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The Approach to Specialized Transdisciplinary Information-analytical System Development

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*Abstract***.** The article proposes an approach to the specialized transdisciplinary system development that allows ensuring access to modern achievements in the field of education, science, and technology. Such an approach involves an information-analytical system designing for supporting the educational and research activities of the student youth using the software platform "Trans-disciplinary Educational Dialogues of Applications' Ontology Systems" (TEDAOS). The TEDAOS software tools provide the formation of ontological models in the form of knowledge prism, that are proposed to be used to present the results of student youth activities, the results of scientific and technical researches held in fundamental and applied research institutions, as well as curriculum, educational and methodological materials. The information-analytical system being developed allow to aggregate and integrate information resources and systems, created in various formats according to different standards and technologies, by using the ontological approach to knowledge representation to support the youth educational and research activities.

*Keywords***:** Information-analytical System, Transdisciplinary, Student Youth, Ontology, Module.

1 INTRODUCTION

In the modern world, knowledge and information generate new knowledge; their volumes and influence on the productive development of society are growing. This challenge requires from humanity new ways and means of disseminating and using global knowledge for further progress and is the main property of a knowledge and information society.

At the same time, information, and communication technologies in modern development conditions are not just a technical infrastructure related to computerization, but also a global tool for disseminating the ideas of the scientific and technological revolution and the latest technologies. Therefore, the symbiosis of information, knowledge, information and communication technologies allows you to use the resources of the information society to solve practical problems of science and technology.

Nowadays, open access to science is becoming the property of the whole world, not just a single group of scientists whose results of long-term work remain buried in various universities or research organizations archives. The evolution of the scientific communication system, the development of internet resource openness, the filling of electronic knowledge banks, and the transformation of scientific and educational content into the general public domain are critical for the entire world community. An important aspect of this process is the growing number of people involved in scientific and practical activities, as well as the attraction of student youth to research activities. However, for student youth effective work within the framework of their research activities, it is necessary to provide convenient mechanisms for accessing available arrays of scientific information, such as reports on scientific and technical activities, information on scientific and technical products, research results, etc.

Modern informational systems development is aimed at providing open access to information resources. The analysis of the available world and domestic informational Internet-resources shows that there is a problem of inconsistency while choosing standards for information resources metadata creation though. Domestic libraries, archives, electronic journals, and file repositories while providing access to their resources still do not use all the opportunities and achievements of modern information technologies to spread their content to a wider range of users. Such features implement of the unified standards a very complex and time-consuming task that requires considerable resources. At the same time, the modern user wants to receive information immediately and in full, rather than search through the scattered sites of different institutions. Thus, for the end-user, the origin of the information, its format, standard, and technology of creation is not important. This is especially important for student youth that may use such information in their research activities but may not be able to find information in distributed sources. Therefore, the urgent task is not to implement unified requirements for the description of information resources that reflect the current state of science, and technology, but to develop software and informational tools to ensure integration of existing disparate resources and data, as well as their meta-descriptions developed according to different standards and in various formats.

The paper describes the approach to

transdisciplinary information-analytical system development that allows supporting student youth educational and research activities.

The structure of the paper is the following: Section 2 gives analyses of related works and backgrounds for the research. Section 3 depicts characteristic features of information and analytical system for student youth educational and research activities support. Section 4 describes the structure of such a system. In section 5, the main features of TEDAOS software platform that is proposed to be used as the basis for information-analytical system development are given. Section 6 presents conclusions and plans for future work.

2 STATE OF ART AND RELATED WORKS

Nowadays, the results of scientific research, theoretical and practical developments aimed at knowledge improvement in a specific subject domain are being disseminated through "scientific communication". Scientific communication is considered a complex system with a distributed environment. Such a system is intended to facilitate the intellectual exchange of information through a wide range of IT tools through a network.

The Internet has radically changed the practical and economic environment for the distribution of scientific knowledge. The concept of “open access” to scientific and educational information has become a concrete embodiment of this global trend. “Open access” (OA) is a free, fast, permanent, full-text, real-time access to scientific and educational materials for any user through the global information network. Benefits of open access implementation for different groups of users are the following:

- for scientists - free access to the latest research in the subject field they are involved in, more active dissemination and impact of their work, and therefore an increase of their citation and scientific authority;
- for scientific and educational organizations – improvement of their general scientific authority, prestige in the scientific world and ratings; new opportunities for managing scientific communication of the organization;
- for publishers: broader presentation and visibility of the publication; increased citation and increased impact;
- for libraries: easy access to sources of scientific information; providing better quality access to information on the end-users’ demand; new partnerships with re-searches, teachers, publishers;
- for the national economy, development of science and society: acceleration of scientific progress, productivity, knowledge transfer.

