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Article

Information Technology for the Intelligent Analysis of Labor Market and Educational Content Matching

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Abstract: The article explores the task of making higher education more profession-oriented. In this context, we consider the technology of structuring and matching professional activities and content of professional education curricula with the help of ontology. This technology employs intelligent analysis of labor market and educational content matching with the aim to organize educational programs and verify professional competences based on their ontological properties. The article also considers development of a professional training cognitive map that can help design the student's personalized educational trajectory factoring in the given parameters.

Keywords: field of professional activity, parsing, educational content, professional requirements, ontology, content markup, intelligent analysis.

1. Introduction

The current dynamics of economic, civil and technological development continuously boosts requirements for the quality of theoretical and practical training of specialists as prescribed by the Federal State Educational Standards. At the same time, it is important to organize support for a future specialist in his formation as a professional by building an individual professional development trajectory for a student both when he/she is in the university and after graduation.

The internal personality development, together with external factors, can be considered the basis for vector modeling of the person's professional development. E.F. Zeer identifies a number of factors influencing personal advancement in a dynamic professional space, including periodic age-driven personality changes, continuity of education, and the dominating activity related to the profession. The interplay of these three aspects defines development of a person in the professional and educational process and professional life. It covers the time when the person grows from understanding professional inclinations and interests to the career end [1]. According to the author, personal trajectory of professional formation features a change in the direction of the development vector caused by violation of the sequential, linear, ordered professional formation process and the emergence of moments of instability.

The problem of employment and professional development of the students is a major one from the perspective of the country's social and economic state and that of the entire system of Russian higher education. The solution to this problem lies in the development of mechanisms that will guarantee an effective relationship between the labor market and the educational services market. Educating a specialist, it is very important to take into account the future employment and career development opportunities based on the real needs and requirements of the labor market. In addition, it is very important for future specialists to know and understand the employment opportunities and the vector of their individual professional development after the graduation [2,3,4].

The lack of balance between higher education market and that of intellectual labor is another urgent problem, which stems from the underdeveloped state of these markets. The qualifications of young specialists seeking employment at the market is steadily lower than expected. Competencies of the graduates are the results of application of the university's educational products, and they are the main factors coordinating interaction of the higher education market and the intellectual labor

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market (Figure 1). Effective and harmonious development of the national economy requires optimization of this interaction.

A university needs to simultaneously work on at least two independent markets, those of higher education and intellectual labor. In order to provide competitive education, it has to develop and implement educational programs that revolve around real-life needs and follow project-like approach to (see Figure 1). This should be a collaborative effort with the employers seeking talent at the intellectual labor market. The natural results of such activities are:

1. Training specialists and implementing real innovative projects that ensure sustainable development and competitiveness of the economy of the country and its regions.

2. Transformation of the universities into innovative technological and social development centers of the federal and regional levels.

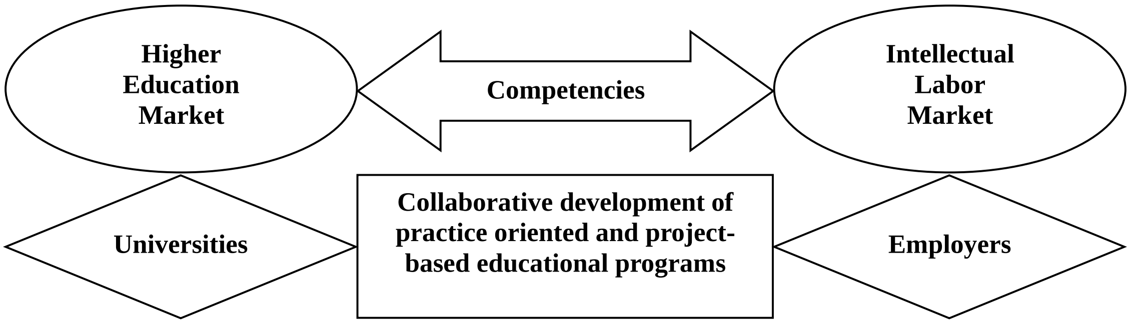


Figure 1. Universities and Employers interaction schema for educational programs development.

Therefore, the task of managing the specialists' training process, taking into account individual development priorities and needs of the employers, becomes more and more urgent. Aligning the education content with the employers' interests, as well as the students professional development personalization opportunities will facilitate social and professional adaptation of the young specialists graduating from higher education establishments, with the constantly changing character of the labor market factored in.

2. Problem definition

According to the authors' experience, it takes from 6 to 12 months of additional training and adaptation of graduate IT specialists to fully master their first job tools, frameworks, development stack for a particular IT project. This is time and money lost; the problem is current for companies fulfilling the needs of their growing IT teams. The industry develops and adopts tools and computer languages at a much faster rate than universities and education supervision bodies update and implement the relevant standards.

One of the main requirements for professional education, according to the current Federal State Educational Standard of Higher Education 3++, is the professional orientation of educational content. Therefore, its development should be fully aligned with professional activity. A study [5] proved that this fields can be adequately represented by an ontological model. It is necessary to implement the field ontology so that it most fully reflects the professional field structure in its correlation with the professional activity of an educational organization a specialist graduates from. This requires extensive involvement of specialists and experts in a particular professional field.

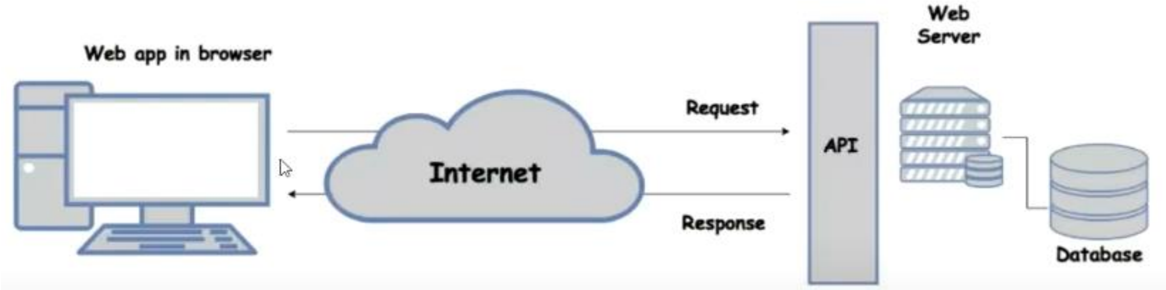
Professional field ontological model and educational content structure can be represented as graphs. They can be compared by means of a single mathematical apparatus implemented through ontologies, with the help of a relational model of ontology presentation, as an option. This will enable using the information resources available with the educational organization, collated with the professional field elements and educational content. Hereby, the role of the universities is to balance professional and social education of the students, this balance achievable through coordinated approach to the educational program teaches both professional and universal competencies.

