

Table 1: Expert assessment of the level of basic skills formation

	Levels (%)		
Skills	High	Average	Low
To make a work's goals	20.59	38.24	41.18
Find out missing dates and make unit conversion	23.53	52.96	23.53
Calculate, evaluate the result and find a "dropping out" digit	8.82	38.24	52.94
Synthesize system and technically competent explain the results	11.76	47.06	41.18

Ability to synthesize system and technically competently to explain the received result at the high level 12 students (11.76%) on an average 48 (47.06%) on low 42 possess (41.18%). It is interesting to note that one of the listed abilities only at 6 people (5.88%) clearly expressed and also at 6 people (5.88%) all four skills are expressed clearly.

After analysing the composition of the mistakes made by students in the performance calculation and graphic tasks, we concluded that the students usually do not ask that eventually they should to get, cannot move received prior knowledge to new conditions, to use reference books, to evaluate the result.

Thus, the results of the diagnostic tasks showed that at students participants of experiment basic skills are developed at a relatively low level and need further improvement.

Based on questionnaires of students and teachers we analysed the traditional training system and came to the conclusion that the main shortcomings are as follows:

- Students spend the most part of school hours on lectures during which are engaged in mainly passive forms of work
- Students don't read special literature
- Students don't gain skills to speak on special topics because the biggest part of school hours they listen lectures
- The developed monitoring system (only total control) has no effective feed-back
- Absence of full-fledged work with the theoretical material in the classroom
- Sharp division of lectures and practical training

All the above mentioned disadvantages of the traditional system of education suggest that it is extensive character in which the active, creative role is played by the teacher and the student is a passive object of study.

The main principles of the module training program: Cognitive activity of the student doesn't occur by itself, it is the result of the content and methods of training-active, intensive and problematic. But whichever methods are used it is essential to create such psychological-pedagogical conditions in which students can take an active personal position and fully express themselves as a subject of educational activity.

The program of modular training is also based on these principles and includes the following basic provisions:

- Fragmentation a course of discipline into separate components-modules (Postlethwait and Russell, 1971)
- Synthetic character of lectures (Yutsyavichene, 1989a, b)
- Teacher gives lectures in the problematic character of the main sections of the course (Yutsyavichene, 1989a, b)
- Division of educational group into small groups (on 5 people) it's a professional task offer to each of them for example, carrying out part of lecture or practical class in a certain subject (Selevko, 2008)
- Statement by the teacher during lectures and laboratory works of the questions demanding work with educational literature (Teresyavichene, 1989)
- Carrying out various systematic control
- System of estimation of training results on the basis of an individual cumulative index (Russell, 1974)

Guided by the principles and rules for constructing modular programs formulated by Yutsyavichene (1989a, b), we have chosen the criteria for the formation of the modules in the structure of the course "Theory of Automatic Control" (ACT), the following provisions.

The purpose formulated by the teacher in the beginning of each module has to be directed not only on the organization of informative action but also on prospect of use of its results. Arrangement of the maintenance of a training material in modules, proceeding from the continuity of intra subject communications based on logical structure of discipline and also completeness of a training material and relative independence of the module elements. Creation of educational process by the principle the subject the subject relations in which activity of the student as the operated party in a bigger measure represents the self-government provided by means of the module. The teacher carries out flexible (adapting to the changing conditions and thus keeping focus of system) management, individualizing process of training depending on the level of formation of basic abilities at the student. A necessary condition of realization self-government by educational actions of the student is providing it methodical materials.

Providing systematic feedback (intermediate, thematic, final control). Division of the course "Theory of Automatic Control" (ACT) into modules was carried out on the basis of the analysis and systematization of the maintenance of a training material by two principles: logical structuring (from simple to difficult) and functionality of the training content, i.e., an orientation of the didactic purpose on development of professional abilities.

In this regard in structure of the course "Theory of Automatic Control" (ACT) we allocated three main Functional Modules (FM) of system and operational type: the basic concepts and definitions in the field of ACT, stability of linear systems and quality of management process, synthesis of automatic control systems.

Construction of modules by system-operational principle with the development skills of practical activities contributes for the future specialist formation of his basic and professional knowledge, defining the long-term development and adaptation to new tasks and changing working conditions.

