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The Effectiveness of Model of Independent Work Organization of Future Economists in the Mathematical Training Process

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Abstract

The resent study provided results of the experimental work on checking the effectiveness of the model of independent work organization of future economists during the process of mathematical training based on a competence approach. The independent work is considered by the authors as a planned organized educational process, internally motivated and purposefully carried out by students in the classroom and out-of-class time during the implementation of educational, production and research mathematical tasks in conditions of a gradual reduction of direct or indirect methodological assistance of teacher. Results of such process are the consistent acquisition of cognitive, activity and contextual experience of mathematical tools in the future professional activity. The main stages, a problem, a subject, an object, a purpose, tasks, a hypothesis, criteria and indices of efficiency of the experimental work are defined and the analysis of received results is performed.

Keywords: Independent work; Competence approach; Mathematical training; Experiment; Model.

1. Introduction

Fulfilling needs of society in economists capable of using modern mathematical tools to solve professional problems is an important factor in the innovative economic development of country. This is due to requirements to improve the quality of mathematical training of future economists in the higher education. The successful solution of the problem of improving the quality of mathematical training of future economists is possible only if an organization of independent work of students is effective (Antúnez, 2016). We defined stages of the independent work organization of future economists in the process of mathematical training on the basis of the competence approach (Kasatkina, 2012), and developed a model of the organization of independent work of future economists in the process of mathematical training on the basis of the competence approach (Kasatkina, 2017). Therefore, the evaluation of this model and obtained results is particularly appropriate (Kozhabergenova *et al.*, 2018).

2. Methods

The following methods were used in the research:

- Observation as a method of knowledge allowing to obtain the primary information in a set of empirical statements and establish the primary schematization of interpretation of concept of "independent work in the process of mathematical training";
- Induction as a kind of conclusion from particular facts, provisions to general conclusions allowing us to identify structural elements of professional competence in the process of self-mathematical training of students;
- Elementary theoretical analysis and modeling method giving us the opportunity to study and analyze the conceptual provisions of competence education (Abakumova, 2007; Akhmetzyanova, 2009; Baydenko, 2004; Bermus, 2005), and pedagogical modeling and design (Dahin, 2005; Lodatko, 2010; Yakovlev, 2006) in order to build our own model of the organization of independent work of future economists in the process of mathematical training on the basis of a competence approach (Kasatkina, 2017);
- Experiment as a strictly controlled pedagogical observation (Akhmetzyanova, 2015) which allows justifying the working hypothesis, accurately records results, carefully analyzes data, and as a result, formulates final conclusions (Sadriev and Andrianova, 2017).

3. Results and Discussion

We considered an independent work on the process of mathematical training as a planned organized educational process, internally motivated and purposefully carried out by students in the classroom and out-of-class time during the implementation of educational, production and research mathematical tasks in a gradual reduction of direct or

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indirect methodological assistance of teacher. Its result was a consistent acquisition of cognitive, activity and contextual experience of using mathematical tools in future professional activities.

We developed a model of independent work organization of future economists in the process of mathematical training on the basis of a competence approach presented by purposeful, theoretical-methodological, structural-meaningful, instrumental-technological and resultant-diagnostic components.

In order to test the effectiveness of developed model of the independent work organization, the experimental work was carried out on the basis of Nizhnekamsk and Naberezhnye Chelny branches at Kazan Innovative University (KIU) named after V. G. Timiryasov (NB and NChB of KIU).

We identified main stages of the experimental work:

I. The stage of preparation of experiment including the definition of problem, subjects, objects, purposes, objectives and hypotheses of experiment; selection of criteria characterizing the formation of professional competencies of future economists in the process of independent mathematical training; the establishment of the duration of the experiment.

II. The stage of experiment, which includes monitoring the progress of experimental work on the implementation of model of self-organization of future economists in the process of mathematical training based on the competence approach by monitoring, control sections, testing, analysis of results of independent activity of students. At this stage, we carried out diagnostics of structural elements' development of professional competences in the process of self-mathematical training of future economists in each course of teaching mathematical disciplines at three levels (cognitive, activity and contextual) on the threshold and advanced levels, and monitoring changes in qualitative indicators of mathematical training. The obtained results were processed and analyzed.

III. The stage of generalization of results including the analysis of results of experimental work, conclusions about the effectiveness of a developed theoretical model of the independent work organization of future economists in the process of mathematical training based on the competence approach, systematization and generalization of results.

The problem, which should be solved by the pedagogical experiment, is as follows: Mathematical training of future economists on the basis of model of organization of independent work. The main idea of experiment is that if the developed model of organization of independent work is used in the process of mathematical training of students, the problem of independent mathematical training of future economists will be solved.

