EDUCATEE'S THESAURUS AS AN OBJECT OF MEASURING LEARNED MATERIAL OF THE DISTANCE LEARNING COURSE

Alexander Aleksandrovich RYBANOV,
PhD in Technical Sciences, Associate Professor,
Informatics and programming techniques Department,
Volzhskii Polytechnic Institute,
Branch of the Volgograd State Technical University,
Volzhskii, RUSSIA

ABSTRACT

Monitoring and control over the process of studying the distance learning course are based on solving the problem of making out an adequate integral mark to the educatee for mastering entire study course, by testing results. It is suggested to use the degree of correspondence between educatee's thesaurus and the study course thesaurus as an integral mark for the degree of mastering the distance learning course. Study course thesaurus is a set of the course objects with relations between them specified. The article considers metrics of the study course thesaurus complexity, made on the basis of the graph theory and the information theory. It is suggested to use the amount of information contained in the study course thesaurus graph as the metrics of the study course thesaurus complexity. Educatee's thesaurus is considered as an object of measuring educational material learned at the semantic level and is assessed on the basis of amount of information contained in its graph, taking into account the factors of learning the thesaurus objects.

Keywords: e-learning, thesaurus, learning management system, thesaurus metrics, knowledge measurement, study course material, knowledge testing.

INTRODUCTION

Educational process presupposes purposeful influence on the educatee's thesaurus. Currently, there is no possibility of knowledge monitoring based on the degree of correspondence between educatee's thesaurus and the study course thesaurus in distance learning systems. In distance learning system, educational process consists of sequence of the cycles of providing educatee with educational material and learning the educational material by the educatee. The cycle of learning certain educational material by educatee results in expansion of the educatee's thesaurus. Definition of the "individual's professional thesaurus" concept is given in the I.R.Abdulmyanov's work (2010). Study course thesaurus is a set of the study course objects (concepts, laws, theorems, statements, etc.) with relations between them specified.

Educatee's thesaurus is an object of measuring educational material learned at the semantic level. Let us assume that a distance learning system with the study course described by the thesaurus I_d provides educatee with an educational material described by the thesaurus I_s. Possibility of learning the educational material, described by the thesaurus $I_f \subseteq I_d$, by the educatee can be as follows:

1) If $I_f \subseteq I_s$ then there will be no changes in the educatee's thesaurus during the education since this information is already known to the educatee.

2) If $I_f \cap I_s \neq \emptyset$ and $I_s \subset I_f$ then the educational material can be learned by the educatee

if desired, and as a result educatee's thesaurus will be expanded.

The educatee acquires a maximum amount of semantic information when their thesaurus is coordinated with the study course material's thesaurus i.e. if the educational material is understandable to the educatee and carries an information, which is absent in their thesaurus.

Thesaurus presentation of the educational material and also of the current educatee's state of knowledge ensures adaptive selection and ordering of the educational information. Process of the thesaurus forming based on using the knowledge presentation methods is described in detail in the S.Bechhofer's and C.Goble's work (2001). Understanding of not only thesaurus object's attributes, but also relations of the object with other objects are characteristic of the process (D.Soergel, B.Lauser, A.Liang, F.Fisseha, J.Keizer, S.Katz, 2004).

Metrics described in the works by D.Bonchev and G.A.Buck (2005) and A.Gangemi, C.Catenacci, M.Ciaramita and J.Lehmann (2005) can be used for quantitative assessment of complexity of the thesaurus presented in the form of a graph. Metrics used for ontologies can be used for comparative analysis of thesauruses since thesauruses can be considered as ontology types. But to use the ontologies comparison metrics, described in the works by A.Lozano-Tello and A.Gomez-Perez (2004) and A.Maedche and S.Staab (2002), for comparative analysis of the study course thesaurus and educatee's thesaurus, the metrics must be improved since the result of comparison of the educatee's thesaurus and the study course thesaurus must be a mark describing not only correspondence between their structures, but also the degree of mastering the study course.

