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Searching and Updating Research Materials for Renewing Curricula of Academic Disciplines Using Example of Logistics

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Abstract. The research covers the preparation and use of academic publications' materials for the analysis of development dynamics of a narrow subject area's ontology by searching for new concepts (keywords). This technology should be applied annually to monitor the dynamics of the appearance of new keywords that are not included in the course materials of a higher education institution on a relevant academic discipline. In this research, logistics is chosen as a narrow subject area by the example of which the use of the proposed methodology for the analysis of development dynamics of an academic discipline's ontology is demonstrated. A more narrowly focused goal associated with this methodology is to search for new concepts in logistics when formulating the theme of upcoming research conducted by a young specialist. Identification of rare keywords that are not presented in course materials of higher education institutions on a relevant subject is a poorly formalized research problem the solution to which does not guarantee success. It is feasible to generate annual life cycle curves for the identified concepts even if they do not change gradually over time because their behaviors can be important for planning future research.

Keywords. Development dynamics of ontology; narrow subject area; curricula of academic disciplines.

1 Introduction

The purpose of the research is to prepare and use academic publications' materials for the analysis of development dynamics of a narrow subject area's ontology by searching for new concepts (keywords) to update course materials of a higher education institution on a relevant academic discipline. In this research, logistics is chosen as a narrow subject area by the example of which the use of the proposed methodology for the analysis of development dynamics of an academic discipline's ontology is demonstrated.

Instead of ontology, the prototype will account for the materials provided in the curriculum of a specific academic discipline (CAD).

This document obligatorily contains concepts (keywords of the studied discipline) and connections between them (as a rule, these are "whole-part" connections). CAD is the most important document guiding students through the subject of the studied discipline and its updating is of great significance for achieving the necessary learning goals.

As an academic discipline, logistics is the basis (core) of several specialties of Bachelor's and Master's Degree programs in higher education institutions. A more narrowly focused goal is to search for new concepts in logistics for upcoming research conducted by a young specialist. However, the initial variant of the purpose of the research will be studied here. Proposed stages of the research:

1. Estimation of the life cycle of logistics as an academic discipline based on the dynamics of academic publications. The dynamics will be analyzed through multiple search queries in the Scientific Electronic Library *e-library* and a set of annotations with keywords and references.
2. Formation and analysis of a "words-texts" matrix to identify new logistics concepts and keywords that are not presented in course materials and estimate the upward or downward dynamics of researchers' interest in the identified concepts.
3. Automated analysis of the "words-texts" matrix to cluster words and texts and search for prototypes of new keywords that can be included in curricula of academic disciplines with the help of the following programs:

   - FrequencyOfWords - the program is designed to generate a "words-texts" matrix from a set of texts. This matrix is suitable for identifying connections in texts' dictionaries and their filtration.
   - CorrTable - the program analyzes the "words-texts" matrix generated on the basis of a set of texts belonging to a narrow subject area. Pairs of words that can be potentially included in the list of bigrams and key concepts belonging to the narrow subject area are singled out from the matrix using automated exhaustive search. Such words are characterized by a high value of the ratio of the standard deviation to the texts' average compared to the original sample. Moreover, their use in a pair has a high correlation in two texts.
   - BigramsInText - the program contains a list of pairs of words and text(s) where they were used. The analyzed text is divided into "phrases" without punctuation marks (except for hyphens and quotation marks). This allows finding all phrases where pairs of words form bigrams suitable for identifying two-word key concepts that belong to a certain subject area in an explicative context.
   - HapaxToBigrams - the program contains a list of words used only in one text as well as these texts. Its results coincide with the results obtained using the program BigramsInText.

This set of programs is called ONT-01 because it is designed to collect concepts based on which a prototype of the topic's ontology reflecting the set (collection, corpus) of analyzed texts can be constructed. Logistics is of interest as an academic discipline. This is why the ontological basics of this category that are accepted in education courses of higher education institutions are of great importance.

