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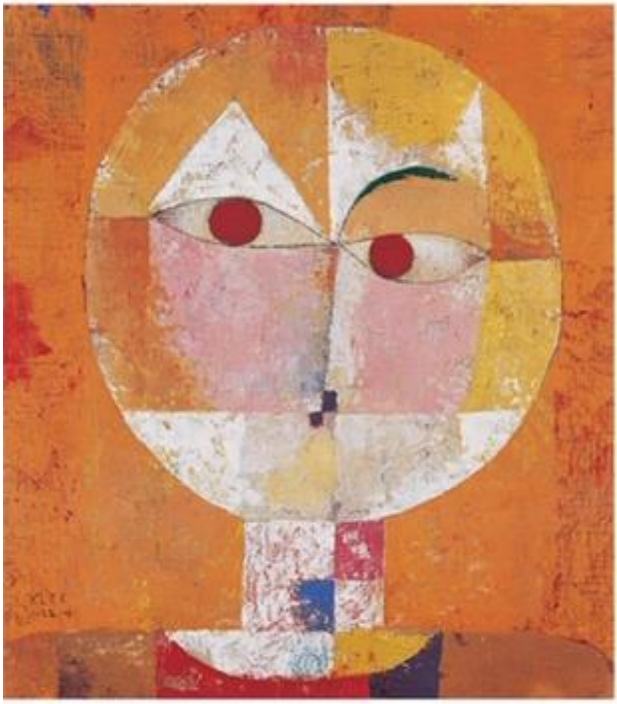

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Development of cognitive interest in the study of mathematics among students majoring

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Abstract

The purpose of the research is to theoretically substantiate and practically develop the system of fostering cognitive interest in the study of mathematics among students majoring in mining via comparative quantitative research methods. The results of the teaching experiment show that the students in the

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experimental group have a higher quality of mathematical competency. In conclusion, to test the hypothesis that introduction of the instructional system in the learning process in college would enhance the level of mathematical competency of students, the final academic achievement of the students involved in the experiment was assessed for mathematical disciplines.

Keywords: Cognitive, Interest, Mathematics, Higher Learning.

Desarrollo del interés cognitivo en el estudio de las matemáticas entre estudiantes con especialización

Resumen

El propósito de la investigación es fundamentar teóricamente y desarrollar prácticamente el sistema de fomentar el interés cognitivo en el estudio de las matemáticas entre los estudiantes que se especializan en minería a través de métodos comparativos de investigación cuantitativa. Los resultados del experimento de enseñanza muestran que los estudiantes en el grupo experimental tienen una mayor calidad de competencia matemática. En conclusión, para probar la hipótesis de que la introducción del sistema de instrucción en el proceso de aprendizaje en la universidad mejoraría el nivel de competencia matemática de los estudiantes, se evaluó el logro académico final de los estudiantes involucrados en el experimento para disciplinas matemáticas.

Palabras clave: Interés, Cognitivo, Matemática, Educación Superior.

1. INTRODUCTION

Pedagogical science has accumulated vast and diverse experience regarding the problem of improving vocational education. Nevertheless, the problem of vocational education and its psychological and pedagogical aspects has not been sufficiently developed or addressed. The problem of developing and forming students' cognitive interests in learning is one of the central ones aimed at improving the educational process, enriching the teacher's practice and experience, and allowing one to target the objective and subjective values of teaching and learning. The review of educational literature has identified that in order to achieve a certain pedagogical result, it is necessary to develop a set of external requirements that will ensure a positive outcome when satisfied. In this study, the development of cognitive interest in learning mathematics by college students is such a pedagogical outcome, and the instructional system for its development is such a set of external requirements (PETUNIN & TRIFONOVA, 2006).

The review of research, educational and psychological literature has shown that by now certain pedagogical material addressing the issue of formation and development of cognitive interest has been accumulated. However, a number

of aspects in this problem have not yet been adequately covered; in particular, the scientifically grounded approach to the problem of developing a cognitive interest in the study of mathematics by technical college students has been underrepresented in the literature. This contradiction determines the problem of research that consists in identifying and substantiating an instructional system that would contribute to the development of cognitive interest in the study of mathematics by in students majoring in mining (HOGHEIM & REBERA, 2015).