In distance learning systems, degree of mastering the study course is assessed by the results of educatees testing (J.Myrick, 2010). Currently, much attention is given to increasing accuracy of assessing results of education in distance learning systems. For this purpose, A.A.Rybanov's work (2013) suggests taking into account the process of forming final answer to test items by the user, and the work by K.Scalise and B.Gifford (2006) suggests innovative test item forms for computer-aided knowledge testing. Integral mark for quality of mastering the distance learning course is calculated on the basis of educatee's marks for all tests within the study course. For example, the Moodle system has the following approaches to calculation of integral mark for quality of mastering study course (S.S.Nash, W.Rice, 2010): "mean of grades", "weighted mean of grades", "simple weighted mean of grades", "mean of grades" (with extra credits), "median of grades", "lowest of grades", "highest of grades", "mode of grades", "sum of grades". Among all the approaches, only the "weighted mean of grades" takes into account complexity of learning an educational module by determining the weight factor for the test associated with the module. There is a problem of determining weight factors of educational modules within the distance learning course. Determining the factors by the subjective weighing method (i.e. the factors are determined by the author of the distance learning course) results in error in the final mark value. Thesaurus presentation of the study course will allow determining weight of each thesaurus object more soundly and objectively. Weights of the tests can be determined by comparing test items with thesaurus objects within the study course.

Thesaurus objects, which are difficult for learning, can be identified on the basis of thesaurus presentation of the educational material and comparative analysis of the educatees testing results. Set of such thesaurus objects can be used for more well-grounded strategy of correcting educational material and tests.

More precise learning curves can be constructed by using degree of correspondence between educatee's thesaurus and the study course thesaurus as a learning achievements metric (Figure: 1). Learning curves are a basis for classification of educatees into extroverts and introverts: introverted subjects have a concave learning curve that is caused by a long phase of latent accumulation of knowledge and skills.
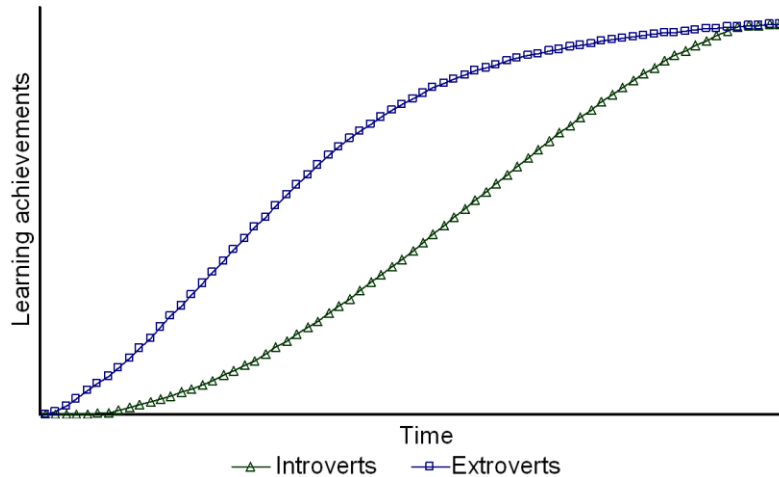

Figure: 1
Dynamics of changing learning achievements during education.

All above mentioned directions of monitoring and control over the process of studying within the distance learning course are based on solving the problem of making out an adequate integral mark to the educatee for mastering entire study course, by testing results. This problem can be solved by measuring degree of correspondence between educatee's thesaurus and the study course thesaurus.

MATHEMATICAL DESCRIPTION

Model of the distance learning course thesaurus
Thesaurus describing the system of the study course objects can be presented in the form of an oriented graph $G = (V, E)$; where V is a set of vertexes (study course thesaurus objects), E is a set of arcs (oriented edges describing the logic of studying the study course objects). Let us introduce the following symbols: $n = |V|$, $m = |E|$. Let us consider the set E of the logical relations between the study course thesaurus objects. Let us assume that $(v_i, v_j) \in E$ if v_i is a direct semantic component of v_j. Let us also assume that A is an adjacency matrix of the study course thesaurus graph G, where the matrix element $a_{ij} = 1$ if $(v_i, v_j) \in E$, and otherwise $a_{ij} = 0$. Then A^L is a matrix showing quantity of the paths with the length L which are between any two objects v_i and v_j.

14

The quantity of these paths is determined by the figure on intersection of i th line and j th column of the matrix A^L. Let us designate an element of the matrix A^L as $a_{ij}^{(L)}$.

