

# Towards Narrowing a Conceptual Gap between IT Industry and University

Peteris Rudzajs, *Riga Technical University*, Ludmila Penicina, *Riga Technical University*,  
Marite Kirikova, *Riga Technical University*, Renate Strazdina, *Riga Technical University*

**Abstract** - The situation when the number of the students and the popularity of the engineering education in general and IT education in particular is not increasing dramatically due to the fact that there exists an opinion that engineering education is complex and time-consuming from one side and that the graduates are not sufficiently prepared for the industry from another, requires the University to perform a series of actions that can improve the current situation. One of the areas for improvement is the quality of the study programs in the sense of their suitability to ‘customers’, namely Students and Industry. Previous research shows that the knowledge requirements monitoring system and the processes behind it can improve the quality of the study programs, e.g. the results of the Value Network Analysis demonstrate that the Monitoring System can give additional value to both the University and the Industry. Developing a monitoring system prototype requires narrowing the gap between industry and university and introduces new ways of industry-university cooperation.

**Keywords:** cooperation, feedback, inter-organizational knowledge flows, skills framework, study program

## I. INTRODUCTION

The paper is positioned in the area of knowledge management in the engineering education ecosystem [1]. This ecosystem encompasses an institution providing engineering education (further in the text – University) and directly or indirectly related organizations that contribute to and/or benefit from the results of activities of the University. We address the following research question: How the relationship between industrial organizations (further in the text – Industry) and University might be strengthened in terms of innovative methods and tools of cooperation. Basically, the design science is applied as a research method [2], i.e., an innovative artefact is developed and tested regarding its applicability for the intended purpose. The research described in this paper is rooted in investigations in the area of knowledge requirements analysis that are reported in [3] – [5]. Previous work proved that specific information systems support is needed to monitor changing knowledge requirements that come from industrial partners, standardization bodies and other institutions interested in the result of engineering education. It identified also that a gap exists between conceptual structures used for describing knowledge requirements in Industry and University. This conceptual gap hinders the possibility of understanding industrial needs of graduates’ knowledge by university and getting the right perception of the scope of available knowledge by industrial organizations.

To narrow the identified conceptual gap the architecture of knowledge requirements monitoring system (an innovative artefact) was designed that allowed for fusion of knowledge requirements obtained from different sources thus supporting a higher availability of information concerning industrial knowledge needs and strengthening the links “industry → university” and “university → industry” via use of the knowledge requirements monitoring system [5]. In order to implement and start to evaluate the knowledge requirements monitoring system, the first prototype has been developed and the next prototypes are planned. This paper describes in detail exactly how the conceptual gap can be narrowed and what challenges are to be resolved in the implementation of an artefact – a knowledge requirements monitoring system prototype.

The paper is structured as follows. An analysis of the current status of industrial understanding of university potential of knowledge provision is given in Section II. The conceptual gap between knowledge representation in terms of Industry and University is analyzed in Section III. Several theoretical approaches that potentially could narrow the conceptual gap between knowledge descriptions by Industry and University and may improve University-Industry collaboration are proposed. Then the issues of applying the proposed approaches are discussed in Section IV. At the end of the paper brief conclusions and directions for future work are presented. All practical implementations described in the paper refer to engineering education in the area of computer science and information technology.

## II. INDUSTRIAL AND ACADEMIC KNOWLEDGE

One might think that nowadays the Industry is the source of scientific discoveries and technological progress and as a result – the driver of social change, but really what is at the source of scientific discoveries are new ideas. First comes the idea, which then during the accomplishment of the experiments can be proved wrong or right and the discovery is brought out. An idea is something that makes the discovery possible, and the most favourable environment for the birth of ideas is the academic environment. In an academic environment there should not be an emphasis on urgency – academic workers should be more relaxed in conducting the experiments and have a creative view of the problem without the specific technology frameworks – scientists are better in „thinking outside the box” than Industry workers, who might focus on the particular tool or standard that is related to the product or service that Industry is rendering [6]. Therefore

University can be ahead of Industry in understanding future trends and potential knowledge needs in particular engineering areas. On the other hand the Industry is more aware of current needs and often has a deeper understanding of the existing technologies. These differences often cause some problems in University-Industry cooperation.

