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ONTOLOGY-BASED METHODS AND TOOLS FOR VALIDATION OF NON-FORMAL LEARNING OUTCOMES

Serhii Pryima[a] [0000-0002-2654-5610], *Oksana Strokan*[a][0000-0002-6937-3548], *Julia Rogushina*[b] [/0000-0001-7958-2557], *Anatoly Gladun*[c] [0000-0002-4133-8169], *Andriy Mozgovenko* [a] [0000-0002-7445-8925]

[a]Dmytro Motornyi Tavria State Agrotechnological University, 18 B.Khmelnytsky Ave, Melitopol, Zaporizhzhia obl., 72312, Ukraine

[b]Institute of Software Systems, National Academy of Sciences of Ukraine, 44 Glushkov Pr., Kyiv, 03680, Ukraine

[c]International Research and Training Centre of Information Technologies and Systems, National Academy of Sciences and Ministry of Education of Ukraine, 44 Glushkov Pr., Kyiv, 03680, Ukraine

We analyse modern approaches to the interaction of the educational services market with the labour market through recognition of non-formal and informal learning outcomes. The authors prove the expediency of semantic technologies used for information processing at the knowledge level, analyze the Semantic Web standards and specifics of their use for education and labor market applications. ESCO classifier that combines services of the labour market and the educational market is examined in detail. This classifier allows jobseekers and employers from different EU member states to handle information on learning outcomes more efficiently. The analyzes of practical ESCO classifier usage on example of the European Employment Service (EURES) demonstrates that this approach provides all necessary information for jobseekers abroad.

The ontological analysis is an efficient way to model the ideas of various domains that allows to represent formally their semantics. Hence, the research analyzes the ontological model for this information system and its components; in particular, the authors provide the described content of the ESCO ontological model which consists of three elements – occupations, skills and qualifications. Original method of semantic identification and documentation of non-formal and informal learning outcomes based on competence analysis is proposed. Main element of this method is atomic competence. Enhanced formal model of domain ontology that provides representation of competence matching is developed.

The paper offers an information system for semantic identification and documentation of non-formal and informal learning outcomes based on the ESCO ontological model and semantic matching of its main concepts. The authors select and analyze the main stages of the system development and substantiate the choice of software tools for its implementation. Access to the RDF-repository is provided with SPARQL query language. The architecture and user interface of information system proposed in this research work allow to carry out the semantic identification and documentation of non-formal and informal learning outcomes. Thus, they increase the efficiency of managing the information about these outcomes.

Key words: information system, learning outcomes, non-formal learning, informal learning; ocupation, competences, skills, ontology, ESCO, Semantic Web.

Introduction

Lifelong learning [1] is a key factor in personal and professional development. Guiding principles for lifelong learning andworker engagement suppose that industry leaders work cooperatively with high school, post-high school technical/vocational education and college/university programmes but continuous training is provided to workers across all occupations in production supply chains. The accession of Ukraine to the European educational space [2] causes important changes in the structure and semantics of the educational process. The concept of lifelong learning, which was not only invoked with reference to education and schooling, but also as a way to solve the problems of unemployment and preparation for the job market. In new framework the main principles becomes technology, personalization, self-education and self-development. Recognition of learning outcomes (knowledge, skills, abilities and competencies) achieved through non-formal and informal (spontaneous) learning, including through open educational resources, is necessary for access to the labor market and lifelong learning. Employer organizations, trade unions, chambers of commerce and industry, national bodies involved in the recognition of professional qualifications, employment services, youth organizations, education providers, and civil society organizations are the most interested parties in providing opportunities for the recognition of non-formal and informal learning. .

All stakeholders contribute to more systematic approach to the recognition of non-formal and informal learning outcomes [3], increasing the "visibility" and value of learning outcomes obtained outside of formal learning systems. Now lifetime employment becomes an exception because the majority of employees change job several times in their work lifespan. Labor market change, reflecting evolutions in technologies, markets and organizations, requires that skills and competences can be transferred within a new working environment.

Successful implementation of this task facilitates the development of vertical mobility of citizens in vocational education and labor market, and horizontal mobility from one professional trajectory to another through the mechanism of official recognition of partial qualifications acquired in formal, non-formal and informal learning.

Rapid expansion of the computer technology, data storage and software for the analysis of Big Data sets fundamentally change the ways of information interchange on the labor market. Subjects of the labor market have possibilities to describe their proposals and requirements through various informal characteristics which are often intangible (e.g. team spirit, social skills, leadership skills). Use of different terms to describe such characteristics actualizes the problem of comparing the semantics of such descriptions.