Therefore, an information technology (IT) is needed for structuring professional field description and educational content by marking the latter in accordance with the field ontology. It allows balancing the interests of society, labor market and university, including personal interests of teachers and students, as prescribed by the Federal State Educational Standard [6–8].

3. Intelligent Analysis of the Labor Market

Let us consider the problem of professional training of IT specialists specializing in applied informatics. This is a multifaceted domain; there are dozens of relevant vacancies open on the market.

We gather data on the vacancies using Head Hunter (hh.ru) open API [9–13] (see Figure 2a). Figure 2b presents the Python code in Jupiter notebook that parses the site. We extracted 1130 unique vacancies. Part of the code to store data into a CSV file is shown on Figure 2c.



a) Open API scheme

```
import requests
import json

def get_vacancy_idxs(pageN,idxs):
    url = "https://api.hh.ru/vacancies"
    querystring = {"specialization":"1.395","1.400":"","1.420":"","1.474":"","1.475":"","1.536":"","1.3":"","1.9":""
    headers = {
        'User-Agent': "PostmanRuntime/7.15.0",
        'Accept': "*/*",
        'Cache-Control': "no-cache",
        'Postman-Token': "e9113f34-84fc-4028-aa10-08001de3769a,7bc059ec-8fcc-4ef8-8728-70f69f7c68af",
        'Host': "api.hh.ru",
        'accept-encoding': "gzip, deflate",
        'Connection': "keep-alive",
        'cache-control': "no-cache"
        }
```

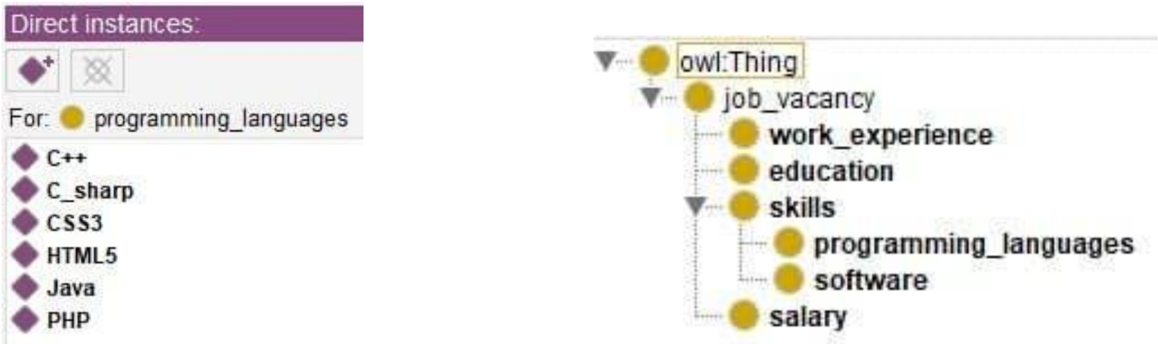
b) Fragment of the code loading job vacancies

```
data_fp['conditions']=data_fp['conditions'].apply(elim_com)
data_fp['requirements']=data_fp['requirements'].apply(elim_com)
data_fp['responsibilities']=data_fp['responsibilities'].apply(elim_com)
data_fp.to_csv('data_forprint.csv',encoding='utf8')
data.to_csv('data.csv',encoding='utf8')
```

c) Code to store data to the file

Figure 2. The technology to download and structure vacancy descriptions.

At the parsed data evaluation phase, we analyze the gathered data about the field of professional activity. The structure of the field is represented in the job offer structure from the vacancies aggregator web site. After information gathering, the data classification process links it to particular professional units, which are knowledge, ability, skill, methodologies, methods, personality, tools, languages. We built the ontological model of the professional activity field based on the employer professional requirements extracted from hh.ru. Figure 3 shows ontology subclass hierarchy for "Programming languages" class based on employer requirements. It consists of seven classes with five types of relations between class instances (Figure 3b). Classes shown on Figure 3a are developed based on the professional units listed above. The ontology classes are linked by inclusion of individual instances in different classes via the relevant relation type (see Figure 3b). Figure 4 shows the fragment of ontology covering "09.03.03". The ontology was built based on 84 vacancies.



a) field of professional activity class hierarchy

b) class relations

Figure 3. Class relations in the field of professional activity.