Then:

$$a_{ij}^{(L=1)} = a_{ij}.$$

(1)

$$a_{ij}^{(L+1)} = \sum_{k=0}^{n} a_{ik}^{(L)} a_{kj}.$$

(2)

The graph G describing the study course thesaurus must meet the following requirements:

1) There must be no isolated vertexes in the study course thesaurus graph:

$$\sum_{i=1}^{n} a_{ik}^{(L=1)} + \sum_{j=1}^{n} a_{kj}^{(L=1)} \neq 0, \ \forall k = \overline{1, n}.$$

(3)

2) There must be no circuits in the study course thesaurus graph, i.e. any matrix A^L must meet the following condition:

$$\sum_{k=1}^{n} a_{kk}^{(L)} \neq 1.$$

(4)

3) There must be no duplicate connections between vertexes of the study course graph, i.e. if there are arcs (v_i, v_j), (v_j, v_k) and (v_i, v_k), the arc (v_i, v_k) can be removed as it, according to the transitivity property, duplicates requirements to the sequence of studying the thesaurus objects v_i and v_k.

Let us assume that the entrance study course thesaurus objects are all objects v_k which meet the following condition:

$$\sum_{i=1}^{n} a_{ik}^{(L=1)} = 0.$$

(5)

Let us also assume that the exit study course thesaurus objects are all objects v_k which meet the following condition:

$$\sum_{j=1}^{n} a_{kj}^{(L=1)} = 0.$$

(6)

When analyzing the subject matter thesaurus, it is important to know what objects are used for forming other objects, and what these other objects are. To describe relative duration of forming the study course thesaurus objects, the reachability matrix D is used:

$$D = \sum_{L=1}^{N} A^L.$$

(7)

Here d_{ij} is an element of the matrix D which shows in what quantity of the cycles after the object v_i the object v_j will be formed; N is the order of the study course thesaurus graph: $A^N \neq 0$, $A^{N+1} = 0$.

Metrics Of Complexity Of The Distance Learning Course Thesaurus On The Basis Of The Graph Theory

To describe *characteristics of the study course thesaurus* presented in the form of graph G, the following graph metrics can be used:

1) **Order of the study course thesaurus graph:** $n(G) = n$.

2) **Size of the study course thesaurus graph:** $s(G) = m$.

3) **Diameter of the study course thesaurus (length of the maximum path between the entrance objects v_i and the exit objects v_j of the thesaurus, expressed by a number of the arcs, which make this path):**

$$diam(G) = \max_{d_{ij} \in D} d_{ij}. \tag{8}$$

4) **Structural redundancy $R(G)$ of the study course thesaurus graph shows excess of the total quantity of connections between vertexes of the graph G over the minimum quantity of connections:**

$$R(G) = \frac{m}{n-1} - 1. \tag{9}$$

5) **Edge density $Q(G)$ (characterizes proximity of the graph G to the fully connected graph):**

$$Q(G) = \frac{2m}{n(n-1)}. \tag{10}$$

6) **Absolute depth of the graph $H'(G)$ (A.Gangemi, C.Catenacci, M.Ciaramita, J.Lehmann, 2005):**

$$H'(G) = \sum_{j}^{|P|} N_{j \in P}. \tag{11}$$

Here $N_{j \in P}$ is the length of the j th path belonging to the set of all paths P in the graph G.

7) **Average depth of the graph $h(G)$ (A.Gangemi, C.Catenacci, M.Ciaramita, J.Lehmann, 2005):**

$$h(G) = \frac{1}{|P|} \sum_{j}^{|P|} N_{j \in P}. \tag{12}$$

Quantitative *characteristics of the study course thesaurus objects* can be described by the following metrics:

1) **Let us define the weight of the study course thesaurus object associated with the vertex v_k as a quantity of all paths passing through the vertex v_k:**

$$w_k = \sum_{i=1}^{n} d_{ik} + \sum_{j=1}^{n} d_{kj}, \tag{13}$$

Here d_{ij} is an element of the reachability matrix D, which shows how many paths, irrespective of their lengths, there are between the vertexes v_i and v_j.

2) **Rank of the object v_j of the study course thesaurus (equal to quantity of the arcs entering the maximum length path in the graph G, from the entrance study course thesaurus object to the object v_j):**

$$P_j = L \text{ at } \sum_{i=1}^{n} a_{ij}^{(L)} > 0 \text{ and } \sum_{i=1}^{n} a_{ij}^{(L+1)} = 0. \tag{14}$$

When ranks of all study course objects are determined, it is possible to construct the study course thesaurus graph ordered by cycles.