2. MATERIALS AND METHOD

During workshops on the topic, it is recommended to solve profession-oriented tasks that allow students to develop a cognitive interest in the study of mathematics. For example, a practical exercise to draft a mine-working complex: to draft a coal mine project according to geological exploration data. The projected opening scheme of a mine field and a mining system is given by the teacher according to the baseline data (DOWKER, 2019).

For self-study, students are advised to perform individual profession-oriented problem-based tasks with elements of partially searching or research methods. Thus, problem-based lectures, problem-based tasks with profession-oriented content, profession-oriented test assignments, research and illustrative laboratory works, the textbook Mathematics for Students Majoring in Mining developed by us and approved by the Ministry of Education of the Republic of Kazakhstan and many other materials laid the groundwork for creating an instructional system aimed at developing cognitive interest in the study of mathematics among students majoring in mining (CAROLYN ET AL., 2018).

3. RESULTS

The effectiveness of the elaborated instructional system aimed at developing a cognitive interest in the study of mathematics among students majoring in mining can be assessed only experimentally. The structure of a pedagogical experiment is as follows:

1) Ascertaining experiment;

2) Teaching experiment.

These experiments have such common features as conducting an initial assessment and a questionnaire survey, leveling the experimental conditions on a number of parameters, preparing experimental materials, and statistical processing of the results with subsequent conclusions. At the final stage, we determined the effectiveness of introducing the presented instructional system aimed at developing a cognitive interest in the study of mathematics among students majoring in mining into the learning process (DAVID ET AL., 2019).

To this end, the reference level of mathematical competency was analyzed. For this, in the first lesson, it was suggested that the students majoring in mining at Karaganda State Technical University take part in an individual quiz consisting of ten assignments based on high school course in algebra and geometry; the data are shown in Table 1. The level of pre-university mathematical competency of technical college students certainly affects the subsequent study of mathematics in college, and analysis of the results allows for the conclusion that the performance data have very little

divergence and do not depend on the study year (MOSES ET AL, 2018).

Table 1: Quantitative results of the reference level of mathematical competency in 2015-2018 academic years

Academic year	Number of students	Assessment of reference level of mathematical competency (as %)			
		<50%	50-74%	75-89%	90-100%
2015-2016	88	24.1	34.8	28.9	12.2
2016-2017	59	25.3	34.1	26.8	13.8
2017-2018	62	26.5	36.2	25.6	11.7

During three years, 209 first-year students majoring in mining were engaged in the experiment in Karaganda State Technical University; they were divided into control and experimental groups (Table 2).

Table 2: Grouping of students

Academic year	Group			
	Control		Experimental	
	number of students	as % (of total number)	number of students	as % (of total number)
2015-2016	42	47.7	46	52.3
2016-2017	28	47.5	31	52.5
2017-2018	32	51.6	30	48.4
Total	102	48.8	107	51.2

The analysis of educational literature for identification of criteria for cognitive interest formedness degree has defined the following criteria (COSTICĂ, 2014):

- The propensity of students to study;

- Their insight into the processes under study;

- The ability to apply mathematical competency in mining engineering practice;

Thus, we propose to evaluate the effectiveness of developing a cognitive interest in the study of mathematics among students majoring in mining according to these criteria that are characterized by the indicators presented in Table 3. Each of the above criteria was evaluated at three levels: low, sufficient, and high. For each criterion, we consider a level to be high if the student shows all the respective indicators (BAKAR, 2018).

The results of the ascertaining experiment show the formedness degree of cognitive interest in studying mathematics among students majoring in mining.

In the course of a teaching experiment, the students in the experimental and control groups were taught under the same curriculum but the learning process for students in the experimental group included the elaborated instructional system of developing a cognitive interest to studying mathematics among students majoring in mining. To evaluate the effectiveness of the elaborated instructional system, at the end of the course in mathematics, tests were run according to the same criteria as during the ascertaining experiment (PIPERE & MIERIŅA, 2017).