General principles of ontology-building are not included in the research. It would be sufficient to consider recent education courses as a representative basis for the hierarchical network of concepts used in logistics courses. These concepts can be found in courses' tables of contents and textbooks' indices. The completeness of the concepts' system is associated with the completeness and specificity of courses that depend on the specialization of a higher education institution for which a particular textbook or study guide was written.

This is why the difference in courses' ontologies can be explained by the specialization of a particular course. The problem that this research aims to solve is to estimate the degree of novelty of course materials against the background of recent academic publications. This will help to avoid or at least mitigate the deterioration of course materials. Consequently, a university graduate will have sound theoretical training to work with research and production subjects related to what he or she has studied in the last two years.

Comparison of existing courses allows evaluating the scope of a studied discipline and the narrowness of a course's specialization. However, it may be that a course is divided into several disciplines. To evaluate the completeness of a

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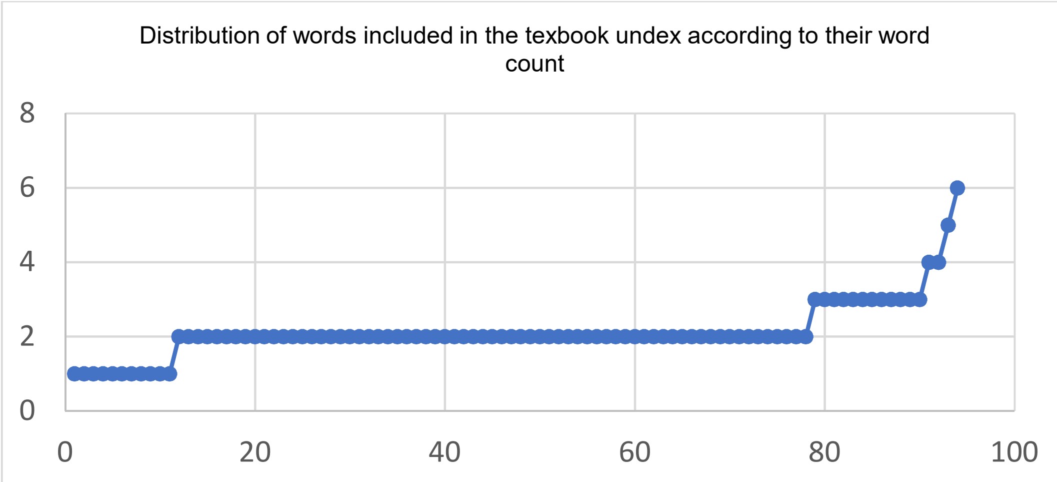

Fig. 1. Illustration of information provided in the text

course from the standpoint of its novelty, it is necessary to identify the appearance of new concepts and notions in the academic literature that relate to the development of the subject covered in the course.

Existing methods of building initial ontologies of education courses as well as methods suitable for these purposes [15-20] cannot solve the aforementioned problem. The proposed methodology does not imply the work of ontology-building specialists and focuses only on identifying new concepts and keywords that can be used to evaluate the feasibility of including them in a constantly updated curriculum of a particular academic discipline. In this case, it is necessary to identify terms that can potentially turn into keywords at a relatively high abstraction level but have not yet become a part of the concepts' network studied in the course.

In contrast to searching for basic keywords belonging to the subject area of logistics, in this case, the search is aimed only at new, recently appeared keywords that have not been included in curricula of academic disciplines related to a particular subject area for this or another reason. These new keywords should possess the following characteristics to distinguish them from those that are already accepted in education courses:

1. They should not be presented in dictionaries (lists), compiled on the basis of textbooks or study guides on logistics for higher education institutions. Thus, keywords mentioned in textbooks should already be included in ontologies of higher education institutions' courses so they need to be filtered out from the texts of academic publications on logistics.
2. They should be rarely used. In other words, they should be presented in a limited number of recent publications.
3. New keywords should be found neither at the top of the hierarchical structure of logistics ontology nor at the highest abstraction level of this subject. This level of abstraction is typical of concepts expressed by one or a few words that are often characterized by a supersystemic nature.
4. The most preferable approach here is to search for two-word key concepts, that is, bigrams.

Let us clarify the latter characteristic by the following example.