Semantic technologies that are aimed at knowledge-level processing of information can solve this problem because they are able to formalize, analyze and process the content of information resources (IRs). These technologies are based on the application of domain knowledge and knowledge about the users of these information technologies, providing automated analysis of information on the Web. One of the results of such processing is an achievement of semantic compatibility of open educational resources that allows to use and integrate information about results of non-formal and informal learning from different sources and databases in various information systems (IS).

Thus, the implementationof ISs of semantic identification and documentation of the results of non-formal and informal learning is an urgent and timely scientific task.

Multilingual classifier of European skills, abilities, qualifications and professions

In order to support the process of recognition of learning outcomes in formal and non-formal and informal learning, the European Commission has developed free Internet portal ESCO [4]. ESCO (European Skills, Competencies, Qualifications and Occupations) is a multilingual classifier of European skills, abilities, qualifications and professions. Classification proposed by ESCO identifies and classifies skills, competencies, qualifications and occupations important to the European labor market, education and training. Use of ESCO classifier provides consolidation of the labor market and the market of educational services, because, on the one hand, it helps education providers better understand the needs of the labor market and adapt curricula to these needs, and on the other hand – helps employers in understanding of the learning outcomes acquired by professionals looking for work.

Structure of ESCO classifier contains three main elements (Fig. 1):

1. occupations;
2. skills and competencies;
3. qualifications.

All these elements are interconnected and allow ESCO to organize common and transparent terminology for the European labor market and education sector.

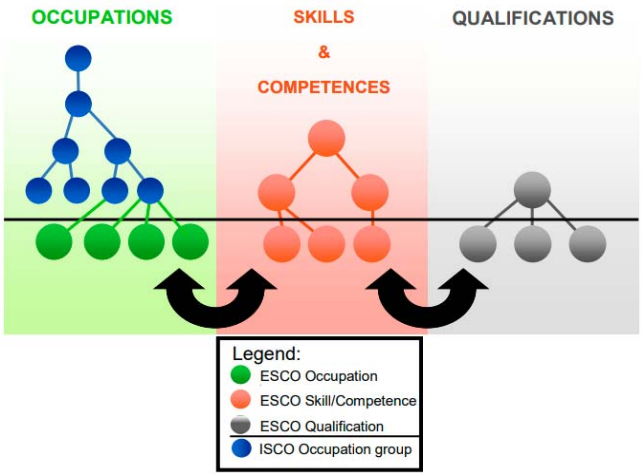

Fig. 1. Structure of ESCO classifier

Each ESCO concept such as profession, skills or qualification has at least one unique term for each of the 27 EU languages. ESCO fixes only one term from the group of terms with a similar meaning that better reflects the semantics of the concept. However, each concept may contain more than one term to refer to the same or similar concepts, and therefore ESCO may contain several terms for each concept in each language. Unacceptable terms may be synonymous (words with similar or identical meanings), but may also be spelling, abbreviations, etc. that terms are used regularly by job seekers, employers or educational service providers to denote the concepts described in the classification with the preferred term.

ESCO also fixes terms that are commonly used on the labor market for profession denotation but are considered obsolete or erroneous. They are called hidden terms because they are useful for indexing and search but they are not available to end users. If user searches for a hidden term on the ESCO portal then he/she is automatically redirected to concept with the best term.

Profession element is a description of all professions that are important for the European labor market. Today, ESCO classifier contains description of 2,942 occupations. Each concept of the Profession describes its meaning, as well as provides useful information about the profession (metadata). The main element that defines professions in

ESCO is the basic idea or understanding of what it is and how it differs from other professions. They are fixed in the description and the note area. ESCO description is a text field that contains a brief explanation of the meaning of the profession and its understanding. Most importantly, it explains the semantic boundaries of the profession. For this reason, a description is always provided for each ESCO employment.

Each Profession in ESCO is associated with basic and additional skills and competencies:

- main skills and competencies are usually relevant to the profession, regardless of the work context, employer or country;

- additional skills and competencies may be actual or arise when in the profession working dependently on the employer, work context or country.

Professions in ESCO are structured by comparing them with the International Standard Classification of Occupations (ISCO-08) developed by the International Labor Organization. ESCO employments and their ISCO-08 hierarchy compose the ESCO Profession element. ISCO-08 provides four upper levels, while the professions at ESCO provide fifth and lower levels. Each ESCO employment is assigned to one group of ISCO-08 elements (even if they are not directly related to it, for example, if they are at the sixth or seventh level).