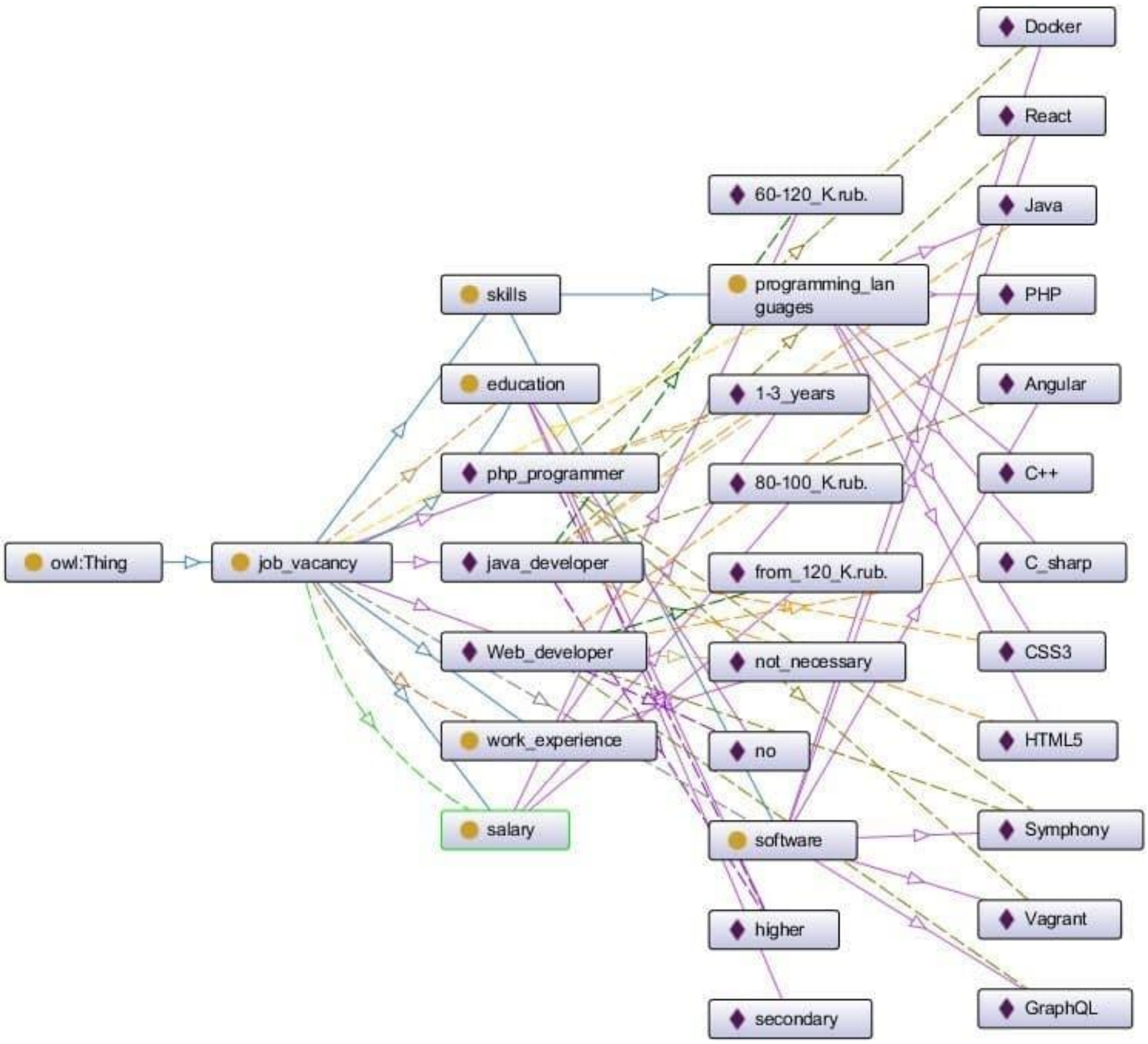


Figure 4. Fragment of ontology of the field of professional activity (the example of 4 vacancies).

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4. Intelligent Analysis of Educational Content

Nineteen courses, 15 competencies and about 3000 classes are used in the educational content ontology (Figure 6), which has been developed by the authors in the context of organization of educational process for the 09.03.03 "Applied Informatics" specialty, SibSUTI. Ontology has two types of relationship: "is a" and "part of". The ontology building blocks are parts of the curriculum, including laboratory classes, exam questions and tests. The structure of the curriculum is embedded in the content markup through academic unit highlights (Figure 5). The latter define the structure of classes and subclasses.

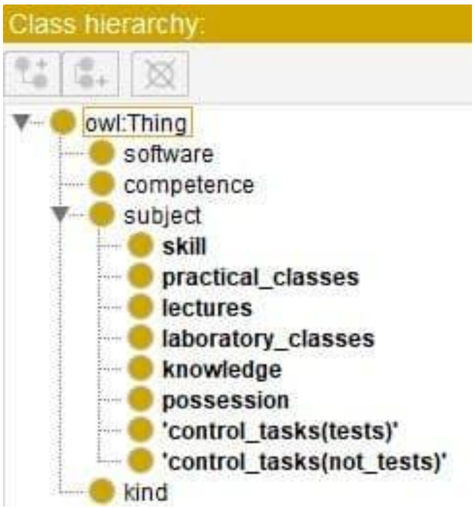

Figure 5. Content academic units.

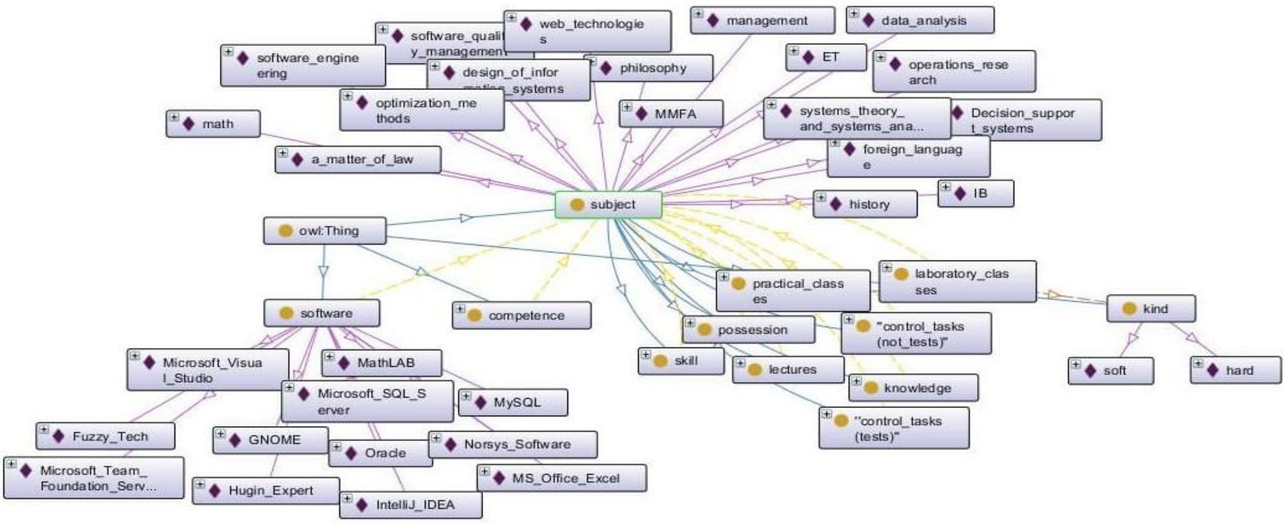

Figure 6. "Applied informatics" educational program ontology (fragment).