Thus, the teaching experiment data show that as a result of introducing the instructional system of developing a cognitive interest in the study of mathematics in mining students into the teaching process, the difference between the mean values of the control and experimental groups is the following (CLARK-WILSON & HOYLES, 2019):

- 13.0 % at a high level;

- 13.6 % at a sufficient level;

- 26.6 % at a low level;

Thereby, the interest in the study of mathematics in the experimental group raised by 17.7% on average as compared with the control group. Let us verify the reliability of differences between the results in the control and experimental groups for all the five criteria of cognitive interest formedness. The data obtained for the 2015-2016, 2016-2017, and 2017-2018 academic years upon all the criteria were summarized in computational Table 5 of criterion χ^2, where:

$n_э$ is the relative frequency of this interval for the experimental group data?

$n_к$ is the relative frequency of this interval for the control group data?

The value of χ_0^2 was calculated by formula $\chi_0^2 = \frac{(n_э - n_к)^2}{n_к}$.

Table 3: Computational table of criterion χ^2 upon the criteria of cognitive interest formedness

Intervals	Frequency $n_э$	Frequency $n_к$	$n_э$(%)	$n_к$(%)	$(n_э - n_к)$	$(n_э - n_к)^2$	$\frac{(n_э - n_к)^2}{n_к}$
First criterion							
low	9	34	8.4	33.4	-25	625.0	18.7
sufficient	77	59	72.0	57.8	14.2	201.64	3.5
high	21	9	19.6	8.8	10.8	116.64	13.3
							$\chi_0^2 = 35.5$
Second criterion							
low	12	40	11.2	39.2	-28.0	784.0	20.0
sufficien	70	50	65.4	49.0	16.4	268.96	5.5

t							
high	25	12	23.4	11.8	11.6	134.56	11.4
							$\chi_0^2 =$ 36.9
Third criterion							
low	14	43	13.1	42.2	-29.1	846.81	20.1
sufficient	72	53	67.3	52.0	15.3	243.09	4.5
high	21	6	19.6	5.9	13.7	187.69	31.8
							$\chi_0^2 =$ 56.4
Fourth criterion							
low	6	26	5.6	25.5	-19.9	396.01	15.5
sufficient	72	61	67.3	59.8	7.5	56.25	0.9
high	29	15	27.1	14.7	12.4	153.76	10.5
							$\chi_0^2 =$ 26.9
Fifth criterion							
low	26	56	24.3	54.9	-30.6	936.36	17.1
sufficient	62	42	57.9	41.2	16.7	278.89	6.8
high	19	4	17.8	3.9	13.4	179.56	46.0
							$\chi_0^2 =$ 69.9

The value of random variable $\chi_0^2 = 35.5$; let us determine the number of degrees of freedom $k = 2$ (since there are three intervals) and find out that the critical value of χ^2 with a significance level of 0.01 is 9.21. Then, if

$\chi_0^2 > \chi^2$, this hypothesis is accepted at this level of significance. Consequently, according to the first criterion, since 35.5 > 9.21, there is no reason to reject Gaussian hypothesis, which confirms the hypothesis of a random selection of students with a probability of 0.99, that is, 99%. The calculated values of variable χ^2 for all the other formedness criteria of cognitive interest in the study of mathematics among students majoring in mining is significantly higher than the critical value χ^2 = 9.21with a probability of 0.99.

Thus, the results of experimental validation obtained after introducing the special methods of developing cognitive interest in the study of mathematics into the learning process are significantly higher compared with the results of the control group, and this comparison is valid for the random selection of students with a probability of 0.99. This confirms the representativeness of the research findings. The consistency degree of measurements is characterized by a correlation ratio—the absolute value of the correlation coefficient. The closer the value obtained is

to unity, the closer the association between the correlated objects is.

To find the correlation coefficient, let us draw up a correlation data table where X is the criteria for formedness of cognitive interest and Y is its levels. The students with the criteria results of 50% on average were considered to have a low level of formedness, the students with 80% of positive results were considered to have a sufficient level, and the students who were able to achieve 95% were considered to have a high level (Table 7).