The Skills and Competence element (often abbreviated as Skills) provides a complete list of skills relevant to the European labor market. ESCO contains 13,485 skills (Fig. 2, a). The Skills and Competence element includes knowledge, skills and competencies that are defined as follows [4]:

- *knowledge*: a set of facts, principles, theories and practices that are related to the field of work or study. Knowledge is described as theoretical and / or factual and is the result of information gaining through learning;

- *skills*: the ability to apply knowledge and use know-how to perform tasks and solve problems. Skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving the use of manual dexterity and the application of methods, materials, tools and equipment);

- *competencies*: the ability to use knowledge, skills and personal, social and / or methodological abilities in work or study, as well as in professional and personal development.

The concepts of "skill" and "competence" must be distinguished. "Skills" refer to the use of methods or tools in specific settings and for specific tasks. "Competence" is broader and refers to a person's ability to face new situations and unforeseen problems, the use and application of knowledge and skills in new areas of activity. However, there is no difference between the skills and competencies described in the relevant ESCO element.

ESCO provides metadata from the Skills group for each profession, including the following:

- preferred term;

- non-core terms (synonyms, spelling variants, abbreviations, etc.);

- hidden terms (for example, outdated or with errors);

- remark about the sphere that explains the semantic boundaries of the concept;

- relations with ESCO professions (shows for which professions the indicated skills or competence are relevant and those for which they are not obligatory);

- the level of re-use that indicates how widely knowledge, skills or competencies can be applied. This is very important for identifying and documenting learning outcomes and, as a result, maintaining professional mobility.

From the standpoint of the publication purpose, the issue of contextualization of skills is considered important. Contextualization is a formation of skills and competencies based on transversal skills and competencies applied in a particular context of the industry or profession. It allows to use quite abstract transversal skills and competencies for more detailed level so that they can be used directly in the profiles of professions.

Qualifications element contains information about the full list of qualifications that are important for European labor market (Fig. 2, b).

Information about qualifications in ESCO is obtained from two sources:

- national databases on the qualifications of EU member states. These qualifications are included in the national qualification frameworks that refer to the European Qualifications Framework;

- other qualifications provided directly by the awarding bodies. They are not part of the national qualifications framework, but are also relevant to the European labor market.

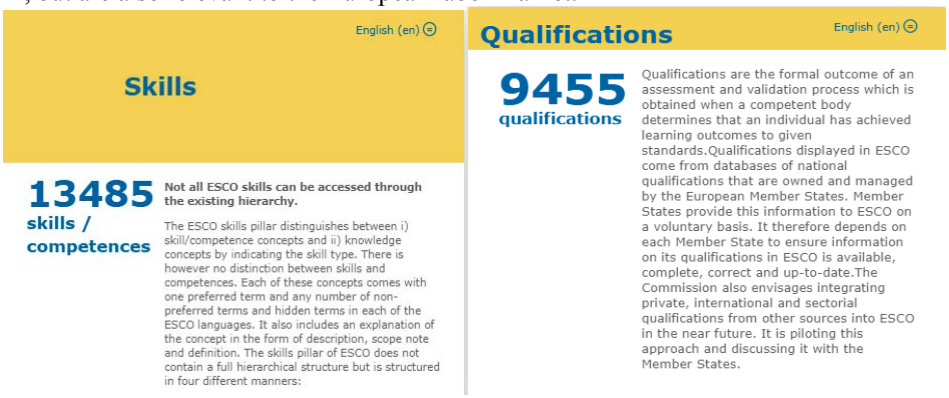

Fig. 2. Skill and Competence element of ESCO classifier

These include private, industry and international qualifications.

Unlike the Professions and Skills groups, the Qualifications group is completed exclusively by external sources and not by data created by the European Commission. The general scheme of ESCO classifier is represented in fig. 3.

Qualification supports an understanding of the individual qualifications required by employers, public and private employment services, employees, jobseekers, educational service providers, etc. This information should be as complete and transparent as possible to meet their needs.