5. Educational Content Markup Technology

Data markup is a very important, but rather complex, long and labor-intensive process. It allows marking up thousands of pieces of information, with tags added to images or pieces of text. The technology for marking up educational content is, in fact, a technology for creating a digital twin of the curriculum. The following main functions can be distinguished therein:

1. Creation of the educational content academic units.
2. Educational content markup.
3. Cognitive map building.

Creation of the educational content academic units is actually the process of formation of the content's ontological model. This procedure was discussed earlier; basically, it is the process of defining the educational content academic units (see Figure 5) establishing their interrelations.

The educational content markup process includes tags extraction from the curriculum and marking up academic units by tags, maintaining a tag vocabulary and marking the data itself. The task of the department methodologist is to extract all kinds of tags from the curriculum after studying it, keep a vocabulary of these tags and, subsequently, mark the data. The next step is the cognitive map building, data visualization on the screen and XML document generation.

The relational database shown in Figure 7 has been developed to represent the field of professional activity model and educational content in the computer memory. The EL_ONTOLOGY structure was formed in the process of parsing. It consists of four types of elements: class, subclass, request, property. Table 2 shows the frequency distribution of elements by vacancies for the "Web development" course.

There is the EL_CONTENT – TAGS structure on the other side of the data model (Figure 7) representing educational content under the "Applied informatics" specialty. The content elements are typified into 10 categories. Tags (TAGS_CONTENT relation) are assigned to the representation of each element, serving as templates for the content mark-up process. A tag is a link to an element and a search pattern. Search patterns are string literals enabling database search. Usually they are stems of words or combinations thereof: tester, develop*app, etc. Abbreviations are possible, e.g., CSS. The quantitative parameters of this structure of the "Web development" course are shown in Table 1.

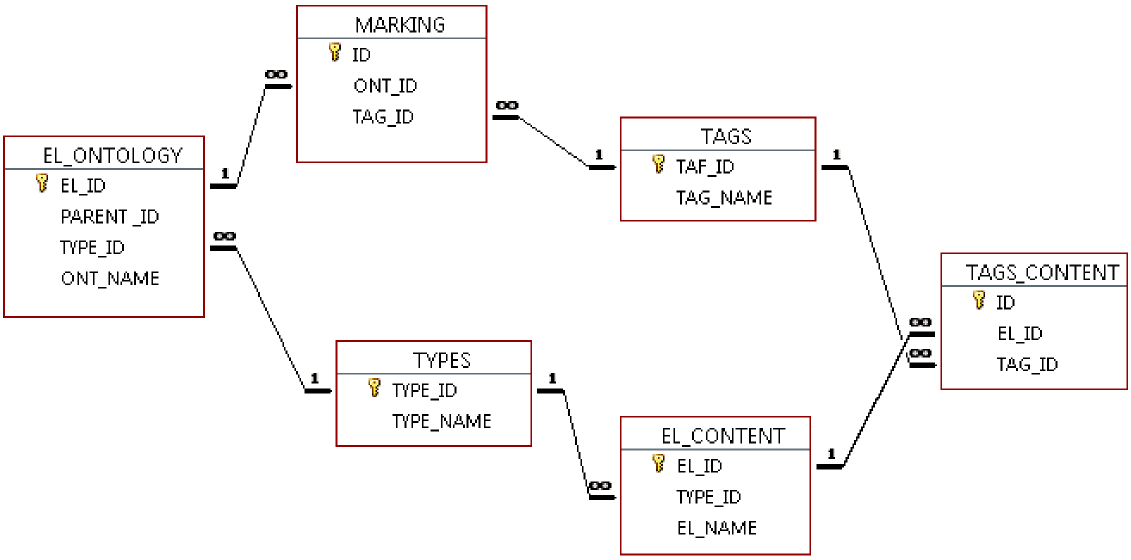

Figure. 7. Database schema, professional field structured data and educational content.

Table 1. Educational content structure parameters, "Web development" course.

Element type	Element count	Tag count
1 Knowledge	5	18
2 Skills and abilities	5	23
3 Competencies	2	14
4 Course topics	7	28
5 Lectures	17	35
6 Laboratory classes	18	41
7 Projects	22	38
8 Evaluative monitoring questions	16	47
9 Exams questions	31	61
10 Required software	9	11
Total	132	316

Content markup is done by correlating field of professional activity ontology elements with educational content elements. The markup is represented by the MARKING relation in the data model (Figure 7). The quantitative parameters of this markup for the "Web development" course are shown in Table 2.

Table 2. Educational content markup parameters for the "Web development" course.

