



colloquium-journal

ISSN 2520-6990

Międzynarodowe czasopismo naukowe

**National security
Historical sciences
Philological sciences
Pedagogical sciences
Philosophical sciences
Physical education and sports
№15(102) 2021
Część 3**



colloquium-journal

ISSN 2520-6990

ISSN 2520-2480

Colloquium-journal №15 (102), 2021

Część 3

(Warszawa, Polska)

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PEDAGOGICAL SCIENCES

УДК 378.146

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[DOI: 10.24412/2520-6990-2021-15102-31-37](https://doi.org/10.24412/2520-6990-2021-15102-31-37)

STATISTICAL EVALUATION OF THE RELATIONSHIP BETWEEN THE COMPONENTS OF COMPETITIVE SELECTION AND SUCCESS IN HIGHER MATHEMATICS OF ECONOMIC STUDENTS

Abstract

The paper investigates the correlations between the competition score, the external examination score in mathematics and the grades in higher mathematics of students in the branch of knowledge 07 "Management and Administration" of a particular institution of higher education. The calculated values of prognostic validity indicate a fairly close linear relationship between the components of the 2018 competitive selection and the success (current and final) of freshmen in higher mathematics. Instead, for the 2019 introductory campaign, there is a downward trend in the correlation between these indicators. The most significant changes were related to the current success of students in the second semester. This feature is explained by the introduction of distance learning.

Keywords: *prognostic validity, correlation coefficient, competitive selection, competitive score, external independent evaluation (EIE), higher education institution (HEI)*

Formulation of the problem. The introduction of a nationwide system of external independent evaluation (EIE) in Ukraine has radically changed the approaches to the final certification of graduates of secondary schools, which in turn has transformed the rules for admission of applicants to higher education institutions. The system of external evaluation at the state level is constantly being improved in order to conduct high-quality, independent measurement of knowledge in the disciplines chosen by graduates and calculate on their basis a single unbiased competitive score, which allows to select those students who are better able to study.

Such an objective model of competitive selection is implemented by determining the relevant profile subject and the introduction of weights of external evaluation disciplines for a particular professional field. The assessment of the adequacy of the applied model of competitive selection is investigated by the indicator of *prognostic validity* of the competitive score [1]. Namely, with the help of the correlation coefficient between the indicator according to which the competitive selection is carried out and the results of the student's success during the first year of study. Thus, evaluating the indicator of prognostic validity, it is possible to study the influence of the results of external evaluation in individual subjects or their corresponding weights on success, and on their basis to build optimal models of competitive selection.

The object of such research in this article will be the results of the success of first-year students in the branch of knowledge 07 "Management and Administration" in higher mathematics. The choice of this discipline is determined by several factors. First, higher mathematics is the basis for the study of a number of disciplines of the economic-mathematical cycle and

only one of this group is studied in the first year. Secondly, among all the disciplines taught in the first year, success in higher mathematics is most correlated with knowledge of elementary mathematics, which is a profile subject for this field of knowledge and makes the greatest contribution to the structure of the competitive score of the entrant. Third, the study of higher mathematics curricula provides for the largest number of hours (7 credits) of all disciplines of the first year, and therefore it is the most difficult to master.

Formulation of the goals of the article. The purpose of this work is to analyze the statistical relationships between the components of the competitive selection conducted in 2017–2019, and the success of students in the branch of knowledge 07 "Management and Administration" in higher mathematics.

Analysis of recent research and publications. The study of the prognostic validity of competitive selection for HEI is given due attention in many foreign countries (USA, Israel, Spain, Great Britain, etc.), and the results of these studies are systematically covered in collective monographs [2 – 4] and scientific articles [5 – 8]. In these works the efficiency of the current models of selection for universities is studied in detail and possible directions of their further improvement are determined.

In Ukraine, this scientific direction is just beginning to develop, and therefore only a small number of works are devoted to this issue [1, 9 – 17]. In particular, the most thorough study of the quality of competitive selection of students of higher education institutions based on the results of external evaluation during 2008–2015 was conducted in a scientific and practical publication [1]. The work is based on the study of three dimensions of the quality of the admission system: the

prognostic validity of the competitive score, the fairness of evaluation and their public perception. This paper emphasizes the high prognostic validity of external evaluation, although it is shown that for the branch of knowledge 07 "Management and Administration" its value is only in the range of 0.41 – 0.54. The authors also emphasize that the rules of the game, in the sense of using external evaluation tests for admission to universities and final school certification, are constantly changing, and therefore the study of their statistical patterns is always relevant for researchers.