The index of the textbook "Logistics" by V. N. Zhigalova contains one hundred terms. 11 terms consist of one word, 67 - of two words, 12 - of three words, and 4 - of four and more words. The word count of four other terms is questionable. These are freight traffic, make-or-buy problem (MOB), Kanban system (in Japanese, Kanban means a "signboard" or a "billboard"), and Optimized Production Technology system (OPT). However, two-word terms constitute about 70% of the sample. Terms consisting of one word (i.e., agent, broker, dealer, distributor, supplies, reputation, incoterms, commissioner, tender, terminal, and transport) are characterized by a supersystemic nature with regard to logistics. Terms consisting of more than one word are at a lower abstraction level in the logistics ontology (e.g., deterministic calculation method, link in a logistics system, total cost concept, supply chain in logistics, transportation invoice, direct logistics channels, min-max system, stochastic calculation method, consignment note, customer service level, expert calculation method, echelon logistics channels, fixed order quantity system, distribution level of a logistics flow, fixed interval reorder system, and fixed replenishment frequency system).

Based on this example, it is feasible to search only for two-word key concepts. The necessary reference materials include:

- A conceptual dictionary of recent education courses on logistics (published up to 2018).
- A conceptual dictionary of academic publications on logistics over the last 5 years.

It is necessary to identify the rarest and most recent concepts from the latter dictionary that are not included in the former one.

Identification of rare terms and estimation of their potential to become keywords can be carried out by reading a plethora of recent publications and manual selection performed by experts in a particular subject area.

This research, however, considers a situation when this problem needs to be solved by a young logistics specialist who is familiar with the introductory course provided in his or her higher education institution.

A program-algorithm complex used to solve the aforementioned problem will not be examined here in detail. However, the key points of its rationale for the analysis of logistics courses as well as obtained results will be provided below.

The proposed methodology was presented by P.P. Makagonov during the international conference session on June 20, 2020 [1].

2 Model of the Logistics Life Cycle

As was previously demonstrated by Ruiz Figueroa and Makagonov [3], the life cycle of a narrow subject area should have its own empirical model that is described by some parameter *S*, the model of which constitutes a logistic curve *S(t)* denoting the cumulative number of publications for the time *t*:

$$S(t) = \frac{1}{1 + \exp\left(-k\left(t - T_{ip}\right)\right)}. \quad (1)$$

Here, T_{ip} denotes the abscissa of the inflection point, *k* – the tangent of the slope of the curve in the inflection point.

A rising branch of a cubic parabola between the left minimum and the right maximum is more preferable as a model than a logistic curve. This model is easier to generate by calculating the polynomial coefficients with the help of methods provided in Excel for searching for the trend based on a set of points of the initial distribution.

Academic publications best reflect the success of a scientific paradigm's development. Moreover, academic publications on a narrow subject area are best suited for content analysis due to better self-organization, the higher linguistic discipline of researchers, and the stricter selection of articles before publication.

Development dynamics of a scientific paradigm can be represented by the cumulative frequency of academic publications and academic conferences' reports on topics related to the core of the paradigm. A representative sample of a scientific paradigm's manifestations from a temporal perspective usually resembles a logistic curve. In the case with a "young" and immature paradigm, the sample is well approximated by a J-shaped curve that can potentially develop into an S-shaped curve. This J-shaped curve normally has a starting point that corresponds to the time of appearance of the first academic publication marking the beginning of a new scientific paradigm's life cycle.

If the sample is formed on the basis of data that do not contain the initial stage of the paradigm's development, then the curve may have the form of an upper branch of a logistic function, the outgo to the horizontal asymptote of which is poorly manifested.

Table 1. The total number of publications: 15,773

Year	Number of publications	Cumulative number of publications
2016	3,461	3,461
2017	3,572	7,033
2018	3,657	10,690
2019	3,838	14,528
2020	1,245	15,773

Let us consider the simplest appropriate mathematical representations of the aforementioned heuristic J-shaped and S-shaped models. In a simplified manner, complete J-shaped and S-shaped models can be represented by a segment of the curve of a cubic parabola, between the left minimum and the right maximum of the following function:

$$S(t) = a_3 \times t^3 + a_2 \times t^2 - a_1 \times t + a_0. \quad (2)$$

Logistics as a science has a long development period. This is why the number of recent publications constitutes from 3500 to 3800 texts and is characterized by a positive dynamic.

