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USE OF SEMANTIC TECHNOLOGIES IN THE PROCESS OF RECOGNIZING THE OUTCOMES OF NON-FORMAL AND INFORMAL LEARNING

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В роботі проаналізовано публікації, пов'язані з тенденціями розвитку національних систем кваліфікацій, які мають пов'язати ринок освітніх послуг з ринком праці. Такий аналіз дозволяє визначити, що ефективним інструментом для рішення цієї проблеми є ESCO – Багатомовний класифікатор європейських навичок, компетенцій, кваліфікації та професій. ESCO визначає і класифікує навички (як «м'які», так і «жорсткі»), компетенції, кваліфікації і професії, які мають значення для європейського ринку праці, освіти та професійної підготовки. Класифікатор ESCO є основою для створення «паспорту набутих компетенцій» і використовується у кількох ініціативах Європейської Комісії у сфері навичок та кваліфікацій, спрямованих на підвищення прозорості ринку праці та освітніх систем. Розробка інструментальних засобів, які дозволять ефективно використовувати ESCO та забезпечують перехід від кваліфікаційної моделі до повноцінних компетентнісних моделей, вбачається актуальним і своєчасним науковим завданням
Через те, що суб'єкти на ринку праці можуть описувати свої пропозиції або вимоги через неформалізовані характеристики, які часто є нематеріальними (наприклад, командний дух, соціальні навички, лідерські навички), і для опису таких характеристик можуть використовуватися різні терміни, встановлення діалогу між ними потребує співставлення семантики таких описів. Розв'язувати таку проблему мають семантичні технології, які спрямовані на обробку інформації на рівні знань, тобто здатні формалізувати, аналізувати та обробляти зміст (семантику) інформаційних ресурсів.
Зважаючи на це, у публікації представлено теоретичне обґрунтування системи UkrESCO, призначеної для формуванні паспорту набутих компетенцій, пошуку вакансій та співставлення компетенцій з вимогами до вакансій на основі моделі ESCO з використанням технологій Semantic Web та інформаційних ресурсів відкритого інформаційного середовища Web.
Систему UkrESCO можна розглядати як інтелектуальну надбудову над існуючими системами порівняння та оцінки компетенцій, співставлення кваліфікацій з вакансіями, формування паспорту набутих компетенцій.
Практична реалізація системи UkrESCO може стати ефективним інструментом формування в українському суспільстві розуміння цінності освіти впродовж життя у особистісному й професійному саморозвитку людини.
Ключові слова: ринок праці, ринок освітніх послуг, професія, знання, навички, компетенції, онтологія, Semantic Web, ESCO.

В работе проанализированы публикации, связанные с тенденциями развития национальных систем квалификаций, которые должны связать рынок образовательных услуг по рынком работы. Такой анализ позволяет определить, что эффективным инструментом для решения этой проблемы является ESCO – Многоязычный классификатор европейских навыков, компетенций, квалификации и профессий. ESCO определяет и классифицирует навыки (как «мягкие», так и «жесткие»), компетенции, квалификации и профессии, которые имеют значение для европейского рынка работы, образования и профессиональной подготовки. Классификатор ESCO служит основой для создания «паспорта приобретенных компетенций» и используется в ряде инициатив Европейской Комиссии в сфере навыков и квалификаций, направленных на повышение прозрачности рынка труда и образовательных систем. Разработка инструментальных средств, которые позволяют эффективно использовать ESCO и обеспечивают переход от квалификационной модели к полноценных компетентностным моделям, представляется актуальной и своевременной научной задачей.
Из-за того, что субъекты на рынке труда могут описывать свои предложения или требования через неформализованные характеристики, которые часто являются нематериальными (например, командный дух, социальные привычки, лидерские привычки), и для описания таких характеристик могут использоваться различные термины, могут возникать проблемы сопоставления семантики таких описаний. Разрешать такую проблему позволяют семантические технологии, направленные на обработку информации на уровне знаний, то есть способные формализовать, анализировать и обрабатывать смысл (семантику) информационных ресурсов.
Учитывая это, в публикации представлено теоретическое обоснование системы UkrESCO, предназначенной для формировании паспорта приобретенных компетенций, поиска вакансий и сопоставления компетенций с требованиями к вакансии на основе модели ESCO и с использованием технологий Semantic Web и информационных ресурсов открытой информационной среды Web.
Систему UkrESCO можно рассматривать как интеллектуальную надстройку над существующими системами сравнения и оценки компетенций, сопоставление квалификаций с вакансиями, формирование паспорту приобретенных компетенций.
Практическая реализация системы UkrESCO может стать эффективным инструментом формирования в украинском обществе понимания ценности образования в течение жизни в личностном и профессиональном саморазвитии человека.
Ключевые слова: рынок труда, рынок образовательных услуг, профессия, знания, навыки, компетенции, онтология, Semantic Web, ESCO.