Vacancy (subclass)	Occurrence frequency (request, property)	Content markup label count
Java/JavaScript developer	0,072	86
Linux/Java support engineer	0,056	69
web department lead	0,033	56
Web-developer	0,050	54
PHP-developer	0,067	53
Web-development team lead	0,022	53
Fullstack-developer	0,072	52
Development engineer	0,006	52
Bitrix web developer	0,028	51
Web-security specialist	0,033	48
web-master/web-developer	0,006	45
.NET developer	0,022	35
PL/SQL developer	0,033	33
Middle, Senior C# developer	0,039	32
Web-master	0,011	32
Web-developer, Bitrix, Yii 2	0,033	31
Web-developer Full Stack	0,028	30
Embedded Web developer	0,044	27
Web-Developer Junior	0,017	27
Programmer	0,006	24
Web-programmer Middle JS ReactJS	0,017	23
Leading js-programmer	0,017	21
Frontend-developer	0,028	20
Senior Web Developer C#	0,028	20
Web-developer ASP.NET	0,028	18
UI/UX Designer	0,022	15
Lead Python programmer	0,022	15
Trainee-programmer PHP	0,011	15
IOS developer	0,022	14
Golang Programmer	0,011	12
Web-designer and php-programmer for startup	0,011	10
C# Programmer	0,017	10
1C Programmer	0,022	9
Senior Software Developer	0,017	8
Web-analyst	0,006	7

The markup algorithm consists of 3 steps: division of EL_ONTOLOGY data into tags; entering them into the vocabulary; marking the ontology data by keywords. A UML class diagram illustrating this task is shown in Figure 8, where the EL_ONTOLOGY relation is represented by the Relationship-Concept aggregate, the instances of which, in turn, are aggregated into facet groups. Obviously, any classification grouping in such a classification system is a set of Tag-(Content Item) relationship sets, where the cardinality of the superset corresponds to the number of facets of the

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classification system. The cardinality of the internal set on each facet group is different and is determined by the number of the above relations. In Figure 8 this set of sets is represented by the "Classification groupings" entity.

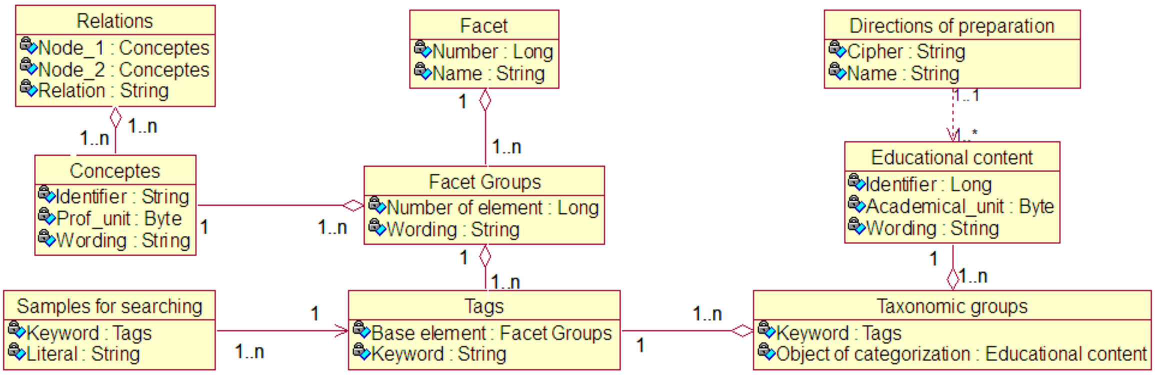

Figure 8. Field of professional activity and educational content matching class diagram.

Then, the matching measure of the i-th curriculum to the elements of the labor market (s_i) in terms of the model considered above can be defined as the included academic units' average degree of classification into facet groups:

$$S_i = \frac{1}{|\Theta_i|} \sum_{k=1}^{K} \sum_{\Theta_{ij} \in \Theta_i} \deg_k(\Theta_{ij}) \to \max, \quad (1)$$

where Θ_i is a set of academic units included into the i-th curriculum; Θ_{ij} – j-th element of the Θ_i set; $\deg_k(\Theta_{ij})$ – j-th academic unit classification degree for the i-th curriculum by k-th facet group; K – number of facet groups. At the same time, faceted groups correspond to the set of professional units (see Figure 3). The higher the classification degree of an individual academic unit according to the F1-FK facets, the more significant it is in a given field of professional activity. This formula shows the ratio of the cardinalities of the element sets and is a matching measure as a relation to records.

Using the field of professional activity and educational content matching model (see Figure 8) it is also possible to calculate the degree of compliance between the q-th segment of the labor market and the educational content elements:

$$L_q = \frac{1}{|\mathrm{H}_q|} \sum_{k=1}^{K} \sum_{\mathrm{H}_{qj} \in \mathrm{H}_q} \deg_k(\mathrm{H}_{qj}) \to \max, \quad (2)$$

where H_q is a set of professional units included in the q-th labor market segment requirements; H_{qj} – j-th element of H_q set; $\deg_k(\mathrm{H}_{qj})$ – classification degree of the j-th professional unit of the q-th labor market segment by the k-th facet group.

The course cognitive map is built by the automatic markup process (see Figure 9). This process can be applied to the whole curriculum. The cognitive map shown in Figure 9 demonstrates the conceptual coverage of vacancies in the Novosibirsk regional labor market by elements of the "Web development" course educational content. The markers on it indicate the logical correspondence between Table 2 vacancies and 132 content elements the parameters of which are shown in Table 1.

Personalized learning trajectories can be built on such a cognitive map and factor in the specific parameters learned at the intellectual labor market, as well as the identified student's preferences and inclinations.

If there is a system for assessing the results of development of competencies, such a formalized field and course description can be used to automate learning guidance and tutoring, informing students in a gamified manner which technologies and competencies they need to master in order to "level up" for successful employment, taking into account the current requirements of the

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employers. The authors' experience in the IT field, interaction with companies, teaching information technology at the university suggests that the availability of such career guidance and knowledge transfer tools would be demanded by both students and employers.

