INTEGRAL INDICATOR OF LEVEL DIFFERENTIATION OF RESEARCH COMPETENCE FORMATION LEVEL OF FUTURE ECOLOGISTS

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Abstract

Environmental pollution has actualized the search for effective technologies for environmental protection, which requires ecologists with an updated professional component to be implemented, accelerated the dynamics of the educational process, and led to a constant search for methods and means of forming distinct competencies – the components of the training of future environmentalists.

According to the Bologna Declaration, the formation of research competence as an important component of professional competence is the deciding feature of the educational process for the preparation of future ecologists. An important task is to develop an appropriate diagnostic toolkit to determine the level of development of research competence through a specific indicator.

The article establishes the essence of the definition of "integral indicator", presents pilot studies to determine the list of components of the integral indicator of research competence of future environmentalists. The diagnostics of the level of formation of the research competence of students-ecologists for the given integral indicator in separate educational institutions of the ecological direction has been carried out.

The directions of further work on specification of the list and experimental verification of the components and integral indicators, presented in this article for estimation of the level of formation of research competence in the process of professional training of environmental specialists are determined.

Keywords: integral index, integral indicator of research competence of future ecologists, research competence of future ecologists.

1. Introduction

The increased level of pollution of the environment by the mankind has actualized the search for effective technologies of its protection, which high quality realization needs ecologists with a professional competence, updated, according to modern requirements. The transfer of the social paradigm from the industrial to the informational one and the influence of social integration processes such as globalization, democratization, creation of the united information space, fast development of information technologies, intensive good exchange between countries, mutual integration of cultures changed requirements to the professional ecological education. The indicated social phenomena accelerated the dynamics of the educational process, caused the search for methods and means for the professional training of future ecologists, urgent for today.

Scientists and educational institutions continually work for specifying the list of competences, that must be mastered by a future ecologist, that help him/her to solve production tasks with dignity in future. According to the general European tendencies of education development, especially Bolognese declaration, the determining sign of the educational process of training future ecologists must be formation of the research competence in them as an important component of the professional one. An important element in this problem that needs scientific understanding is elaboration of correspondent diagnostic instruments for determining the formation level of the research competence by a certain indicator.

Native scientists conducted a series of works for studying the process and conditions of the research competence formation in the system of training future specialists in:
– informatics [1];
– technologies [2];
– economics [3];
– mathematics [4];
– chemistry [5];
– social pedagogy [6] and so on.

These works elucidate peculiarities of different models of the research competence formation, study pedagogical conditions, determine criteria, their indicators and formation levels of this quality of future specialists. The analysis of the aforesaid works indicates that each author has own vision of the solution of this pedagogical problem, offers different forms and means of the research competence formation. But in these works there is no coordination as to the united methodology, list of criteria, their indicators and pedagogical conditions of this quality formation. There are also diverse approaches as to determination of the research competence formation level of future specialists of different profiles by a certain indicator, grounded statistically and scientifically.

Scientists, who study the problem of the competence approach in education, pay attention to the complicacy of the competences diagnostics. In separate cases this task was solved by elaborating an integral indicator that gives a possibility to determine the research competence formation level. The popularity of this direction is conditioned by a rather wide circle of tasks that can be solved by such indicator, among which it is worth underlying a possibility of comparison of objects, determination of their structure, their classification as to the studied quality level, determination of its general level, classification of new objects as to the determined structure, revelation of the correspondence degree of studied objects to a certain imaginary ideal and determination of directions of improving a situation and so on.

The analysis of studies on this problem indicates that a question of measuring the research competence formation level remains urgent. This article offers the author's own interpretation as to the structure and possibilities of using an integral indicator of diagnosing the research competence formation level of future ecologists.

2. Aim of Research

To elaborate a theoretically grounded and practically probated integral indicator of determination of the research competence formation level of future ecologists.