A search query in e-library by subject "Logistics" for the period from 2016 to 2020 gave the results in Table 1.

The query was made in the middle of 2020 so that year was not taken into account while calculating the coefficients of the approximating cubic parabola for the cumulative number of publications. The approximation in the form of a cubic parabola is of the following form:

$$y = 16x3 - 773.5x2 + 16026x – 120467, \quad R^2 = 1 . \quad (3)$$

Here, y denotes the cumulative number of publications starting from 2016, x - time in years (excluding 2000), R - the coefficient of determination.

A positive value of the coefficient given the third degree means that despite a significant number of texts published annually, the life cycle of logistics as a subject area in the scientific and technical literature is still at an early developmental stage. If the coefficient is positive under a higher degree (a3=16), the curve of the forecasted number of publications goes into infinity. This means that the subject of logistics will not become obsolete in the next 20-30 years and specialists in this field will be in demand for a long time. However, the subject may significantly change in the details over time.

The number of publications within the considered period is so large that the number of analyzed texts needs to be limited to evaluate all scientific interests. Let us take 50 publications per year under the condition that the search query implies a decrease in texts' relevance so that the first 50 publications are the most relevant. Such a limited analysis will not allow identifying numerous underrepresented scientific endeavors. However, the main new topics will be included in the analysis.

It should be clarified that the research does not aim to build a generalized ontology of the aforementioned subject. Notions and concepts are presented in sufficient detail in the review "Logistic paradigms: Functional, resource, innovative" (link: https://mybiblioteka.su/tom3/3-6190.html). However, it is important to compare and contrast notions in the curriculum of an academic discipline with notions appearing in recent academic publications for the former to remain up-to-date and meet the standards of contemporary science.

It should be also mentioned that a simple comparison of notions, concepts, and keywords from a particular article with the academic discipline's curriculum can be very useful in evaluating the limitedness of the curriculum compared to the contents of logistic paradigms and concepts from a temporal perspective. The purpose of this research is to help experts in logistics to realize the need to adjust or supplement the contents of the academic discipline's curriculum promptly. This adjustment or supplement can relate only to that part of the subject's ontology that is associated with topics of a high abstraction level thus slightly expanding the subject according to the latest industrial trends. Studying the dynamics of the recent linguistic scientific dictionary in comparison with the dictionaries of logistics courses can contribute to the achievement of the aforementioned goals.

3 Results of Application of the Program Complex to a Set of Texts on Logistics

Let us consider the results of the application of the program complex by the example of a comparative analysis of the logistics subject area accompanied by the corresponding course materials published before 2018 and the search for new key concepts in recent academic publications. The first stage implies searching for the words that can potentially become new key concepts. This process is associated with the following filtration procedures:

1. Compilation of a list of words included in 7 course materials on logistics published before 2018.
2. Compilation of a “texts-words” matrix for a set of 250 academic texts on logistics published in the period from 2016 to 2020.
3. Exclusion of words presented in the dictionary that is compiled based on course materials on logistics from the matrix.
4. Exclusion of frequently encountered words presented in a large number of academic texts from the matrix.
5. Selection of rare words from those remaining in the matrix and generation of bigrams, that is, two-word phrases that can potentially become new key concepts in logistics.

These pairs of words are well correlated within particular academic texts on logistics. It should be noted that to limit the scope of the problem during the search for the correlated pairs of words, only those words that are used in one text from the analyzed corpus are singled out from the entire list. Such words are further analyzed separately.

The obtained list of potential two-word key concepts is subject to search for simple phrases containing both candidate words from academic texts. In this case, a simple phrase means a phrase without punctuation marks (except for dashes and quotation marks) containing two words that can potentially become a two-word key concept. Here, the automated part of the procedure aimed at identifying a two-word key concept is over and manual selection of phrases containing possible concepts begins. This selection is necessary to exclude widespread terms from the list.

