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Professional Training of Emerging Fuel and Energy Industry Professionals Based on Factor Analysis

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***Abstract* – The development of mathematical competencies and the ability to apply mathematical modeling is one of the key aspects of training engineering experts. The study showed a statistically significant increase in the objective assessment of knowledge in the experimental group compared to the control one (8.12 – 7.56 points on a 10-point scale in the experimental group and 5.15 – 6.68 points in the control one). The largest possible standard deviation in the study is 0.72, which indicates the statistical significance of the results obtained. The proposed methodology differs from the most commonly used design and modular methods in integrity and consistency.**

***Keywords* – engineering education; factor analysis; mathematical competence; modular training.**

1. Introduction

The mathematics education of fuel and energy industry professionals plays an important role in preventing the most complex technological violations [1];

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it should form the basis for the ability to quickly and properly address real issues related to the operation of complex technical equipment and predict its behavior [2], [3].

According to modern research, mathematics education should be aimed at the development of subject-oriented mathematical competence as the most important component of professional competence [4]. The development of general scientific knowledge [5], [6]. The key goal of the formation of the skills based on the development of subject-oriented mathematical approach is the study of basic concepts and objects of mathematics, the development of clear logical thinking, the ability to apply mathematical methods to address production and economic problems of enterprises operating in the oil and gas industry [7], [8].

The use of economic and mathematical methods to solve identical problems increases the efficiency of economic analysis by expanding the factors under study, justifying management decisions, selecting the optimal use of economic resources, identifying and mobilizing reserves for increasing production efficiency [9]. Given the fact that all business processes are interconnected, and there is both direct and indirect relationship between them, it is possible to use mathematical methods processing economic parameters that change under the influence of various factors to model the economic activities of enterprises. Thus, an important methodological issue in the analysis of enterprise activities is the study and measurement of the influence of factors on the studied economic indicators. A thorough analysis of factors allows drawing reasonable conclusions about the activities of the enterprise, determining production reserves, justifying the strategy and management decisions, predicting the results of activities, assessing their sensitivity to the changes in external and internal factors. Factor analysis (FA) makes it possible to identify and analyze these indicators, as well as to study their degree of influence [1], [10].

Factor analysis is most successfully implemented in the solution of tasks related to the analysis of production and economic activities of enterprises; factor analysis is studied within the economic theory as part of the basic curriculum of most technical disciplines [11].

Economic factor analysis is the final stage in the development of subject-oriented mathematical competence in bachelors of the oil and gas industry [12]. This also applies to specialists of the Oil and Gas Business field of study who ensure the key processes in this area, as well as to specialists of such fields of study as Electricity and Electrical Engineering; Automation of Technological Processes and Production involved in the production and technological processes of the oil and gas sector. The education on this specialities in the field of oil and gas can help in solving economic problems as well as the specialists will be ready for all requires of economic industry in which they will work. According to this fact Factor Analysis would be relevant in the engineering education application as well as it gives the opportunity to determine the most common strategies and take into account all aspects of the problems in the oil and gas industry and explain how to solve them in the process of engineering education [13], [14]. It is considered that this Factor Analysis approach can be used in the connection with the methods of in order to achieve more positive results in the engineering education and make it more effective [15].

The book by Barone-Adesi and Carcano [9] considers multivariate analysis used to manage risks in stock trading and commodities, which include energy resources. Christodoulakis [16] examines the methods of factor analysis to analyze the dynamics of conflict and assess the economic costs associated with force majeure factors, for example, civil wars, while a number of other authors conduct a comprehensive assessment of the economic consequences of natural disasters [17].

The study by Sibirskaya et al. [18] considers a wide range of issues related to the methodology, organization, and technologies of analytical work, demonstrates the possibilities of analytical tools and statistical indicators to study socio-economic processes, make forecasts, organize effective campaigns, and improve management decisions.

On the basis of the above, it should be recognized that the current stage of development of higher education requires a thorough analysis of the accumulated experience in order to develop professional mathematical competence in students to teach them to address problems with the help of factor analysis.