From the University point of view, the following issues are relevant in University-Industry collaboration [7]:

1. The primary goal of the University is to teach and educate students and to develop students' self-confidence and mental capabilities to produce creative individuals capable of independent thinking and mature judgement;
2. Academic research is an open activity where staff is valued by publication record and research is motivated by promotion and requires maximum publicity;
3. In University research is mainly to look for and extend new knowledge in an absolute way. Acquisition of knowledge itself is valuable, but in Industry knowledge itself does not make profit – Industry has to be able to sell the knowledge in the form of a product or service at a profit;
4. For faculty staff, research is a part-time activity;
5. It is not the function of University to give professional training – University's objective is to teach the students the general principles of problem solving skills and how to find the needed knowledge and transform it into useful information. As a result a University graduate is capable of learning any technology demanded by the Industry in the most agile and effective way. This is a winning situation for Industry as well – as Industry employs an adaptable person with critical and systematic thinking skills.

From the Industry point of view, the following issues may hinder University-Industry collaboration [7]:

1. The research done in the Industry is a strictly closed activity – new developments require protection, mainly through patents, thus communication and publication of the discoveries in the Industry are restricted;
2. Industry sees the research pointless unless investment can be justified by turning discoveries into products – in the industry the principle „negative or null results are results as well” does not work;
3. In Industry research is a full time activity;
4. Information and Communication technology (ICT) graduates lack the business oriented thinking.

There are examples of win-win scenarios for University-Industry collaboration. Industry can be the source of financial support for University, in return Industry can get the opportunity to use the scientific equipment and facilities in the laboratories of the University or enhance the educational level of the employees by taking the continuing education courses provided by University. In addition to formal engineering skills, Industry can provide valuable guidance for courses and student projects which are relevant to industry, collaboration with Industry representatives can improve the students' communication and social skills as well as provide the knowledge of how technology relates to business.

Industry is always tool oriented – Industry must get profit by selling a product or rendering a service which is only possible by using some specific tools and frameworks, as a result the skills required by the Industry are always bound with or even defined using a particular technology or tool. Nowadays Industry sees software tools and technologies as long-term investments and is interested in hiring people specializing in this particular tool or technology. However University does not teach a specific technology or tools. This difference in perception of the main focus of relevant knowledge causes a kind of conceptual gap between Industry and University.

### III. A CONCEPTUAL GAP BETWEEN UNIVERSITY AND INDUSTRY

The difference between University and Industry in understanding of the essence of knowledge, skills and competences is reflected most visibly in the existence of two international competence description frameworks. Namely, SFIA (Skills Framework for the Information Age) [8], based on Bloom taxonomy [9] and developed by University, and European e-Competence Framework (ECF) [10] developed by Industry. The motivation for development of ECF was the fact that SFIA and similar frameworks do not meet the needs of Industry because of the structure of knowledge that reflects cognitive domains, such as understanding, knowledge, comprehension, application, synthesis, and evaluation [9]. Industry is more interested in a graduate's ability to take on responsibility and lead in particular skill domains. On the other hand the form of competence descriptions is more simplified in industry, e.g., knowledge is structured as social, business, and technical skills and activities [11]. Thus describing competences by University and Industry is like speaking in different languages.

Theoretically the following approaches could be used to try to bridge the conceptual gap between University and Industry and to facilitate their collaboration in provision of engineering education:

- Approach 1: Use of extended skill description frameworks
- Approach 2: Using “translation” tools that automatically interpret skills expressed in Industry terms into skills expressed in University terms and vice versa (not discussed in detail in this paper)
- Approach 3: Giving an opportunity for industry to evaluate technology oriented elective courses directly or indirectly
- Approach 4: Equipping Industry with University insights in skill development trends

All the above mentioned approaches can be utilized via a knowledge requirements monitoring system thus giving an opportunity for University and Industry to exchange knowledge and influence each other's understanding of current and future skills, knowledge and competence requirements. Fig. 1 reflects the knowledge requirements monitoring system (KRMS) equipped with collaboration