3) Degree of the study course thesaurus object is determined by summing up in-degree and out-degree of vertex v_k associated with the thesaurus object:

$$a_k = \sum_{j=1}^{n} a_{kj} + \sum_{i=1}^{n} a_{ik}. \tag{15}$$

The metrics presented above allow assessing topological complexity of the study course thesaurus graph and give an idea about complexity of learning the distance learning course.

Metrics of Complexity of the Distance Learning Course ThesaurusoOn the Basis of The Information Theory

Let us describe the metrics of complexity of the study course thesaurus on the basis of the Shannon's information theory (C. E. Shannon, W. Weaver, 1949). According to the information theory, informational entropy $H(a)$ of a message of N symbols divided, according to some criterion, into k groups of N_1, N_2, ..., N_k symbols is calculated by the following formula:

$$H(a) = - \sum_{i=1}^{k} p_i \log_2 p_i = - \sum_{i=1}^{k} \frac{N_i}{N} \log_2 \frac{N_i}{N}, \tag{16}$$

Here $p_i = \dfrac{N_i}{N}$ is probability of presence of the i th group symbols in the message.

Study course thesaurus graph is specified by a final set of elements (vertexes, edges, arcs, cliques, etc.). Let us assume that N is a quantity of the study course thesaurus graph's elements. Weight of each study course thesaurus graph's element is w_i, $i = \overline{1, N}$.

Let us determine the total weight of the study course thesaurus graph by the following expression:

$$W = \sum_{i=1}^{N} w_i. \tag{17}$$

Probability of presence of i th element with weight w_i in the study course thesaurus graph is calculated as follows:

$$p_i = \frac{w_i}{W}. \tag{18}$$

Thus probability scheme of the study course thesaurus graph can be described by Table: 1.

Table: 1
Probability scheme of the study course thesaurus graph

Element	1	2	...	N
Weight	w_1	w_2	...	w_N
Probability	p_1	p_2	...	p_N

Entropy of the study course thesaurus graph with total weight W **and weights of the elements** w_i **,** $i = \overline{1,N}$ **for the specified probability scheme (Table: 1) is determined by the following expression:**

$$H = -\sum_{i=1}^{N}\frac{w_i}{W}\log_2\frac{w_i}{W} = -\sum_{i=1}^{N}\frac{w_i}{W}\log_2 w_i + \sum_{i=1}^{N}\frac{w_i}{W}\log_2 W = \log_2 W - \frac{1}{W}\sum_{i=1}^{N}w_i\log_2 w_i \text{ . (19)}$$

According to the Shannon's information theory, amount of information is defined as decrease in the system entropy relative to the maximum entropy, which can exist in the system with the same quantity of elements:

$$I = H_{\max} - H \text{ .} \tag{20}$$

Informational entropy of the study course thesaurus graph possesses the maximum value when $w_i = 1$ **(Formula 19) and is determined as follows:**

$$H_{\max} = \log_2 W \text{ .} \tag{21}$$

Thus expression for determining amount of information contained in the study course thesaurus graph takes the following form:

$$I = \frac{1}{W}\sum_{i=1}^{N}w_i\log_2 w_i \text{ .} \tag{22}$$

This expression is the metrics of complexity of the study course thesaurus and can be used for assessing degree of correspondence between the educatee's thesaurus graph and the study course thesaurus graph.

Educatee's thesaurus model

Let us define educatee's thesaurus graph $G' = (U,E')$ **as a subgraph of the set of vertexes of the study course thesaurus graph** $G = (V,E)$ **; where** $U \subseteq V$ **and** E' **consists of all those arcs of the graph** G **whose both ends belong to** U **. Each vertex of the graph** G' **is associated with a learned object of the distance learning course and, as a quantitative characteristic, is described by degree of mastering** $\lambda_k \in [0;1]$ **the educational material connected with the concept** u_k **.**