Open Access Repositories provide free access to scientific materials, their archiving and storing on a long-term basis, as well as the ability to share metadata and ensure the immutability of e-publishing. They provide permanent storage and secure posting of publications, permanent publications URLs, rapid dissemination of research results through the global scientific community, metadata and full-text search through digital materials, obtaining guaranteed high indexing results on Google and other search engines, the opportunity to enrich research CVs with full texts of their publications, rating and citation index raising, new opportunities for international partners’ search, etc. And though there are many online resources nowadays that provide free (or relatively free) access to scientific and educational materials (Web of Science, Scopus, Index Copernicus, Google Scholar, Astrophysics, PubMed, Mathematics, Chemical Abstracts, Springer, Agris, GeoRef, Open Ukrainian Citation Index (OUCI)), there is no single unified information space that provides open access to modern achievements in the field of science and technology. Nowadays, there exist users’ high demand for open access, as well as practical foreign and domestic experience of open access providing. Despite this fact, the development and implementation of distributed information systems that provide aggregate access to scientific resources are associated with a number of problems. As well there is a problem of heterogeneity and interoperability of metadata standards used for such resources accessibility through a worldwide network.

Today, one of the promising areas of the integrated use of distributed information resources is the study of network-centric transdisciplinary knowledge systems as heterogeneous ordered information environments. Computer ontologies are selected by the software and information tools for working with knowledge in such systems, which make it possible to distinguish basic concepts from a certain knowledge domain and establish connections between them. The ontology allows, on generally accepted and generally accessible principles, to conceptually expose and represent the interdisciplinary connections of certain knowledge domains. Ontology, as an analogue of the “model”, serves as a means of communication between transdisciplinary distributed information resources and systems through a combination of descriptions of resource content based on an object-oriented formalization procedure with descriptions of interpretation functions that control the process of supplying and filling an information resource. The formal structure of the ontology simplifies computer processing, which allows you to represent the specific tasks of the information environment. The use of ontological tools is also effective in the aggregation of information resources from various sources and environments, their presentation, and interpretation in the process of scientific research.

Recently, ontological models have become one of the most promising approaches to solving these kinds of problems. Systems designed on the basis of ontological models solve the problem of heterogeneous information search for non-connected subject domains. The ontological model allows to structure and systemize information, as well as organize its formalized presentation [1]. Ontological models have also been used

in the development of search engines.

Within the framework of the educational process, various diverse heterogeneous information systems are functioning simultaneously. They are designed to receive, accumulate, structure, and exchange information arrays. For such systems integration, it is in need to use the knowledge representation model. Ontological models facilitate knowledge access, ensuring an adequate exchange of information between people and such heterogeneous systems.

Nowadays, the ways in which knowledge is acquired, perceived, and transferred are constantly changing due to the exponential growth of information and communication technologies. Article 12 of the World Declaration on Higher Education in the 21st Century [2] determines that higher education institutions should be an example of new information and communication technologies` benefits and potential usage. Therefore, the importance of ontologies usage is obvious, especially as a technological tool used for adequate information exchange and knowledge access.

Ontologies play an important role in various aspects of education, such as search and web-access to educational materials [3], educational processes digitalization to increase the effectiveness of studying activities [4, 5], information structuring and systematizing [6], data exchange between different departments or educational institutions [7], and the learning process organization [8].

In [9] the authors analyzed 2792 scientific papers from digital databases (ACM Digital Library, IEEE Xplore, Scopus, and Web of Science) related to the use of ontologies in an education subject field. Based on the relevance of keywords, annotations, and headlines to the given search criteria 352 papers describing the original ontology research were obtained. Then, 52 key papers have been selected using data mining and data analysis tools that can fully depict the current state of ontology usage in the educational process.

Studies on the use of ontologies in the education system can be divided into groups according to the purpose of their application:

- ontologies usage to develop curricula, create descriptions of their contents in the form of courses and information resources, manage learning outcomes and simulate curriculum management [10, 11];
- ontologies usage in the process of e-learning [12, 13];
- ontologies usage to improve the mechanisms of recommendations of academic sources and resources or a detailed description (metadata) of interests corresponding to disciplines[14, 15];
- ontologies application for academic assessment, the implementation of which requires the integration of relevant data, usually distributed in separate systems [16, 17];
- ontologies usage for educational institution management [18, 19];
- ontologies application for software development in order to improve information retrieval [20].