Table 4: Correlation Table

X / Y	1	2	3	4	5	n_y
50	8.4	11.2	13.1	5.6	24.3	62.6
80	72.0	65.4	67.3	67.3	57.9	329.9
95	19.6	23.4	19.6	27.1	17.8	107.5
n_x	100	100	100	100	100	$N = 500$

Based on the tabulated data, we find conditional mean values y_{x_i} of Y for all the values of X :

$$\bar{y}_{x=1} = 80.42; \quad \bar{y}_{x=2} = 80.15; \quad \bar{y}_{x=3} = 79.01;$$

$$\bar{y}_{x=4} = 82.38; \quad \bar{y}_{x=5} = 75.38.$$

Conditional mean values $\bar{x}_{y_j}$ of X for all the values of Y are:

$$\bar{x}_{y=50} = 3.32; \bar{x}_{y=80} = 2.90; \ \bar{x}_{y=95} = 3.11.$$

Thus, we obtain:

n_{x_i}	$n_{x_i} x_i$	$n_{x_i} x_i^2$	$x_i n_{x_i} \bar{y}_{x_i} = x_i \sum_{j=1}^{l} n_{ij} y_j$
100	100	100	8042
100	200	400	16030
100	300	900	23703
100	400	1600	32954
100	500	2500	37690
$\sum = 500$	$\sum = 1500$	$\sum = 5500$	$\sum = 118419$

n_{y_j}	$n_{y_j} y_j$	$n_{y_j} y_j^2$	$y_j n_{y_j} \bar{x}_{y_j} = y_j \sum_{i=1}^{k} n_{ij} x_i$
62.6	3130	156500	10700
329.9	26392	2111360	77072
107.5	10212.5	970187.5	30647
$\sum = 500$	$\sum = 39734.5$	$\sum = 3238047.5$	$\sum = 118419$

In accordance with the formula for calculating the correlation coefficient, $r \approx 0{,}89$. Based on the obtained value, we can conclude that, since the sample correlation coefficient is close to unity, there is a close association between the selected criteria of formedness of cognitive interest in the study of mathematics among students majoring in mining. Therefore, the effectiveness of the training conditions has been confirmed, their goal is to develop a cognitive interest in the study of mathematics among students majoring in mining, which in turn improves the quality of their mathematical competency.

4. DISCUSSION

To test the idea of research on improving the quality of mathematical competency, the overall academic achievement of students from the control and experimental groups was analyzed (Table 8).

Table 8: Quantitative results of the resulting level of mathematical competency

Year of study	Number of students		The resulting level of mathematical competency (as %)							
			Failing		Passing/FAIR		Good		Excellent	
	Groups		Groups							
	Control	Exp.	Control, people/	Exp., people /	Control, people /	Exp., people /	Control, people /	Exp., people /	Control, people /	Exp., people /
2015-2016	42	46	2/4.0	1/1.6	19/44.4	13/290	14/34.8	21/44.7	7/16.8	11/24.4
2016-2017	28	31	1/3.2	0/0.0	2/8.1	0/0.0	19/67.7	23/72.6	6/21.0	8/26.0
2017-2018	32	30	5/14.3	0/0.0	21/66.7	17/57.1	6/19.0	10/33.3	0/0.0	3/14.3

The results clearly bring out that the levels of mathematical competency of the students in the control and experimental groups are markedly different. Thus, in the 2015-2016 academic year, the grade point average in mathematics among students of the experimental group was 4.0, while in the control group it amounted to 3.6. In the year 2016-2017, the control group had a grade point average of 3.6, while the experimental group had 4.1, and in the year 2017-2016, the experimental group had 4.1 and the control one had 3.5 points (Figure 3).

