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CURRICULUM MANAGEMENT INFORMATION SYSTEM

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Abstract

The paper describes the draft of curriculum management system based upon competency-based approach for Petrozavodsk State University. The system is to help school-leavers and students to choose the occupation as well as to upgrade curricula by means of employers' demand comparison with graduates' feedback. The problem of educational and professional competencies is being scrutinized via the competency ontology. System implementation scenarios, ways of data representation, and analyzing tools are proposed.

Keywords: Curriculum management, undergraduate education, information technology, web information system, decision making.

1 INTRODUCTION

The role of IT (information technology) is increasingly growing in current universities' activities. Besides the matters of study process control, IT is used in decision-making at curriculum assessment or curriculum management. Formal methods implementation based upon IT is especially crucial for universities and countries that lack flexible management traditions in curricula (without state participation based upon employees and students feedback) [1, 2]. Our paper is dealing with curriculum management information system for Petrozavodsk State University, a typical Russian university. IT was chosen as one of the most dynamic and perspective fields in a labor market. Curriculum upgrading in IT field, its approaching to new industry requirements is influencing university's development level of as a whole.

One of the key moments for such information system development is formalization of the concept of competencies. Competency-based approach is well-known in contemporary society, is being widely implemented in Russian state educational standards. Unfortunately there is no common system of competencies even for such perspective fields as IT.

The paper deals with analysis of information resources relating to IT-competencies as well as questions of competency ontology development. A general concept of information system as a multifunctional system for decision-makers (enrollees, students, employers, faculty's administration) is developed. A method of data collection for information system is presented based upon employers', lecturers', graduates', students' surveys as well as data processing on students' studies for the previous years. The architecture of information system is based upon Web-technologies with different interfaces for various groups of users. Information models for systems' data representation are scrutinized. Approaches to data analysis necessary to be implemented in the system are also outlined.

2 GOALS AND PROBLEMS

We suppose to develop expert-analytical information system which would unite interests of different target groups – school leavers, administration, university teachers, students, graduates, employers.

The goal is to help school leavers to choose perspective educational program and enter the given university; motivate them study well on a chosen disciplines so that they find a well-paid job.

The system is planned to function as follows. Data related to performance at university is being collected for each student. Based upon this data competency evaluations (obtained at university) are being compiled. The system shows to a student possible organizations in which he could be employed (those employers who are satisfied with obtained competencies) as well as salaries, working conditions etc. A student sees concrete possibilities of successful employability. Employer is able to introduce some revisions dealing with students curricula. These revisions shall illustrate which competencies the student shall develop, and how they are important in this organization.

Such information system is one of the alternatives to the concept of transparent information system. Transparent information system is a new information platform creating new system of links among

labor market actors, educational services market, members of the society and public/professional organizations [3].

The necessity of creation of such an environment is based upon European experience of “Early warning system”. It deals with a constant tracking of employers' demand for competencies and supply (universities' curricula). It is pointed out [4] that in case the demand is sustainable, it is necessary to adjust supply changes. (Figure 1)