Let us present *dynamics of the process of studying the educational material* described by the thesaurus $G = (V,E)$ **as a final ordered sequence of the educatee's thesaurus graphs:**

$$\rho = \{G'_1,...,G'_i,...,G'_r\} \text{,}$$

$$G'_i \cap G'_{i+1} = G'_i \text{ ,} \quad i = \overline{1,r-1} \text{,}$$

$$G'_r \cap G = G'_r \text{,}$$

$$\Delta_{i+1} = n(G'_{i+1}) - n(G'_i) \text{.}$$

Here G'_i **is a subgraph of the set of vertexes of the graph** G'_{i+1} **,** $U_i \subset U_{i+1}$ **;** G'_r **is a subgraph of the set of vertexes of the graph** G' **,** $U_r \subseteq V$ **;** Δ_{i+1} **is a quantity of new objects with which the educatee's thesaurus graph** G'_i **has been expanded. The set** ρ **describes the process of changing the educatee's thesaurus, connected with learning new objects of the study course thesaurus. During learning the study course, there is an expansion of conceptual base of the educatee's thesaurus which leads to increase in relations between the concepts. Let us determine the weight of an object in the educatee's thesaurus, associated with vertex** u_k **, as product of the degree of mastering** $\lambda_k \in [0;1]$ **the study course thesaurus object by the educatee and weight of this object in the study course thesaurus graph:**

18

$$w'_k = \lambda_k w_k .$$

(23)

Metrics of the study course thesaurus can be used as metrics of complexity of the educatee's thesaurus.

Degree of correspondence $\delta(G'_i)$ **between the educatee's thesaurus graph** G'_i **and the study course thesaurus graph** G' **can be determined as follows:**

$$\delta(G'_i) = \frac{I'(G'_i)}{I(G)} * 100\% ,$$

(24)

Here $I'(G'_i)$ **is amount of information in the educatee's thesaurus graph** G'_i **which is calculated by the formula (22).**

RESULTS AND DISCUSSION

To analyze the metrics suggested in this paper *(Formulas 8-12, 22, 24)*, the experiment has been carried out in which the process of studying educational material has been modeled. Educational material thesaurus graph presented in Figure: 2 consists of 50 objects. Entrance objects of the educational material thesaurus are the objects 1, 4, 12, and 44. The educational material thesaurus graph has the following values of the metrics: $diam(G) = 8$, $n(G) = 50$, $R(G) = .020$, $Q(G) = .041$, $H'(G) = 809$, $h(G) = 3.487$, $I(G) = 1796.002$.
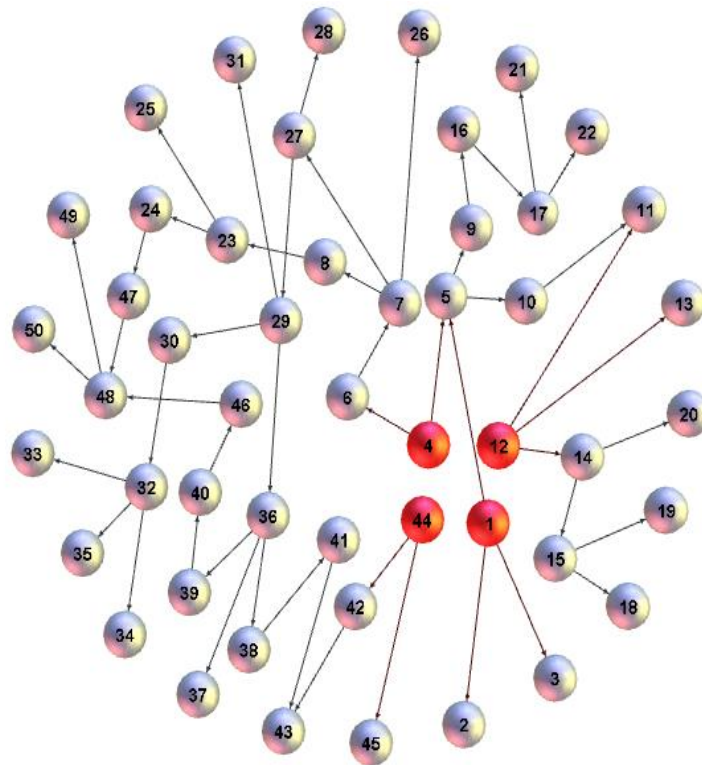

Figure: 2
Educational material thesaurus graph G

19

The purpose of the experiment was tracking the changes in the metric characteristics of the educatee's thesaurus graph formed during studying the educational material.

Initial data for carrying out the experiment are as follows:

Dynamics of the process of studying the educational material presented with the thesaurus graph G is described by the following sequence of changing the educatee's thesaurus graph (See Appendix):

$$\rho = \{G_1', G_2', G_3', G_4', G_5', G_6', G_7', G_8', G_9', G_{10}'\}.$$

Metrics of the educatee's thesaurus graphs are shown in Table: 2.