Each of the modules of students training has the program and methodical providing, acts as a special form of assistance to achievement of the general integrated psychology and pedagogical result in professionally and personal development of students.

RESULTS AND DISCUSSION

Checking stage of the experiment: Testing of the proposed program of modular training was held in FEFU in natural conditions of educational process during the IV semester of 2013-2014 academic years in the study of the course "Theory of Automatic Control" (ACT) on the specialty "Technology of mechanical engineering".

The Experimental Group (EG) consisting of 34 people was created. For comparison of results of the academic progress at the rate of ACT at traditional and experimental system of training as the Control Group (CG) we chose also students (34 persons) of the specialty "Technology of Mechanical Engineering" but 2012-2013 academic years. Assessment of the qualitative composition of EG and CG was made based on the analysis of the entrance exams results (physics and mathematics), the results of examinations for the 1st and 2nd course on the theoretical foundations of electrical engineering and higher mathematics, specially designed diagnostic tasks. The survey showed that the Grade Point Average (GPA) on the entrance exam the students of the experimental group were: on physics 3.9, on math 3.8, students in the control group: 3.7 and 3.8, respectively. Grade Point Average (GPA) in higher mathematics of 1st and 2nd year students experimental group 3.7 (control group: 3.6); by electrical engineering in both groups 3.8. Grade Point Average (GPA) for the diagnostic task in the experimental and control groups was 3.3.

To exclude influence on the experiments results of different individual styles of teaching activities in both groups a lecture class conducted by the same teacher and laboratory work two another.

Table 2: Expert assessment of knowledge of students by the ACT course based on the tasks and exam

	Tasks				Exam			
Score point (%)	"3"	"4"	"5"	GPA	"3"	"4"	"5"	GPA
Experimental group	29.41	44.12	26.470	3.97	44.12	41.17	14.710	3.71
Control group	61.76	29.41	8.820	3.47	70.59	23.53	5.880	3.35

Table 3: Expert assessment of student's knowledge on the basis of multi-level engineering test assignments

	Module 1				Module 2				Module 3			
Level of task (%)	1	2	3	4	1	2	3	4	1	2	3	4
Experimental group	35.3	29.4	26.50	8.8	23.5	20.6	41.2	14.70	17.7	23.5	35.3	23.50
Control group	67.7	26.5	5.88	-	58.8	23.5	14.7	2.94	50.0	29.4	17.7	2.94

In processing the results of the experiment we are primarily interested the moment associated with the level of knowledge assimilation (in this case at the rate of ACT) which are the basis for the formation and development of basic skills.

The analysis was carried out on the basis of multilevel engineering test tasks on 1, 2 and to the 3 module of discipline, estimates for tasks and total examination estimates of students of experimental and traditional systems of training.

Engineering tasks of the first level of complexity offered a choice of the correct answer from the offered options. The student who completes a task at this level got 2 score points. Tasks of the second level assumed performance of actions on algorithm on the basis of the available knowledge. The student who completes a task at this level got 3 score points. Tasks of the third level included more difficult operations demanding variable decisions. The students who complete a task at this level got 4 score points. Tasks of the fourth level demanded ability of finding and correct mistakes. Using this criterion were analysed gnostic components engineering activities. The student who completes a task at this level got 5 score points. A criterion level of learning we have chosen Grade Point Average (GPA) for each of the listed types of works of students of experimental and control groups. Results of research are given in Table 2 and 3.

The analysis of results showed that the GPA for performance of multilevel engineering test and examination at students of experimental group is higher, than at students of control group. For a settlement and graphic task the assessment "3" was received by 10 students of EG (21 students of CG), "4" 15 (respectively 10) students,"5" 9 (respectively 3) students. Estimates for examination were distributed as follows: "3" 15 in EG (24 in CG), "4" 14 (8), "5" 5 (2), respectively.

The analysis of results showed that in experimental group upon transition from the module to the module positive dynamics of the decision by students of tasks on the more difficult level is observed. If during the 1st module test on the 1st level of difficulty have done by 12 people (35.29%), then the module 2 by 8 (23.53%) and the 3 only 6 (17.65%). At the same time increased the number of students who have completed the task of the fourth level of difficulty from 3 persons (8.82%) by the 1 module to 5 (14.71%) and 8 (23.53%), respectively by 2 and 3 module. It is observed positive dynamics in the control group. Reliability of results at the level of 0.05% is confirmed with statistical processing by student's t-test.