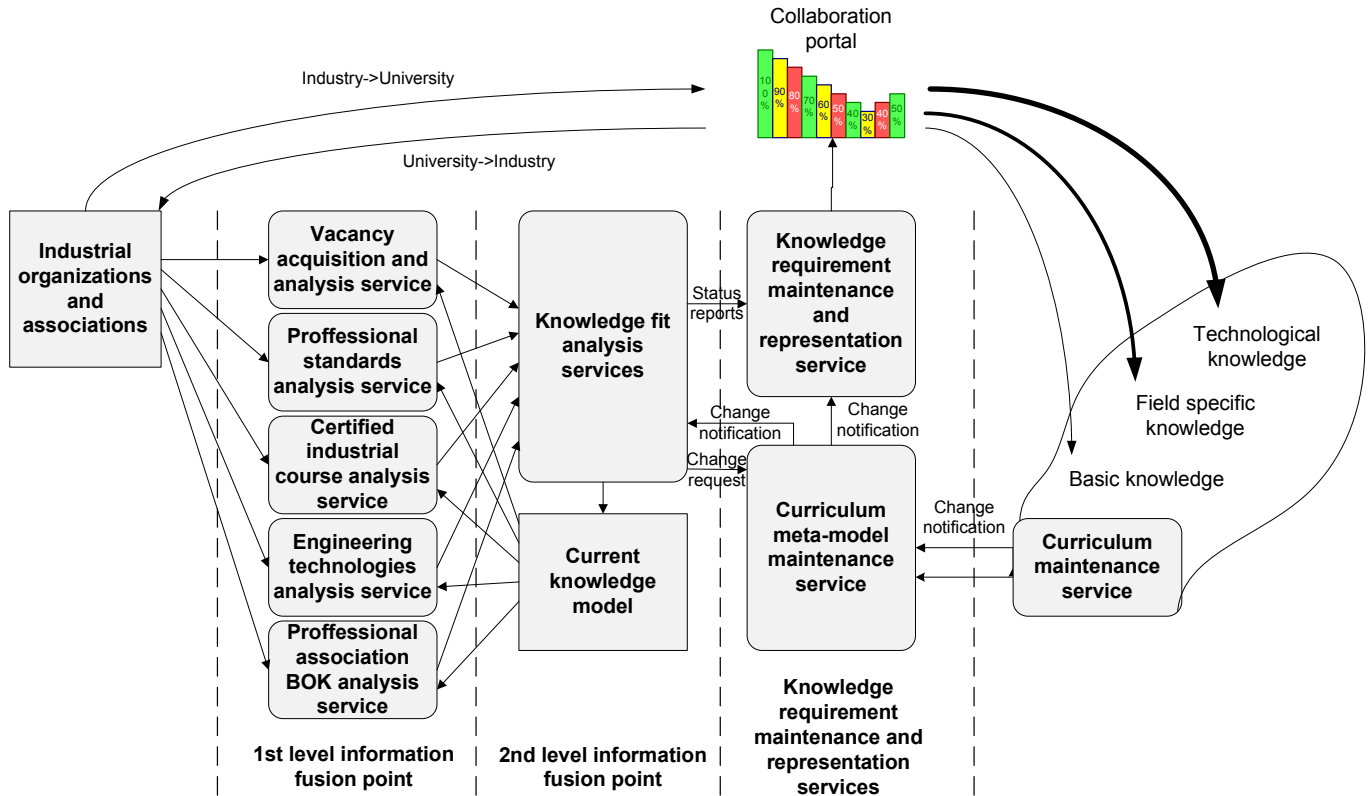


Fig. 1. Knowledge requirements monitoring system (KRMS)

portal for reflecting information that can be used for facilitation of knowledge exchange between University and Industry.

KRMS is built upon two level information fusion services that help to amalgamate knowledge requirements from different sources outside University. Amalgamated knowledge can be used in the curriculum development process [3] – [5]. On the other hand this knowledge can be exposed in the Collaboration portal in forms of representation convenient for Industry and students. By doing this University helps individual Industry partners to be informed about industrial knowledge requirements in general (Approach 4 above).

University knowledge provided in fields of engineering can be divided into basic knowledge, field-specific knowledge and technological knowledge. In many cases technological knowledge is taught in elective courses. We consider “course” as a single subject available in the particular study program. Different industrial tools are used also in teaching field specific knowledge. In order to harmonize University’s teaching potential and industrial needs it is possible to ask industry for rating technology oriented courses. The results of ratings may be used for informing students about current Industrial needs and expectations (Approach 3 above).

In order to try to bridge the conceptual gap between University and Industry we have developed the Adjusted SFIA (ASFIA) framework which utilizes the mechanism for linking the specific ASFIA framework skill to a particular industrial tool or technology (Approach 1 above).

This helps to get a more complete picture of labour market demands in terms of existing University courses as well as

determine the “dark spots” in University’s ability to produce competitive and marketable graduates. The combination of the above mentioned approaches gives an opportunity to enhance knowledge circulation in both directions: University → Industry and Industry → University (Fig. 1). It also gives an opportunity for Industry to influence Technological and Field-specific knowledge taught in University. Fig. 1 shows that Technological knowledge is the one that can be influenced more heavily than field specific knowledge via KRMS. Basic knowledge practically is not influenced by Industry in practice, however analysis of changes in field-specific knowledge may lead to some changes in basic knowledge, too [5].