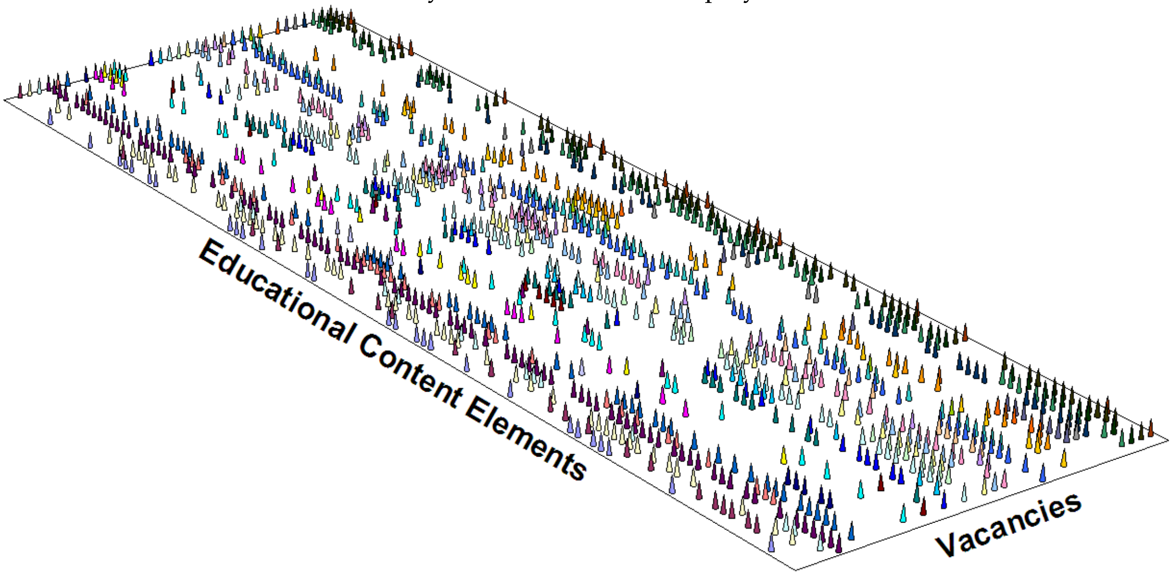

Figure 9. Educational content cognitive map markup "Web development" course.

6. The Labor Market Analysis Technology and Educational Content Matching

The resulting coverage enables assessment of the match of educational content to the labor market elements and vice versa, the formulas used for the purpose are (1) and (2), respectively. It also allows calculating their mutual (integral) influence. So, the mutual integral matching measure of the i-th curriculum's educational content and the professional requirements of the q-th labor market segment is defined as the product:

$$I_{iq} = S_i \times L_q. \tag{3}$$

We developed a tool in order to study these characteristics. Its main window is shown in Figure 10.

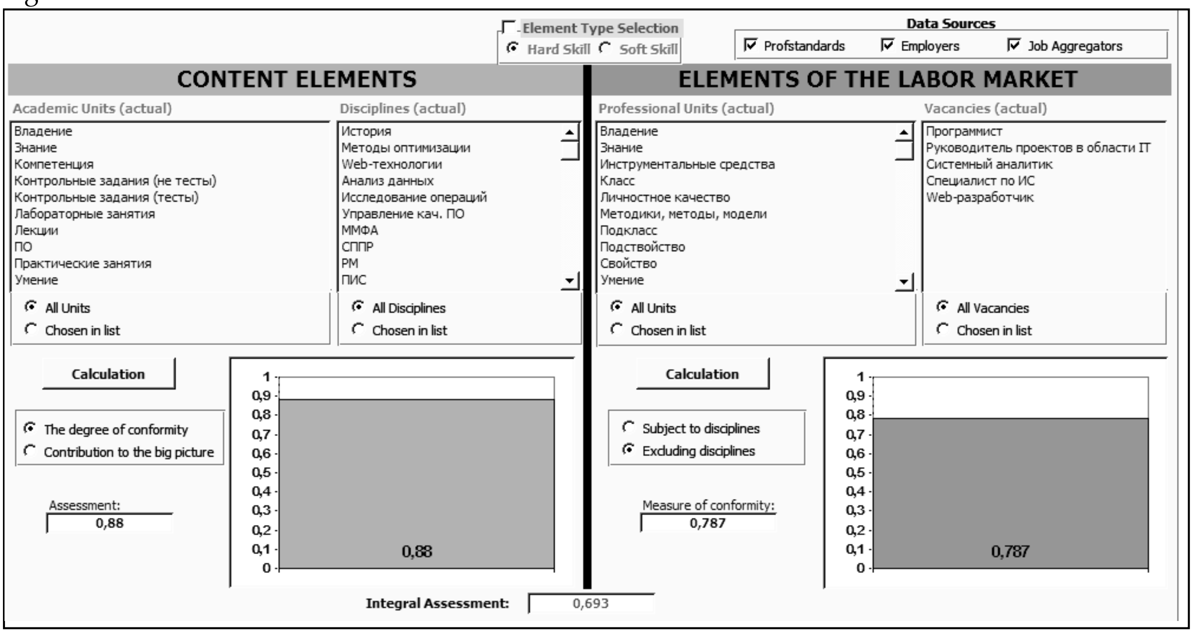

Figure 10. The tool for assessment of match of educational content to elements of the labor market.

In addition to assessing the integral match of the curriculum content as a whole with a certain labor market segment's professional requirements, it is also interesting to assess this match for each course separately. In this case, formula (1) can also be used, with the a modification that only academic units of the analyzed course are considered. As a result, we obtained a ranked list of courses reflecting the degree of mutual correspondence between the content of a specific course and the requirements of the labor market for vacancies in applied informatics (Table 3).

Table 3. The integral match of educational content of the 03.09.03 "Applied Informatics" curriculum to the IT job vacancy professional requirements (fragment).

Course	Matching measure (formula (1))	Integral measure (formula (3))
1 Software engineering	0,71	0,68
2 Information systems design	0,61	0,60
3 Web-technologies	0,61	0,53
4 Optimization methods	0,53	0,53
5 Systems theory and system analysis	0,57	0,51
Whole educational program	0,88	0,69

In general, the results obtained paint an expected picture: the courses giving professional training match the professional requirements (as seen on the labor market) the best.

Reverse analysis allows finding vacancies on the labor market which are most relevant to the given curriculum content (Table 4).

Table 4. Integral match of IT-vacancies and 03.09.03 "Applied Informatics" educational content (fragment).