A radically opposite and critical view on the implementation of the competitive score of the EIE (and its low prognostic validity) is given in [2]. Its author believes that the system of scaling the results of external evaluation is not transparent, masks the true level of preparation of applicants and needs improvement. According to his observations, the results of teaching students in higher mathematics are weakly related to the scores of the relevant EIE certificates.

The study of correlations between the results of external evaluation and grades in higher mathematics of freshmen is also devoted to [9–12]. However, the conclusions obtained by the authors of these works differ significantly. If for engineering specialties [9–10] the results of students' studies in higher mathematics are weakly related to the scores of the relevant EIE certificates ($R < 0.5$), then for economic specialties [11–12], on the contrary, the correlation between these indicators was quite significant ($R > 0.7$).

Determining the optimal formula for calculating the competitive score for a number of specialties is given in [13–16]. Thus increase in prognostic validity of competitive selection is reached by means of variation of weight coefficients of EIE disciplines.

We also note the results of [17], which for the first time studied the correlations between the components of competitive selection for a master's degree in "Law". The author shows that not all test blocks of a single professional test of external evaluation are equally important for the competitive selection of masters, and the highest value of the indicator of prognostic validity are the ratings from the test block "Law". Despite the fact that this study was conducted on a small sample, and therefore is only approximate and evaluative, the results are quite important from a scientific point of view, as the EIE for admission to the law degree was used for the first time.

In [18] it was shown that the presence of anomalous values in the assessment of first-year students, significantly affects the value of the prognostic validity of competitive selection, and therefore distorts the real results of the study. To eliminate such a negative impact, the author of the article developed and practically tested an algorithm for detecting anomalous estimates with their subsequent exclusion from the sample.

Presentation of the main research material. The preparation of a bachelor's degree in economics in universities of the III–IV accreditation levels involves mastering of a cycle of natural and mathematical disciplines of this professional direction. In accordance with the curricula of the branch of knowledge 07 "Management and Administration"

to such normative disciplines of mathematical direction can be attributed: higher mathematics, probability theory and mathematical statistics, statistics, econometrics, optimization methods and models. The purpose of their study is the acquisition by students of basic mathematical knowledge necessary for solving problems in professional activities, in particular, in the construction and analysis of economic and mathematical models of economic phenomena and processes; developing skills of mathematical research of applied problems, formation of logical thinking.

The foundation for studying these disciplines is undoubtedly the knowledge of elementary mathematics, that is, the knowledge gained by current students during their studies at secondary schools of the I–III degree. Determination of the level of such knowledge takes place during the external independent evaluation (EIE), after which the entrant's competition score is formed, which is necessary for participation in the general competition while the entry to the university.

The competition score of each entrant is calculated on the basis of certificates of external evaluation of relevant disciplines by the national information system "Competition" of the Public Association "Center for Educational Policy" of the Ministry of Education and Science of Ukraine [19]. The data archive of this system is publicly available and is one of the main sources of statistical information for this research.

Starting from 2017, the competitive score of the entrant when entering the bachelor's degree on the basis of complete general secondary education is calculated according to the new method, which includes additional adjustment factors:

$$C_5 = C_1 \cdot E_1 + C_2 \cdot E_2 + C_3 \cdot E_3 + C_4 \cdot A + C_5 \cdot O_s \cdot R_a \cdot B_a \cdot V_a \cdot P_a, (1)$$

where E_1, E_2, E_3 – points of external independent evaluation; A – the average score of the document on education; C_1, C_2, C_3, C_4, C_5 – non-negative weights set by the university; O_s – a score for the successful completion of preparatory courses for admission to the specialty (specialization), which is given special support; R_a, B_a, V_a, P_a – adjustment factors (regional, sectoral, rural and priority).

The calculation of the C_5 according to formula (1) in the formation of the ranking ranking of entrants, must meet the following three main conditions:

1) conducting an independent and adequate measurement of knowledge of each entrant in the chosen disciplines (implemented as a result of the EIE, taking into account the average score of the certificate and the score for additional courses, if any);

2) ensuring the selection of those entrants who are able to better study in the

chosen specialty (this task is implemented by determining the profile subject for the relevant professional field and the introduction of weights of HEI disciplines for this area);

3) taking into account social, migration and sectoral problems (implemented by introducing regional, sectoral, rural and priority coefficients in formula (1)).