The subject of the experimental work covers the developed model of independent work organization of future economists in the process of mathematical training on the basis of a competence approach.

The object of the experiment covers students of the first, second and third courses of the faculty of economics.

The purpose of experiment is to test the effectiveness of a developed model of independent work organization of future economists in the process of mathematical training based on the competence approach.

Hypothesis of experiment consists of the following case: For improving the efficiency of independent work organization of future economists in the process of mathematical training, it is necessary to implement a developed model.

Experimental work was cyclically carried out from 2014 to 2017 in the NB and NChB of KIU: 1 cycle- 1 course (2014-2015), 2 courses (2015-2016) and 3 courses (2016-2017); 2 cycles – 1 course (2015-2016) and 2 courses (2016-2017); 3 cycles – 1 course (2016-2017). The students attended the experiment the first, second and third courses (total number: 251 subjects, control group (KG): 124 subjects; experimental group (EG): 127 subjects) and teachers of Higher Mathematics Department. The formation of groups is carried out under the condition of uniform distribution of students with different average scores on the certificate in the first year of study at the University allowing us to conclude that the differences in the level of pre-university preparation of students from KG and EG are insignificant. In addition, a representative sample was provided by examining 100% of students without special selection.

Validity and reliability-stability of experiment results are provided by testing the hypotheses: 1) In the absence of a difference between experimental results in the groups of Nizhnekamsk and Naberezhnye Chelny branches of the KIU named after V.G. Timiryasov; 2) the absence of a difference between results of the experiment in groups of different cycles in the corresponding courses of mathematical training, regardless of branches.

We determined the performance indices of model of independent work organization of future economists in the process of mathematical training on the basis of competence-based approach, in other words, the formation of structural elements of professional competencies in the process of self-mathematical training of future economists.

The structural elements of professional competencies, which are formed in the process of self-mathematical training of future economists, determine the criteria for assessing the formation of professional competencies in each course of mathematical training of students at two levels: threshold and advanced levels. Similarly, each level is considered by authors at three levels (cognitive, activity and contextual).

The first course is shown as an example.

The threshold level includes the cognitive level: knowledge of basic methods of matrix algebra and mathematical analysis used to solve economic and mathematical problems; an idea of the parameters and criteria for the applicability of some mathematical methods for solving applied economic problems; at the activity stage: the ability to recognize and analyze possible ways of solving educational mathematical problems, choosing the way to solve them, the ability to use a universal conceptual apparatus, the arsenal of methods of linear and vector algebra, mathematical analysis in solving economic problems; at the contextual stage: the ability to independently master the method of calculating the economic indicator using the mathematical apparatus, selecting the appropriate method of

mathematical calculation of economic indicators, and carrying out calculations of indicators based on standard mathematical techniques.

In the first year, the advanced level includes the cognitive level: knowledge of abstract concepts of mathematical analysis used to describe and model various professional mathematical problems; at the activity stage: the ability to apply analytical methods in the preparation of economic sections of the plan; using the methods of matrix algebra and mathematical analysis in modeling economic processes; at the contextual stage: the ability to create mathematical models of economic systems and objects by means of matrix algebra and mathematical analysis.

The experiment results are presented using multi-dimensional data representation technology (OLAP-technology) (Fig.1).

Figure- 1. Multi-Dimensional Cube of Experimental Results (KG / EG)

Advanced level

Threshold level

Cycle	Step	Cognitive	Activity	Contextual
1 cycle	1 course	10,0% / 4,9%	70,0% / 70,7%	17,5% / 19,5%
	2 courses	10.0% / 7.3%	60.0% / 48.8%	27.5% / 36.6%
2 cycles	1 course	12,2% / 9,1%	68,3% / 61,4%	14,6% / 22,7%
	2 courses	12,2% / 4,5%	48,8% / 43,2%	31,7% / 38,6%
3 cycles	1 course	11,6% / 9,5%	65,1% / 59,5%	18,6% / 21,4%
	2 courses	—	—	

Fig 2 shows the multidimensional cube of experimental results.