Vacancy	Matching measure (formula (1))	Integral measure (formula (3))
1 Software developer	1,00	0,88
2 IT Project Manager	1,00	0,88
3 Systems Analyst	0,99	0,87
4 Information systems specialist	0,98	0,86
5 Web-developer	0,53	0,46

In addition to the quantitative analysis of the ontological models of the curricula content and professional requirements of employers (as they match each other), we can perform a qualitative analysis, i.e. identify "uncovered" elements of these ontologies where matching equals zero. $\{H_g^{`} \subseteq H_q | L_q = 0\}$ for field of professional activity. $\{\Theta_i^{`} \subseteq \Theta_i | S_i = 0\}$ for educational content.

Thus, professional units not covered by the educational content of the 09.03.03 "Applied Informatics" curriculum are, for example, Refactoring, Ruby, Rails, Jest, Rspec, React, Vue, Angular, Laravel, Symfony, Yii. REST, SPA, WebSocket, FastReport, DataGrip, Docker, GitLab, Subversion, Mercurial, etc., 134 positions in total, which is 21% of the total number of atomic professional units. This information is, in fact, the key to making educational content offered at the higher education establishments more specialized professionally. It draws the essence of the education elements and labor market closer together and reveals their discrepancy at the substantive level.

On the other hand, there are also elements of educational content that have nothing to collate to on the labor market, for example: "Able to perceive the intercultural diversity of society in socio-historical, ethical and philosophical contexts" in the "History" course; "Using regular expressions" in the "Web development" course; "Descriptive analysis" in the "Data analysis" course, etc. In total, 80 content elements (out of 666 available in the database for 16 courses) found not matches in the labor market requirements were identified, which is 12%. The parameters of collation between educational content and labor market requirements are shown in Table 5.

Table 5. Parameters of educational content coverage by the demand for IT specialists, "Applied Informatics" curriculum (fragment).

Course	Total quantity of the elements	Not represented on the market, number	Not represented on the market, %
1 Information security	49	13	26,53
2 Operational research	31	8	25,81
3 Decision support systems	33	8	24,24
4 History	5	1	20,00
5 Risk management	39	7	17,95
Total	666	80	12,01

This information, on the contrary, demonstrates the redundancy of educational content or labor market imperfections if we assume that given educational content is perfect.

7. Development of the Course's Digital Twin

Development of the digital economy poses new challenges for state and education, including big data processing. The changes are so rapid that management decisions must be made quickly, and the educational process should be improved with innovations. At the same time, the requirements of employers are rapidly changing, personnel with digital skills enjoys the ever-increasing demand on the labor market. It is difficult to develop the process of making educational content more efficient for students and teachers and keep the quality of education intact at the same time. The development of the course's digital twin allows solving the problem of rapid adaptation in the face of changes in educational documentation and content.

Digital twin of an educational course enables rapid creation of high-quality education content. This content has to meet the requirements of the labor market and regulators. The process needs to digitalize generation of the necessary documentation [14], as well as assess the importance of curricula.

Digital twin is a technology designed to simplify and improve the work of object physical prototypes, entire systems and individual processes [15,16]. This is a virtual prototype of the educational program in the university electronic information system for educational environment. It is an integral part of the developed model for analyzing the compliance of educational content with the requirements of the labor market. Within the framework of this model, the digital ecosystem of the university contains subsystems for monitoring the labor market and professional standards, subsystems for formal and meaningful modeling of the curriculum, subsystems for ontological modeling and markup to analyze their compliance. The university electronic information system enabling educational environment is a complex solution relying on various platforms, the main components of which are the "University" information system that allows managing the educational process and the training course management system based on the Learning Management System (LMS) Moodle. At the same time, the basic mechanisms of the "University" are not enough for digitalization of the curriculum creation process. Therefore, currently the process of creating an educational program relies on two platforms: the formal part is based on the "University" information system, and the content part is in the LMS Moodle. Implementation of the educational program digital twin assumes a seamless integration of these two platforms with significant improvements.

Figure 11 shows a conceptual model of development and usage of the course's digital twin. On the one hand, it is necessary to identify market requirements by parsing job aggregators and analyzing professional standards (see section 3). On the other hand, we need to identify the content of the curriculum with the help of its digital twin (see section 4). Next, we build ontologies based on the results of parsing of professional standards and analysis thereof, as well as the curriculum's content. Then we match these detailed representations using a conceptual scheme to analyze conformity of educational content to labor market requirements and vice versa (see Section 5). With the help of these results and the capabilities of digital twins, it is possible to quickly and proactively change educational content in accordance with the requirements of the labor market.