Table: 2
Metrics of the educatee's thesaurus graphs

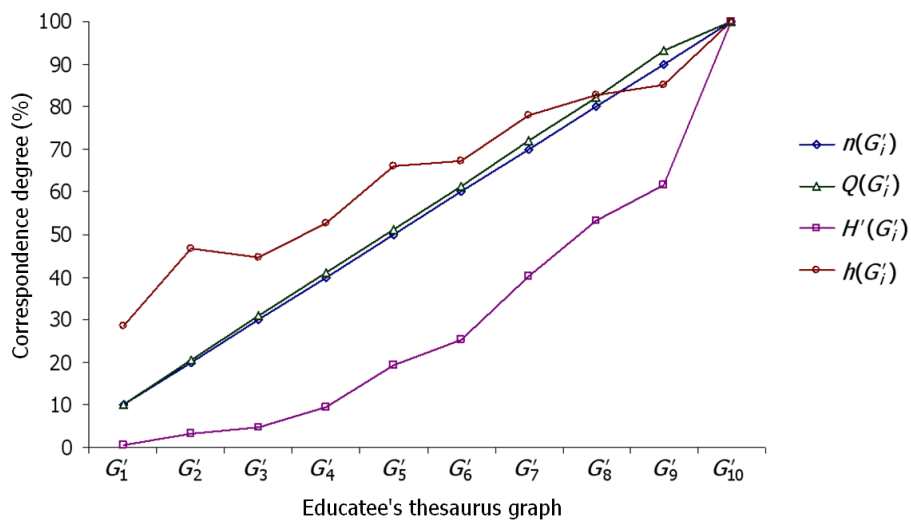| Educatee's thesaurus graph	$diam(G_i')$	$n(G_i')$	$R(G_i')$	$Q(G_i')$	$H'(G_i')$	$h(G_i')$
G_1'	1	5	0	.400	4	1.000
G_2'	3	10	0	.200	26	1.625
G_3'	3	15	0	.133	39	1.560
G_4'	4	20	0	.100	77	1.833
G_5'	5	25	0	.080	157	2.309
G_6'	5	30	0	.067	204	2.345
G_7'	7	35	0	.057	324	2.723
G_8'	7	40	0	.050	430	2.886
G_9'	8	45	0	.044	499	2.970
G_{10}'	8	50	.020	.041	809	3.487

Figure: 3
Dynamics of changing the degree of correspondence between the metrics $n(G_i')$, $Q(G_i')$, $H'(G_i')$, $h(G_i')$ and similar metrics of the educational material thesaurus graph

20

The metrics based on the graph theory (Formulas 8-12) do not take into account the degree of mastering the objects of the educational material thesaurus by the educatee and therefore will have identical values for identical in topology thesaurus graphs of various educatees. Besides, the process of expanding conceptual base of the educatee's thesaurus not always means changing values of the metrics $diam(G'_i)$, $R(G'_i)$ and increase in the metrics $h(G'_i)$ (for example, educatee's thesaurus graphs G'_2 and G'_3). The metrics $n(G'_i)$ and $Q(G'_i)$ do not take into account the weight of the objects of the educational material thesaurus; therefore the degree of correspondence between these metrics for educatee's thesaurus and educational material thesaurus depends linearly on quantity of the objects with which the conceptual base of the educatee's thesaurus is expanded.

The metrics $H'(G'_i)$ takes into account the weights of the educational material thesaurus objects and can be used only for assessing complexity of the study course thesaurus.

> ➢ **Degree of mastering λ_k the educational material connected with the concept u_k of the study course thesaurus graph G: $\lambda_k \in [0;1], \forall k = \overline{1,n}$. The quantity λ_k is described by the following concept mastering categories: unsatisfactorily - $[0;.61)$; satisfactory - $[.61;.76)$; good - $[.76;.90)$; excellent - $[.90;1]$. Since in case of unsatisfactory mastering the study course concept all the concepts arising out of it cannot be mastered, the quantity λ_k changed within the interval $\lambda_k \in [.61;1]$.**
> ➢ **Expansion of conceptual base of the educatee's thesaurus occurs with increments $\Delta = 5$ concepts.**

Results of changing the metrics $I(G'_i)$ are shown in Table: 3, and the correspondence degrees $\delta(G'_i)$ are shown in Table: 4.