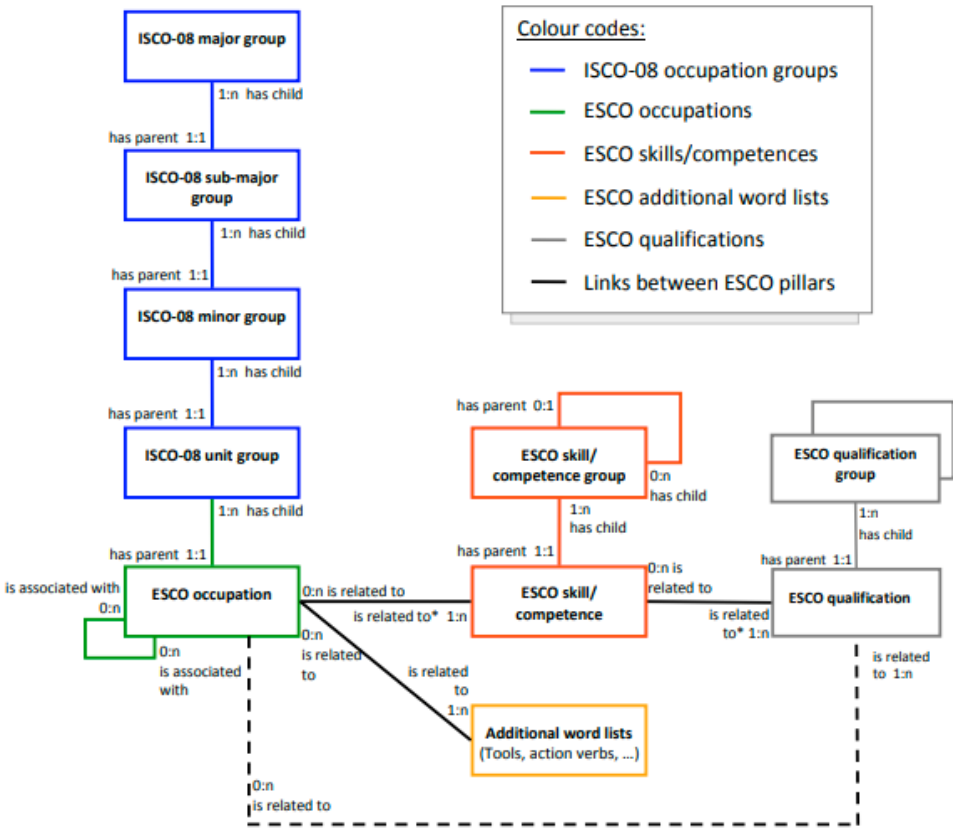

Fig. 3. General scheme of ESCO

Practice of ESCO use

ESCO classifier is published in the Linked Open Data format. This conception provides the ability to create a system that easily adapts to domain and allows developers to use it as a building block in services for job search, career guidance and self-assessment. ESCO classifier is available in various formats (SKOS-RDF, CSV), so that users can integrate it into their services and other types of software. In addition, ESCO provides local API and API of Web Services so that applications and Web services can request real-time information from the classifier.

The practice of ESCO classifier use shows its effectiveness in a number of international projects and initiatives. In particular, the European Employment Services (EURES) [5] – a network of about 400 "European advisers" from national employment services, employers' associations, trade unions, local and regional authorities and higher education institutions actively applies ESCO classifier. EURES is designed to increase the efficiency of the common labor market, as potential jobseekers need to receive reliable information on the number and nature of vacancies in EU countries, as well as professional requirements for potential candidates.

As opposed to public employment services, EURES does not take care of job search, but provides the necessary information for jobseekers abroad: addresses of job search Web portals; general information about the country; taxation system; social guarantees; information on work permits and residence permits; living conditions in EU countries; legislation governing labor relations, etc. EURES has integrated online IR for collecting of job vacancies across Europe.

The EURES portal is a clear example of fundamental changed in ways of information exchange on the labor market in recent decades caused by the use of electronic means. Growth of computational capability and improvement in information processing methods make it possible to process big data sets that become available to employers, for example, through the use of social networks. This changes the traditional model of the staff employment where employers formulate their requirements and wait for the appropriate candidate.

However, different subjects on the labor market describe their proposals or requirements through different informal characteristics. Different terms can be used to describe such characteristics, and it causes problems of their

semantic comparing. Such problems can be solved by processing of knowledge and use of intelligent information technologies and appropriate models, methods and languages.

Methods of semantic identification and documentation of non-formal and informal learning outcomes

Tools for semantic identification and documentation of non-formal and informal learning outcomes should be quite dynamic. They have to take into account changes in the world around them, use background knowledge and ensure the retrieval of new information from the Web resources. This requires the use of technologies oriented on intelligent processing of distributed information.