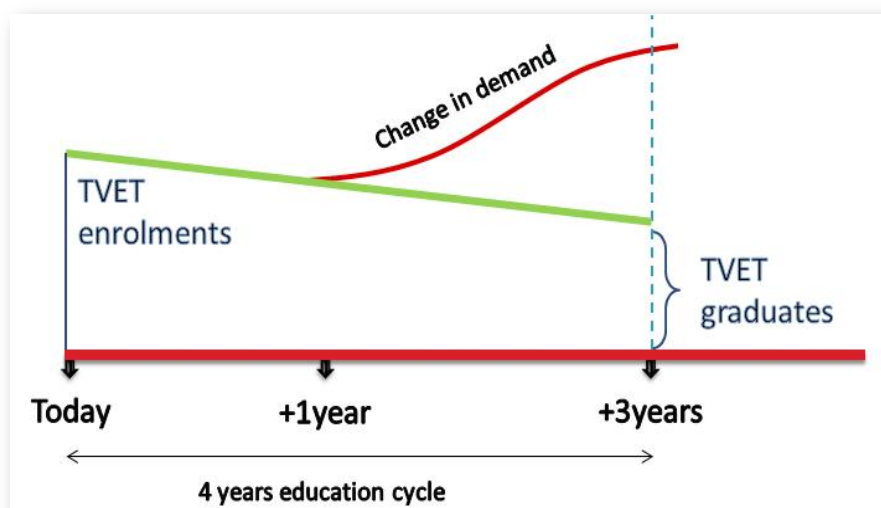


Fig. 1 Changes in supply for professional competencies

That is why it is important beforehand for business, state, population to possess updated data on current and perspective labor market. The “Early warning system” (developed with assistance of the European Training Foundation (ETF), European Centre for the Development of Vocational Training (CEDEFOP), International Labor Office (ILO) is aimed at such data dissemination and bridging labor market. The necessity of such systems development was discussed in Prague on the 6-7th of March 2014 at international workshop «Validation Seminar on Methodological Guides for Skills Anticipation and Matching» [4].

Prototype development for such transparent information system as part of university will let information channels efficiency upgrading between employers and job-seekers. The system delivers a number of indicators characterizing all layers of employability process to the actors – employer, university, job-seeker. These indicators are school leavers performance evaluation, their proficiency at school, salaries, successful employability, working conditions, other options. It is supposed that transparent information system development in the region reflecting not only current and perspective labor market parameters but also performance at universities, results in terms of prestigious job, will help attract students to university and as a result will positively influence university image, lecturing staff, social-economic development of regions.

The goal of suggested system from the point of view of university administration is a possibility to comply disciplines and educational competencies with occupational competencies which will be demanded by employers while graduate's employability.

One of the objectives for university administration is that such system will contribute to university attraction for school leavers. This is possible by means of scientifically proved results dissemination that in case a student is enrolled at prestigious major, will show excellent results, he/she with high probability will be employed with a good salary.

Here we observe compliance with school-leavers goals – such system is highly necessary for pragmatic choice of perspective and successful occupation and correspondingly major.

Employers' goal is to have possibility to choose best students evaluating them in terms of necessary disciplines, which would contribute to occupational competencies development.

As a result, plenty of goals unite on one hand employers, on the other – a graduate, a student, a school leaver. The university will be an inter-agent with the function of provision a school leaver with a possibility to obtain skills demanded by employers. This means that university shall possess such system which would play a role of “transfer function” between a school-leaver and employer. In necessary university could correct curricula so that the outcome would be skills demanded by employers. Structural model of such cooperation is presented at Figure 2.

