

Model of Integral Assessment of Innovation Implementation in Higher Educational Establishments

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Abstract—The concept of innovative educational environment of higher education establishment is considered and its main components are highlighted. The model of the integrated assessment of implementing innovations in higher education establishment is constructed. The developed model for assessing the level of development of the innovative educational environment of a specific higher education establishment during a certain period has been applied and a graphical analysis of the calculation results has been carried out.

Keywords—innovative educational environment, integrated assessment, mathematical model, rating scale

I. INTRODUCTION

THE rapid development of information and communication technologies leads to significant changes both in the global and in the local dimension in all spheres of human activity. These changes require the introduction of new approaches and legislative acts in the field of education. Thus, among the priority directions of the state policy on the development of higher education in the context of European integration of Ukraine, the problem of constant improvement of the quality of education, modernization of its content and forms of organization of the educational process is determined; improvement and development of ecosystems of higher educational establishments; implementation of educational innovations and information technologies [1]. In this case, the theoretical model of «innovative person», which is socially and culturally developed, is considered as a guide; this person is capable of imaginative, creative solution of the tasks and is a highly competitive specialist on the modern labor market [2]. As a result, the innovative orientation of human activities predetermines socio-economic transformations that require a

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corresponding renewal of educational policy, the desire to improve the educational process, its adaptation to modern requirements [3].

The research on the issues of “innovative development of education” is devoted to scientific works of such scholars as Blum A., Dubaseniuk O., Anderson L., Kolupayeva A., Oleinik A., Gilbert N., Troitzsch K., Zalabak P. S. and others. They paid attention to the issues of revitalization of cognitive activity of students on the basis of the usage of information and communication technologies, the implementation of new forms and innovative teaching methods, individualization of educational interaction. However, these issues should be further explored in order to identify new ways and methods for improving the quality and level of educational services.

The purpose of the article is to explore the main components of the innovative educational environment of a higher educational establishment and on the basis of these components to develop the model its integrated assessment, which will determine the level of innovation and provide an opportunity to identify areas for their further development.

For that purpose, it was set a number of tasks:

- to study the main components that form the innovative educational environment of a higher education institution;
- to develop a structural scheme that shows the main components of the IEE, their elements and interrelationships between them;
- to develop a model of the integrated assessment of the IEE of the HEE, which will enable an effective analysis and an adequate decision on the directions of the institution's development and a reasonable choice of a particular strategy;
- to develop a rating scale to determine the level of development of the HEE based on the obtained integral indicator;
- to propose ways of further development of the HEE on the basis of modern innovative methods and technologies of training.

II. METHODS

According to the research of sources [1-9], in order to be proportional to time, education should be innovative. Innovative technologies in education are permanent innovations in the educational process and involve intensifying the search, experimentation, individualization, introduction of the latest methods, tools and forms of learning [1].



All this requires the formation of an innovative educational environment (IEE) of HEE, which will be a guarantee of effective education through improving of information, interactivity of the use of information electronic resources, educational electronic systems and automated educational management systems and, in general, will promote the comfort and quality of providing educational services. In particular, the development and implementation IEE of the HEE will enable:

- to modernize and develop existing information, software and technical support;
- to increase the efficiency of communication between teachers and students, and also between the structural subdivisions of HEE;
- to become more involved in international programs of exchange and the development of innovative projects, grants, start-ups;
- to create high-quality personnel support;
- to increase the success rate of education and the level of mastering and application of the knowledge gained in practice.

IEE should include various types of providing, the environment for their use and exploitation in order to create comfortable conditions for high-quality educational activities. Its implementation and joint use by students, teaching staff and personnel of structural subdivisions; the establishment of effective informational and communication links between them will enable to form a functionally integrated ecosystem of the innovative educational environment of the HEE.

According to this, the main components of this system can be:

- information, software and technical support;
- students, teachers, practitioners from different spheres of activity;
- employees of structural subdivisions and administration of HEE;
- means of support and management of the material and technical base;
- means and methods of control of organizational, managerial and educational activities of HEE, etc.

On the basis of these components and their elements, it is possible to create a structural scheme of the innovative educational environment, indicating the interconnections between the main components (Fig. 1).