#### IV. TOWARDS THE PROTOTYPE

This section discusses the main aspects of designing the Knowledge requirements maintenance and representation service. This service is a part of KRMS reflected in Fig. 1. The core element of KRMS is a unified knowledge representation model that forms the basis for further activities – mapping knowledge requirements from various knowledge sources (e.g., vacancy description, study course description, etc) to this model; knowledge requirements visualization; and knowledge gap identification between different information sources (e.g., between study course and professional certification course). To address these proposed activities, the main emphasis is put on technologies and methods to represent and organize knowledge. Knowledge that we are interested in is skills, tools and technologies that are described in information sources

(e.g., study course). The elements of KRMS are developed as Web Services and are utilized in the University's portal which is built on the uPortal platform and developed using Java programming language.

#### A. Unified Knowledge Representation Model

Skills representation should be made on the basis of some existing skills frameworks that define the structure of skills (categories, subcategories, or the level of skills), such as SFIA [8] and ECF [10] or others. After a deeper analysis of skills frameworks, we have chosen SFIA as the basis for knowledge requirements representation. This framework is chosen due to it showing the best conformance to the interpretation of how skills should be organized given by representatives of the University in which the prototype is developed. In the case of SFIA, skills are organized in categories, subcategories, skills and levels of skills. Skills cover mainstream IT, user IT and also the interface of IT and business. The 86 skills are grouped into 6 categories: Strategy & Architecture, Business Change, Solution Development & Implementation, Service Management, Procurement and Management Support and Client Interface [12]. One of implementations of SFIA is described in [13]. The example of how skill "systems development management" is identified in SFIA framework is given in Fig. 2. The category is "Solution development and implementation", subcategory "Systems development" and the skill is further described with attributes such as code, name, general description, level of skill and description of this level. Often there are situations when one skill is expressed in other words, to deal with this we propose to adjust framework to our needs by adding an attribute called "synonym". Such an attribute could be useful when dealing with knowledge

requirements mapping to a unified knowledge representation model.

When vacancies or study course descriptions are prepared there are usually included various tools and technologies that are required or obtained in every particular case. Taking this into consideration more adjustments to SFIA should be done. There are a lot of taxonomies for describing tools and technologies (e.g., Google directory, Yahoo directory, etc), but we have chosen a taxonomy provided by the O\*net Resource Centre [14] for its simplicity that is a very important feature of the taxonomy which is used at the stage of prototyping. The chosen taxonomy is organized in two levels, namely, there are categories and examples of a particular category. For example, there is a category "Requirements analysis and system architecture software" and examples are "IBM Rational Requisite Pro", "Architecture description language ADL" and others. Tools and technologies attached to skills are represented in Fig. 2.

Tools and technologies will be added as a category to ASFIA. As SFIA and chosen taxonomy have not been mapped yet, initial mapping should be done. It means that some tools or technologies should be referenced to every skill. Definitely, in the first attempts this could not be done fully, therefore the model and initially provided vocabulary (skills and tools and technologies) should be dynamic, so that the structure of the model and vocabulary can change by adding new skills and technologies or because of the impact of detected new trends in Industry or University. Tools and technologies also could be mapped to skills by users during the process of describing information source or in the mode of managing and organizing a unified knowledge representation model and vocabulary. As we can see, the unified representation model called ASFIA is formed from two parts – SFIA and tools and technologies.