Table: 3
Values of the metric $I(G'_i)$ (bits)

Educatee's thesaurus graph	λ_k					
	$[.61;.76)$	$[.61;.90)$	$[.76;.90)$	$[.76;1]$	$[.90;1]$	1
G'_1	1.675	2.208	3.103	5.009	5.917	6.755
G'_2	28.339	33.437	38.247	47.923	52.808	58.894
G'_3	46.415	57.029	69.461	79.970	91.289	97.400
G'_4	127.073	166.283	167.941	191.029	220.562	240.865
G'_5	265.555	276.504	349.899	379.486	425.265	465.161
G'_6	337.307	389.449	443.160	481.549	540.448	589.141
G'_7	459.584	551.091	637.198	725.756	767.073	830.528
G'_8	610.144	690.862	798.965	922.250	996.544	1068.03
G'_9	677.172	809.849	922.813	1001.127	1121.270	1208.266
G'_{10}	1005.884	1221.713	1353.899	1457.382	1667.390	1796.002

Table: 4
Values of the correspondence degree $\delta(G_i')$ (%)

Educatee's thesaurus graph	λ_k					
	$[.61;.76)$	$[.61;.90)$	$[.76;.90)$	$[.76;1]$	$[.90;1]$	1
G_1'	.093	.123	.173	.279	.329	.376
G_2'	1.578	1.862	2.130	2.668	2.940	3.279
G_3'	2.584	3.175	3.868	4.453	5.083	5.423
G_4'	7.075	9.258	9.351	10.636	12.281	13.411
G_5'	14.786	15.396	19.482	21.129	23.678	25.900
G_6'	18.781	21.684	24.675	26.812	30.092	32.803
G_7'	25.589	30.684	35.479	40.410	42.710	46.243
G_8'	33.972	38.467	44.486	51.530	55.487	59.467
G_9'	37.704	45.092	51.382	55.742	62.431	67.275
G_{10}'	56.007	68.024	75.384	81.146	92.839	100

Comparative analysis of the experimental data (Figure: 4) has shown that:

➢ **When the degree of mastering the objects of the educational material thesaurus increases, the degree of correspondence $\delta(G_i')$ between the educatee's thesaurus graph G_i' and the educational material thesaurus graph G increases too.**

➢ **Increase in complexity of topology of the graph G_i' caused by expanding conceptual base of the educatee's thesaurus leads to increase in the degree of correspondence $\delta(G_i')$ between the educatee's thesaurus graph G_i' and the educational material thesaurus graph G .**

➢ **The greater the weight of the study course thesaurus objects learned by the educatee, the greater the increment $\Delta\delta$.**
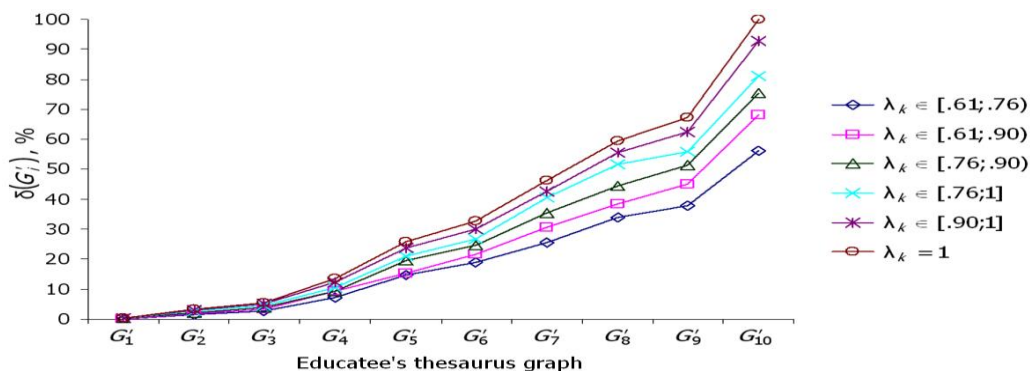

Figure: 4
Dynamics of change $\delta(G_i')$ during expanding the educatee's thesaurus.

These facts allow to conclude that the metric $\delta(G_i')$ constructed according to the information theory is an objective assessment of the degree of mastering the distance learning course.