We consider these components in more detail. Thus, one of the important components of the IEE is information support and software, which is a set of normative bases and implemented decisions regarding the volumes, locations and forms of existence of the information used in the educational environment, as well as related software that allows creating, editing, retaining and transmitting information in the system of HEE [2, 4-6]. In particular, it is possible to retain educational information in the form of electronic repositories, databases, packages and libraries of applied curricula. It is possible to have an access to this information by using telecommunication facilities of the object-dynamic environment for the management of distance learning, which forms the advanced educational and methodological information support. It is necessary to ensure the information security of the main components of the IEE on the basis of threat identification and formulation of security policy rules based on selected modes

and the appropriate class of protection of valuable information [7].

Direct access to electronic learning tools provides material and technical support, which is a set of hardware and software tools and classrooms with the availability of high-tech equipment for using in the educational process.

Organizational support allows carrying out of various educational activities, which contribute to gain qualitative theoretical knowledge and practical skills. Teachers, in cooperation with IT specialists and other activities, will have the opportunity to organize and conduct the interactive training events: master classes, trainings, webinars, etc., thereby providing students with access to communication in social media and on the official website of the Institute about educational activities. In this case, engaging in international programs will enable the launch of certain innovative projects, due to an optimized educational environment that is being created to improve the learning activities of the HEE [8].

The functional support includes the management apparatus of the HEE and the departments of the educational process management, which carry out both the direct management of the organizational activities of the IEE, and the provision of educational opportunities and components [9].

The special monitoring sector will allow constant control of the effectiveness of the learning activities, the quality of the gained knowledge, as well as the communication between students and teachers.

After defining the main components of IEE of the HEE, it is possible to create a model for their integral assessment. The simulation will provide an opportunity to carry out an effective analysis and make adequate decisions, in particular, will help to determine the ways of the development of an institution and a reasonable choice of a particular strategy [10, 11,12], etc.

In general, the model of the integral assessment of IEE of HEE can be represented as a target function [10] of many variables (1):

$$E^t = F(X_1, X_2, \dots, X_n), \quad (1)$$

where E^t is an estimation of IEE of HEE at time t ; X_1, X_2, \dots, X_n is the vector of indicators of IEE of HEE at the time t .

The number of figures and groups of indicators to which they belong may vary [13,14,15].

In the structural scheme of the IEE of the HEE, their hierarchical structure is synthesized, in which each index has an independent value and at the same time is a element of the estimation of the vector indicators of the IEE of the HEE at the time t ; X_1 – vector indicator of information support and software; X_2 – vector-level indicator of the level of optimization of the study space; X_3 – vector-indicator of material and technical support; X_4 – vector-indicator of organizational support; X_5 – vector indicator of functional support; X_6 – vector-indicator of control effectiveness of the IEE.