3. Methodology and instruments of research

Based on the analysis of scientific-methodological sources, devoted to the problem of elaborating an integral indicator for diagnosing the competence formation level, there were studied the definitions of "integral indicator" and "research competence of a future ecologist" as base ones. The last one was defined as an integrative quality of a future specialist in the ecological sphere, demonstrated in the acknowledged readiness to realize active research operations, having knowledge of methods and methodology of scientific study, abilities to determine the essence, aim, tasks, object and subject of a study, to work assuredly with reference and scientific sources, to formulate a working hypothesis, to plan and to conduct a study, to analyze obtained data, to find interconnections between components of a studied process or phenomenon, to make conclusions, to prepare publications or speeches, to maintain research works, to work in a team effectively and to be responsible for research results; the ability to transfer from the procedural activity to the creative one to strive for self-development and improvement in the professional activity [7, p. 21].

This quality must form at integrating correspondent knowledge, research skills, experience and motivation component that is an internal need of a person in the research activity. Today pedagogical practice doesn't contain the generally acknowledged methodology of determining the research competence formation level of future ecologists by a correspondent integral indicator, so its elaboration and substantiation became the main task of this article.

In the system of higher professional ecological education a result of the natural-scientific training must be the research competence – an integral characteristic of qualities of a specialist-ecologist that reflects his/her level of fundamental natural-scientific knowledge, natural-scientific worldview, experience of cognitive and practical activity, enough for realizing professional activity.

A competence is provided by its components formation. For diagnosing formation of a certain competence, there are used certain diagnostic instruments, including competence criteria, their indicators and formation levels.

The conducted analysis of the scientific literature testified that scientists separate different numbers of formation levels of a certain competence. Authors mainly differentiate levels accord-

ing to a subject of their study, giving them own names. Thus, V. Barkasi determines the following levels: high, sufficient, middle and low [8]. O. Bigich separated the competence formation process in the levels: literacy (student acquired methodical knowledge), profession (student acquired methodical skills) and mastership (student acquired methodical abilities) [9]. In turn, O. Volchenko separates three competence formation levels: reproductive, reconstructive and creative [10].

For estimating the research competence formation level of future ecologists, we elaborated the correspondent diagnostic instruments: criteria (*motivation-value, cognitive, practical, reflexive*) and formation levels (*reproductive, reconstructive and creative*) [11, p. 138].

Depending on manifestations of these criteria in students – future ecologists, we can state about a certain research competence formation level in whole.

Scientists understand an integral indicator as a certain conventional numerical measurer of a latent quality of a studied phenomenon. The aim of its construction is a compact description of a certain quality of a studied phenomenon for saving main properties of the structure of studied objects. The matrix of symmetric binary ratios can act as initial data, used for constructing an integral indicator. A generalized indicator, obtained as a result of its processing, can be used for solving problems of recognition images and automatic classification of objects [12].

This approach was used at constructing an integral indicator for realizing of students-ecologists by research competence formation levels.

For selecting indicators of the research competence formation in 2016, there was conducted the pilot research, included teachers, scientists, employers and students-ecologists – participants of Olympiads and conferences – only 25 respondents.

Then an expert group of five scientists and three teachers of natural disciplines of the higher category offered to compare research competence formation indicators of students for establishing their important share in specially elaborated blanks, using the method of expert estimation by comparison in pairs (**Table 1**). A blank of the expert estimation of research competence formation indicators included 14 ones, most often named by respondents in the process of the pilot research. If an expert thought that an indicator, placed in the left column of the table is more important than one in the upper line, «1» was put in the square at crossing the column and the line, if vice verse – «0» was put. If an expert confirmed the equality of indicators, «0,5» was set in the square.

Table 1

Blank of expert estimation of importance of research competence formation level indicators of students (expert № _____)

In order	1 2 3 4 5 6 7 8 9 10 11 12 13 14 Range	Importance level
1) value attitude of future ecologists to the chosen profession		
2) understanding of social importance of the profession		
3) motivation to realization of research activity		
4) interest to studying fundamental natural disciplines		
5) system of knowledge on research methodology		
6) mastering of scientific theories, notions and conception of natural sciences		
7) use of information-communication technologies for solving research tasks		
8) skills of work with scientific sources		
9) skills of planning and conducting researches		
10) ability to use ICT in researches		
11) experience of research work		
12) self-estimation, self-control		
13) mutual estimation, mutual control		
14) self-education, self-improvement, self-development		

According to the results of the work of each expert, the correspondent matrix was filled. At that the data were processed as following: the range of the indicator R was determined in the full ranging system. An indicator with the highest range was designated as «1».