Thus, the objective requirements for the development of subject-oriented mathematical competence in bachelors aimed at the solution of problems in the oil and gas industry, on the one hand, and the imperfection of its theoretical, methodological, and organizational foundations, on the other, determined the choice and relevance of the research topic [4], [19].

The purpose of the study is to analyze the effectiveness of developed subject-oriented training of university students in the field of mathematics based on the modular competency-based approach on the process of increasing the production and economic activities of the enterprises.

The research objectives are as follows:

1. To develop the modular competency-based approach for the profile differentiation system of the mathematics education of university students with the technological support.
2. To propose the ways for solving problems related to production and economic activities of enterprises through the modular competency-based approach to the organization of professional training of technical students in the field of oil and gas industry.
3. To develop the criteria to analyze differentiated indicators that determine the level of formation of the subject-oriented mathematical competence of university students, which is an integral indicator characterizing the readiness of students for professional activity.

The contribution of the study is the development of an innovative didactic system for the formation of the subject-oriented mathematical competence of bachelors, which makes it possible to adapt professional training of bachelors to modern requirements in the field of the application of mathematical methods, including factor analysis, as well as to solve production and economic problems of the oil and gas sector.

2. Materials and Methods

2.1. Research Sample

The study was conducted at the November Institute of Oil and Gas (a branch of Tyumen Industrial University, Noyabrsk, Yamal-Nenets Autonomous District, Russia). The experiment involved 116 participants that were grouped into the control and experimental groups (each group included 58 participants with an equal number of male and female respondents). The research sample consisted of third-year students studying Oil and Gas Business, Electricity and Electrical Engineering, and Automation of Technological Processes and Production. Given the size of the general population of the sample, the acceptable sampling error does not exceed 1.75.

2.2. Research Design

Factor analysis was taught in all the indicated fields of study. In the experimental group, a modular competency-based approach was used; it is described in the Results section. The control group relied on the standard curriculum for the higher mathematics section adopted in specialized universities in relation to the above disciplines.

The research was performed during one semester; based on the results obtained, testing was carried out. The test included 30 tasks - each professional module contained 10 tasks. The test participant received 1 point for each task if it was performed correctly and 0 points if there were mistakes. The maximum score for each section was 10 points. At the data processing stage, the average score for each test section was calculated for all participants in each of the two groups of respondents, as well as the standard deviation for the scores of each group for each section in order to eliminate the possibility of statistically unreliable conclusions.

2.3. Intervention

The developed modular competency-based approach for the training of technical specialists is based on the set of research methods as well as the analysis of modern domestic and foreign scientific and methodological literature in the field of mathematics education of engineering students; modeling and design of didactic theories, generalization of theoretical and research data; the study and generalization of the experience of leading domestic universities related to the research topic. The significant difference of this developed approach is explained by the connection of theoretical and practical methods with representation of possible strategies for the solving the problem of oil and gas sector.

The research method based on the mathematical modeling with different mathematical procedures is used in order to determine the effectiveness of using mathematical methods in the process of solving problems of the oil and gas sector, including such areas as power supply and automation of technological processes. As a result on the basis of the received results after training with the use of these mathematical procedures it will be possible to understand the ways of solving problems of the oil and gas sector. Also the results will show how to increase learning outcomes and improve the educational process of mathematical training of students in the system of continuing professional education.

2.4. Ethical Issues

No personal data of the study participants were collected or used; each participant was assigned a randomly generated unique identifier, which allowed us to simultaneously preserve the reliability of the data and research results, and protect the identity of the participants.

2.5. Instruments

The data obtained were analyzed, processed and visualized in Microsoft Excel 2013.

2.6. Research Limitation

The study involved only one Russian university; therefore, its results should be carefully extrapolated to the broader research context. In addition, the study considers only one of the modules of professional mathematical competence and should be expanded in the future.

3. Results

The first part of the study is devoted to the technological pedagogical support for the educational process on the basis of the modular competency-based approach. For illustrative purposes, the study describes the application of the approach when organizing professional training of specialists in the areas of Oil and Gas Business, Electricity and Electrical Engineering, Automation of Technological Processes and Production.

The purpose of studying training modules aimed at teaching specialists to solve problems related to the oil and gas sector was the mastery of modern statistical methods and models to ensure the reliability of the information base when addressing problems in the oil and gas industry, including such areas as power supply and automation of technological processes.