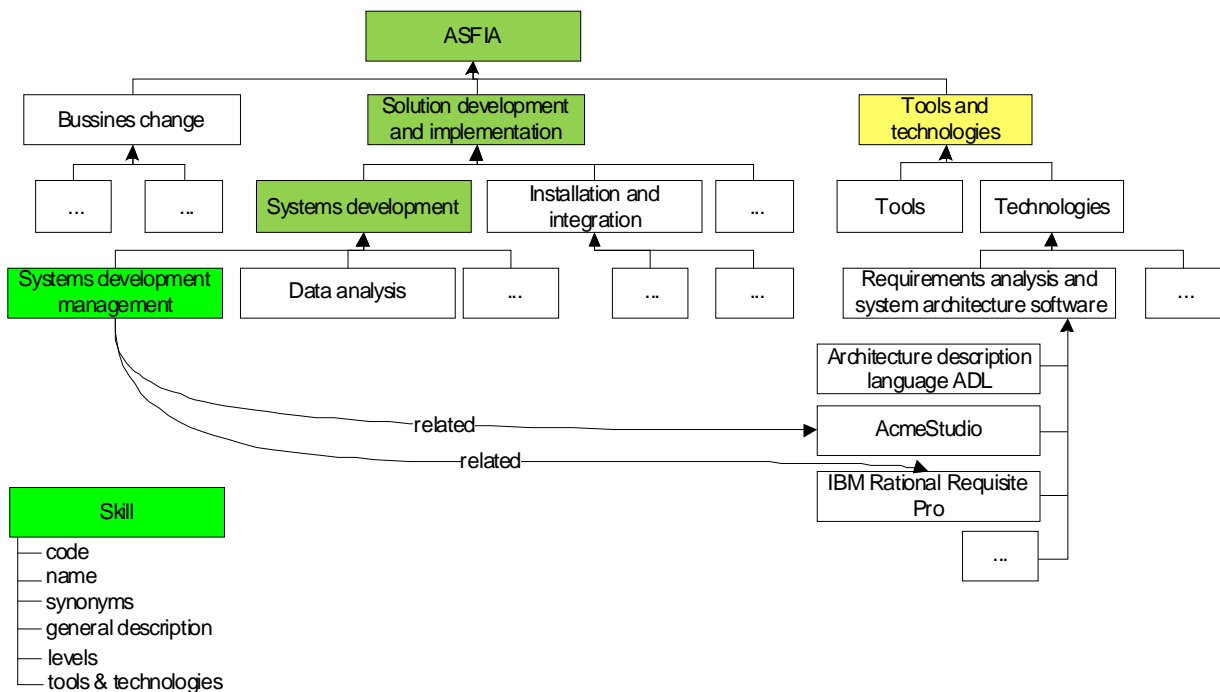


Fig.2. A fragment of Adjusted SFIA (ASFIA) framework

## B. Technology for Describing and Defining Skills

We have discussed the main conceptual part of a unified knowledge representation model, now we should focus on realization of this model. As the aim is to describe and map information sources to the unified representation model, we should ensure that this mapped knowledge could be used not only internally in the information system, but should be discoverable on the Web. An important goal of RDF (Resource Description Framework) is to record knowledge in machine readable format and then provide mechanisms to facilitate the combination of the data [15]. Because of this RDF should serve as a base for further knowledge description. The Simple Knowledge Organization System (SKOS) is one of the applications based on RDF. Because RDF is a formal language that has well-defined logical properties, any controlled structured vocabulary using SKOS is machine readable, i.e. a computer application can read it, "make sense" of it, and use it to provide functionalities such as rich visual search and browse user interfaces [16]. Using SKOS we intend to describe skills and to define the initial vocabulary. Previously described fragment of SFIA (Fig. 2) represented in SKOS is shown in Fig. 3.

```
<skos:Concept rdf:about="SFIA">
<skos:prefLabel xml:lang="en">
  Skills Framework For Information Age
</skos:prefLabel>
<skos:narrower
rdf:resource="SolutionDevelopmentAndImplementation"/>
</skos:Concept>

<skos:Concept
rdf:about="SolutionDevelopmentAndImplementation">
<skos:prefLabel xml:lang="en">
  Solutions development and implementation
</skos:prefLabel>
<skos:broader rdf:resource="SFIA"/>
<skos:narrower rdf:resource="SystemsDevelopment"/>
</skos:Concept>

<skos:Concept rdf:about="SystemsDevelopment">
<skos:prefLabel xml:lang="en">
  Systems development
</skos:prefLabel>
<skos:broader
rdf:resource="SolutionDevelopmentAndImplementation"/>
<skos:narrower
rdf:resource="SystemsDevelopmentManagement"/>
</skos:Concept>

<skos:Concept
rdf:about="SystemsDevelopmentManagement">
<skos:prefLabel xml:lang="en">
  Systems development management
</skos:prefLabel>
<skos:altLabel xml:lang="en">
  Managing systems development
</skos:prefLabel>
<skos:broader rdf:resource="SolutionDevelopment"/>
</skos:Concept>
```

Fig. 3. Fragment of SFIA (see Fig. 2) represented in SKOS

As a result we described the following hierarchy according to the SFIA (see Fig. 4). In the given example we can see 6 main elements used for defining concept hierarchy (see Table 1). The concepts thus are categories, subcategories and skills. All skills defined in SFIA should be described as shown in the example.

As a result we get the tree structure that defines the initial vocabulary. XML Schema is needed for dealing with the attributes of ASFIA. The schema should contain elements defined in Fig. 2. Updating example with attributes of skills and relating technologies to skill, gives the structure reflected in Fig. 5.