The paper analyzes publications related to the development trends of national qualifications systems, which should link the market of educational services to the labor market. Such an analysis suggests that an effective tool for solving this problem is ESCO – the Multilingual Classification of European Skills, Competences, Qualifications and Professionals. ESCO defines and classifies skills (both "soft" and "hard"), competences, qualifications and occupations that are relevant to the European labor market, education and training. ESCO classifier proposes the basis for creating a "passport of acquired competencies". It is used in several European Commission initiatives in the field of skills and qualifications aimed at increasing the transparency of the labor market and educational systems. The development of tools that allow the effective use of ESCO and ensure the transition from a qualification model to full competency models, is seen as an up-to-date and timely scientific task.
Subjects of the labor market can describe their proposals or requirements through non-formalized characteristics that are often non-material (such as team spirit, social skills, leadership skills) and use different terms to describe such characteristics, therefore the problem of comparing the semantics of such descriptions is occursed. Semantic technologies aimed at the information processing at the knowledge level (oriented on formalizing, analyzing and processing the semantics of information resources) can solve such a problem.
In this regard, the publication presents the theoretical substantiation of UkrESCO designed to create a passport of acquired competencies, to search for vacancies and to compare competencies with job requirements based on the ESCO model using Semantic Web technologies and information resources of the Web open information environment.

UkrESCO can be considered as an intelligent superstructure over existing systems that compares and evaluates competencies, matches qualifications with vacancies and form a passport of acquired competencies. Practical implementation of UkrESCO becomes an effective tool for the formation in Ukrainian society of understanding of the value of throughout life education in the personal and professional self-development of person.
Key words: labour market, market of educational services, occupation, knowledge, skill, ontology, Semantic Web, ESCO.

The problem of recognizing the outcomes of non-formal and informal learning

The socioeconomic challenges of Ukraine exacerbate the need for the effective use of the country's human potential. Aging of the population, the negative balance of interstate migration, imbalances in the structure of demand and supply in the labour market require innovative approaches to address the problem of the country's population employment and, as a result, the productivity and competitiveness of the national economy.

A prerequisite for the effective use of human potential through the individual's approaching the new possibilities in the labour market is the recognition of the outcomes (knowledge, skills, abilities and competences) of non-formal and informal learning. Such recognition enables a better combination of skills and abilities and, as a consequence, facilitates professional and geographical mobility, satisfies the lack of skills and abilities in the growing sectors, accelerates economic renovation.

The opposition to rapid economic and technological changes, frequent workplace changes throughout life prompts the person to become more and more involved in the learning process, to master the most demanding skills more energetically in order to increase chances in the labour market, and to improve one's own well-being.

In today's globalized world, where technology allows knowledge to be mastered in many different ways, non-formal and informal learning is gaining more significance and importance. At the same time, the opportunities for such learning, both for personal development and professional growth, are practically unlimited either in time or in space. It is becoming more and more common to acquire knowledge at work or through participation in the activities of public organizations, or in the virtual space, both individually and together with others. More often, businesses are offering their employees the opportunity to improve the skills they have through organized but non-formal learning.

Acquiring knowledge or skills beyond formal learning and recognizing the outcomes of such learning in the labor market requires the development and testing of appropriate methods, mechanisms and tools. In order to develop national tools so that the educational services market could approach the labour market, it is advisable to use the global, and first of all, European experience.

The European practice of identifying, documenting, evaluating and recognizing the outcomes of non-formal and informal learning in the EU member states is aimed at meeting the objectives of the Europe 2020 strategy [1] to achieve an intellectual, sustainable and comprehensive non-discriminatory growth. Recognizing the outcomes of non-formal and informal learning has been part of the European political agenda since 2001, when the EU Commission identified lifelong learning as a learning through life activity to improve knowledge, skills, abilities and competences within the framework of personal, public, social and labour prospects. In 2004, the Common European Recognition Principles were adopted in the form of the Council Conclusions, and in 2009, the Commission, together with Cedefop, published European Guidelines for the recognition of non-formal and informal education, which provided politicians and experts with technical recommendations on recognition.