The importance degree of each indicator was determined by the formula:

$$P_i = P_{max} \times R_i / R_{max},$$

where $P_{max}=1$ – importance degree of an indicator with the highest range; R_i – range of an indicator; R_{max} – highest range.

The calculations by the data, obtained from all experts, were realized by this method.

As a result of determining the importance coefficient of all research competence formation levels of students, there was formed the matrix, including the results of the calculation of importance indicators' coefficients by the estimation of each expert (P_1–P_8) (**Table 2**).

Table 2

Matrix of results of determination of coefficients of importance indicators, dispersions and reliable intervals

Expert Indicator	P1	P2	P3	P4	P5	P6	P7	P8	Piav	S_i	V_i
1	0,55	1,00	0,63	0,63	0,90	0,78	0,85	0,83	**0,77**	0,021	0,018
2	0,3	0,44	0,47	0,47	0,30	0,56	0,45	0,61	**0,45**	0,010	0,009
3	0,95	1,00	1,00	1,00	0,80	0,94	0,70	0,89	**0,91**	0,010	0,009
4	0,95	0,78	0,95	0,95	0,60	0,94	0,60	0,72	**0,81**	0,022	0,018
5	0,7	0,72	0,79	0,79	0,60	0,89	0,90	0,89	**0,79**	0,010	0,008
6	0,95	0,72	0,95	0,95	0,70	0,89	0,75	0,78	**0,84**	0,011	0,009
7	0,3	0,78	0,58	0,58	0,45	0,44	0,50	0,78	**0,55**	0,024	0,020
8	0,55	0,83	0,68	0,68	0,55	0,67	0,65	0,67	**0,66**	0,007	0,006
9	0,55	0,94	0,74	0,74	0,65	0,44	0,70	0,56	**0,67**	0,020	0,017
10	0,55	0,78	0,53	0,53	0,65	0,56	0,50	0,67	**0,60**	0,008	0,007
11	0,6	0,22	0,53	0,53	0,60	0,78	0,50	0,39	**0,52**	0,023	0,020
12	0,95	0,83	0,95	0,95	1,00	1,00	0,80	0,94	**0,93**	0,005	0,004
13	0,2	0,28	0,26	0,26	0,30	0,33	0,20	0,39	**0,28**	0,004	0,003
14	1,00	0,78	0,53	0,53	1,00	0,89	1,00	1,00	**0,84**	0,038	0,031

Based on the obtained data P_i, there was determined the average value of importance coefficient of indicators of the research competence formation gradations of students by the formula:

$$P_{iav} = \sum P_{ij} / n,$$

where n – number of experts, (in our case n=8); i – number of indicator; j – number of expert.

Taking into account the results of scientific studies by V. Logvinenko, A, Asherov and I. Fedorov [13], we'll accept that the average value P_{iav} is an importance measure of a factor or indicator.

For determining the dispersion of expert estimations by each indicator, there was used a formula, used in mathematical statistics for small samples:

$$S_i = \sqrt{\sum (P_{ij} - P_{iav})2 / (n_1)},$$

where n – number of experts; P_{ij} – coefficient of indicator's importance, according to j-th expert; value n_1 determines the number of freedom degrees.

The value of the reliable interval was determined at importance level 0,95 (reliability level 95 %) by the formula:

$$V_i = t_\varphi \times S_i / \sqrt{n},$$

where V_i – reliable interval; t_φ – Student coefficient, $t_\varphi = 2,3646$.

The obtained data were transferred in correspondent **Table 3** for visual perception of the results of indicators' importance.

Table 3

Importance of research competence formation indicators

Criteria	Indicator	P_{iav}
Motivation-value	1. Value attitude of future ecologists to the chosen profession	0,08
	2. Understanding of social importance of the profession	0,05
	3. Motivation to realization of research activity	0,09
	4. Interest to studying fundamental natural disciplines	0,08
	Σ	0,30
Cognitive	5. System of knowledge on research methodology	0,08
	6. Mastering of scientific theories, notions and conception of natural sciences	0,09
	7. Use of information-communication technologies for solving research tasks	0,06
	Σ	0,23
Practical	8. Skills of work with scientific sources	0,07
	9. Skills of planning and conducting studies	0,07
	10. Ability to use ICT in studies	0,06
	11. Experience of research work	0,05
	Σ	0,25
Reflexive	12. Self-estimation, self-control	0,1
	13. Mutual estimation, mutual control	0,03
	14. Self-education, self-improvement, self-development	0,09
	Σ	0,22
Totally		1,00

According to the experts, the most important and significant indicators were considered as ones of motivation-value criterion, which summary importance is $P_{1-4av} = 0,30$ and the reflexive criterion "Self-estimation, self-control", which obtained the highest range ($P_{12av} = 0,1$) from the experts. Thus, the experts accepted these indicators as important for estimating the research competence formation level.