A large number of research papers are dedicated to ontologies development for students' characteristics analysis. For example, the authors of [21] developed an ontological model of the student profile, taking into account the process of thesaurus formation. Using such an ontological model it is possible to increase the student's competence and objectively evaluate his knowledge.

Based on the results of the domestic and foreign experience analysis, the paper authors considered the advantages of ontologies usage in education and science, as well as best developments for educational, scientific, and research ontological information systems. Such analysis is taken into account to develop a transdisciplinary system for student youth educational and research activities support.

3 CHARACTERISTIC FEATURES OF INFORMATION-ANALYTICAL SYSTEM

It is proposed to develop a specific transdisciplinary information-analytical system (IAS) for student youth educational and research activities support. Such system software and information tools will provide integrated access to information arrays reflecting the results of fundamental and applied research held in different organizations.

Architectural and technological features of transdisciplinary IAS are:

- model-driven architecture is characterized by a high level of formalization of the domain ontology and the mechanisms of ontology-driven;
- high level of transdisciplinary knowledge integration;
- ontological software and information tools for the computer-aided construction of domain ontologies (methodology, technology, and software implementation).

The ontology-driven architecture of the transdisciplinary IAS will allow to realize all the advantages of a network-centric information educational and research environment and to solve the problems of knowledge bases openness, the unification of the presentation of the conceptual structures, and computer-aided construction of new knowledge bases taking into account already existed ones.

The transdisciplinary information-analytical system includes the following software and information tools:

- identification of the basic categories of scientific and technical products representation, their contextual descriptions and semantic relationships, computer-aided classification and cataloging based on the procedures of semantic-linguistic analysis in the form of ontological interactive documents;
- formation of contextual connectivity of information

arrays based on the identification of contextual indeterminacies and their inclusion in an existing or being created network ontological representation by computer-aided classification and additional identification;

- interactive interoperable semantic and contextual connectivity of the results of fundamental and applied research general categories based on dynamically generated thematic catalogs;
- formation of ontological knowledge capsules, which include a network ontological presentation of educational research projects of the Junior Academy of Sciences of Ukraine students, semantically connected network ontological representations of the achievements of the National Academy of Sciences of Ukraine in the field of science and technology and connected indexes of additional information sources, if necessary, as well as contextual connectedness indexes with thematically related scientific information, educational programs of the Ministry of Education and Science of Ukraine, educational and methodological materials;
- aggregated presentation of physically and thematically distributed network information resources created in various formats, according to various standards and technologies, in the form of transdisciplinary knowledge systems;
- formation of ontological descriptions of educational research projects of the Junior Academy of Sciences of Ukraine students and the achievements of the NAS of Ukraine in the form of interactive documents, the transdisciplinary contexts of which provide the formation of an interactive knowledge base;
- supporting the users` interaction of transdisciplinary information and analytical system in the process of implementing joint collective projects in various networked environments according to thematic profiles.

In the field of scientific and innovative research, the formation of such a transdisciplinary IAS is one of the important practical applications of ontological engineering. With the help of models, methods, and technologies that will be created, qualitatively improved results of fulfilling urgent tasks in the field of education can be implemented:

- computer-aided development of transdisciplinary knowledge systems for educational and research purposes;
- significant reduction in labor, time, and financial costs for the knowledge systems formation.

Besides, ontological means of forming transdisciplinary knowledge systems are able to ensure the functioning of a network-centric information-analytical environment:

- effective computer-aided processing of general language and subject knowledge will significantly accelerate the processes of designing knowledge systems and scale the services of their use;
- unlike the subjective, system-ontological approach involves strict (as far as possible at this stage of the development of science) structuring of domain terms and concepts. The categorical level is represented by the top-level ontology, which design should be included in the general algorithm for the development of modern knowledge bases.

4 INFORMATION-ANALYTICAL SYSTEM STRUCTURE

The technological basis of IAS is the built-in language-invariant tools of semantic analysis and program modules for the dynamic structuring of various information resources that deal with the educational and research process. Let us give a short description of some main constituent elements of the information-analytical system (see Fig. 1).

Ontology viewer module. The ontology viewer module provides an ontology representation and searches through the index zone. Anonymous users can only view public ontologies (from public ontology sites or ontologies for which link access is enabled), while authorized users can additionally view ontologies from their personal account and ontologies accessed by the administrator.

Ontology libraries subsystem. The ontology libraries subsystem is used to represent the set of user-owned ontologies. Using ontology libraries, it is possible to select one or more ontologies that the user will work with. The system includes three types of libraries: public library presents the contents of the selected ontological site, the personal library presents the contents of the selected user personal account, and application library displays a list of ontologies from all available IAS applications.