Figure-2. Disclosure of a Multidimensional Cube of Experimental results (KG / EG)

Advanced level

Cycle	Step	Cognitive	Activity	Contextual
1 cycle	1 course	2,5% / 2,4%	0,0% / 2,4%	0,0% / 0,0%
	2 courses	2,5% / 2,4%	0,0% / 4,9%	0,0% / 0,0%
2 cycles	1 course	2,4% / 4,5%	2,4% / 2,3%	0,0% / 0,0%
	2 courses	2,4% / 4,5%	4,9% / 6,8%	0,0% / 2,3%
3 cycles	1 course	2,3% / 2,4%	2,3% / 4,8%	0,0% / 2,4%
	2 courses	—	—	—

Threshold level

Cycle	Step	Cognitive	Activity	Contextual
1 cycle	1 course	10,0% / 4,9%	70,0% / 70,7%	17,5% / 19,5%
	2 courses	10,0% / 7,3%	60,0% / 48,8%	27,5% / 36,6%
2 cycles	1 course	12,2% / 9,1%	68,3% / 61,4%	14,6% / 22,7%
	2 courses	12,2% / 4,5%	48,8% / 43,2%	31,7% / 38,6%
3 cycles	1 course	11,6% / 9,5%	65,1% / 59,5%	18,6% / 21,4%
	2 courses	—	—	—

Presentation of experiment results in this way allows to trace the dynamics of indices of structural elements' formation of professional competencies in the process of independent mathematical training. In addition, the use of OLAP-technology allows for various manipulations (stratification, cutting) required for a detailed or, conversely, a summary analysis of the results of the experiment.

Analysis of results of experiment in the first year of mathematical training is shown as follows:

-In the first cycle of experiment, the number of future economists with the advanced level of structural elements' formation of professional competencies in the experimental group exceeds the same index for the control group by an average of 0.8% (-0.1% for cognitive, 2.4% for activity and 0.0% for contextual levels);

- In the second cycle of experiment, the excess of the number of students with the advanced level of structural elements' formation of professional competencies in the experimental group is over the same index in the control group with an average of 0.6% (2.1% for cognitive, -0.2% for activity and 0.0% for contextual levels);

- In the third cycle of experiment, the number of bachelors with the advanced level of structural elements formation of professional competencies in the experimental group exceeds the same indicator in the control group by an average of 1.6% (0.1% at the cognitive and 2.4% at the activity and 2.4% at the contextual levels).

Results of experiment in the second year of mathematical training allow us to draw the following conclusions:

- In the first cycle of experiment, the excess of number of students with the advanced level of structural elements' formation of professional competencies in the experimental group is over the same indicator in the control group with an average of 1.6% (-0.1% for cognitive, 4.9% for activity and 0.0% for contextual levels);
- In the second cycle of experiment, the number of future economists with the advanced level of structural elements' formation of professional competencies in the experimental group exceeds the same indicator in the control group by an average of 2.1% (2.1% for cognitive, 1.9% for activity and 2.3% for contextual levels).

By analysis of obtained indices during the first cycle of experiment in the third year of mathematical training of students, we can conclude that the number of future economists with the advanced level of structural elements formation of professional competencies in the experimental group exceeds the same indicator for the control group by an average of 3.2% (2.3% for cognitive, 4.8% for activity and 2.4% for contextual levels).

For the entire period of training in mathematical disciplines (from the first year to third) on the first cycle of experiment, we can argue the following dynamics of the mathematical training level in the process of independent work: An increase in the number of students with the advanced level of structural elements' formation of professional competencies in EG exceeds two times higher than obtained results in the experiment course on EG and KG of all considered cycles in all courses of study on mathematical disciplines, and it allows us to conclude that the formation of structural elements of competencies is slower in KG in the process of organization of independent mathematical training. In EG, the average indcies are higher, and there is a stable positive dynamic of their formation.

4. Summary

The independent work in the process of mathematical training is determined by authors as a planned organized educational process, internally motivated and purposefully carried out by students in the class and out-of-class time during the implementation of educational, production and research mathematical tasks as a gradual reduction of direct or indirect methodological assistance of teacher. Results are consistent acquisition of cognitive, activity and contextual experience of using mathematical tools in the future professional activity. The structural elements of professional competencies, which are formed in the process of self-mathematical training of future economists, determine the criteria for assessing the formation of professional competencies in each course of mathematical training of students at two levels: threshold and advanced levels, each which is considered by authors at three levels (cognitive, activity and contextual). The use of a developed model of independent work organization in the process of mathematical training of students helps to solve the problem of independent mathematical training of future economists.

5. Conclusion

We implemented the model of independent work organization of future economists during the mathematical training process based on the competence approach. We then identified structural elements of professional competencies formed in the process of organizing independent work on each course of mathematical training of students of control and experimental groups at three stages (cognitive, activity and contextual). Analyzing the dynamics of indices of structural elements' formation of professional competencies in the process of mathematical training of students of control and experimental groups during the experiment and summarizing results, we found that experiment results confirmed the hypothesis and the implementation of the developed model could improve the efficiency of independent work organization of future economists in the process of mathematical training based on the competence approach.

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