Thus, for example, the content of the major modules of professional mathematical training of specialists in the field of solving problems of the oil and gas sector within Oil and Gas Business is presented as follows:

Application of probability and statistical analysis in the field of modeling in the oil and gas industry includes:

- Methods of experimental planning theory;
- Methods of pattern recognition theory;
- Mathematical modeling of technological processes of transportation of oil and gas products.

The major course content within Electricity and Electrical Engineering, as well as Automation of technological processes and production, includes the same sections, but in the field of power supply and automation of technological processes, respectively.

In addition to the basic modules of the application of probability and statistical analysis in the field of solving problems of the oil and gas sector, the module related to the factor analysis in the management of economic activity of enterprises has been added to the content of professional training.

The need to introduce this module is due to the fact that when managing an enterprise operating in the fuel and energy sector, the tasks related to the analysis of economic activity and the use of economic factor analysis are most successfully implemented. Bachelors of Oil and Gas Business, Electricity and Electrical Engineering, Automation of Technological Processes and Production studying probabilistic and mathematical methods in various disciplines solidify their knowledge of factor analysis methods when considering problems related to the analysis of production and economic activities (Table 1).

Table 1. Factor analysis in the management of economic activity of enterprises

Key characteristics of the deterministic approach to analysis	Deterministic analysis stages	Deterministic model types	Mathematical interpretation	Examples of deterministic models in economic analysis
Determination of a deterministic model based on logical analysis Complete (rigid) correlation between the indicators. Impossible separation of the results of the influence of concurrent factors that cannot be combined in one model. Study of relationships in the short term.	Construction of an economically sustainable (from the standpoint of factor analysis) deterministic factor model. Selection of the method of analysis and the preparation of conditions for its implementation. Implementation of counting procedures. Making conclusions.	Additive models	Algebraic sum of indicators $y = \sum_i x_i$	Balance model of commodity supply: $N_{stock\,I} + N_a = N_\text{p} + N_d + N_{stock\,II}$, , where Ns is total sales at the beginning of the period; Nstock I is commodity stock at the beginning of the period; Na is the volume of goods arrived at the warehouse; Nd is the departure of goods for various reasons; Nstock II is commodity stock at the end of the analyzed period.
		Multiplicative model	Product of factors $y = \prod_{i=1}^{n} x_i$	Two-factor model of sales volume: $N_\text{p} = N \times O$, where N is the average number of employees; O is output per employee.
		R-ple models	Ratio of factors $Z = \frac{x}{y}$	R-ple model of the product turnover period $\text{T}_{period} = \frac{\bar{S}_g}{n_\text{p}}$, where Tperiod is the period of goods turnover (in days); Sg is the average stock of goods; np is daily sales volume.
		Mixed models	Combination of the models described $Z = \frac{\prod_i x_i}{\prod_i y_i}$; $Z = \frac{\sum_i x_i}{\sum_i y_i}$; $Z = \frac{\prod_i x_i}{\sum_i y_i}$ etc.	Integral indicator of profitability: $R_e = \frac{R_{sales}}{F_\text{e} + E_{fix}}$ where Re is return on equity; Rsales is sales profitability; Fe is capital intensity of fixed assets; Ez is the coefficient of fixing current assets.

We can consider some issues of the application of deterministic factor analysis related to the analysis of the economic activity of enterprises, which students find difficult when solving the assigned tasks.

In mathematical theory, there are deterministic and stochastic types of factor analysis.

Deterministic factor analysis is a method used to study the influence of factors, which have a functional relationship with the resulting indicator, i.e. the resulting indicator can be presented as a product, quotient, or an algebraic sum of indicators, which are factors of a deterministic model. The characteristics and stages of the deterministic factor analysis, and the types of deterministic models are presented in Table 2.