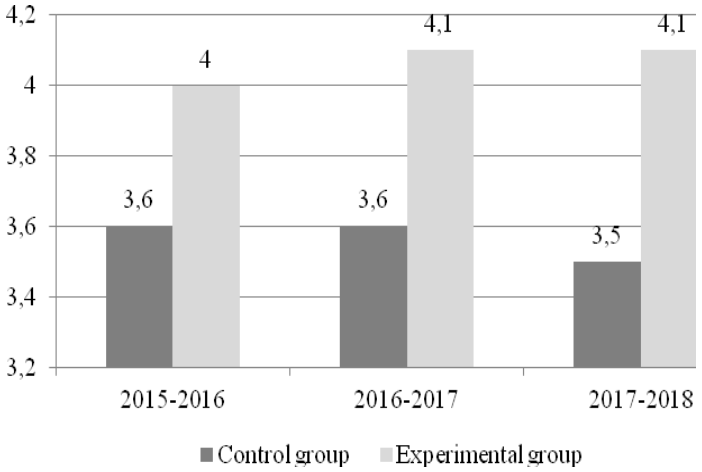

Figure 3: Grade point average in mathematical disciplines

Thus, the level of mathematical competency of students in the experimental group is on average 11.4% higher than that of the students in the control group.

According to the experimental research results, it has been found that, having the same reference academic background in the discipline, the control group students have lower results than the students included in the experimental group. In the 2013-2014 academic year, the grade point average was 3.8 and in the year 2014-2015, it was 3.7 points. Beginning with 2015-2016, when students began to study in the control and experimental groups, a contrast started to be observed, since the achievement in the control group was 3.6 points, whereas the results in the experimental group improved to 4.0 points, with a difference of 0.4 points between the groups.

Thus, the grade point average of the reference level of mathematical competency in the control group was 2.99 and in the experimental group it was 3.04 (the difference was 0.05 points, which is 1%), whereas the resulting level of mathematical competency in the control group was 3.57

and in the experimental group it was 4.07 (a difference of 0.50, or 11.4%) (Figure 4).

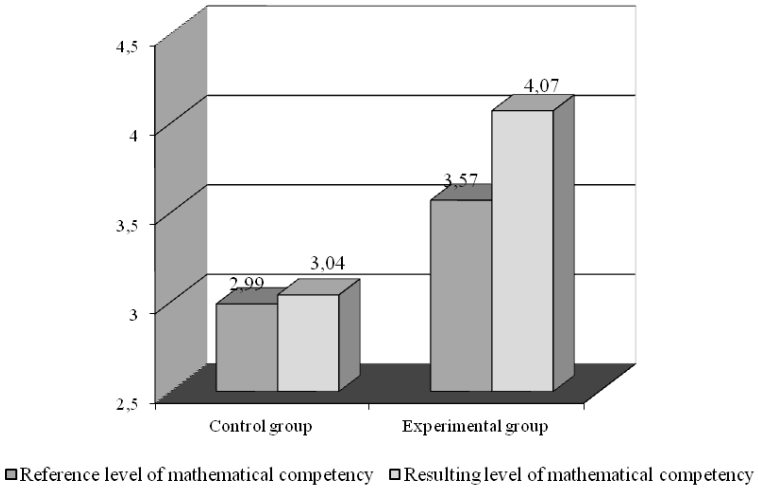

Figure 4: Bar chart of the reference and resulting mathematical competency

The results of the teaching experiment show that the students in the experimental group have a higher quality of mathematical competency. Consequently, it can be concluded that the proposed teaching technology included in the learning process, namely, solving problem-based profession-oriented tasks, allowed for the development of

cognitive interest in studying mathematics by college students, thereby contributing to an improvement of their mathematical competency.

The analysis of techniques available to improve the quality of mathematical competency of students proves that the methodology presented by the authors is unique and first proposed, and the research confirms that one way to improve the quality of mathematical competency of technical college students can be to develop a cognitive interest in the study of mathematics. It is advisable to assess the cognitive interest development level according to the criteria proposed by the authors and to rationally apply the created instructional system in order to foster cognitive interest.

5. CONCLUSION

Based on the developed theoretical considerations and the experimental and pedagogical results obtained, the following conclusions should be inferred:

1. The analysis of pre-university training competency level indicates a problem—a low level of the required mathematical competency.

2. The analysis of psychological and educational literature has allowed us to identify that the level of mining students' mathematical competency can be improved by means of developing a cognitive interest in the study of mathematics.

3. Based on the educational research and psychological literature study on the problem of cognitive interest development, a model aimed at fostering cognitive interest in the study of mathematics among students majoring in mining was developed.

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