Since the adoption of the Copenhagen Declaration on the expansion of European cooperation in vocational education and training, a number of initiatives have been launched to develop European tools for recognizing the outcomes of non-formal and informal learning, in particular, in 2004 Europass was established, which includes CV (Europass-CV) and portfolio of documents which citizens can use to improve reporting of their qualifications and competences within Europe.

Despite the launch of the above European initiatives, the progress in recognizing the outcomes of non-formal and informal learning in Europe is uneven and slow, the existing discrepancies between the EU member states further restrict the comparability and transparency of recognition systems.

First and foremost, the problem lies in the lack of effective tools for identifying, documenting, evaluating and recognizing the outcomes of non-formal and informal learning that would allow all those who wish to officially acknowledge their knowledge, skills, abilities and competences, regardless of the conditions in which learning took place.

Taking into account the above mentioned, the development of tools for identifying, documenting, evaluating and recognizing the outcomes of non-formal and informal learning, which allow combining the educational services market with the labour market, is seen as an urgent and timely scientific task.

The problem of analyzing the tools for recognizing the outcomes of non-formal and informal learning, which allows to combine the educational services market with the labour market, ensuring the transition from a qualification model (confirmation of professional skills by diplomas and certificates on taking training courses) to full competency models, is relevant and requires an urgent solution. This problem is being addressed by both domestic researchers (Yu. Borimchuk, L. Boiarchuk, M. Makhsma) and foreign ones (L. Brever, J. James, S. Lins, P. Luksha, D. Pieskov, M. Afanasiev) [2-6]. In respect of practical implementation, the recognition of the outcomes of non-formal and informal learning is the focus of both state and private commercial institutions and companies.

The transition from confirmation of professional skills by diplomas and certificates on taking training courses to full competency models with the introduction of "passports of acquired competences" will make the process of mastering the competences more manageable on the part of the students and will enable them to raise the question of the contribution of each educational element in the personal competence profile [7]. However, in order this practice

could work and models of competences could be recognized by the educational market and the labour market, they must be transnational in nature, and a single platform is needed for their support and development. There are good reasons to introduce the typology of study certificates (passports, diplomas, certificates) into educational practice, which would correspond to different competences and qualifications.

One of the first prototypes of the "Digital Diploma" was the Digital Lifelong Diploma, DLD [8]. The idea is to capture in a single document all learning outcomes that its owners receive from different sources throughout their lives, both official ones, such as Harvard or Michigan, and unofficial ones such as Khan Academy, iTunesU, Coursera, etc. The DLD team has already made great progress in developing a digital diploma. They managed to include nearly all of the academic disciplines in America into the catalogue of their platform, and also to catalogue hundreds of unofficial providers of educational services and thousands of courses they have provided.

A significant event in the context of recognition of learning outcomes was the European Commission's support for the VM-Pass, VM project (Virtual Mobility). It was envisaged that the project would support the virtual mobility of students through the creation of an innovative "Learning Passport" [9], a kind of certificate that is filled in by the educational institution and an online-student on his/her own, and which is a standard sample where non-formal learning and assessment can be documented. In this case, not only subjects and courses are documented, but also independent examinations which were passed, internships and specific skills, such as mastering programming languages, etc. It would be advisable to include the already achieved practical results in the "passport", in particular the implemented projects, which will make it possible to supplement the professional portfolio, since the taken online courses speak of perseverance, desire for self-study and self-discipline, because not everyone goes through them, although they give an additional idea of the directions and fields of knowledge the person is most interested in.

Despite the significant number of projects implemented owing to the "passport of acquired competences", one should keep in mind the lack of tools that would really be able to combine the educational services market and the labour market, employers with jobseekers, to combine occupations, qualifications and learning outcomes (competences). Employers should have access to more accurate and up-to-date information on the skills and qualifications of jobseekers in order to understand their professional qualifications better. Learning outcomes are usually defined in terms of knowledge, skills and competences. Common terminology will foster dialogue between the labour market and education, training of those who are interested within and between sectors and borders. In particular, employers will be able to understand better the suitability of the job candidates for the post on the basis of their qualifications, educational services providers will be able to receive feedback about the needs of the labour market, detect gaps in qualifications and adapt them appropriately. In turn, jobseekers will be able to get advice on which qualifications could enhance their employability.