## C. System Usage Scenario

The prototype supports the following basic user classes:

1. Course administrator;
2. Vacancy administrator;
3. Industry representative;
4. Study department representative.

The course administrator is responsible for course description input and mapping of the course skills to the ASFIA framework. In the course adding form the course administrator specifies information about the study course such as its goals, topics, summary, prerequisites, literature, credits, degree type, learning outcomes, skills and used technologies. When defining the skills of the course, mapping to the ASFIA framework is performed. The mapping of the skills means linking the course skill with the appropriate ASFIA skill – in the result the skills of the course are standardized. A basic process of mapping is demonstrated in Fig. 6. Using this scheme the students who have graduated courses mapped to the ASFIA are getting descriptions of their skills in a broadly accepted and consistent format.

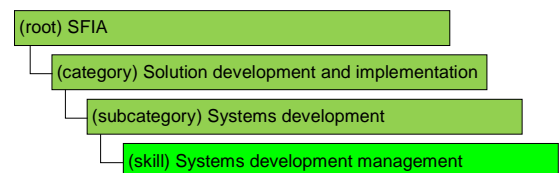


Fig. 4. Described hierarchy

TABLE 1  
MAIN MODEL ELEMENTS

skos:Concept	Concept is the basic building block of all SKOS descriptions
skos:prefLabel	Each concept has a preferred label
skos:altLabel	Every concept could have alternative labels dealing with synonyms
xml:lang	Defines the language of the label (both for preferred and alternative)
skos:broader	Indicates a generalization relationship with another concept (parent)
skos:narrower	Indicates a specialization relationship with another concept (child)

```
<skos:Concept
rdf:about="SystemsDevelopmentManagement">
<skos:prefLabel xml:lang="en">
  Systems development management
</skos:prefLabel>
<skos:altLabel xml:lang="en">
  Managing systems development
</skos:prefLabel>
<skos:broader rdf:resource="SolutionDevelopment"/>
<skill:code>DLMG</skill:code>
<skill:generalDescription>
  The management of resources in order to plan,
  estimate and carry out programmes of systems
  development work to time, budget and quality targets
  and in accordance with appropriate standards.
</skill:generalDescription>
<skill:levels>
  <skill:level>
    <skill:levelNum>5</skill:levelNum>
    <skill:levelDescription>
      Agrees, with business management, systems
      development projects which support the
      organisation's objectives and plans. Ensures that
      management is both aware of and able to provide the
      required resources, and that available resources are
      properly utilised and accounted for. Monitors and
      reports on the progress of systems development
      projects, using appropriate quality assurance
      processes to ensure that projects are carried out in
      accordance with agreed standards, methods and
      procedures.
    </skill:levelDescription>
  </skill:level>
  <skill:level>
    <skill:levelNum>6</skill:levelNum>
    <skill:levelDescription>....</skill:levelDescription>
  </skill:level>
</skill:levels>
<skos:related rdf:resource="AcmeStudio"/>
<skos:related
rdf:resource="IBMRationalRequisitePro"/>
</skos:Concept>
```

Fig. 5. Updated example

Another user group performing the mapping is the vacancy administrator – this role can be assigned to University employees or Industry representatives. The vacancy administrator inputs into the system the description of the vacancy – title, required skills, technologies, benefits etc.

To make the skills and used technologies of the vacancy recognizable by the system in order to find the study course with the related learning outcomes, the vacancy administrator needs to link the skills of the vacancy to the ASFIA framework. Vacancy mapping to ASFIA also could be done by using the previously identified Approach 2. As the result correlation points between the skills of the course and the skills of the vacancy are found and they become compatible. After the mapping the system is able to determine which courses the potential vacancy candidate has to graduate (skills

from courses are combined to complete the potential skill set of a graduate) in order to apply for the job.

The study department representative will be able to get reports from the system that provides the following information:

- which study courses are the most adequate according to the demands of the modern industry labour market
- what skills required by industry are not covered in the corresponding study program
- what are the trends of industry demands.

These reports can be used as the source for the university business intelligence data and quality management processes. Also the study representative will be able to search for courses according to different parameters and link courses to vacancies or suggest specific courses to the industry representatives.

The Industry representative will be able to browse the courses by different parameters, e.g. it will be possible to get the course list according to the specific skill or vacancy. The contractual commitment between an Industrial enterprise and the University will be made in order to define the Industry representative with the access rights to the system. The evaluation of the courses can be organized by the human resources department of the Industrial enterprise. The prototype is built assuming, that that there is one opinion per one enterprise.

The Industry representative will have the functionality of marking the elective course as important or not relevant and give the suggestions to produce more competitive learning outcomes, in that way study department representatives will be able to get feedback about the importance of the study course from the point of view of Industry.