The experts established the least range for the indicator of the reflexive criterion "Mutual estimation, mutual control" ($P_{13av} = 0,3$).

The research competence formation level of a certain student-ecologist (integral indicator IO_n) was determined by the formula:

$$IO_n = P_{1n} + P_{2n} + ... + P_{14n}.$$

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The general research competence formation level of a student was established by comparing its obtained integral mark (IO_n) with limits of internal marks of levels, calculated by the sum of indicators' importance (**Table 4**).

Table 4
Limits of marks of research competence formation levels of students

Limits of integral marks	Research competence formation level of students
0,00–0,33	reproductive
0,34–0,66	reconstructive
0,67–1,00	creative

4. Research results

This method of determining the research competence formation level by the elaborated indicator IO_m was probated in five educational institutions that train specialists in "Ecology". The obtained results allowed to differentiate students by research competence formation levels (**Fig. 1**).
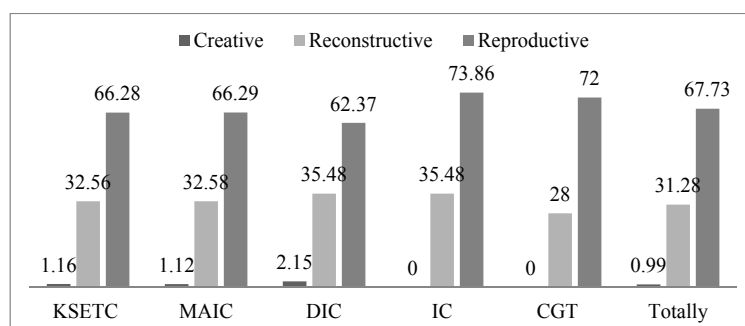

Fig. 1. Distribution of students of higher educational institutions by research competence formation levels, (%): KSETC – Kamyansky state energetic technical college; MAIC – Mirgorod artist-industrial college, named after M. Gogol of Poltava national technical university, named after Yuriy Kondratiuk; DIC – Dnipro industrial college; IC – Ingulets college of the higher educational institution "Kryvy Rih national university"; CGT – college of geological survey technologies, named after Taras Shevchenko

According to the obtained data, there was revealed an essential share of students with the reproductive research competence formation level (62–74 %). This situation is an eloquent evidence of the topicality of the problem of research competence formation of future ecologists. It also testifies tat:

– learning-methodical materials that favor formation of abilities to research activity in students are not enough used in the usual process of training ecologists;

– the process of research competence formation of ecologists is mainly realized at the reproductive level, by traditional methods, little attention is paid to updating the content of professional education, activation of educational activity;

– creative research tasks are used extremely not enough, the projecting method is almost not used at all at teaching academic disciplines (only seldom, by separate teachers);

– formation of separate components of the research competence is mainly fragmental and unconscious.

The conducted study doesn't exhaust all aspects of the problem of research competence formation of future ecologists. Specification of the list of components of the aforesaid integral indicator of the research competence of future ecologists and the further experimental verification of the effectiveness of the diagnostic instruments of estimation of the research competence formation level in the process of professional training of specialists of the ecological sphere, given in this article, need further studies.

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5. Conclusions

1. Based on the analysis of theoretical-methodological principles and practical experience of formation of certain competences in the educational process, the data, obtained as a result of the conducted pivot and expert studies, there were determined:

– the content essence of the definition "integral indicator";

– the components of the integral indicator of level differentiation by research competence formation levels of future ecologists.

2. The elaborated integral indicator allows to diagnose the research competence formation level of future ecologists at certain stages of the educational process and is offered to be used in the educational process of professional educational training.

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