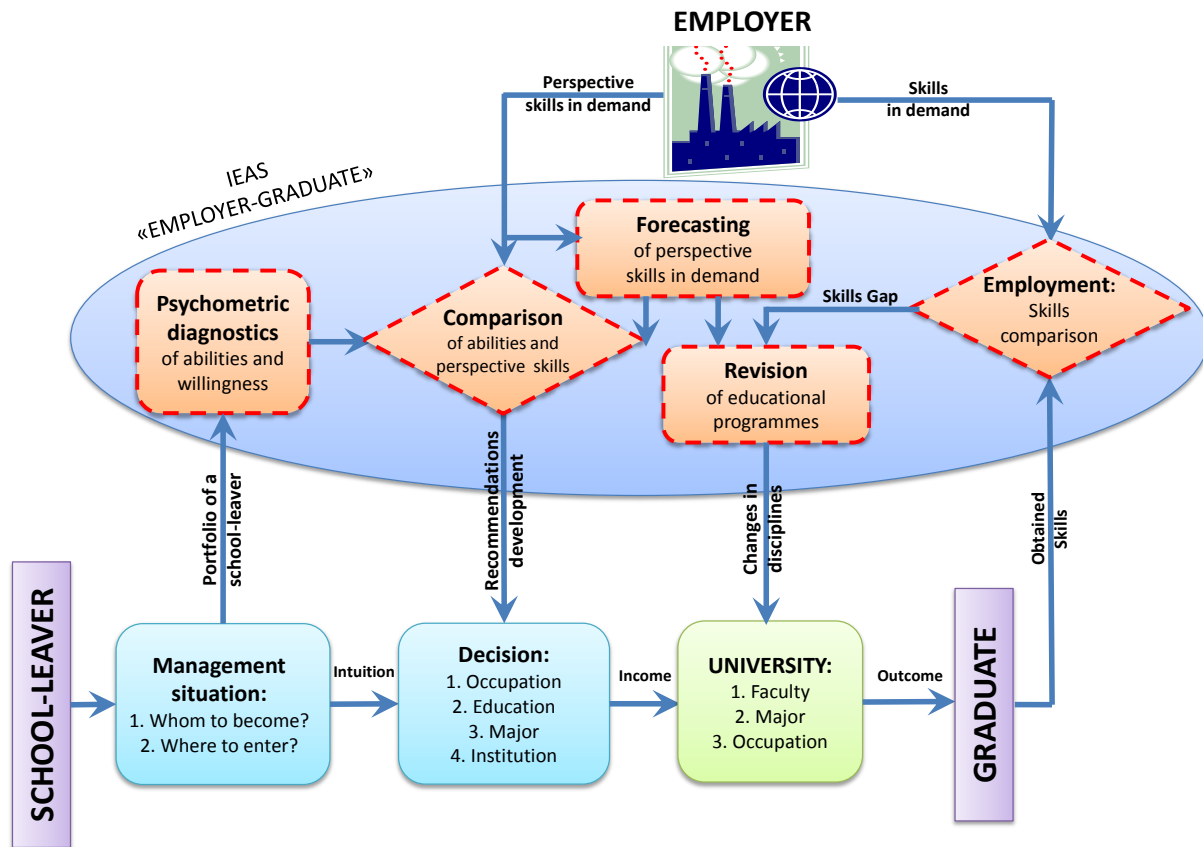


Fig. 2 Information expert-analytical system model «Employer-graduate»

On the left forecast-oriented professional guidance for a school-leaver is presented. As a result psychometric assessments and occupational profile are defined, inclinations to a certain type of occupation activity are determined. The obtained results are compared with forecast information on perspective in-demand skills in a labor market. Then based upon comparative analysis and ranking, recommendations are developed which occupations are preferable for filling.

Also the system holds a background information influencing the decision-making process. A tool with a friendly interface is implemented containing a number of indicators (working conditions, occupation characteristics etc.). Navigator on perspective occupations will reflect such parameters as demand, salary range, popularity, complexity and turnaround time, occupation lifetime etc. Intellectual system of information search and filter will provide ranging in accordance with the above-mentioned criteria which will help a school-leaver to take a decision (which occupation to choose, which university to enter taking into account individual capabilities defined as a result of psychometric assessment). The system will also deal with information where one can get such education (list of educational institutions), price, and employment possibilities (a list of employers).

On the right the process of student studies as well as graduate employability who already decided upon chosen education institution is reflected. After graduating he/she is communicating with an employer when the obtained competencies are compared with competencies demanded by an employer. In case both are satisfied with competencies and salary, the employment is taking place.

In case of huge competency gap educational institution might revise curricula adding disciplines that would provide necessary competencies development.

The proposed system will thus deliver the following functions:

For students and school leavers – evaluation of the employment probability with a level of salary taking into account school-leavers indicators' (unified state exam score, average score of the Certificate of Completed Secondary Education, school-leaver characteristics etc.)

For employers – showing the students possessing necessary competencies to provide corresponding salary and working conditions.

For university – professional guidance of school-leavers and their attraction. The system is reflecting which factors (disciplines, students abilities) contribute to successful employment. Based upon such knowledge a university can propose changes in curricula.

Outlined on the Figure 2 formal model is scientifically conditioning on competency-based approach implementation in a labor market:

1. At first a student is gaining competencies during study process.
2. After graduation a graduate is selling competencies to employer.

The object of the pilot study is the Faculty of mathematics and information technology at Petrozavodsk State University.