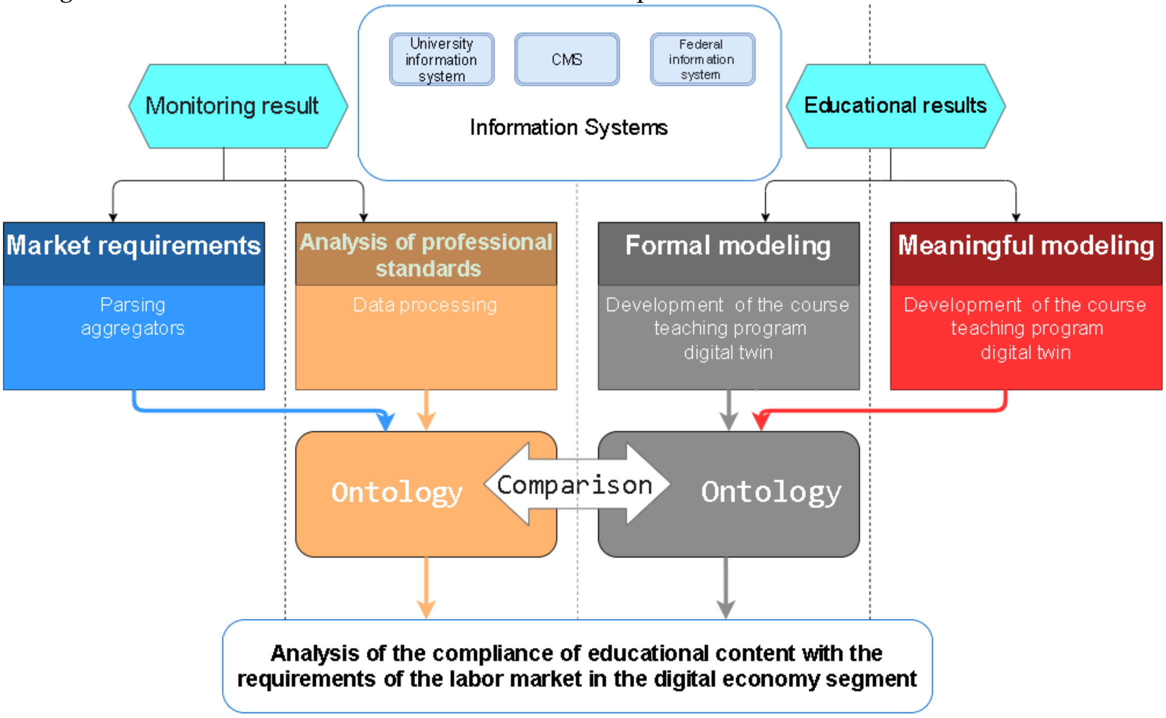

Figure 11. Course's digital twin, conceptual model, development and use.

A substantial part of the data is loaded from curricula into the course teaching program document. Data exchange between LMS Moodle and the "University" information system is implemented on the basis of web services. Obtaining or changing the objects of "University" information system is initiated by the methodologist of the department from the side of LMS Moodle. The data entered by the teacher in LMS Moodle is transferred back to the "University" information system. Only new or updated objects are transferred in order to reduce the load.

The teacher creates and edits the educational content of the course teaching program content part, relying on a ready-made teaching program document form with all the data from the curriculum. After the content part is filled in, data with content is automatically transferred from LMS Moodle to the "University" information system. Based on the parsing of the labor market vacancy aggregator and the analysis of professional standards, the teaching program's digital twin offers current employer requirements to the teacher, which the latter uses to develop more relevant content. Any supervisory authority and management can easily check the documentation and content of courses for compliance with regulatory requirements, as well as check the quality of the educational process in any of the courses and the educational program as a whole, and make appropriate management decisions.

LMS Moodle and "University" information system data exchange is proposed to be implemented through web services, as shown on Figure 11. Retrieving or updating "University" information system objects should be initiated by LMS Moodle. Data transfer is supposed to be carried out in JSON format. Conversion to JSON format should be performed via XSD schemas using the "XML Data Transfer Objects" technology.

8. The Principle of Organizing an Educational Program with Ontology-based Competency Verification

Individual educational trajectories and advanced qualification requirements for candidates and promoted specialists can be automatically generated and kept up to date using algorithms based on professional field ontology. The ontology can be built with a higher precision based on the analysis of competencies primary to the carriers of unstructured data (job and work experience

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descriptions, regulations, standards, technical specifications, documentation and program source codes) with the involvement of specialized professionals. Unlike open resources of job aggregators, where the reliability of data is low, first-hand information is always more valuable and relevant.

It is necessary to establish an effective knowledge transfer from professionals to teachers and students to improve the education quality in the information technology field and help solve the problem of insufficient training of university graduates that disallows meeting employer requirements. This can be done with the help of an ontology with a dynamic digital professional standard generated on its basis as follows:

1) specialists and recruiters are directly involved in the formation and maintenance of the ontology via shared formalized requirements for level of competency expected from a hired or a promoted employee, taking into account business and regional specifics;

2) teachers create adaptive curricula and create educational content linking the assessment elements and educational content fragments to ontology, taking into account cognitive map and automated coverage reports;

3) under the professors' supervision, students choose an individual learning path in senior courses as elective courses, individual courses tasks, coursework projects and final thesis in accordance with the professional field ontology as it covers the competencies acquired, based on the approximate requirements of specific employers' vacancies.

The model for verifying competencies development proposed by the authors can be supplemented by preserving a digital training trail in open sources (student portfolio on the university website, program code in public version control services) with time and authorship fixation in public blockchain networks, which would boost employers' trust in candidate's education, speed up search and simplify recruitment by automating the required competencies verification without using time consuming tests, tasks, interviews, etc.

Such a system may be demanded not only by universities, but also by technology companies and IT companies to support their corporate universities and internal corporate training programs, automate the HR work and increase the efficiency of interaction with universities.

9. Conclusion

Implementation of the proposed model, which aims to enable effective interaction between employers, educational institutions, teachers and students and accounts for the strict requirements of the Higher Education Federal State Educational Standard, will obviously require serious efforts designed to change business processes at the faculty level and to develop, deploy and support the information system. This system, in addition to the subsystems described in this paper, capabilities to generate all the necessary reports and documents, should also include the following components.

1 Model of the formalized processes designed to extract, obtain and use professional knowledge [17,18] for solving problems in the IT field.

2 A technology of predictive modeling of professional requirements based on professional and socio-economic trends.

3 Automated domain ontology [5] development technology and analysis of its coverage by the educational content based on unstructured data parsing and information retrieval (vacancies, technical assignments, source codes of programs, open databases, instructions, documentation, professional standards and educational programs).

4 An effective personalized adaptive modular training trajectory construction model with optional verification of specialized competencies for compliance with a specific project, vacancy or grade requirements.

5 Technology for development of an automatic digital assistant and career guidance methodology relying on personalized learning, gamification, development of professional competencies and students' knowledge control.

6 An automatic training digital footprint capturing technology for competency verification with learning outcomes recording in the public blockchain.

The ontological approach proposed by the authors can be used to improve the quality of higher education, create an effective system of interaction between employers, universities and the professional community, increase the efficiency of the processes of hiring and training employees not only in the field of IT, but also in any other area of professional activity.

The information technology presented in this paper is developed and deployed by the authors in the Kuban State University, Krasnodar, Russia and the Siberian state university of telecommunications and information science, Novosibirsk, Russia. Further research will be aimed at expanding the cognitive map and building educational trajectories on it within the automated system of higher education specialization in order to optimize professional training in universities and integrate them deeper with the emerging digital economy.

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