From the point of view of the HEI, the selection of entrants who are able to study better and the determination of a reasonable value of the minimum number of

points in the entrance exams with which the entrant is allowed to participate in the competition is one of the priorities. And such an assessment of the conformity of the competitive score to the results of the first-year student, as noted above, is carried out using the indicator of the prognostic validity of the competitive selection. That is, using the correlation coefficient between the indicator on which the competitive selection is carried out and the student's learning outcomes during the first year.

It should also be noted that when forming the rating list of entrants to the branch of knowledge 07 "Management and Administration" does not take into account the sectoral and priority coefficients, as well as additional points for preparatory courses. Therefore, formula (1) in our case takes a simplified form:

$$C_S = (0,45 \cdot E_1 + 0,25 \cdot E_2 + 0,2 \cdot E_3 + 0,1 \cdot A) \cdot R_c \cdot V_c, \quad (2)$$

In (2) the weight coefficients of the EIE disciplines, which were selected by the test HEI for this branch of knowledge, are also given. The largest value of the coefficient (0.45) corresponds to the profile subject (Mathematics).

Since 2018, test HEI, within this specialty, began to apply two different, according to the list of subjects of external evaluation, models of calculation of C_S . In the first model, the profile subject E_1 , with the highest weighting factor ($C_1 = 0.45$), is Mathematics, E_2 – Ukrainian language and literature and E_3 – at the choice of the entrant or Geography or Foreign language.

In the second model, the profile subject E_1 is the History of Ukraine, E_2 – respectively, remained the Ukrainian language and literature, and E_3 – at the

choice of the applicant or Geography or Mathematics. Thus, according to this scheme, even those entrants who did not pass or did not pass the threshold of "passed / failed" EIE in mathematics, which is quite important for this study, had the opportunity to enter the university. More about such a two-model system of selection of applicants is discussed in [17].

Table 1 shows the number of students enrolled in the 2017–2019 test HEI and calculated their average values of the competitive score and the score of EIE Mathematics. Here and further in the text the general statistical indicators of success of freshmen in the branch of knowledge 07 "Management and administration" of specialties 071 "Accounting and taxation", 072 "Finance, banking and insurance" and 076 "Entrepreneurship, trade and exchange activity" of separate HEI will be analyzed.

First of all, it is noteworthy that in 2018 the number of freshmen enrolled in the HEI has almost halved compared to 2017. Such a sharp decline in the number of students is due to the lowest in history, the number of school leavers, and hence the number of entrants to the HEI, which was observed in 2018. As a result, there is also a decrease, although quite small, the average competitive score and a more significant decrease in the average score of the EIE Mathematics. In the following years, the number of enrolled entrants is gradually increasing, and in 2020 it has almost reached the level of 2017 and is 108 people.

Table 1.

**Descriptive statistics of students enrolled in the test HEI
branch of knowledge 07 "Management and Administration" in 2017 - 2019**

Indicator	Year of joining HEI		
	2017	2018	2019
Number of enrolled students	115	60	85
Number of students who submitted certificates of EIE Mathematics	115	46	57
Average competitive score	144,96	143,97	145,52
Average EIE score Mathematics	130,18	127,82	130,5

Starting from 2018, as noted above, even those entrants who did not have the certificates of EIE Mathematics had the opportunity to enter the test HEI. And if at first there were only 14 such freshmen, then the following year their number doubled.

The rather low average competitive score of the External Examination Mathematics (Table 1) of the students enrolled in the HEI in 2017–2019 also attracts attention. That is, despite the fact that for this field of knowledge mathematics is a profile subject with the highest weighting, the level of training of freshmen in this discipline was relatively weak. Instead, the average competitive score calculated by formula (1) is much higher than the corresponding indicator of EIE Mathematics (Table 1). This significant difference in these values is due to the following factors:

1) artificial increase of the competitive score of the entrant as a result of introduction of regional and rural coefficient;

2) the general tendency of deterioration of quality of school physical and mathematical preparation of entrants which is observed in recent years;

3) the branch of knowledge 07 "Management and Administration" (despite the fact that mathematics is a profile subject with a fairly large weighting factor) is more attractive for humanitarian-oriented entrants, for whom the external evaluation score in the second E_2 and third E_3 subject is significantly higher than the EIE score in mathematics E_1 . Experience shows that for many freshmen in economics, the presence of a significant number of disciplines of the economic and mathematical cycle in the curriculum of the specialty is even a surprise.