Recently, developers of distributed information systems exhibit a tendency to transition from the use of relational databases to ontological knowledge bases (KBs). This is due to the development of the Semantic Web conception [6] that is based on tree main elements – ontologies [7], Web-services [8] and software agents [9]. The ground of ontological KBs is ontology – a formalized, explicit description of domain, and Web-services used by software agent need in knowledge represented by these ontologies. Ontological KBs include the set of classes (concepts) and descriptions of the various relations between them, as well as the set of class individuals. Semantics of data is defined by connection with element of description of domain knowledge and meaning of this connection. For example, if domain ontology describes learning outcomes then semantics of resume of potential employee can be defined formally by some elements of this ontology [10]. In ontological engineering ontologies are used for formal modeling of the system structure, i.e. they define the relevant objects, subjects of domain and relations between them [6-8]. Now domain ontologies are usually represented by the OWL [11] language developed by the Semantic Web initiative that is an add-on to the RDF language [12]. RDF provides information in the form of an oriented marked graph. The basic elements of RDF are triplets <subject, predicate, object>.

One of the most practical approaches to formalizing the results of non-formal and informal learning is based on the Semantic Web standards that provide knowledge re-use, automated export to new applications and building a common terminological framework for interaction between different ISs.

The Semantic Web technologies can be exploited for development of the Web-oriented tools for semantic identification and documentation of non-formal and informal learning outcomes:

- personal software agents provide personalization of interaction with all subjects of labor market;
- semantic Web-services support various groups of functions as registration and job search; registration and resume search; comparison of vacancies and resumes at the semantic level; search for educational service providers; comparison of training courses and programs with professions and provide their independent modular development;
- computer ontologies (or sets of ontologies) determine the semantics of relations between professions, jobs, knowledge, skills, competencies and qualifications, between other concepts of this domain, etc., as well as between their characteristics.

Ontological model of competencies

Ontological analysis is an effective tool for modeling ideas about various domains, which allows you to display their semantics. An important element of IS for recognizing the results of non-formal and informal learning is development of ontological model for domain conceptualization. This model uses data and knowledge collected during modeling. One of the main success factors behind the use of domain ontologies lies in the ontologies modeling language's ability to provide a set of modeling primitives that can directly express relevant domain concepts [13]. For example, ontologies can be used for representation of various learning courses [14]. Ontology allows to describe formally any concepts, groups of classes, relations between objects and types, elements of classes, etc. Formal model of domain ontology defines main elements of ontological analysis: concepts, relations and rules their interpretation [15].

In order to formalize the basic concepts of the domain and the relation between them, we use in this research the enhanced formal model of ontology [16]: $O = \langle X, R, F, T \rangle$

This model consists of the following elements:

- $X = X_{cl} \cup X_{ind}$ is a finite set of basic concepts of ontology where X_{cl} is s set of classes, $X_{ind}$is a set of instances of these classes, such that $\forall a \in X_{ind} \exists A \in X_{cl}, a \in A$;
- $R = r_{ier\_cl} \cup \{r_i\} \cup \{p_j\}$ is a finite set of relations between classes and instances of ontology classes where r_{ier_cl} is a hierarchical relation between ontology classes and properties of classes characterized by properties such as antisymmetry and transitivity, $r_{ier\_cl} : X_{cl} \to X_{cl}$; $\{r_i\}$ is a set of object properties that establish the relation between instances of classes: $r_i(a, a \in X_{ind}) = b, b \in X_{ind}$, $r_i : X_{ind} \to X_{ind}$; $\{p_j\}$ is a set of data properties that establish relations between instances of classes and values: $p_i(a, a \in X_{ind}) = t, t \in T$, $p_i : X_{ind} \to Const$, such that within sets of object properties and relation properties may also be hierarchical relations $r_{ier\_obj} : \{r_i\} \to \{r_i\}$, and r_{ier_data}, $r_{ier\_data} : \{p_j\} \to \{p_j\}$;

- F is a finite set of characteristics of ontology classes, instances of classes and their properties;
- T is a finite set of data types (for example, string, integer).

From the point of view of the solved problem the basic classes of the developed IS ontology are competence; profession; qualification; knowledge; as well as subjects associated with these classes: owners (potential employees with certain knowledge and skills), customers (employers) and providers (persons and organizations that provide educational services that allow for professional development).

Thus, the ontology contains the following classes X_{cl} (the list of classes is arranged alphabetically, not by relevance): knowledge, candidate, qualification, competence, country, course, skill, education passport, concept, course provider, profession, job, employer, term. If necessary, these classes are specified and supplemented by subclasses and properties. For example, skills are divided into "soft" and "hard", basic and additional.

Protégé ontology editor [17] is used to visualize these relations in a way that is more understandable to system users. Instances of some classes X_{ind} are included in the ontological model (for example, individuals of "Skills"). Other instances of the ontological model are replenished in process of system operation. For example, profiles of job candidates, requests from employers and offers from educational service providers are added to ontology when user input this information.