Table 2. Key characteristics and models of deterministic factor analysis

Initial factor model	**Techniques for constructing deterministic factor models**	**Mathematical transformations with a factor system**	**Deterministic factor model**	**Examples of deterministic models in economic analysis**
y= **Error!**.	Factor system lengthening method	$x_1 = x_{11} + x_{12} + \cdots + x_{1n}$	$y = \frac{x_{11}}{x_2} + \frac{x_{12}}{x_2} + \cdots + \frac{x_{1n}}{x_2}.$	*Re* =R/C_{fa} R/C_{fa}=Re_{sales}/F_{ci} where *Re is* return on equity; *R is* revenue; C_{fa} *is* average cost of fixed assets; Re_{sales} *is* return on sales; F_{ci} *is* capital intensity of fixed assets
	Factor system extention method	The numerator and denominator are multiplied by the same number	$y = \frac{x_1 \times a \times b \times c}{x_2 \times a \times b \times c} = \frac{x_1}{a} \times \frac{a}{b} \times \frac{b}{c} \times \frac{c}{x_2}$	
	Factor system reduction method	The numerator and denominator are divided by the same number	$y = \frac{x_1/a}{x_2/a};\ \frac{x_1}{a} = x_{11};\ \frac{x_2}{a} = x_{21};\ y = \frac{x_{11}}{x_{21}}.$	

3.1. *Techniques for Constructing Deterministic Factor Models*

In some cases, to study the relationship between the indicators that influenced the resulting indicator, it is necessary to construct a deterministic factor model by lengthening, expanding, and reducing the factor system.

The detail or depth of factor analysis is largely determined by the number of factors, the influence of which can be quantified; therefore, multiple multiplicative models (MMM) are of great importance in the analysis. The construction and solution of these models are based on the following principles:

- The place of each factor in the model should correspond to its role in the formation of the resulting indicator;
- The model should be built based on a two-factor model by sequentially dividing factors, usually qualitative ones, into their components;
- When deriving a formula for a multiplicative model, it is recommended to arrange the factors in the order of their replacement from left to right. This rule has to be observed when using the chain substitution method and its modifications.

Factor model construction is the first stage of deterministic analysis. It is followed by the selection of a method to solve it (Table 3).

Table 3. Techniques for constructing deterministic factor models

Initial factor model	**Techniques for constructing deterministic factor models**	**Mathematical transformations with a factor system**	**Deterministic factor model**	**Examples of deterministic models in economic analysis**
y= **Error!**.	Factor system lengthening method	$x_1 = x_{11} + x_{12} + \cdots + x_{1n}$	$y = \frac{x_{11}}{x_2} + \frac{x_{12}}{x_2} + \cdots + \frac{x_{1n}}{x_2}.$	$Ren_{к}$ =Пр/S_c Пр/S_c=$Ren_{пр}$/$F_{ср}$ where $Ren_{к}$ *is* return on equity; *Пр* revenue; S_c *is* average cost of fixed assets; $Ren_{пр}$ *is* return on sales; $F_{ср}$ *is*capital intensity of fixed assets
	Factor system extention method	The numerator and denominator are multiplied by the same number	$y = \frac{x_1 \times a \times b \times c}{x_2 \times a \times b \times c} = \frac{x_1}{a} \times \frac{a}{b} \times \frac{b}{c} \times \frac{c}{x_2}$	
	Factor system reduction method	The numerator and denominator are divided by the same number	$y = \frac{x_1/a}{x_2/a};\ \frac{x_1}{a} = x_{11};\ \frac{x_2}{a} = x_{21};\ y = \frac{x_{11}}{x_{21}}.$	

3.2. *Methods for Assessing the Influence of Factors in Deterministic Factor Analysis*

Generally, the deterministic model can be represented as a function of several variables:

$$y = f(x_1, x_2, \dots, x_i, \dots, x_n).$$

The task of deterministic factor analysis is to determine or quantify the impact of each factor on the resulting indicator.

There are various methods of deterministic factor analysis: chain substitution, the method of absolute differences, logarithmic method, the method of sharing, and integral method.

In our study, we will consider the methods described in Table 4.