To study the prognostic validity of the components of competitive selection in Table. 2 and Table. 3 presents the calculated coefficients of Pearson's linear correlation between the indicators that were used as criteria for selecting students for admission and student performance during the first year of test HEI. Grades in higher mathematics as well as the average rating score

of students were obtained on the basis of electronic data on the success of the automated management system of higher education. It should be noted at once that all calculations were performed only after testing the samples for the presence of anomalous estimates with their subsequent exclusion from the population. The algorithm presented in [18] was used for such analysis. As a result, in 2018, three people were excluded from the sample, and in 2019 – two people. These are students who missed almost all classes and were later expelled from the HEL.

Since the discipline "Higher Mathematics" is studied by students during the first year, in Table 2 presents separately the correlation coefficients for the current success of the first and second semesters as well as the final success after the exam. Let's first analyze the indicators of the introductory campaign in 2018. The data given in Table. 2, indicate a fairly close linear relationship between the scores of EIE Mathematics and grades in higher mathematics. This is typical for both the current success of freshmen and the final. However, in the second semester there is a decrease in the correlation between these indicators ($\Delta R = 0.097$).

Also, the competitive score calculated according to formula (2) has a fairly high prognostic validity in 2018. Its correlation coefficient with the current performance of students is higher than 0.7 for both semesters and is equal to 0.68 for the final indicators of higher mathematics. The obtained results are also quite consistent with the data presented in [12]. This article examines the correlations between the components of the 2017 competitive selection and the current performance in higher mathematics of students in the branch of knowledge 07 "Management and Administration". The obtained values of the prognostic validity of the competitive score ($R = 0.776$) and the score of the EIE Mathematics ($R = 0.747$) also showed a fairly close linear relationship with the current success of students in the first semester and are almost equal to the corresponding indicators in 2018 (Table 2).

External evaluation Ukrainian language and literature correlates somewhat worse with the results of students' studies in higher mathematics in comparison with other prognostic criteria (Table 2). However, the obtained correlation coefficients are greater than 0.5, both for the current and for the final success, and therefore indicate a sufficiently high level of prognostic validity of the subject.

Table 2

Correlation indicators between the components of the competition score and success in higher mathematics of students in the branch of knowledge 07 "Management and Administration" in 2018 and 2019

Prognostic criterion	Year of entry	Sample size	Current student performance in higher mathematics			Final success of students in higher mathematics
			first semester	second semester	Academic year	
EIE Mathematics	2018	44	0,765	0,668	0,742	0,683
EIE Ukrainian language and literature		57	0,525	0,559	0,562	0,505
Competitive ball		57	0,721	0,720	0,745	0,680
EIE Mathematics	2019	56	0,604	0,400	0,521	0,563
EIE Ukrainian language and literature		83	0,604	0,520	0,590	0,557
Competitive ball		83	0,636	0,481	0,580	0,565

In 2019, there were significant changes in the values of correlation coefficients (Table 2). In particular, for EIE Mathematics and competition score there is a tendency to reduce their prognostic function. This is especially true of the correlation with the current performance of students in higher mathematics in the second semester ($R < 0.5$). Compared to last year's data, we have a decrease in the correlation coefficients $\Delta R = 0.268$ for EIE Mathematics and $\Delta R = 0.239$ for the competition score. Regarding the final success, the changes were less significant, namely $\Delta R = 0,120$ and $\Delta R = 0,115$, respectively.

Here are the main factors that caused the following negative changes:

1) Starting from 2018, a two-model system of competitive selection of entrants in the branch of knowledge 07 "Management and Administration" was introduced by the test HEL. This new approach to the formation of the rating list, as shown by the analysis conducted in [17], led to a decrease in the overall prognostic validity of the competitive selection. At the same

time, the decrease in correlation coefficients was due to the use of an alternative model of C_S calculation, in which the EIE of History of Ukraine instead of EIE Mathematics was used as a profile subject. In 2018, only a third of students were enrolled in this model, and in 2019 their share was already half of the total. Therefore, in 2019 there is a more significant decrease in correlation coefficients compared to 2018.