Multicriteria optimization module. The multicriteria optimization module is de-signed to rank alternatives by specified criteria. The module automatically creates a list of criteria for optimization, using the ontology, then the expert should rank the criteria by importance according to one of the ranking scales. As the result, the module displays the ontology object list, ranked according to the selected parameters.

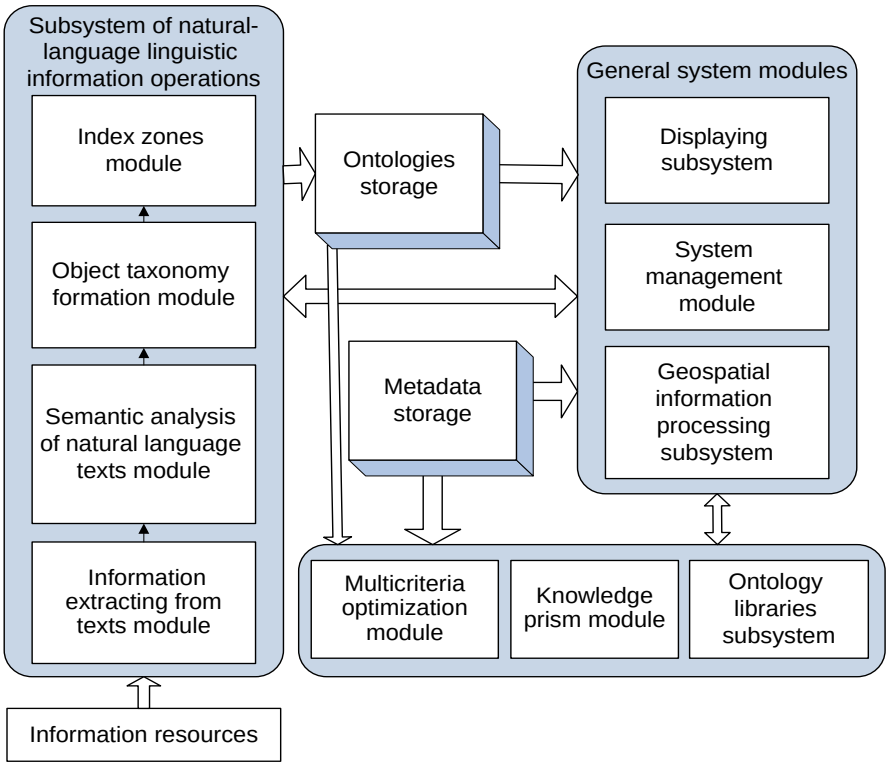

Fig. 1. Structural diagram of the information-analytical system.

The subsystem of natural-language linguistic information operations. The subsystem of natural-language linguistic information operations is intended for processing and analysis of natural-language texts. The subsystem can be used to determine the semantic closeness or distance between alternative documents. It also easily determines the scope and content of changes made to the document (the work done to improve or distort documents). The subsystem allows performing pre-analysis, structural, morphological analysis, and probabilistic and statistical analysis of a given text while highlighting word forms, collocations, and their linguistic characteristics. On this basis, the text is marked and then the linguistic and stylistic portrait of the author is formed. Then, with the help of the text analysis and comparison methods, the text marked in the previous step is compared with the text templates that were previously stored in the lexicographic base. The result of the subsystem's operation is the determination of the overall similarity coefficient for each pair of texts that were analysed. Using such a coefficient, similar texts are sorted by coefficient meaning descending.

The knowledge prism module. Such a module is designed to display tree-like data structures in a multidimensional view. It allows representing of ontologies available from IAS in the form of a multidimensional cube taking into account all relations between ontologies data.

The process of the information-analytical system forming consists of three consecutive stages:

1.Basic components development.

2.Thematic ontologies formation.

3.Index zones filling.

The stage of thematic ontologies formation declares the ontologies` design and their informational filling for a given domain. Such ontologies are used both for storing information (information ontologies) and for managing software modules execution. IAS deals with several types of ontologies:

- searching ontologies (ontologies used in the search process) includes domain thesauruses that can be used to form search requests in index zones and knowledge prism ontologies that contain search requests already generated by the researcher;
- reference ontologies are ontological representations of directories, lists, catalogs, etc. Such ontologies give background information that may be useful to students in the learning and research process;
- regulatory ontologies are ontological representations of normative documents involved in learning and scientific process, such as educational programs, curriculums, educational standards, etc.;
- methodological ontologies are ontological representations of various methodological materials and other educational documents.