Table 4. Methods of deterministic factor analysis

Methods of deterministic factor analysis	**Method application algorithm**	**Formalized algorithm of the method application**
Chain substitution	Determination of a number of intermediate values of the resulting (generalizing) indicator by successive substitution of the basic values of the factors with the reported ones. The difference between intermediate values is equal to the change in the resulting indicator due to the replaced factor.	In a formalized form, the algorithm for applying the method of chain substitutions is described as follows: $y^0 = f(x_1^0, x_2^0, \dots, x_i^0, \dots, x_n^0);$ $y_1^* = f(x_1^1, x_2^0, \dots, x_i^0, \dots, x_n^0);$ $\Delta y(x_1) = y_1^* - y_0.$ $y_2^* = f(x_1^1, x_2^1, \dots, x_i^0, \dots, x_n^0);$ $\Delta y(x_2) = y_2^* - y_1.$ … $y_i^* = f(x_1^1, x_2^1, \dots, x_i^1, \dots, x_n^0);$ $\Delta y(x_i) = y_i^* - y_{i-1}^*.$ … $y^1 = f(x_1^1, x_2^1, \dots, x_i^1, \dots, x_n^1);$ $\Delta y(x_n) = y_n^* - y_{n-1}^*.$
Method of absolute differences	The change in the resulting indicator due to each factor is determined as the product of the deviation of the studied factor by the basic or reported value of another (other) factor(s) depending on the chosen sequence of substitution	The algorithm for solving the two-factor model by the chain substitution method is described as follows: $\left.\begin{array}{l}1. Z^0 = x^0 \times y^0 \\ 2. Z^* = x^1 \times y^0\end{array}\right\\} \Delta Z(x) = Z^* - Z^0 = (x^1 - x^0) \times y^0 = \Delta x \times y^0$ $\left.\begin{array}{l}2. Z^* = x^1 \times y^0 \\ 3. Z^1 = x^1 \times y^1\end{array}\right\\} \Delta Z(y) = Z^1 - Z^* = (y^1 - y^0) \times x^1 = \Delta y \times x^1$

When using the method of chain substitutions, it is necessary to observe the rules of the sequence of substitutions:

- If the factor model contains quantitative and qualitative indicators, the quantitative ones are substituted first;
- If the factor model contains quantitative or qualitative indicators; the sequence of substitution is determined by logical analysis. The dependence of production volume on the average annual number of personnel and output is described with the help of a two-factor model: $V = N \times O$ (Table 5).

Table 5. Indicators that determine the volume of production

Production volume indicators	**Base period**	**Fiscal period**	**Deviation**
Production volume (V), thousand roubles	6720	7480	+760
Average number of employees (N), people	16	17	+1
Output per employee (O), thousand roubles	420	440	+20

The numerical implementation of the calculation algorithm is the third stage of the factor analysis:

1. $V^0=N^0\times O^0=16\times 420=6720$ thousand roubles – base value;
2. $V^*=N^1\times O^0=17\times 420=7140$ thousand roubles – intermediate value;
3. $V^1=N^1\times O^1=17\times 440=7480$ thousand roubles – reported value.

The change in the volume of production due to a change in the number of personnel will be:

$\Delta V(N)$=7140-6720=420 thousand roubles

The change in the volume of production due to a change in the production output will be:

$\Delta V(O)$= 7480-7140=340 thousand roubles

The cumulative influence of factors equal to the sum of the influences:

$\Delta V=\Delta V(N)+\Delta V(O)$=420+340=760 thousand roubles

Table 6. Influence of factors on the prodiction volume

Factors	The degree of the influence of factors, thousand roubles	The specific weight of the influence of factors, %
Average number of employees	420	55.3
Output	340	44.7
Total	760	100

To calculate the specific weight of the influence of factors, it is necessary to find the ratio of the influence of each factor to the total deviation (Table 6). The calculation allows us to draw the following conclusions: if we compare the reporting period and the base one, we will see that the production volume increased by 760 thousand roubles, including due to an increase in the average number of employees - by 420 thousand rubles and due to an increase in output - by 340 thousand roubles. The indicators of an increase in the volume of production by 44.7% are due to an increase in the quality indicator (labor productivity) and by 55.3% - due to the extra involvement of workers.

The number of calculations can be reduced by using a modification of the chain substitution method - the method of differences.

3.3. Method of Absolute Differences

The algorithm for solving the two-factor model by the chain substitution method is presented in Table 3 (the method of absolute differences).