Let us have a look at the results of the material collecting procedure. In this case, the proposed method is not the best option because the query includes only one word (logistics) without any specification of the subject. Let us demonstrate how the consistent application of ONT-01 programs reduces the search sample and increases the quality of the remaining material.

There are groups of bigrams different in their characteristics in relation to the time of their appearance and the contents of the dictionary of the curriculum of the Logistics academic discipline that was compiled based on the text published in 2018.

For example, 13 out of 50 abstracts of academic articles published in 2020 have no overlaps with the dictionary of the curriculum. There are also bigrams and one-word concepts that appeared only in 2018 or 2019 and thus are not included in the curriculum.

A relatively short list of new logistic terms was obtained after the exclusion of words used in annotations that coincided with textbooks' dictionaries. Let us examine the main phrases consisting of keywords for the period from 2016 to 2020.

1. Airships, cruise and cargo submarines (especially for the Arctic region), string transport, private spaceships allowing flights to the Moon and Mars constitute advanced and innovative means of transportation;
2. Development of the Russian logistics infrastructure in the Arctic region as a factor of global competition;
3. Boat pilot;
4. Economic Order Quantity (EOQ) model;
5. The last mile;
6. Urban sprawl;

Table 2. For the sample consisting of 50 texts per year

Year	Words found	Hapaxes found
2016	5172	3718
2017	5610	2116
2018	5103	1877
2019	5351	2190
2020	6133	2633
The curriculum of the logistics academic discipline	709	162

7. Unmanned aerial vehicle (UAV);
8. Unmanned technical;
9. Unmanned civilian aircraft systems;
10. Building Information Model (BIM) or Modeling - an information model (or modeling) of buildings and constructions including any infrastructural object, for example, utility networks (water, gas, electricity, sewer, communication), highways, railroads, bridges, ports, tunnels, etc.;
11. Geoinformation and satellite;
12. Cross-border dynamics;
13. Discounters;
14. Additional loading of drones;
15. Green logistics;
16. Cross-border online stores;
17. Intralogistics - logistics within four walls;
18. Corruption risks;
19. Criminal threats;
20. Criminal fraud;
21. Logistic bush as a set of branches;
22. Logistics mix. Logistics mission;
23. Pilot boat;
24. Network healthcare companies;
25. Logistics mission mix;
26. Pilot boats' modernization;
27. Multi-agent systems;
28. Ineffective use of WMS;
29. Omnichannel retail;
30. The last mile;
31. SAP programming environment;
32. Uberization;
33. Supply chains with regard to logistic bush;
34. Digital transformation of the last mile in logistics;
35. The fourth industrial revolution;
36. The Silk Road.

Economic coordination of the EAEU and the Silk Road project.

The following topics and concepts should be emphasized:

- Drones and unmanned aerial vehicles as well as "the last mile" in the "delivery chain";
- Digitalization (in a temporal perspective). The curriculum contains no information about this phenomenon;
- International logistics in comparison with the dictionary and curriculum text;
- Examples of bigrams that are not included in the curriculum but are worth including in an updated version of the document.

4 Overview of Results of the Analysis of the Query "Logistics" in e-Library

As the result of the conducted analysis, about 40 new key logistics concepts consisting of two-five words were singled out from about 18500 words used in 250 academic publications that were filtered with the help of 15500 words used in textbooks and course materials on logistics. The list of new concepts contains the following important development areas:

- The Arctic region and the Northern Sea Route;
- Specification of port logistics;
- The last mile problem and unmanned aerial vehicles;
- Information logistics software - specification;
- Partial specification of the already known key concepts of a higher abstraction level.

The latter areas can be too detailed to include them in the hierarchical structure of logistics ontology that is suitable for the learning process. Thus, the software can become obsolete before it is included in the courses. The other development areas are promising enough to be included in the curricula.