2) Another factor in the reduction of the studied indicators, mainly in the second semester, is the forced introduction of distance learning. As it turned out, the quarantine restrictions caused by the Covid-19 pandemic had a significant impact on student performance. Teachers and students were forced to adapt to new methods of distance learning, which were unusual for them, in a relatively short time. Some freshmen, especially in rural areas, had significant communication problems due to the low quality of Internet communication. As a result, such students had lower scores in the current semester in the second semester, which significantly affected the magnitude of their correlation

with the components of competitive selection. This situation could be normalized only after the exam and additional rehearsals, as a result of which the correlation indicators with the final success increased.

It should also be noted that the above factors did not affect the prognostic validity of the EIE Ukrainian Language and Literature. Conversely, in 2019, there is a slight tendency to increase the correlation between the scores of EIE in this subject and success in higher mathematics compared to last year's data (Table 2). The only exception is the indicator of the second semester, for which there is also a decrease in the prognostic function due to the introduction of distance learning. Although in this case the decrease was not as significant as in other prognostic criteria. It should also be added that the EIE Ukrainian language and literature is the best predictor of the average performance of freshmen in comparison with other subjects of EIE. This result was obtained in [17] for students in the branch of knowledge 07 "Management and Administration" according to the results of the 2018 admission campaign. As you can see from Table. 2, a similar trend begins to appear in 2019, even for the current success of students in higher mathematics.

Given the fact that in calculating the competitive score of entrants, from 2017 began to apply additional adjustment factors: regional (R_a), sectoral (B_a), rural (V_a) and priority (P_a), the issue of their impact on the prognostic validity is also relevant. competitive selection.

As noted above, for this sample, the C_S adjustment was performed at only two coefficients: rural (V_a) and regional (R_a), but only the V_a can have an effect (albeit insignificant, as it is only 1.02) on the prognostic validity. competitive selection, because the R_a is applied

within the entire sample, which leads only to a proportional increase in the C_S of each entrant.

A study of the impact of the rural coefficient on the prognostic validity of the competitive selection in 2017 was conducted in [11]. This article revealed a slight positive change in the correlation coefficient between the competitive score and the score of the current success of students in higher mathematics with the introduction of V_a in the formula for calculating C_S . Since students with rural affiliation also had relatively better academic performance, the paper concluded that the introduction of such a correction factor has a positive effect on the competitive selection model.

We will conduct a similar analysis, but using statistics from 2018 and 2019. In fig. 1 presents a diagram of the quantitative distribution of students in the branch of knowledge 07 "Management and Administration" by place of registration in 2017–2019. As can be seen from Fig. 1, the largest number of students for whom the competitive score was adjusted using the rural coefficient is observed in 2017. At the same time, their share is 46.1% of the total sample size. In 2018 and 2019, the number of students enrolled in HEI with rural registration decreased significantly, and their share was 36.7% and 41.2%, respectively.

To study the impact of V_a on the prognostic validity of competitive selection, its value was removed from the formula (2) of the calculation of C_S and re-correlated analysis. The results of the calculations are presented in Table. 3. For a better comparison of the obtained values in this table are also given the correlation coefficients obtained earlier (Table 2) with the available rural coefficient in (2).

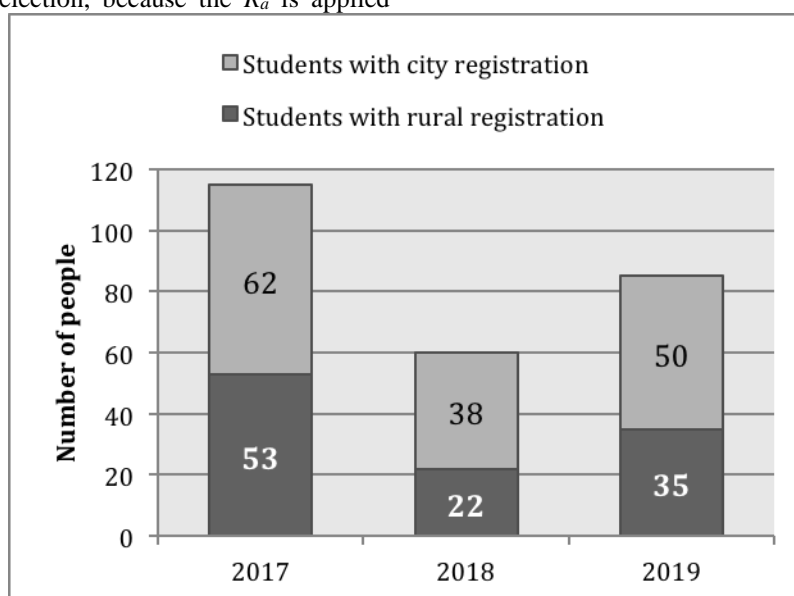


Fig. 1. Quantitative distribution of students in the branch of knowledge 07 "Management and Administration" at the place of registration in 2017-2019

As can be seen from Table. 3, V_a differently affects the correlation coefficients between the competitive score and the current performance of students in higher mathematics. Namely, if in 2018 the V_a slightly reduces

the prognostic validity of the C_S , then in 2019, on the contrary, there is a slight increase. For the final success, changes in the prognostic validity of 2018 are not recorded at all, and in 2019 it is positive.