## V.CONCLUSIONS

The paper discusses how Industry and University cooperation may be enhanced by use of KRMS (knowledge requirements monitoring system). The issues of the development of the prototype of one of the main services of the system that is responsible for knowledge requirements monitoring and representation are outlined. At the current stage of prototype development it is clear that the use of KRMS can help to narrow the conceptual gap between knowledge representations utilized in Industry and University. It can also enable the application of several new approaches in Industry-University collaboration that are proposed in the paper. Application of three approaches, namely, use of extended skill description frameworks; giving an opportunity for industry to evaluate relevance of technology oriented elective courses, and equipping Industry with University insights in skill development trends are discussed in detail. In the future it is intended to extend the prototype with services that provide “translation” tools that automatically interpret skills expressed in Industry terms into skills expressed in University terms and vice versa.



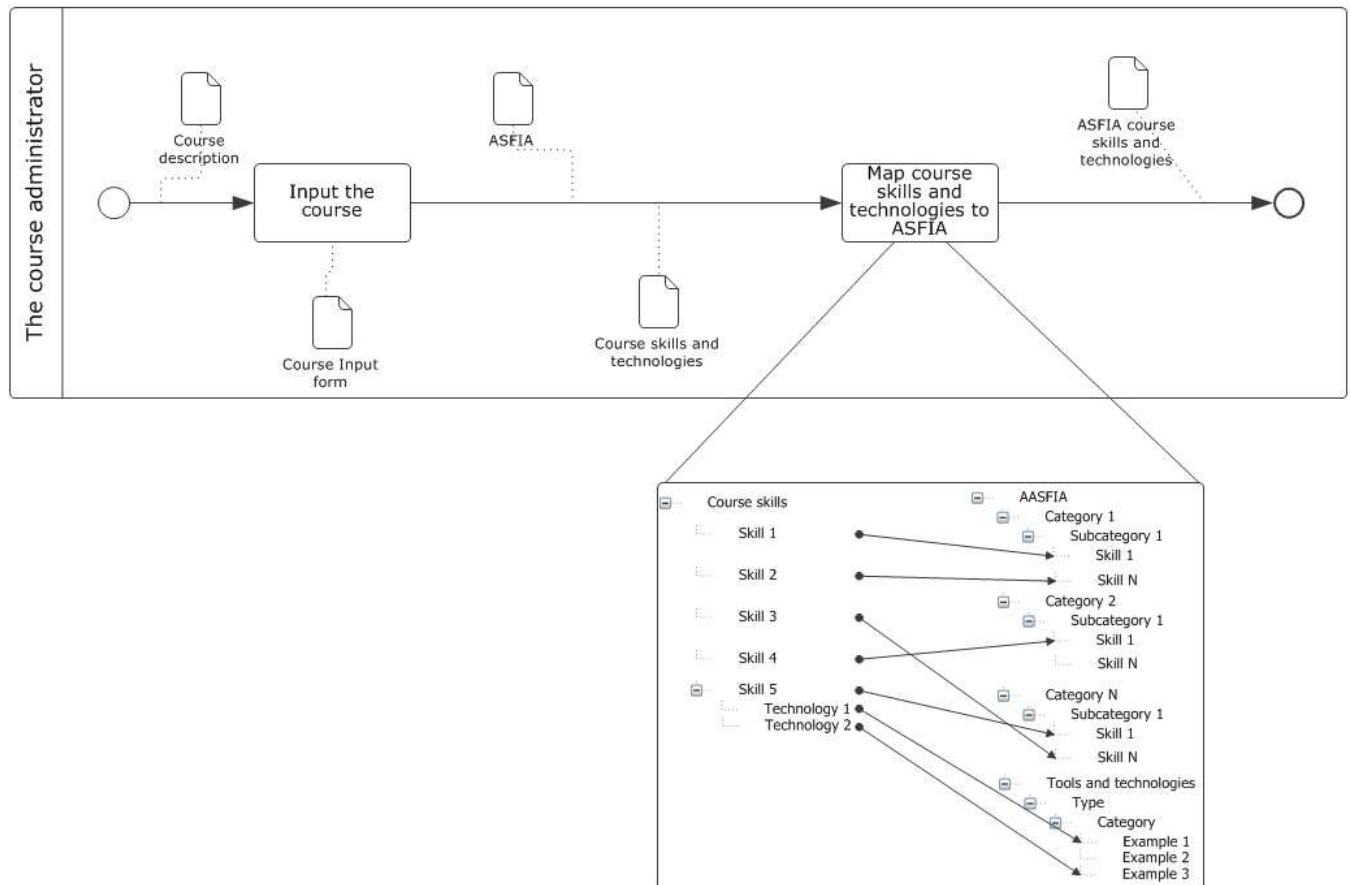


Fig. 6. Study course mapping to ASFIA

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**Peteris Rudzajs** in year 2008 graduated Riga Technical University, Riga, Latvia with bachelor's degree of engineering science in computer control and computer science. He currently is the 2<sup>nd</sup> year master degree student in Faculty of Computer Science and Information Technology, Institute of Applied Computer Systems, Riga Technical University, Riga, Latvia.