In the ancient world, logistics was defined as the art of army supply and control over its movement. The military experience was later used in the civilian economy and transformed into a new subject area related to material flows management both in distribution and production. A similar situation is currently with such concepts as the last mile and unmanned aerial vehicles (even researchers' affiliation and places of publication indicate this [11, 12]). However, rapid economic changes caused by the pandemic can transform the last mile problem into the development of land transportation methods in retail.

The semantics of a simple phrase paired with a two-word concept included in this phrase can point to the fact that this two-word concept is not a fixed collocation. However, together with other words from this phrase, a bigram can help to identify a collocation (it does not have to consist of two words) that has better chances to become a concept or a keyword. Results of the final stage of manual selection remain a hypothesis until they are tested by a subject area expert. If this cannot be done promptly, an online query is a possible way out. This query should consist of a bigram and a single phrase or a part of the phrase containing this bigram.

Let us give an example. A pair of words "logistics mix" was identified in the following phrase: "it is proposed to define the logistics mission of industrial enterprises not as a logistics mix." The contents of course materials on logistics were checked for the use of this pair of words and it was not found. The same result was obtained for the pair of words "logistics mission." A query in the search engine Yandex was made consisting of words from the simple phrase that contained the original pair of words. The query had the following form: "logistics, mission, industrial, enterprises, logistics, mix." The obtained search results constituted at least 60 links where the concept of "logistics mission" was mentioned. The query for the pair "logistics mix" was less successful.

However, one of the most popular research results contains the following information: "Logistics mix (the "7R rule"), i.e., getting the right product, in the right quantity, in the right condition, at the right place, at the right time, to the right customer, at the right price" ([21], p. 465).

Less popular research results include such concepts as "logistics mission, marketing, and logistics mix" and "7R." For example, the article "Logistics mission and environment of a company" contains the following phrase: "In this regard, logistics mission is often interpreted by foreign specialists as the 7R rule or logistics mix (similar to marketing mix)[1]". Moreover, the phrase "Marketing and logistics mix, examples of interaction between sciences" is presented in an article on the economy and economic theory[2]. The aforementioned terms are not new and the authors of education courses should decide whether to include them in the logistics curriculum or not. At the curriculum level, the course on logistics does not contain the term "the last mile." However, it is mentioned in two texts published in 2016.

5 Conclusion

The proposed technology of searching for words that can potentially become keywords proves its

[1] lektsii.org/3-86757.html

[2] otherreferats.allbest.ru/economy/d0022214.html

efficiency. This technology should be applied annually to monitor the dynamics of the appearance of new keywords that are not included in the course materials. The following observations are worth noting:

– The concentration of a large number of bigrams in a small number of texts. For example, the fragment “Airships, cruise and cargo submarines (especially for the Arctic region), string transport, private spaceships allowing flights to the Moon and Mars constitute advanced and innovative means of transportation” [13] is a quote from the text published in 2015 [14] where the word “logistics” is not used.
– The concentration of bigrams in such parts of texts, which are rich in logistics keywords.

The main disadvantages are:

– Inclusion of articles that are written not in Russian but use the Cyrillic alphabet in the sample;
– Multiple repetitions of one phrase in the section “Context” in the reference list.

Identification of rare keywords that are not presented in textbooks of higher education institutions on a relevant subject is a poorly formalized research problem the solution to which does not guarantee success due to at least three reasons:

– The object of search may not be presented in the analyzed material;
– Recognition of a previously unused fixed collocation as a new key concept is subjective;
– Some steps in searching for bigrams are associated with the loss of mainly irrelevant information.

Lists of stop-words should be altered together with a change of the analyzed subject area. However, keeping the lists of excluded words in a particular year allows saving some time for manual processing at the stage of the preparation of data for the next analysis step.

If it is necessary to find 100 main innovations that should be included in the course, it cannot be done based on a sample. To do this, every innovation should be examined separately. Moreover, in some cases, the model (even if it is generated on the basis of a sample) should be applied to the entire set of data.

When it comes to the practical application of the model, the option with samples is not suitable. Thus, it is feasible to generate annual life cycle curves for the identified concepts even if they do not change gradually over time because their behaviors can be important for planning future research. Comparing different concepts’ behaviors is of particular interest.

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