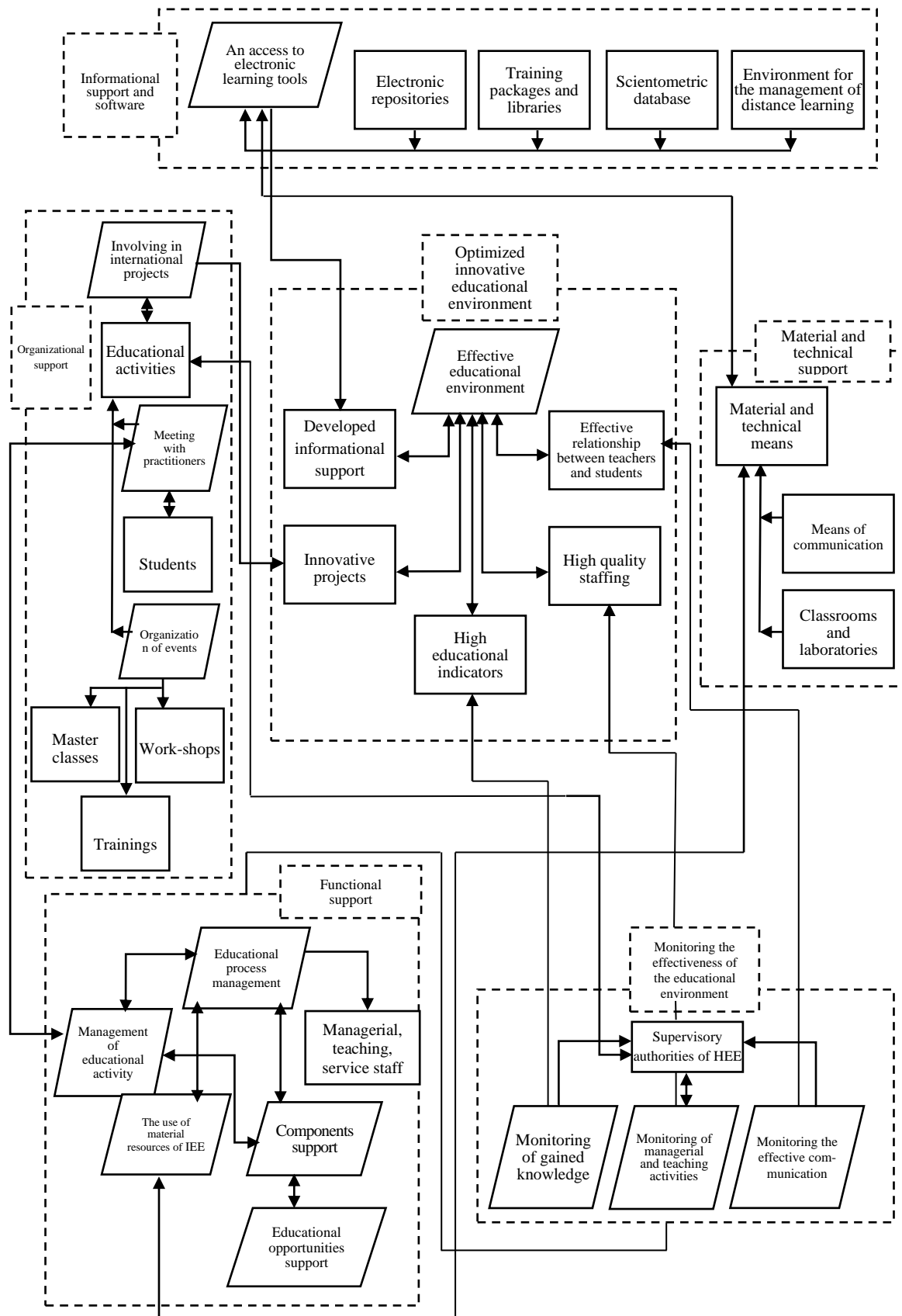


Fig. 1. The structural scheme of innovative educational environment



On the basis of the above information, we will define the target function of the IEE of HEE as a system of six elements X_1, X_2, \dots, X_6 .

We believe that the proposed system of indicators reproduces quantitative and qualitative aspects of the dynamics of the IEE of the HEE, which complement each other and provide an opportunity to obtain an informative and integrated characterization of the IEE of the HEE, to evaluate the conditions for its formation and changes.

A prerequisite for the accuracy of the results of the IEE of HEE evaluation is the reliability of the indicators that will detail the results of the optimization. All selected indicators are named values; therefore the necessary procedure of the method is the preliminary valuation of the studied indicators, which will ensure their comparison and matching [16,17,18].

Considering the fact that we will use indicators-stimulators, the growth of which contributes to the increase of the integral estimation of IEE of HEE and indicators of disintegration, as a result of the growth of which the value of the indicator of the integral estimation of IEE of HEE decreases, normalization will be carried out in different expressions, which is connected with the need to unify those components, on which the ranking is carried out from the minimum to the maximum values, and those in which it is performed in the opposite direction [19,20,21].

For rationing we use the standard approach [10], which is used in mathematical statistics (2), (3):

for indicators of disincentives (2):

$$X_{ij} = \frac{x_{i \max} - x_i}{x_{i \max} - x_{i \min}}, \quad (2)$$

for indicators of stimulators (3):

$$X_{ij} = \frac{x_i - x_{i \min}}{x_{i \max} - x_{i \min}}, \quad (3)$$

where x_i – the value of the i indicator at time t ; $x_{i \min}$ – the smallest among the relevant time indicators; $x_{i \max}$ – the largest among the relevant time indicators.

For implementation of the assessment model the IEE of HEE there is a need to use the estimation of each of the groups of indicators as the model.

The evaluation of information support and software can be achieved through the following indicators of access to e-learning tools: x_{11} – electronic repositories; x_{12} – training packs and libraries of applied curricula; x_{13} – scientometric database; x_{14} – object-dynamic environment of management of the distance education system.

The sub-model of information support and software evaluation has the form (4):

$$f_1(X_1) = \bar{k}_1 * \bar{X}_1 = \sum_{j=1}^n k_{1j} X_{1j}, \sum_{j=1}^n k_{1j} = 1, k_{1j} \neq 0, \quad (4)$$

where \bar{k}_1 – vector-line of specific weights of the significance of value of information support and software indicators; $\bar{k}_1 = (k_{11}, \dots, k_{1n}), n = 1, 4$; \bar{X}_1 – vector-column of value of

information support and software indicators; $\bar{X}_1 = (X_{11}, \dots, X_{1n}), n = 1, 4$; X_{1n} – normalized indicators by formulas (2) or (3).