Thus, the change in the resulting indicator due to each factor is determined as the product of the deviation of the studied factor by the basic or reported value of another (other) factor(s) depending on the chosen sequence of substitution.

We can consider the data presented in Table 4 as an example.

$\Delta V(N)= \Delta N\times O^0$=1×420=+420 thousand roubles
$\Delta V(O)= \Delta O\times N^1$=20×17=+340 thousand roubles
Total: 760 thousand roubles

The change of the substitution sequence provides different calculation results. When the calculation of the influence of output was followed by the calculation of the influence of the number of employees, the change in the volume of production taking into account each factor was as follows:

$\Delta V(O)= \Delta O\times N^0$=20×16=+320 thousand roubles
$\Delta V(N)= \Delta N\times O^1$=1×440=+440 thousand roubles
Total: 760 thousand roubles

The change of the substitution sequence reveals the difference in the calculations that is called the indecomposable remainder, which in this case will be 20 thousand rubles.

In the chain substitution method, the techniques which allow adding the indecomposable excess to the degree of the influence of the qualitative factor in the distribution between the factors of the indecomposable remainder include the addition of the indecomposable remainder and the reception of weighted finite differences.

3.4. Method of Simple Addition of the Indecomposable Remainder

The method of simple addition of the indecomposable remainder is characterized by dividing the indecomposable remainder by 2 and adding the result to the value of the influence of the qualitative and quantitative factors.

Formulas for determining the influence of factors are given below:

$$\Delta F(p)=t^0\times\Delta p+\Delta p\times\Delta t/2;$$
$$\Delta F(t)=p^0\times\Delta t+\Delta t\times\Delta p/2.$$

Remainder in the linear expansion of a function

$F = p \cdot t$ equals $\Delta p \cdot \Delta t$.

If we assume that $\Delta F(p) = \Delta p \cdot t^0$и$\Delta F(y) = \Delta y\cdot t^0$, the remainder (indecomposable remainder) is the difference between the deviation of the resulting indicator from the sum of the influence of factors p and t, i.e. the indecomposable remainder is equal to ΔF-[(ΔF (p) + ΔF (t)]. Let us transform this formula:

$$\Delta F-\Delta F(p)-\Delta F(t)=(p^1\times t^1-p^0\times t^0)-t^0\times\Delta p-p^0\times\Delta t=$$
$$=(p^1\times t^1-p^0\times t^0)-(t^0\times p^1-t^0\times p^0)-(p^0\times t^1-p^1\times t^0)=$$
$$=p^1(t^1-t^0)-p^0(t^1-t^0)-p^0(t^1-t^0)=$$
$$=(p^1-p^0)(t^1-t^0)$$

In the example considered:

ΔV(N)=420×(+1)+(+20) ×(+1)/2= 420+10=430 thousand roubles
ΔV(O)=16×(+20)+(+20) ×(+1)/2= 320+10=330 thousand roubles
Total: 760 thousand roubles

However, this method is not applicable when there are more than two factors.

3.5. The Method of Weighted Finite Differences

In the case of a larger number of factors, the weighted finite difference approach is used in the factor model.

The degree of the influence of each factor is determined based on all possible substitutions; next, the result is added up and the average value is calculated.

$\Delta F^1(p)=t^1\Delta p$
$\Delta F^2(p)=t^0\Delta p$
$\Delta F^1(t)=p^1\Delta t$
$\Delta F^2(t)=p^0\Delta t$
$\Delta F(\mathrm{p})_{cp.}= (\Delta F^1{}_p+\Delta F^2{}_p)/2$
$\Delta F(\mathrm{t})_{cp.}= (\Delta F^1{}_t+\Delta F^2{}_t)/2$
$\Delta F^1(V)=440(+1)=+440$
$\Delta F^2(V)= 420(+1)=+420$
$\Delta F_{av.} = (440+420)/2=430$ thousand roubles
$\Delta F^1(O)=16(+20)=+320$
$\Delta F^2(O)=17(+20)=+340$
$\Delta F_{av.}= (320+340)/2=330$ thousand roubles

The method is applicable for deterministic models with any number of factors, but it requires a lot of effort, and the costs of its implementation are incomparable with the benefits obtained.