These results were achieved primarily due to the fact that in the process of teaching students of the experimental group regularly, at required own pace has engaged in an independent study of theoretical material and constant supervision of the teacher. This fact once again confirms one of the main provisions of the theory of modular training (Postlehwait and Russell, 1971) that the student who learns the information in the activity in active work with educational material, achieves better results than the student, using passive learning techniques.

Checking the level of basic skills development was conducted in accordance with the criteria developed by us the above. Expert judgment exhibited by the students performed computational and graphical task before and after the experiment. Results of the study are presented in Table 4.

Comparative analysis of expert estimations, the students of the experimental group exhibited prior to and after the experiment shows that in the course of the experiment the students is the development of all of the basic skills to a high enough level, however, the greatest changes happened in the level of formation of abilities to formulate the work purposes to find missing data and to translate units of measure.

Thus, before the experiment clearly define the purpose of research 11 people (32.35%) could and 6 (17.65%) could not understand what is required from them, after the experiment, 21 students (61.76%) clearly represented the final result of their work and didn't have who not understand.

At the level of recognition find the missing data and transfer units before the experiment could 5 students

Table 4: Expert assessment of the level of formation of basic skills

	The level of formation (%)					
	Recognition (low) 1		Reproduction (average) 2		Application (high) 3	
Skills	Before experiment	After experiment	Before experiment	After experiment	Before experiment	After experiment
To make a work's goals	17.65	-	50.00	38.24	32.35	61.76
Find out missing dates and make unit conversion	14.71	-	50.00	20.59	35.29	79.41
Calculate, evaluate the result and find a "dropping out" digit	32.35	14.71	41.17	41.17	26.47	44.12
Synthesize system and technically competent explain the results	29.41	8.82	47.06	41.17	23.53	50.00

(14.71%), at the level of reproduction 17 students (50%) but at the level of application 12 (35.29%), after the experiment 0.7 (20.59%) and 27 persons (79.41%), respectively.

Before the experiment on the low level 11 students (32.35%) have calculated, assessed the results and found a "dropping out" digits, after experiment 5 (14.71%), at the medium level both initially and at the end of the experiment 14 (41.17%), at the high level 9 people (26.47%) and 15 (44.12%), respectively.

Before the experiment at the level of studying 10 students (29.41%) synthesized system and technically competently explained the result, at the level of reproduction 16 (47.06%), at the level of the application 8 (23.53%), after the experiment 3 (8.82%), 14 (41.17%) and 17 (50%) students, respectively.

The statistical significance of changes in the level of formation of the above skills was carried out by Pearson's χ^2-test. Distinctions are reliable at the level of 0.05%.

Positive results were obtained while using in the educational process of modular training program it was achieved through targeted training, the fact that in the course of study focused on the practice. Each module is constructed in such a way that its material contributes to the formation the all abilities in general and of a specific one. For example, during the studying of the first module "Basic concepts and definitions in the field of ACT" students increasingly develop the ability to find missing data and convert measurements and the ability to operate with special terms, 2nd module "Stability of linear systems and quality of control process" most favored to the development of the ability to calculate, evaluate the result and find a "dropping out" digits, the 3rd module "Synthesis of automatic control system" is designed primarily to form and improve the ability of students to synthesize the system and is technically competent to explain the result. The development of the ability to formulate the objectives of the research follows automatically from the structure of the modules across the whole course of "Theory of Automatic Control" (ACT).

Specialists confirm that the students of experimental group have higher level of basic skills. During practical training in enterprises practicing engineers were asked to rate the level of students professional training (unfortunately due to economic instability in the country, not all students during practice have jobs in enterprises). The survey results are shown in Table 5 and 6.