The process of optimizing the educational space represents the following indicators for creating an effective learning environment: x_{21} – informational support; x_{22} – innovative projects; x_{23} – educational indicators; x_{24} – staffing; x_{25} – effective relationship between teachers and students; x_{26} – procrastination of the implementation of innovations by students and teachers.

The sub-model of estimating the optimization of the educational space has the form (5):

$$f_2(X_2) = \bar{k}_2 * \bar{X}_2 = \sum_{j=1}^n k_{2j} X_{2j}, \sum_{j=1}^n k_{2j} = 1, k_{2j} \neq 0, \quad (5)$$

where \bar{k}_2 – vector-line of specific weights of the significance of value of optimizing the educational space indicators; $\bar{k}_2 = (k_{21}, \dots, k_{2n}), n = 1, 6$; \bar{X}_2 – vector-column of value of optimizing the educational space indicators $\bar{X}_2 = (X_{21}, \dots, X_{2n}), n = 1, 6$; X_{2n} – normalized indicators by formulas (2) or (3).

The estimation of material and technical support can be done with the following indicators of material and technical means: x_{31} – means of communication; x_{32} – educational classrooms and laboratories.

The sub-model of the material and technical assessment has the form (6):

$$f_3(X_3) = \bar{k}_3 * \bar{X}_3 = \sum_{j=1}^n k_{3j} X_{3j}, \sum_{j=1}^n k_{3j} = 1, k_{3j} \neq 0, \quad (6)$$

where \bar{k}_3 – vector-line of specific weights of the significance of value of material and technical support indicator; $\bar{k}_3 = (k_{31}, k_{32})$; \bar{X}_3 – vector-column of material and technical support indicator. $\bar{X}_3 = (X_{31}, X_{32}), n = 1, 2$; X_{3n} – normalized indicators by formulas (2) or (3).

The dynamics of organizational support is detailed by the following indicators: x_{41} – educational activities for involvement in international projects; x_{42} – students involved in meetings with practitioners; x_{43} – organization of trainings; x_{44} – organization of work-shops; x_{45} – organization of master classes.

The sub-model of organizational support assessment has the form (7):

$$f_4(X_4) = \bar{k}_4 * \bar{X}_4 = \sum_{j=1}^n k_{4j} X_{4j}, \sum_{j=1}^n k_{4j} = 1, k_{4j} \neq 0, \quad (7)$$

Where \bar{k}_4 – vector-line of specific weights of the significance of value of organizational support indicator; $\bar{k}_4 = (k_{41}, \dots, k_{4n}), n = 1, 5$; \bar{X}_4 – vector-column of value of organizational support indicator. $\bar{X}_4 = (X_{41}, \dots, X_{4n}), n = 1, 5$; X_{4n} – normalized indicators by formulas (2) or (3).



An assessment of the functional support can be obtained by analysing the indicators of optimization of the following components of the sub model of IEE: x_{51} – educational process management; x_{52} – management of organizational activity of IEE; x_{53} – the use of material resources of IEE; x_{54} – providing the components; x_{55} – educational opportunities support.

The sub-model of functional support assessment has the form (8):

$$f_5(X_5) = \bar{k}_5 * \bar{X}_5 = \sum_{j=1}^n k_{5j} X_{5j}, \sum_{j=1}^n k_{5j} = 1, k_{5j} \neq 0, \quad (8)$$

where \bar{k}_5 – vector- line of specific weights of the significance of value of functional support indicator; $\bar{k}_5 = (k_{51}, \dots, k_{5n}), n = 1, 5$; \bar{X}_5 – vector-column of value of functional support indicator. $\bar{X}_5 = (X_{51}, \dots, X_{5n}), n = 1, 5$; X_{5n} – normalized indicators by formulas (2) or (3).

The assessment of the effectiveness of IEE can be obtained by analysing the: x_{61} – reporting on monitoring of management activities; x_{62} – indicators of monitoring of teaching activities; x_{63} – indicators of control of students' knowledge; x_{64} – ratings of teachers by students; x_{65} – rating assessments of student activity.