This model is described in OWL Light dialect of OWL and can be visualized by means of Protégé. OWL Lite (as well as OWL DL and OWL 2.0 [18]) are based on the descriptive logic ALC (Attributive Language with Complements), which guarantees the finiteness of the logical inference on this ontology. Model describes the properties of classes (both object properties and data properties) and relation between basic terms and their subclasses.

Ontological models can be used for competence management [19]. We consider problems of matching of different objects dealt with competencies and propose to divide each competence that a person acquires as a result of formal / non-formal / informal learning into a set of atomic competencies [20], and to establish the relation and hierarchy of competencies and qualifications using an appropriate ontology. Atomic competence has the following properties:

- $a \in C$ where C is the set of information objects of the class "Competence", and C_{atomic} is the set of atomic competencies, $C_{atom} \subseteq C$;

- each competence is a union of a non-empty set of atomic competencies $\forall c \in C \exists a_i \in C_{atomic}, i = \overline{1,n}, k = \bigcup_{i=1}^{n} a_i$;

- atomic competence is not a subset of any other atomic competence $\forall a,b \in C, a \subseteq b \Rightarrow b \notin C_{atomic}$.

In order to link competencies with domain terminology it is necessary to define for each $a \in C$ in the domain ontology the corresponding concepts $x_i \in X, i = \overline{1,n}, n \geq 1$ and relations $r_j \in R, j = \overline{1,m}, m \geq 1$ such that $x_{i_a} = r_j(x_{i_b})$. It is impractical to use terms and relations that are not used in the domain ontologies for describing of competencies. Thus, the comparison of the competence of individual user and the requirements for the task is carried out at the semantic level and is reduced to matching of finite sets of atomic competencies [21]. This approach guarantees the comparison for a time proportional to the number of atomic competencies.

Ontology of ESCO classifier

ESCO classifier ontology consists of three elements – professions, skills and qualifications, as well as two additional registers: bodies that award qualifications and bodies that award the context of work, and usually refer to ESCO qualifications. General scheme of ontology of ESCO classifier is shown in fig. 4.

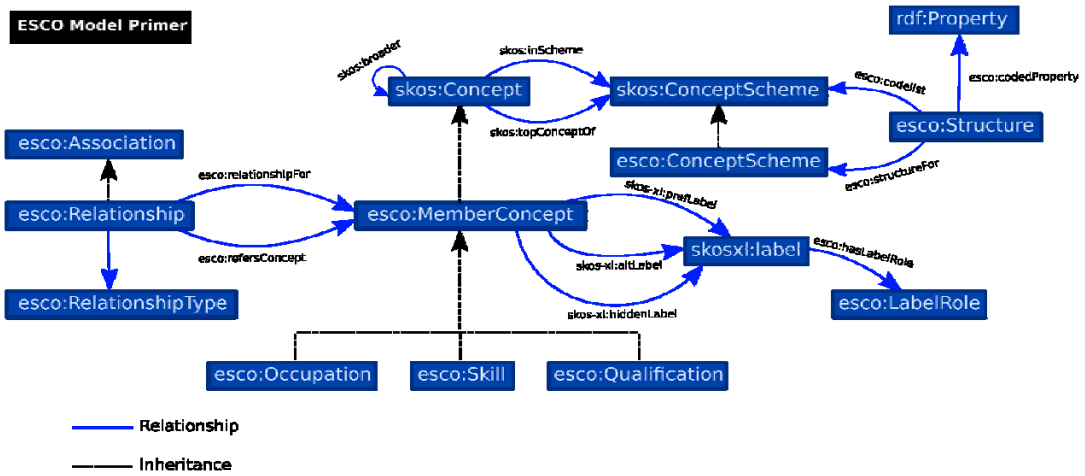

Fig. 4. General scheme of ESCO classifier ontology

ESCO classifier provides opportunities to export ontologies and allows to design industrial software products based on these ontological repositories of knowledge.

Such applications have the following advantages:

- scalability by number of data sources and ontology size;
- extensibility (minimization of the costs connected with adaptation of the application at development of KB scheme);
- facilitating the integration of ontology-based applications into corporate information systems.

Creating an information system for processing results of non-formal and informal learning

All classes of ESCO ontology are stored into Turtle file. The RDF repository is accessed with use of SPARQL query language. SPARQL has the ability to query mandatory and optional graph templates. The answers of SPARQL queries can be represented as result sets or RDF graphs. SPARQL queries and Connector are used for selection of skills and occupations from RDF repository. In the same way, the results of requests are returned to the RDF repository.