Table 5: External expert assessment of the level of professional training of students

Indexes	Experimental group (GPA)	Control group (GPA)
Overall assessment of specialist	3.91	3.12
The complexity of the work which can handle	3.65	3.15
Speed	4.15	3.53
Ability	3.68	3.26
Honesty	3.44	3.44
Diligence	3.35	3.21
Efficiency	3.53	3.29
Hardworking	3.50	3.28
The ability to organize work	3.87	3.12
The ability to decide matters relating to their professional activities	4.06	3.32

Table 6: Emotions in class

Emotion	Before experiment (persons)	After experiment (persons)
Interest	5	23
Fear	22	10
Joy	-	-
Boring	29	11
Pleasure	-	-
Irritation	-	-
Activity	2	28
Shame	2	5
Passivity	32	6

Analysis of the survey showed that all the indicators characterizing the level of professional training, students involved in the program of modular training, exceed students enrolled by the traditional system. The most pronounced difference in the complexity of this research with which they can handle students of the experimental group 3.65 score points and students from the control group 3.15 score points, speed 4.15 and 3.53, respectively the ability to organize their work 3.87 score points (EG) and 3.12 score points (CG), the ability to decide matters relating to their professional activities 4.06 and 3.32 score points, respectively and as a consequence an overall assessment of specialist experimental group 3.91 score points, the control group 3.12 score points.

To achieve professional success of great importance, in addition to successful mastering the profession has a

Table 7: The ratio of students to the course "Theory of Automatic Control" (ACT)

	Answer					
	Experimental group (%)	Control group (%)	Experimental group (%)	Control group (%)	Experimental group (%)	Control group (%)
Question	Yes		No		Don't know	
Was the course was useful for you?	56.25	56.25	6.25	12.5	37.5	31.25
Would you like to continue to study the discipline?	12.5	5	10,5	45	77,5	50
	High		Enough		Low	
How do you assess the level of the course?	37.5	12.5	62.5	87.5	0	0
	Too much		Normally		Not enough	
Is it enough the duration of the course?	18.75	56.3	68.75	45.75	12.5	0
	Yes			No		
Did you understand contents of the course?	31.25	0	68.75	100		
Did you understand terms used in the course?	62.5	62.5	37.5	37.5		
Did answers to your questions lecturer satisfy you?	56.25	50	50	43.75		

positive motivation for it. Therefore in this experiment, we were interested how the program of modular training influences on changes the professional motivation.

At the beginning and end of the study "Theory of Automatic Control" (ACT) course students of the experimental group was offered the test of Ehlers, the purpose of which is to assess the strength of motivation to achieve professional success. Analysis of the results showed that in the process of modular training the number of students who have very high levels of motivation to succeed, increased 2 times, moderately high 1.5. The number of students with an average level of motivation has decreased by 1.4 times with a low level 1.3 times.

We were also interested in the question what emotions experienced students in the classroom, carried out by different methods. To do this for students of the experimental group after the first two lectures by traditional ACT and after studying the course of modular training program was proposed questionnaire by the modified method of Kuzmina (1970). The survey results are shown in Table 7.

Analysis of the data showed that when training by a modular program, student's emotions such as interest to the subject have increased (5 persons before the experiment, 23 people after the experiment) and activity (2 and 28 people, respectively), decreased fear (22 and 10 students, respectively), boredom (29 and 11 before the experiment and after it), passivity (32 and 6 students, respectively). Paradoxical is the fact that an increased number of students experiencing in the classroom for the pilot program a sense of shame (2-5 people). Although, it can be attributed to a higher degree of self-esteem in adolescence when any failure including in educational activity, lead to an exacerbation of the feelings of self-doubt, shame, etc.

At the end of the study course "Theory of Automatic Control" (ACT) for students of experimental group and control group was offered a questionnaire to ascertain how effective and interesting the proposed program of modular training. The survey results are shown in Table 7.

On the question "Which methods of teaching did you like?" "Did the system using individual cumulative index training increase your motivation?" 80% of the students expressed a preference for active methods of teaching and assessment system with individual cumulative index.

CONCLUSION

Thus, the processing of the results of the experiment showed that the modular training program has a positive effect not only on the level of learning and the development of basic skills but also on the formation of positive motivation to the teaching and professional activities and on the emotions of students during class. These facts once again confirm the effectiveness of the proposed program of modular training in our opinion the most promising directions in the field of rational construction of the educational process, combining operational and motivational aspects of the formation and development of professional skills.

The main feature of modular training is a system: system maintenance, alternating informative and educational and professional parts of the module, system control. As a result, significantly increases the quality of training of future specialists in terms of formation and development of his knowledge effective system and skills in a holistic individualized approach to the student's personality, creating the conditions for its independence and the formation teacher atmosphere conducive to raise student's motivation.

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