The European Commission has developed a multilingual classification of European Skills, Competences, Qualifications and Occupations (European Skills, Competences, Qualifications and Occupations, ESCO) (https://ec.europa.eu/esco/portal/home). The ESCO classification identifies and categorizes skills, competences, qualifications and occupations relevant for the European labour market, education and training [10]. The ESCO unites both employers wishing to find the right people for their vacancies and jobseekers looking for jobs matching their skills. The ESCO classification combines labour market and educational services market because, on the one hand, it helps education providers to understand the labour market needs better and adapt curricula according to the conditions, and, on the other hand it helps employers understand the learning outcomes that were gained by professionals looking for a job. Equally important is the fact that the ESCO classification combines labour markets from different EU member countries, allowing jobseekers and employers to deal with skills, training and work more effectively in any European language.

At the basis of the ESCO classification there are three main elements: 1) occupations; 2) knowledge, skills and competences; and 3) qualifications. In the ESCO, each concept is related to at least one term in all ESCO languages. In many cases, the language contains more than one term to refer to the same or very similar concepts. Thus, the ESCO can contain several terms of one concept. Within the framework of the ESCO data model, each term represents a separate element and all of them are related to the concept. This model is based on the Simple Knowledge Organization System (SKOS) ontology [11]. The ESCO is published as Linked Open Data, and developers can use it in a variety of formats (SKOS-RDF, CSV) in programs that provide services such as job search, career guidance and self-esteem. Users can integrate the ESCO classification into their applications and services. In addition, the ESCO provides a local API and API Web services so that applications and Web services could request information from the classification in real time.

The practice of using the ESCO classification has showed its effectiveness with a number of international institutions. In particular, the European Employment Services (EURES – European Employment Services – http://ec.europa.eu/eures/.) – a network that brings together about 400 "Euro Advisors" from national employment services, employers' associations, trade unions, local and regional authorities and educational institutions are actively using the ESCO classification. The EURES portal is a key system for mobility in the EU. EURES has a unified information online resource to collect data on the availability of employment vacancies across Europe and provides European employers and other stakeholders with variety of services and information covering all aspects of recruiting from other European countries [12]. The EURES portal is a good example that in recent decades the increased spread of Web-based technologies has fundamentally changed the way we exchange information in the labour market, and considerably re-oriented it towards the use of electronic means.

Formulation of the problem

The problem of creating electronic tools for describing the educational services market and labour market is greatly complicated due to the increase in the amount of information associated with these services and the complexity of data structures used in these electronic media. Effective processing of such information requires its semantization, that is, the use of various knowledge bases to determine the context of the search, as well as modern methods and means of knowledge management. In order to integrate various terminological approaches in various information resources and queries, it is suggested, taking into account the ESCO, to develop an ontological model for the interaction of educational institutions, employees and employers, and to create methods for its replenishment with information from open Web sources – both natural language and semantically marked.

Use of SEMANTIC WEB tools for the labour market

People in the labor market can describe their proposals or demands through various non-formalized characteristics that are often non-material (such as team spirit, social skills, leadership skills). Various terms may be used to describe such characteristics, and therefore a problem arises in comparing the semantics of such descriptions. This problem has to be solved by semantic technologies aimed at processing information at the level of knowledge, that is, which are capable of formalizing, analyzing and processing the content (semantics) of information resources [13]. They are based on the use of the knowledge of the subject area for which the task is being solved, and the knowledge about the users of these IT, and provide automated analysis of information on the Web. One of the results of such processing is the achievement of the semantic compatibility of information resources (IR), which allows IT-systems to use and integrate information from different sources and databases. It requires the development of appropriate models, methods, languages and technologies.

One of the most popular projects related to the processing of distributed knowledge is Semantic Web [14], proposed by the WWW inventor T. Berners-Lee. Semantic Web offers a powerful, practical approach to obtain the tools of managing large amounts of information and information services [15]. The purpose of this project is to transform the entire set of available IR, accessible through the Web, into a distributed heterogeneous knowledge base. The main components of Semantic Web are ontologies, Web services and software agents. For their presentation within the framework of Semantic Web such open standards of knowledge presentation have been developed as the language of ontology presentation OWL [16], the IP RDF metadata standard [17] and the query language of SPARQL for these formalized knowledge.