As mentioned in [11], the development of applied software based on ontological KBs involves four stages:

Stage 1. Development of ontology scheme.

Stage 2. Integration of ontology into RDF-repository.

Stage 3. Development of IS architecture.

Stege 4. Development of user interface.

First stage is provided by means of Protege editor for creation of ontological classes and properties. classes "Skill" and "Occupation" are selected. The Skill class represents skills in the ontology, and the Occupation class represents professions. Ne04j graph database management system is used to work with big domains ontologies. Fig. 5 shows graph obtained in the Protege ontology editor: a. – complete ontology; b. enlarged graph with description of the main connections.

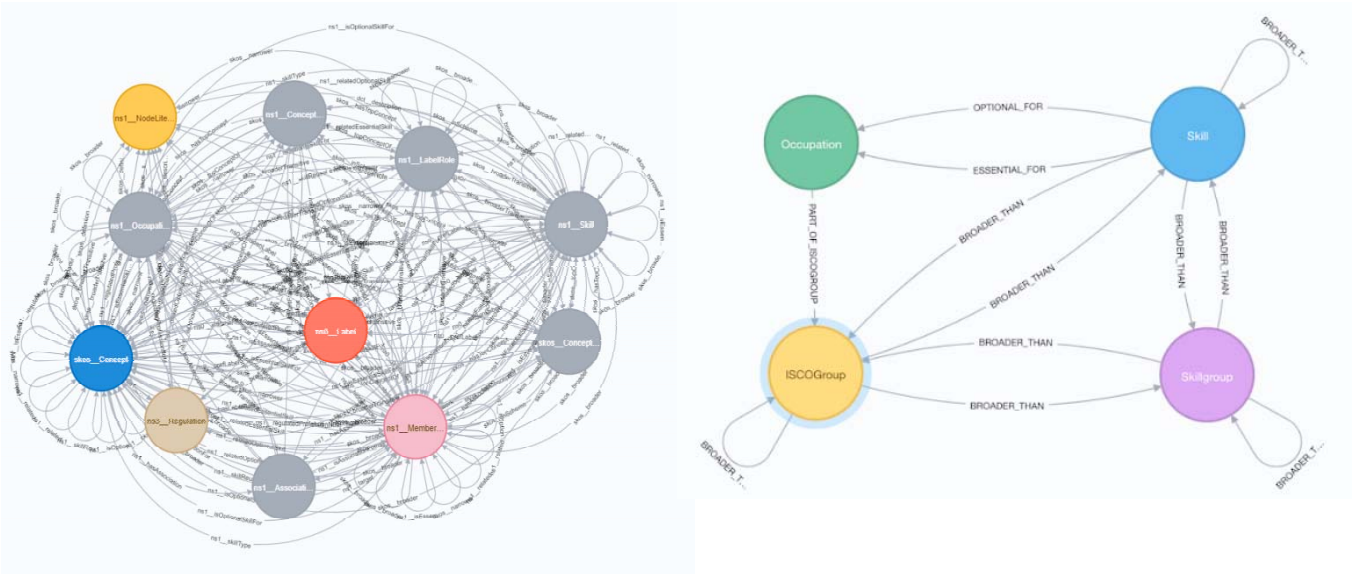

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Fig. 5. Graph obtained in the Protégé ontology editor

The second step integrates this ontology into the RDF repository with use of database of semantic graphs GraphDB. This database complies with W3C standards and links data from various sources, indexes them for semantic search and enrich information with text analysis.

The correctness of the ontology download is checked at http: // localhost: 7200 / sparql. In the input field of the SPARQL query user enters the text of query, for example: "SELECT DISTINCT? P WHERE {? S? P? O} LIMIT 10", and as a result of this query a list of ontology predicates with a limit of no more than ten is displayed.

Addition and modification of data in the GraphDB repository are implemented with use of connectors. GraphDB connectors provide fast search for keywords and boundaries (aggregations) usually realized by external services. Connectors provide synchronization on level of entities defined by unique identifier URI and a set of properties and property values. Connectors can process simple properties (defined by one of RDF triplet) and chains of triplets where the object of one triplet is used as a subject of the next triplet.