While processing it is necessary to achieve the following goals:

1. Data collecting on organizations (employers) in terms of occupations. It is necessary to collect information on employers interested in recruitment of the Faculty graduates describing salary ranges and necessary skills.
2. Data collecting on disciplines of the Faculty. It is necessary to collect all the information on disciplines in terms of semesters starting 2010.
3. Lists of competency development, obtained by students from the Faculty of Mathematics and IT as well as concrete disciplines evaluations in terms of competency development. It is necessary to attract experts (lectures) for the competency list development by eliminating competencies form the draft list and adding new ones. It is necessary to take into consideration developed curricula in which the competencies shall be defined. It is necessary to formalize how the competencies are developed in terms of assessment process ("satisfactory", "good", "excellent").
4. Panel compilation including school leaver portfolio, studying process at the university, employment efficiency for the faculty of Mathematics and IT graduates. It is necessary to collect all the data (unified state exam score, average score of the Certificate of Completed Secondary Education, school-leavers characteristics etc.), information on studies at the University (disciplines scores), data on efficient employability (salary, working conditions etc) for minimum 100 graduates.
5. Mechanism development for competency evaluation and possible employment trajectories elaboration based upon neural network approach.
6. Web information system development and implementation on employers and graduates cooperation. Developed Web system shall foresee authorized access to such target groups as school-leavers, students, graduates of the Faculty of mathematics and information technology, employers interested in recruitment of the faculty graduates as well as university representatives.

3 COMPETENCY SYSTEM

For the competency system development aimed at our goal achievement it is necessary to compare already developed IT-competency systems.

In Russia both educational and occupational standards are developed in IT, both are based upon competency-based approach. Competencies were implemented in educational standards of the third generation [5]. The educational competencies are divided into soft and hard ones. Soft competencies (for example, ability to analyze and generalize) are being formed under studying process at the University via Humanities studying or communicating with lecturing staff. Hard competencies are developed during the process of professional disciplines studying. In standards of the 3rd generation hard competencies are divided into types of activity. Thus, in bachelor standard "Information systems and technologies" the following types of activities are selected – design and engineering, design and

manufacturing, engineering and manufacturing, organizational and administration, scientific research, innovative, operating. For example, competencies for engineering and manufacturing activity include ability to explore IT, ability to prepare documentations on quality management of IT, ability to utilize objects of professional activity. As it is visible, competencies are defined in a very general way without concrete details. In 2015 new educational standard was approved (so-called "3+ generation standard") for bachelor "Information systems and technologies", but competency system became very much alike the previous one, only "general hard skills" were added. They don't depend upon the type of activity, for example, ability to implement simulation methods, to utilize contemporary computer technologies for information searching, etc.

Russian occupational standards [6] were developed much later than the 3rd generation educational standards by the Ministry of Labor and Employment (under the aegis of Russian Union of Manufacturers and Entrepreneurs). Thus occupational standard "Software developer" was adopted in 2013. It is very much visible that educational and occupational standards are not similar. This standards depicts working functions (15 for the Software developer), and for each of the function – skills and knowledge. These competencies are depicted in highly detailed way. Of course these statements don't look like vague competency definitions in educational standards.

Other situation can be seen while comparing educational and occupational IT-standards in the USA and Western Europe. Well-known standard CS2013 was developed by ACM [7], defined the list of mandatory knowledge units combining the core of educational process in bachelor programs in Computer Science. For each knowledge unit a detailed description is proposed and learning outcomes – knowledge and skills which should be obtained during its study are marked. Detailed elaboration in standard CS2013 is much higher than in contemporary Russian educational standards.

Other competency structure is proposed by Information Technology Competency Model of Core Learning Outcomes and Assessment for Associate-Degree Curriculum [8]. This competency model for the Community Colleges was also developed by ACM. It deals with detailed 50 learning outcomes, and each outcome has 3 levels of possession.

While analyzing the systems of occupational competencies, like [9], [10], [11], [12], it is possible to note that the major point is to describe in terms of knowledge and skills a concrete occupation with a defined range of goals. The level of detail description could be different, but as a whole such approach is different from the implemented one dealing with educational standards and curricula development since the main point is to cover a wide but distinct filed of knowledge so that graduates could have a freedom in choosing the occupation. Besides some educational competencies are gained not for the employment but for other disciplines studies (e.g. the majority of mathematical skills in engineering).