The proportional distribution of the remainder by factors is achieved with the help of the logarithmic method.

The examples given make it possible to realize the need to use this method and the algorithm for solving the problem. The emphasis should be placed on the following stages of factor analysis:

- Selection of factors to study the indicators;
- Systematization and classification of factors to ensure consistency;
- Modeling of the relationship between resulting and factor indicators;
- Determination of the degree of influence of factors and the role of each in changing the resulting indicator;
- Use of a factor model for managing business processes.

An experimental study of the implementation of the described pedagogical approach has shown a noticeable increase in objectively recorded learning outcomes. As shown in Table 7, the experiment based on studying each of the three modules demonstrated that the assessments of the experimental group were significantly higher compared to those obtained by the control group. In each part of the test, the change in the assessment does not fall within the statistical error. It should also be noted that the statistical dispersion of the assessments within each group is relatively small, which also increases the value of the result obtained and confirms its purposeful nature. Figure 1 demonstrates that the worst marks received by the experimental group in the part of the training module for which the participants obtained the lowest marks turned out to be significantly higher than the best marks received by the control group in the most successful part of the module (Figure 1).

Table 7. Comparative results of testing with the application of the modular competency-based approach and the data of standard deviations

	Experimental group		**Control group**	
	Average score	Squared deviation	Average score	Squared deviation
Module part 1	8.12	0.55	6.58	0.69
Module part 2	7.94	0.69	5.95	0.72
Module part 3	7.56	0.71	5.15	0.8

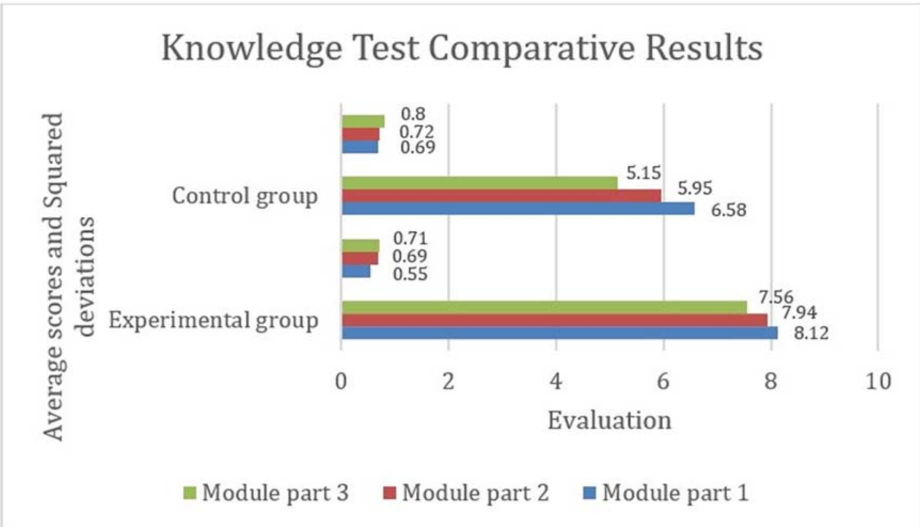

Figure 1. Comparative results of knowledge testing with the application of the modular competency-based approach

This significant gap may be the result of a modular approach and the gradual formation of the skill of applying factor analysis in the form of competency rather than in the form of a set of isolated skills in the field of using mathematical tools. However, these findings require further careful research.

The scientific novelty of the research can be described as follows:

(1) The object of special pedagogical research is the process of increasing the level of professional competence of bachelors in the field of economic factor analysis;
(2) On the basis of a professionally-oriented integrative approach, a didactic system of profile differentiation of the mathematical training of university students has been developed, where both generalized mathematical methods and specific methods of decision-making are the basic sources of knowledge;
(3) System diagnostics of differentiated indicators that determine the level of formation of subject-oriented mathematical competence of university students has been developed.

The theoretical significance of the study is as follows:

(1) The technological support for the innovative educational process has been developed on the basis of the modular competency-based approach;
(2) The integrative component of subject-oriented mathematical competence, which characterizes the degree of students' mastery of fundamental mathematical knowledge and skills to solve professional problems related to production and economic activities, has been determined.