Fig. 6 shows a connector in GraphDB that receives text in a field and searches for defined labels and returns a reference to a class that matches a given query.

```
PREFIX :<http://www.ontotext.com/connectors/lucene#>
PREFIX inst:<http://www.ontotext.com/connectors/lucene/instance#>

SELECT ?entity {
  ?search a inst:SkillSearch ;
      :query "maintain removed cage nets" ;
      :entities ?entity .
}
```

Fig. 6. Example of GraphDB connector

The third stage deals with application architecture development. The main users of the system are employers, job seekers and experts. Web server provides user access to the RDF repository, process requests and their results. EasyRDF and RAP software packages used to interact with ontology repository server allow analysis, queries, manipulation, serialization and maintenance of RDF models. PHP framework Laravel is used in this project framework in view of its increased security and ready-made functionality for installing plug-ins and libraries. This framework has features such as RESTful-routing, caching, user management and authentication. Thanks to all this, Laravel speeds up the development process. General model of architecture of application is shown in fig. 7.

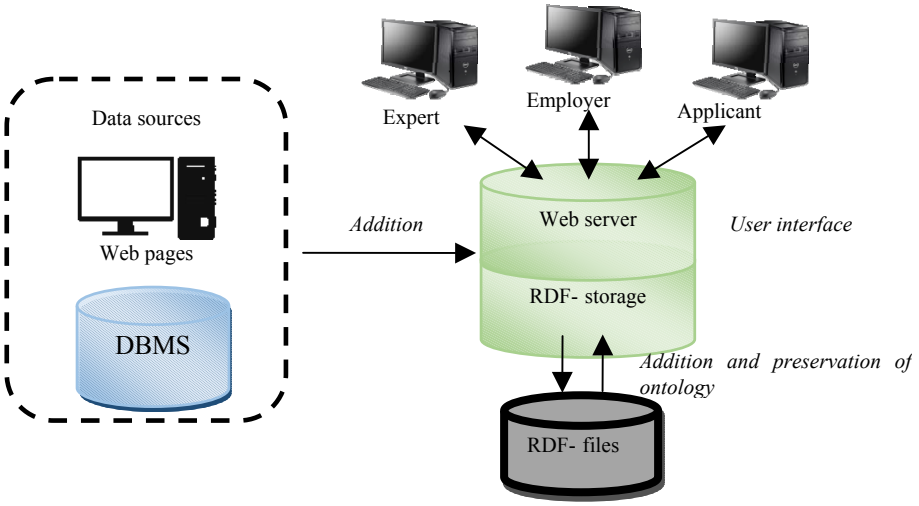

Fig. 7. General architecture of application

In the fourth stage user interface is developed with use of React framework. React is an open JavaScript library that provides partial updating of the Web page content. Choose of React is caused by its speed, simplicity, scalability.

Conclusions

Labor market participants usually describe their proposals or requirements through various informal characteristics, therefore this research work is aimed on problem of comparing the semantics of such descriptions on base of semantic ontologies. Analysis of publications on the topic of the study concluded that the Multilingual Classifier of European Skills, Competencies, Qualifications and Professions ESCO can be used as an effective tool to combine the market of educational services with the labor market. ESCO Classification identifies and classifies skills, competencies, qualifications and occupations that are relevant to the European labor market, education and training. Proposed approach is used efficiently in applied intelligent system [23] that provides competence management for Agro-Advisory.

Information system of recognition of results of non-formal and informal training represented in this work is oriented on the Semantic Web technologies and uses conception of the Web services and RDF-based repositories of ontologies. The developed architecture and user interface of this system allow semantic identification and documentation of non-formal and informal learning outcomes, thereby increasing the efficiency of handling information about these outcomes.

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About the authors:

Serhii M. Pryima,
Doctor of Pedagogical Sciences, Professor,
Professor at the Department of Computer Science.
Number of scientific publications in Ukraine – 43.
Number of international scientific publications – 15.
http://orcid.org/0000-0002-2654-5610,

Oksana V. Strokan,
Candidate of Technical Sciences, Associate Professor,
Associate Professor at the Department of Computer Science.
Number of scientific publications in Ukraine – 20.
http://orcid.org/0000-0002-6937-3548,

Julia V. Rogushina,
Candidate of Physical and Mathematical Sciences,
Number of scientific publications in Ukraine – 150.
Number of international scientific publications – 31.
ORCID http://orcid.org/0000-0001-7958-2557,

Anatoly Ya. Gladun,
Candidate of Technical Sciences, Associate Professor,
Senior Research Officer

Number of scientific publications in Ukraine – 67.
Number of international scientific publications – 53.
https://orcid.org/0000-0002-4133-8169,

Andriy A. Mozhovenko,
Research Assistant at the Department of Computer Science.

E-mail: pryima.serhii@tsatu.edu.ua,
oksana.strokan@tsatu.edu.ua,
ladamandraka2010@gmail.com
glanat@yahoo.com
andrii.mozghovenko@tsatu.edu.ua