The sub-model for assessing the effectiveness of the monitoring of the IEE has the form (9):

$$f_6(X_6) = \bar{k}_6 * \bar{X}_6 = \sum_{j=1}^n k_{6j} X_{6j}, \sum_{j=1}^n k_{6j} = 1, k_{6j} \neq 0, \quad (9)$$

where \bar{k}_6 – vector-line of specific weights of the significance of value of the effectiveness of the monitoring of the IEE indicator; $\bar{k}_6 = (k_{61}, \dots, k_{6n}), n = 1, 5$; \bar{X}_6 – vector-column of value of the effectiveness of the monitoring of the IEE indicator. $\bar{X}_6 = (X_{61}, \dots, X_{6n}), n = 1, 5$; X_{6n} – normalized indicators by formulas (2) or (3).

The result of the calculation of each sub-model involves the determination of the specific gravity of significance. These weights are determined either by expert judgment or by factor analysis.

By obtaining results from the application of the sub-models of the estimation, an assessment model of the IEE of the HEE (10) can be used: using the aggregate indicator, which is formed by a plurality of partial parameters obtained by the calculation of the corresponding sub-models [22].

$$E^t = \sum_{i=1}^n \alpha_i f_i(X_i), \quad (10)$$

where E^t – the assessment of IEE of HEE at the time t ; n – the number of elements of IEE of HEE at the time; α_i – weight of i -th component for calculation the integrated assessment of IEE of HEE (can be obtained by the results of focus group, that is aware of problematic issues).

$\sum_{i=1}^n \alpha_i = 1, \alpha_i \neq 0$; $f_i(X_i)$ – the assessment of i -th component of the ecosystem of educational environment of HEE at the time $t, i = 1, 6$.

The value of E^t has a variation interval – (0; 1). The best integrated assessment of IEE of HEE is in that time, when an index E^t is close to “1” and the worst one when it is close to “0”.

In Table I there is a rating scale that allows us to assess the level of development of the HEE regarding the implementation of innovations, depending on the value of integrated assessment.

TABLE I
RATING SCALE FOR IEE LEVEL DETERMINATION OF THE HEE

The value of integrated assessment	Level
More 0,9	A
Between 0,7 and 0,9	B
Between 0,5 and 0,7	C
Between 0,3 and 0,5	D
Less 0,3	E

Level A – the HEE with a well-developed innovative educational environment.

Level B – the HEE with an average level of development of an innovative educational environment.

Level C – the HEE has the features of riskiness of formation and development of innovative educational environment.

Level D – high-risk HEE with the possibility of formation and development of innovative learning environment.

Level E – the HEE with unsatisfactory level of development of innovative learning environment.

The proposed model is open for making logical changes and additions related to the changes in the structure of the IEE of the HEE in the process of statistical observations.

At the conceptual level, the proposed model involves a systematic analysis of the IEE of HEE and its representation in a hierarchical form. The top position is an integral index, and the bottom ones are generalizing indicators of the components of the IEE of the HEE.

III. RESULTS AND DISCUSSION

For illustrating the application of the developed model, we will carry out an integrated assessment of the state of the IEE during 2015-2017 on the example of the Vinnytsia Institute of Trade and Economics of KNTEU. As input, we will use the indicators of reporting of the HEE during the specified years, characterizing information support, software, technical support; personnel of scientific and pedagogical workers and structural divisions that carry out accounting of educational, organizational, managerial and control activities it the Vinnytsia Institute of Trade and Economics of KNTEU. For the possibility of comparison and further analysis, we will standardize the reporting indicators. Since we use indicator-stimulators (all x_{ij} , except x_{26}), the growth of which contributes to the increase of the integral estimation of the IEE of the HEE and the disintegration indicators (indicator x_{26}), as a result of which the integral estimation of the IEE of the HEE

decreases, the rationing will be carried out according to different formulas respectively (1) and (2). The results of the rationing are given in Table II.