The list of documents that are structured and presented as ontologies is determined in the process of system designing.

An important step in IAS development is to fill the index zones with information resources, both structured (created on the second stage of system development) and unstructured (articles, monographs, dissertations, and

other documents not included in the list intended for structuring).

The transdisciplinary information-analytical system for student youth educational and research activities support developed in such a way to realize the most complete informational network resource for knowledge representation. This resource will contain an ontological description of the fundamental and applied researches results from Ukrainian NAS institutions and will provide their semantic linking with information from the Junior Academy of Sciences of Ukraine, MES curricula, and general educational and methodological materials.

5 TEDAOS SOFTWARE PLATFORM AS BASIS OF INFORMATION-ANALYTICAL SYSTEM

It is proposed to use a software platform "Transdisciplinary Educational Dialogues of Application Ontology Systems" (TEDAOS) as the technological basis of the developed information-analytical system. Paper [22] distinguish TEDAOS as "an innovative complex of programmatic information and methodological knowledge management tools using ontological management approaches to corporate information resources, where people are considered as the source of the birth of new knowledge for transferring them in the form of their own knowledge through the tool TODOS, which is the only integrated point of access – "the single window" – to the information and applications of the system to provide interactive interaction with users".

TEDAOS software tools allow to solve a number of important issues while developing modern information and communication systems:

- information inequality liquidation (access to information is provided regardless of time, space, social affiliation),
- organization of educational, scientific and research processes promotion,
- information and knowledge processes intensification for the scientific communications of the society,
- science promotion among young people,
- creating the conditions for the formation of high-quality scientific personnel,
- dissemination of technical, economic, social, and political innovation.

Computer ontologies are used as software tools for knowledge management in TEDAOS. The ontology allows to outline and reflect the interdisciplinary linkages of particular knowledge using generally accepted principles. In the framework of TEDAOS, ontologies are divided according to their purpose. There are two types of ontologies:

- information ontology is designed to store information about objects (categories of objects). Due to different types of ontologies representation forms developed in TEDAOS such ontologies are convenient for the user understanding,
- management ontology is used to control the behaviour of TEDAOS software modules KIT. Such ontologies contain specific program instructions and web-services, making them inconvenient for perception by the user.

TEDAOS allows forming interactive documents based on ontologies [23]. The input information is presented in the form of an ontological document, that further using TEDAOS tools give access to the contents of the document online. Input information can be either predetermined (static) or dynamically generated based on full-text indexing of information resources set (documents, database and knowledgebase elements, websites or separate webpages, etc.). Dynamic formation of an ontological document allows giving integrated access to physically and thematically distributed information resources. The usage of an interactive document provides interactive interoperable semantic connectivity of information resources n multiple contexts within the task.

Using the of TEDAOS platform, it is possible to get the ontological representation of educational and research activity results that are semantically linked to other information, such as:

- fundamental and applied research results from Ukrainian NAS institutions,
- MES curricula and training programs,
- general educational and methodological materials.

Thus, the platform TEDAOS can be used as a basic technological tool for the development of information and analytical system for student youth educational and research activities support.

6 CONCLUSIONS

Transdisciplinary information-analytical system for student youth educational and research activities support will represent the most complete information-oriented network resource containing a description of scientific and technical products in the form of interactive documents and will provide semantic connectivity with the research projects of the Junior Academy of Sciences of Ukraine, the curricula of the Ministry of Education of Ukraine and educational materials on the basis of the use of mechanisms and tools of ontological management of cognitive and research activities of users to form a network-centric transdisciplinary knowledge base.

The systemological structure of such an interactive knowledge base will correspond to the competencies conceptual system of subjects of education, the structure and content of educational processes declared in the educational programs of the Ministry of Education and Science. All categories and concepts reflecting various disciplinary processes in the form of information resources and digital assets and using in the processes of education and scientific research will have deep semantic

connections.

In the short term of the work results implementation, it is expected to improve the quality of the implementation of educational research projects by providing access to transdisciplinary information resources describing the achievements of the NAS of Ukraine, methodological support and tools and services of a network-centric ontology-driven interactive knowledge base.

In the medium term, an increase in the level of awareness and interest in science and technology is expected, which will significantly expand and enrich the content of the network-centric interactive knowledge base with the development of young researchers and scientists, specialists, experts who want to share their own research experience.

In the long term, the results of work are transformed into an information channel for representatives of state bodies of science, education, and business in the areas of introducing modern scientific and innovative results into the educational sector.

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