Today, the Semantic Web project is actively developing, new languages, standards and tools are emerging, and existing ones are being improved. Therefore, in the process of developing any information system based on the use of the Web resources it is good to focus on these results and create semantic Web services that can effectively take advantage of the new information environment. The use of ontological analysis provides the ability to transfer knowledge to new applications, the ability of automated export of information from semantically marked IR, and the ability to build a common terminology framework for interaction between different resources and information systems. This is also true for applications aimed at supporting the labour market [18]. Semantic Web technologies easily integrate with other modern Web technologies, such as semantic Wiki (for example Semantic MediaWiki).

In view of this, we suggest in the course of the system development whose purpose is to draw up a passport of acquired competences, to search for vacancies and match competences with job requirements based on the ESCO model, that the following Semantic Web technologies should be used:

- to personalize user interaction, personal *program agents* are created for each of the potential employers, jobseekers and individuals who are acquiring or are planning to acquire particular education;
- the system should provide *semantic Web services* to support such functions as:
  – registration and search for vacancies;
  – registration and search for CVs;
  – comparing vacancies and CVs at the semantic level;
  – search for educational institutions able to provide a certain qualification or education;
  – comparison of training courses and programs with occupations;

The relationship between occupations, jobs, knowledge, skills, competences and qualifications, between terms and concepts, etc., as well as between their characteristics, are formalized using *ontology* (or a set of ontologies describing national or regional sets of these concepts).

In addition, the use of knowledge from external ontologies makes it possible to make execution of services more personalized (for example, to take into account the territorial proximity of educational institutions or places of employment).

To make such systems sufficiently dynamic and capable of taking into account changes in the surrounding world, one must ensure that you receive information from Web resources. To do this, it is necessary to use intelligent information retrieval systems capable of finding relevant documents by ontological models [19]. To make such a search faster and more automated, it is advisable to focus on processing of semantically-marked information resources, for example, Wiki-resources.

Architecture and model of the UkrESCO

In the most generalized form the architecture of the UkrESCO looks like this (Fig. 1):

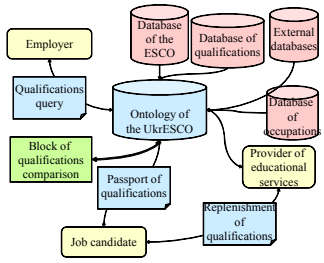

Fig.1. Architecture of the UkrESCO

An important element of the UkrESCO is its ontological model.

Ontological analysis is an effective means for modeling representations about various subject areas (SA) which allows to display their semantics [20]. In order to formalize the basic concepts of the ESCO and the relationship between them, we will use the following formal model of ontology $O = \langle X, R, F, T \rangle$, where $X = X_{cl} \cup X_{ind}$ is a set of basic concepts of ontology, X_{cl} is a set of classes, X_{ind} is a set of their instances; $R = r_{ier\_cl} \cup \{r_i\} \cup \{p_j\}$ is a set of relations between classes and instances of ontology classes, where r_{ier_cl} – hierarchic relations between ontology classes and class properties; $\{r_i\}$ – a set of object properties of class instances; $\{p_j\}$ – a set of properties of the given instances of classes; F – a set of characteristics of ontology classes, instances of classes and their properties; T – a set of data types [21].

From the point of view of the problem being solved, the main classes of the UkrESCO ontology are competence; occupation; qualification, as well as those subjects that may be associated with these classes: owners (potential employees with specific knowledge and skills), contractors (employers) and providers (individuals and organizations providing educational services that allow to increase qualifications).

The main purpose of the UkrESCO creation is to improve the interaction between subjects related to qualifications. The UkrESCO can be considered as an intellectual superstructure over existing systems of comparison and assessment of competences, matching qualifications with vacancies, forming a passport of acquired competences.

However, in order to correctly determine the relationship between them and ensure their comparison, the classes associated with all the basic terms of the UkrESCO are introduced into this ontology.

Thus, the UkrESCO ontology contains the following classes X_{cl} (the list of classes is ordered in alphabetical order, but not by significance): knowledge, jobseeker, qualification, competence, country, course, skill, educational program, course provider, occupation, job, employer. If necessary, these classes are specified and supplemented by subclasses and properties. For example, skills are divided into "soft" and "hard", into the main and additional ones.