TABLE II
 NORMALIZED VALUES OF THE INDICATORS OF VINNYTSIA INSTITUTE OF TRADE AND ECONOMICS OF KNTEU DURING 2015 – 2017

Year / vector-indicator	2015	2016	2017
X ₁₁	0	0,45	1
X ₁₂	0	0,5	1
X ₁₃	0	0	0
X ₁₄	1	1	1
X ₂₁	0	0,63	1
X ₂₂	0	0,66	1
X ₂₃	0	0,66	1
X ₂₄	0	0,71	1
X ₂₅	0	0,3	1
X ₂₆	0	0,5	1
X ₃₁	0	0,7	1
X ₃₂	0	0,4	1
X ₄₁	0	0,73	1
X ₄₂	0	0,33	1
X ₄₃	0	0,45	1
X ₄₄	0	0,5	1
X ₄₅	0	0,2	1
X ₅₁	0	0,5	1
X ₅₂	0	0,5	1
X ₅₃	0	0,33	1
X ₅₄	0	0,4	1
X ₅₅	0	0,5	1
X ₆₁	0	0,44	1
X ₆₂	0	0,2	1
X ₆₃	1	1	1
X ₆₄	1	1	1
X ₆₅	0	0,36	1

The proportion of the value of vector indicators k_{ij} , were determined by the results of a focus group survey that is aware of the problematic issues of Vinnytsia Institute of Trade and Economics of KNTEU in the following way:

$$\bar{k}_1 = (0,3; 0,2; 0,2; 0,3), \bar{k}_2 = (0,2; 0,3; 0,2; 0,1; 0,1; 0,1),$$

$$\bar{k}_3 = (0,5; 0,5), \bar{k}_4 = (0,1; 0,3; 0,2; 0,2; 0,2),$$

$$\bar{k}_5 = (0,3; 0,3; 0,1; 0,1; 0,2), \bar{k}_6 = (0,3; 0,2; 0,2; 0,1; 0,2).$$

The proportion of integrated assessment components of IEE of Vinnytsia Institute of Trade and Economics of KNTEU α_i represented in Table III.

TABLE III
 THE PROPORTION OF INTEGRATED ASSESSMENT COMPONENTS OF IEE OF VINNYTSIA INSTITUTE OF TRADE AND ECONOMICS OF KNTEU

α_i	α_1	α_2	α_3	α_4	α_5	α_6
value	0,2	0,19	0,12	0,12	0,25	0,12

The results of calculating the sub-model of the estimation of the IEE of Vinnytsia Institute of Trade and Economics of KNTEU by the formulas (4) - (10) are presented in Table IV. The specific importance of the estimation of the IEE of Vinnytsia Institute of Trade and Economics of KNTEU is not

accurately interpreted, but during the comparative analysis it represents the dynamics of the investigated phenomenon (Fig. 2).

TABLE IV
 THE RESULTS OF CALCULATING THE SUB-MODEL OF THE ESTIMATION OF THE IEE OF VINNYTSIA INSTITUTE OF TRADE AND ECONOMICS OF KNTEU

Year / sub model/assessment of IEE of HEE at the time t ;	2015	2016	2017
$f_1(X_1)$	0,3	0,535	0,8
$f_2(X_2)$	0	0,607	1
$f_3(X_3)$	0	0,55	1
$f_4(X_4)$	0	0,402	1
$f_5(X_5)$	0	0,473	1
$f_6(X_6)$	0,3	0,544	1
E^t	0,096	0,52	0,96

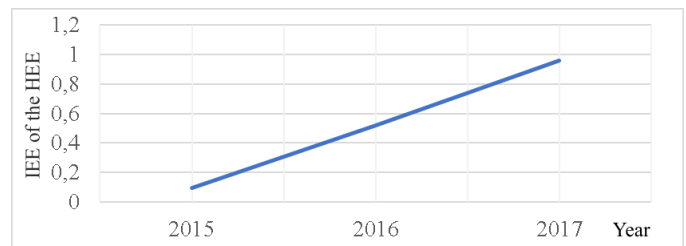


Fig.2. The dynamics of estimation of IEE of the HEE

The results of the evaluation of the IEE of Vinnytsia Trade and Economic Institute of KNTEU during 2015-2017 represent a positive tendency for the development of the IEE of the HEE, but the value of $E^t = 0,96$ in 2017 reflects the dynamics compared to 2015 and does not a priori indicate that in 2017 The Vinnytsia Trade and Economic Institute of KNTEU belongs to the class A.

IV. CONCLUSION

To summarize, as a result of the conducted researches, the main components of the innovative educational environment of the HEE were determined, which made it possible to construct a structural scheme indicating their interconnections.

According to the identified components, a model of the integrated assessment of the implementation of innovations in the educational process of the HEE was constructed, which allows quantifying the level of innovations implementation in the educational activity of the HEE. This methodology can become the basis for identifying further directions for the development of HEE by introducing innovative methods, forms and educational technologies, in particular such as SMART technologies, interactive learning methods, design technologies, etc.

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