He works as a Scientific Assistant in Faculty of Computer Science and Information Technology, Institute of Applied Computer Systems and as a Software Engineer in Information Technology department, Riga Technical University, Riga, Latvia.

**Ludmila Penicina** in year 2008 graduated Riga Technical University, Riga, Latvia with bachelor's degree of engineering science in computer control and computer science. She currently is the 2<sup>nd</sup> year master degree student in Faculty of Computer Science and Information Technology, Institute of Applied Computer Systems, Riga Technical University, Riga, Latvia and the 2<sup>nd</sup> year MBA student in Riga International School of Economics and Business Administration, Riga, Latvia.

Ludmila Penicina works as a Scientific Assistant in Faculty of Computer Science and Information Technology, Institute of Applied Computer Systems and as a System Analyst in Information Technology department, Riga Technical University, Riga, Latvia.

**Marite Kirikova** is a Professor in Information Systems Design at the Department of Systems Theory and Design, Faculty of Computer Science and Information Technology, Riga Technical University, Latvia. She has more than 90 publications on the topics of requirements engineering, business

process modeling, knowledge management, and systems development. She has done field work at Stockholm University and Royal Institute of Technology, Sweden, Copenhagen University, Denmark, and Boise State University, USA. Currently in her research she focuses on information systems design in the context of agile and viable systems paradigms.

**Renate Strazdina** is Leading Researcher at Riga Technical University Department of System Theory and Design. Renate is doctor of engineering science from 2006 when she defended the doctoral theses "Information system feasibility study in turbulent environment" at Riga Technical University. Renate is Lecturer at Riga Technical University and Business and Information Systems Consultant at the international audit and consulting firm.

Renate is a member of Association of certified chartered accountants and member of program committees of different information system related conferences.

**Pēteris Rudzājs, Ludmila Penicina, Mārite Kirikova, Renāte Strazdiņa. Kā samazināt konceptuālo plaisu starp universitāti un industriju**

Šobrīd ir izveidojusies situācija, kurā inženierzinātņu (tajā skaitā informācijas tehnoloģiju) jomas studentu skaits un popularitāte nepieaug uzskatu dēļ par tās sarežģītību, kā arī dēļ tā, ka augstskolu absolventi nav pietiekami labi sagatavoti darbam industrijā. Šis ir viens no iemesliem, kas liek universitātei veikt pasākumus pašreizējās situācijas uzlabošanai. Viena no uzlabojumu jomām ir studiju programmu kvalitātes uzlabošana ar mērķi piemēroties „patērētājiem”, proti, studentiem un industrijai. Iepriekšējie pētījumi ir pierādījuši to, ka zināšanu prasību monitoringa sistēma un ar tās palīdzību īstenotais process var uzlabot studiju programmu kvalitāti, piemēram, vērtību tīkla analīzes rezultāti uzskatāmi parāda, ka monitoringa sistēma var dod pievienoto vērtību gan universitātei, gan industrijai. Monitoringa sistēmas prototipa izstrādes gaitā tiek risinātas dažādas pētījumu problēmas un iezīmētas jaunas pieejas industrijas-universitātes sadarbībā.

**Петерис Рудзайс, Лудмила Пеницина, Марите Кирикова, Ренате Страздня. Как сузить концептуальное несоответствие между университетом и индустрией**

В данный момент сложилась ситуация, что в инженерии (в том числе и в сфере информационных технологий) число студентов и популярность программ не возрастает из-за взглядов о сложности процесса обучения, а также из-за того, что выпускники высших заведений недостаточно хорошо подготовлены к работе в индустрии. Это одна из причин, которая заставляет университет проводить мероприятия для улучшения создавшейся ситуации. Одна из сфер улучшения – улучшение качества учебных программ, с целью приспособиться к „потребителям”, то есть к студентам и индустрии. Предыдущие исследования доказали, что система мониторинга требований знаний может улучшить качество учебных программ и быть полезной университету, также и индустрии. Во время разработки прототипа системы мониторинга решаются разные исследовательские проблемы и обозначаются новые направления в сотрудничестве индустрия – университет.