The practical significance of the study is as follows:

(1) The content of the basic modules of professional training of specialists in the field of using mathematical methods for solving problems of the oil and gas sector has been developed, including such areas as power supply and automation of technological processes;
(2) In the course of the implementation of the pedagogical technology, educational and methodological materials have been developed, including the curricula of courses, textbooks, methodological instructions for studying modules aimed at professional training of bachelors and other educational materials;
(3) The research results can be used in the educational process of mathematical training of students in the system of continuing professional education.

4. Discussion

The results of research similar to the present study usually show the high efficiency of specialized training programs designed for engineering specialties [20]. Remote forms can include both sharing of theoretical information and teacher instructions through cloud services along with the possibility of receiving advice through social networks, and complex forms of interaction with the help of specialized programs [21], [22].

Simulation or situational modeling programs based on real experience are the most often used specialized programs designed for engineering training and mathematical modeling. Such programs can relate to both the sphere of economics and mathematical forecasting of economic phenomena, as well as modeling production activities or the operation of complex technical devices [3], [10]. In comparison to our developed training program scientists propose approaches to encourage students to develop modeling programs in order to ensure a deeper understanding of both the economic or technical processes being studied and the mathematical methods for their modeling [12]. Thus the approach of personal training based on the personality-oriented method is proposed for the development and improvement the nuclear industry through the learning with the help of digital technologies [23]. For example, the Canadian researchers propose the methodology of online learning for the improvement of education in the energy sector as well as for collaborating and learning [24].

It is considered that the developed in our study approach is not found in foreign (European or American) research literature as well as it provides for a step-by-step development of the skill of applying factor analysis starting with the understanding of the methods of deterministic analysis and building models of chains of deterministic models. Therefore, in comparison to is the engineering training often relies on a modular approach based on linking the existing knowledge of computational mathematics and basic modeling concepts previously mastered to practical "cases" of real situations that need to be solved based on new knowledge [25]. This method is often called project-based method, and it is becoming increasingly popular with a lot of modern research devoted to it [26], [27].

In comparison to our proposed approach, the integration of theoretical material into the solution of real life problems rather than the separate formation of a significant part of theoretical knowledge before the start of solving practical problems is more often implemented [4]. From our point of view, this method is limited by the fact that it forms a situational approach rather than a holistic one. In this case, the specialist is able to use the algorithms they have developed during training, but is not ready to look for a solution to a non-standard situation, the ″case‶ of which has not been considered. A number of Western researchers also point to this drawback in the mentioned approaches to mathematical training of engineering students [28].

5. Conclusion

The results of the study show the effectiveness of the developed professional training on the basis of a modular competency-based approach for the specialists in Oil and Gas Business, Electricity and Electrical Engineering, Automation of Technological Processes and Production on the solution of production and economic problems of the oil and gas sector, including power supply and automation of technological processes has been implemented. It is considered that the professional training modules designed to address problems of the oil and gas industry have influenced the ensuring the reliability of the information base both in the development of mathematical models of technological processes and in the analysis of production and economic activities of enterprises operating in the fuel and energy sector.
The experimental study also show the effectiveness of the applied modular training system as well as its results indicate a statistically significant increase in the objective assessment of knowledge in the experimental group compared to the control one (8.12 – 7.56 points on a 10-point scale in the experimental group and 5.15 – 6.68 points in the control one). Therefore, the maximum standard deviation does not exceed 0.72, which means that all the results obtained are statistically significant. The received indicators show that the methodological support developed on the basis of the modular competency-based approach ensures better academic performance when profiling the mathematical training of engineering specialties and can be used in other educational institutions. The practical significance and the prospect for further research of the study are based on the opportunity to expand the study of the modular competency-based approach through the example of other engineering training modules and involve a larger sample of respondents taking into account their stratification by gender, competence and other criteria. Also it is possible to use the developed professional training with the modular competency-based approach in other studies as well as it has positive influence both on the process of engineering education and solving economic problems in the field of oil and gas industry that has impact on the economic development of society as well as it includes theoretical and practical methodologies.

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