Influence of the rural coefficient on the value of the correlation coefficient between the competition score and the success of students in higher mathematics in 2018 and 2019

Prognostic criterion	Year of entry	Sample size	Current student performance in higher mathematics			Final success of students in higher mathematics
			first semester	second semester	Academic year	
Competition score calculated by formula (2)	2018	57	0,721	0,720	0,745	0,680
Competitive score without taking into account the rural coefficient		57	0,725	0,722	0,750	0,680
Competition score calculated by formula (2)	2019	83	0,636	0,481	0,580	0,565
Competitive score without taking into account the rural coefficient		83	0,632	0,477	0,575	0,570

Thus, the fluctuations of the values of the correlation coefficients between C_s and grades in higher mathematics, with the introduction of V_a , are quite insignificant and are not explicitly natural. However, it should be noted that the negative trend was observed only in 2018, when the number of students with rural enrollment and their share in the total sample was the lowest, compared to other years. And for the current success, a decrease in the values of the correlation coefficients was not detected at all.

Thus, the introduction of the rural coefficient in the formula for calculating the competitive score is generally the social nature of state support for rural youth. At the same time, the change in prognostic validity is quite insignificant, and mostly positive. However, to confirm this conclusion, it is necessary to conduct additional research on larger samples and take into account the average performance of students in all disciplines of the first year, not only in higher mathematics.

Conclusions. A statistical study of the correlations between the components of competitive selection and performance indicators in higher mathematics for first-year students in the branch of knowledge 07 "Management and Administration" indicates that:

1) External Evaluation Mathematics and the competitive score of the introductory campaign in 2018 are quite strong predictors of the current and final success of students in higher mathematics ($R \in [0,668; 0,765]$). Instead, the corresponding correlation indicators for the EIE in the Ukrainian language and literature are less significant ($R \in [0,505; 0,562]$).

2) In 2019, there is a tendency to reduce the degree of correlation. Moreover, the lowest correlation indicators were obtained in the second semester of the 2019-2020 academic year ($R \in [0,400; 0,520]$) for the current success in higher mathematics. Such significant changes are primarily due to the introduction of distance learning.

3) The introduction of the rural coefficient in the formula for calculating the competitive score of applicants has a very small impact on the prognostic validity of competitive selection and is not explicitly natural.

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UDC 37.091.12.001.893

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ETHICS OF PEDAGOGICAL COMMUNICATION IN THE CONTEXT OF THE STUDENT DEVELOPMENT OF SCIENCE

Abstract.

The article considers various aspects of pedagogical ethics of a teacher in the context of his professional activity. The meaning of the concepts "professional ethics" and "pedagogical ethics" is revealed. Features of pedagogical ethics of the teacher which are shown in the course of its activity are allocated. The relationship between the professional competence of a teacher and pedagogical ethics, which is its component, is shown.

Keywords: professional competence, professional ethics, pedagogical ethics, communication.

Problem statement. In the context of humanization of education, pedagogy of cooperation to ensure a personality-oriented approach in the organization of the educational process, moral values of future teachers, development of skills in mastering various pedagogical tools, readiness for ethically adequate behavior in different situations of changing student life. The implementation of these tasks is associated with the assimilation of students of pedagogical universities norms and principles of pedagogical ethics. It is no coincidence that the main goal of the National Doctrine of Education Development in Ukraine in the XXI century is "providing opportunities for self-improvement of the individual, the formation of intellectual potential as the

highest value of the nation" [8], the development of creative abilities of students.

Ukraine's economic development involves improving the training system. Studying in a higher educational institution requires from the future specialist both professionally significant knowledge and personal creative abilities.

Training a specialist of modern scientific level requires the creation of certain conditions for the formation of professional skills and the development of personal qualities. Therefore, during the training of future professionals, the teacher should introduce innovative methods not only of teaching but also of communication with students. [1].