The use of an ontological model allows us to establish the relationships between these classes clearly and unambiguously and ensure their unified common understanding [22]. It is important that such a model fixes not only hierarchic relations $\{r_i\}$, but also specific for the subject area connections $\{p_j\}$. For example, you can clearly indicate that the employer specifies the qualifications that a job candidate must hold, and the education passport for the job candidate can be changed by the course provider adding additional skills and qualifications to the education passport associated with that candidate. Using Protégé ontology editor allows you to visualize these relationships in a way that is understandable to the users of the system (Fig. 2). Instances of some classes X_{ind} are added to the ontological model when developing the UkrESCO. For example, instances of "Skills" contain the elements imported from the ESCO. The ontological model is replenished by other instances in the process of system operation. For example, these are job candidates' profiles, employers' requests, and educational services providers' proposals. This model is described in OWL Light language and can be visualized by means of Protégé's Ontology Editor. OWL Lite (just like OWL DL and OWL 2.0) are based on descriptive logic ALC (Attributive Language with Complements), which guarantees the completeness of logical output on this ontology. The model describes the properties of classes (both object properties and data properties) and the relationship between the basic terms and their subclasses [23].

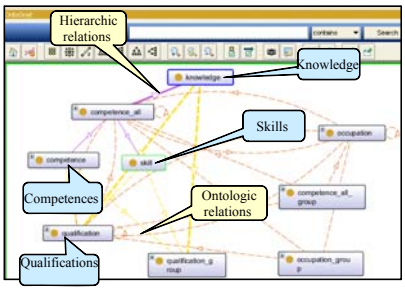

Fig.2. Ontology of the UkrESCO

Each instance of the information objects (IO) $x \in X$ can be represented as $\langle (\{r_{obj_i}, \{x_k\}), (\{r_{data_j}, \{d_m\}) \rangle$, where r_{obj_i} – the object properties of the subject area ontology, r_{data_j} – the properties of the subject area ontology data, $x_{k\_}$ optional instances of different classes of the IO, d_m – constants of different types. Each r_{obj_i} can be considered as $r_{obj_i} : \{x_{in_{i_1}}, \ldots, x_{in_{i_k}}\} \to \{x_{out_{i_1}}, \ldots, x_{out_{i_m}}\}$, that is, for each object property, the region value and area of determination from subsets of the IO are determined.

Instances of different classes in the UkrESCO are associated with different object properties r_{obj_i}. The object property of an association has no additional constraints (such as transitivity, symmetry, etc.) and therefore does not reflect additional semantics that allows them to be presented in OWL Light language. In addition, the UkrESCO uses semantically loaded object properties such as "requires prior learning", "based on education level", etc., which may have additional restrictions.

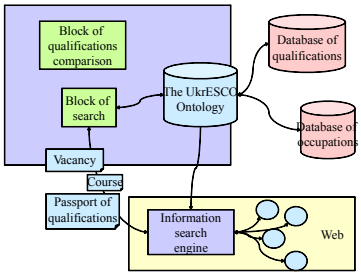

Fig.3. Use of the UkrESCO ontology by search engines

Interaction of the UkrESCO with search engines

An important feature of the UkrESCO is the ability to search for new resources in the information space of the Web. In order to automate this search, it is suggested to use the knowledge of the subject area in which this system operates (Fig. 3). This knowledge is formalized in the form of the UkrESCO ontology, and therefore it can be applied without any additional processing in the systems of semantic search, oriented to the use of ontologies, for example, in [25].

It is this ontology that allows you to describe what information objects you need to find on the Web, identifying their structure and the necessary elements. For example, you can search for potential employees (ontology class "educational program"), educational services (ontology class "course provider") and employers (ontology class "vacancy"). It is clear that such results will be much less reliable than those obtained inside the UkrESCO from registered users, but the availability of such a search can significantly expand the system's capabilities and ensure its connection with the open environment. This property is a characteristic difference from most similar systems. It provides obtaining information not only from relevant databases, but also from all the unstructured Web content. This opportunity should be used to find only those vacancies and CVs that occur very rarely.