CONCLUSION

Comparative analysis of metrics of the educational material thesaurus graph has shown that the metric $H'(G)$ *(Formula 11)* or metric $I(G)$ *(Formula 22)* can be used for assessing complexity of the distance learning courses. To assess the degree of correspondence between the educational material thesaurus graph and the educatee's thesaurus graph, it is recommended to use the metric $\delta(G_i')$ *(Formula 24)* constructed on the basis of the semantic information amount measure since it takes into account the degree of mastering the educational material thesaurus objects by the educatee. The suggested metrics can be used for monitoring the distance learning process.

BIODATA and COTACT ADDRESSES of AUTHOR

Alexander Aleksandrovich Rybanov, PhD in Technical Sciences, Associate Professor. *He's head* **of the Informatics and Programming Techniques Department, Volzhskii Polytechnic Institute, Branch of the Volgograd State Technical University. He has more than 15 years teaching and administration experience in education. His research interests are technological pedagogical content knowledge, pedagogical measurements, web-based distance education, e-learning, communication and information technologies. He's a member of the editorial board of the Vestnik Magistratury Journal published by the Scientific Publishing Centre "Colloquium" (Russia) and** *member of the Russian Academy of Natural History.*

Alexander Alexandrovich RYBANOV
PhD in Technical Sciences, Associate Professor.
Informatics and programming techniques Department,
Volzhskii Polytechnic Institute, Branch of the Volgograd State Technical University,
404121, 42a Engelsa Street, Volzhskii, Volgograd region, RUSSIA
Phone: +7 (88443) 41-22-62
E-mail: vit@volpi.ru
www.volpi.ru

REFERENCES

Abdulmyanova, I.R. (2010). Formation of professional personal thesaurus as a goal of the professional education. *Tomsk State Pedagogical University Bulletin*, **2010, № 2, p. 36-39.**

Bechhofer, S., Goble C. (2001). Thesaurus constructiom through knowledge representation. *Data & Knowledge Engineering*, **2001, Vol. 37, № 1, p. 25-45.**

Bonchev, D., Buck, G.A. (2005). Quantitative Measures of Network Complexity. In *Complexity in Chemistry, Biology, and Ecology*, *D. Bonchev* **and D. H. Rouvray, Eds., Springer, New York, 2005, p. 191-235.**

Gangemi, A., Catenacci, C., Ciaramita, M., Lehmann, J. (2005). Ontology evaluation and validation. An integrated formal model for the quality diagnostic task. *Technical Report*, available at http://www.loa-cnr.it/Files/OntoEval4OntoDev_Final.pdf.

Lozano-Tello, A., Gomez-Perez, A. (2004). Ontometric: A method to choose the appropriate ontology. *Database Management*, 2004, 15(2), p. 1–18.

Maedche, A., Staab, S. (2002). Measuring similarity between ontologies. *Knowledge Engineering and Knowledge Management. Ontologies and the Semantic Web, 13th International Conference, EKAW 2002*. Siguenza, Spain, Vol. 2473, p. 251-263

Myrick, J. (2010). *Moodle 1.9 Testing and Assessment*. Birmingham: Packt Publishing Ltd., 2010.

Nash, S.S., Rice, W. (2010). Moodle 1.9 Teaching Techniques. Birmingham: Packt Publishing Ltd, 2010.

Rybanov, A.A. (2013). Set of criteria for efficiency of the process forming the answers to multiple-choice test items. *Turkish Online Journal of Distance Education*, Vol. 14, No. 1, 75-84.

Scalise, K., Gifford, B. (2006). Computer-Based Assessment in E-Learning: A Framework for Constructing "Intermediate Constraint" Questions and Tasks for Technology Platforms. *Journal of Technology, Learning, and Assessment*, 2006, Vol. 4(6). Retrieved [date] from http://www.jtla.org.

Shannon, C.E, Weaver, W. *(1949). The Mathematical Theory of Communication. The University of Illinois Press*, Urbana, Illinois.

Soergel, D., Lauser, B., Liang, A., Fisseha, F., Keizer, J., Katz, S. (2004). Reengineering thesauri for new applications: the AGROVOC example. *Journal of Digital Information*, 2004, Vol. 4, available at ftp://ftp.fao.org/docrep/fao/008/af234e/af234e00.pdf.

G'_1　　G'_2　　G'_3　　G'_4

G'_5　　G'_6　　G'_7

G'_8　　G'_9　　G'_{10}