Thus, educational and occupational skills around the world might be completely different. In this case a problem of bridging different competency systems rises. This problem can be solved by means of competency ontology development embracing both educational and occupational competencies. The task of competency ontology development has already been analyzed in the literature. Thus, in the paper [13] the software system based upon such ontology for the goal of worker's competency management is proposed. The goal of comparison with educational competencies for such ontology is not settled. The paper [14] suggested a software framework for ontology-driven e-learning systems, which are implemented for competencies obtaining. The author defines competencies as the pair that consists of a skill and a knowledge. Thus the ontology is developed embracing competencies, skills, and knowledge. Competencies are linked with each other – for each competency prerequisite competencies and target ones are defined. Skills are generalized into general skills by means of which it is possible to link various competency systems. Thus in our project it is possible to take ontology [4] as the foundation which should be complemented with such objects as curricula and occupations.

4 INFORMATION SYSTEM

Information system implementation for faculty curriculum management shall provide remote access to information for users. It means the necessity of a Web system development with a single databank. We select the following types of the system users – school-leavers and their parents, students, graduates, employers, representatives of the faculty. An access to the system shall be implemented by means of safe authorization, system's functions depend upon users. Below the scenarios for Web system are implemented for different types of users.

4.1 System implementation scenarios

4.1.1 School-leavers and their parents.

The implemented Web system shall provide possibilities to school-leavers and their parents to look through information which could help in decision-making: lists of majors and necessary enrollment exams; graduates' efficiency employment on a various majors; links between successful studying process and efficient employment; the list of employers who gave work to students and graduates in accordance with their majors.

4.1.2 Students and school-leavers.

Systems' functions for students and school-leavers include data introduction on successful learning at university; employment efficiency (in case a student or a graduate is employed); lists of employers with a range of working conditions and salary.

4.1.3 Employers.

For employers the following is proposed: deliver information on vacancies and skills; look through the lists of unemployed students and graduates who might suit the vacancy best.

4.1.4 University representatives (Faculty).

For the faculty a wide-range of data is provided that will result in more effective curriculum management: revise the competencies obtained by students; look through the evaluations performed by the system on how the students could develop competencies which are necessary for employers.

4.2 Data representation, methodology and algorithms

The information system shall implement the following data while operating:

The link "many-to-many" between educational programs and developed educational competencies – information should be combined via lecturing staff surveys.

The link "many-to-many" between occupations and necessary occupational competencies - information should be combined via employers' surveys.

Panel of data on successfully employed graduates – graduates portfolio before entering the University, history of a graduate studying at the University, successful employment. Thus, we divide the definitions of educational competencies (obtained) and occupational ones (necessary). So we can build up a neural network that will show off which occupational competencies a graduate developed, what is the influence of each educational discipline upon occupational competencies development. Such tables of links between educational disciplines and occupational competencies are being compiled at the beginning via panel data on successfully employed graduates.

Thus, the structural data of the system includes 3 dynamic tables for such links as "educational discipline" – "educational competencies", "occupation" – "occupational competencies", "educational discipline" – "occupational competencies". While the system is operating, dynamic tables are specified and result in accurate data deliver.

It is necessary to achieve the following goals while the system is operating:

- Links unveiling between the disciplines and developed educational competencies (the level of their development).
- Links unveiling between educational competencies and occupational ones.
- Educational programs adjustment aimed at linking with occupational competencies.

The achievement of the above-mentioned goals will let to upgrade the level of education and students' efficiency employment:

- Students and graduates will be able to cooperate with employers.
- School-leavers can evaluate graduates' employability at various educational programs.
- University representatives can evaluate the linkage between implemented educational programs and employers' demands as well as take necessary administrative decisions.

5 CONCLUSIONS

Curriculum management information systems play important role in university education performance upgrading. Such systems help school-leavers and students to take aware decisions while choosing future occupations as well as aimed at curricula upgrading by means of employers' demand comparison with graduates' feedback.

Different user groups are united in one system via competencies. The problem of educational and occupational competencies linkage is unveiled while analysing existent competency systems. This link can be sustained via common competency ontology.

Curriculum management system implementation shall provide a remote access to all target groups what is proved by necessity of a Web information system development with a single databank. Expert-analytical functions pose additional requirements on data delivery and analyzing tools.

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