Interaction of the UkrESCO with Wiki-resources

Due to the fact that obtaining information from the unstructured Web resources (even with the help of semantic search) requires human involvement to filter out the obtained results, it is advisable to provide the UkrESCO with semantically-marked resources. The most widespread among these resources today are resources organized on the basis of Wiki-technology and which are semantically expanded. This is due to the fact that users can easily replenish and update such Wiki pages, and their semantic markup can be easily transformed into a corresponding ontology.

Existing tools for ontological analysis allow you to make a comparison between Wiki-ontology (that is, the ontology whose elements are the basis of the semantic markup of the Wiki resource) and the ontology of the UkrESCO. On the basis of such a comparison, you can find pertinent pages and obtain not only information on CVs and vacancies from them, but also more important information – information about occupations, specialties and courses. Usually, the update of the Wiki resources is executed more frequently compared with the updating of knowledge bases and ontologies because it can be done not only by knowledge engineers but also by ordinary users who are knowledgeable in the relevant subject area.

Wiki-ontology is an ontology built on a semantically marked Wiki resource (a set of Wiki pages containing semantic markup) [21, 25]. It contains only the knowledge that can be directly obtained from the semantic markup. Therefore, in this ontology there are no, for example, such characteristics of classes and properties as equivalence, lack of intersection, etc.

In this model, a set of concepts is constructed as a combination of such Wiki elements as pages and categories $X = X_{wiki\_categor} \cup X_{wiki\_page}$ associated with different types of relationships with $R = \{r_{ier\_cl}\} \cup \{r_{link}\} \cup \{r_{sem\_prop}\}$: a set of classes is a set of Wiki categories $X_{wiki\_categor}$, between which there are hierarchic relations; a set of instances is a set of Wiki-pages X_{wiki_page}, between which there are references r_{link} and semantic relations $r_{sem\_prop_i}, i = \overline{0,m}$; a set of data types is supplemented by a specific class – "Wiki-page". This model can be upgraded with such Wiki elements as templates, forms, custom pages, and more.

When searching for pertinent Wiki-pages, you need to compare classes $X_{wiki\_categor}$ and semantic properties $r_{sem\_prop_i}, i = \overline{0,m}$ of Wiki-pages with classes X_{cl} and object properties $r_{ier\_cl} : X_{cl} \to X_{cl}$ of the UkrESCO ontology. If they match (or the level of compliance is higher than the specified rating), then the UkrESCO ontology set must be replenished with an instance corresponding to the found Wiki-page, that is, to create an instance of the specified class in which the value of the object properties is of the value derived from this Wiki-page .

It is important that such replenishment can be performed completely autonomously and does not require any efforts of users and developers of the UkrESCO.

The same Wiki resources can be found by external search engines or recommended by developers of the UkrESCO based on thematic relevance and high level of trust. An example of such a resource is the electronic version of the Great Ukrainian Encyclopedia.

Similarly, you can use non-semantic Wiki resources (for example, Wikipedia), taking into account the categorization of pages, but in this case, the replenishment of the UkrESCO ontology requires human involvement to determine the properties of the instance.

Conclusions and prospects of further research

The analysis of the publication made it possible to conclude that an effective tool that allows to combine the educational services market with the labour market is the Multilingual Classification of European Skills, Competences, Qualifications and Occupations (the ESCO). The classification of ESCO identifies and classifies skills (both "soft" and "hard"), competences, qualifications and occupations that are relevant to the European labour market, education and professional training. The ESCO classification is the basis for creating a "passport of acquired competences" and is used in several European Commission initiatives in the area of skills and qualifications aimed at increasing the transparency of the labour market and educational systems. Since people in the labour market can describe their proposals or demands through non-formalized characteristics that are often non-material (such as team spirit, social skills, leadership skills) and different terms may be used to describe such characteristics, there occurs the problem of comparing the semantics of such descriptions. This problem is to be solved by semantic technologies aimed at processing information at the level of knowledge, that is, which are capable of formalizing, analyzing and processing the content (semantics) of information resources.

In this regard, the publication presents the theoretical substantiation of the UkrESCO system designed to create a passport of acquired competences, to search for vacancies and to compare competences with job requirements based on the ESCO model using Semantic Web technologies and information resources of the Web open information environment.

The UkrESCO system can be considered as an intellectual superstructure over existing systems of comparison and assessment of competences, matching qualifications with vacancies, forming a passport of acquired competences.

Practical implementation of the UkrESCO system may become an effective tool for the formation of understanding of the value of lifelong learning in the personal and professional self-development of a person in Ukrainian society.

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