Towards managing learning outcomes in the jungle of qualification standards

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***Abstract*— Today not only universities but also companies and professional organizations are players in the education sector. Moreover, companies and professional organizations have developed widely known and generally accepted standards and skill frameworks for specific areas that differ from universities' study programs in terms of ease of understanding and extent of applicability. In order to ensure conformity among all players, mapping of standards, skill frameworks, and study programs should be performed and where applicable in this process ICT solutions should be applied. The paper addresses the above mentioned issues and proposes possible solutions by introducing learning outcomes management technology containing the component for supporting the mapping of learning outcomes to qualification/competence standards and accreditation criteria.**

***Index Terms*—Computer aided analysis, Education, Knowledge management, Quality management.**

I. Introduction

Globalization, advances in ICT, ever growing volume of available knowledge, and knowledge management applications have changed the stage on which university education has to play its role in modern society. Due to practical and economic reasons education has become an attractive business for consulting companies, associations and other professional development and vendor organizations. This puts into focus the question about the correspondence between university education and education claimed as valuable by professional organizations. An additional important factor is that many professional organizations develop and issue standards or skill frameworks that list skills, knowledge and competences needed in a particular business area, e.g., European e-Competence framework (e-CF)[2], Supply Chain Council's SCOR People [19], International Institute's of Business Analysis (IIBA) competency model [9], etc. Concepts presented in these frameworks are more understandable for employers than university curricula descriptions [16]. Taking into consideration that study programs need industrial acceptance to be attractive for both (1) students and (2) accreditation organizations, transparent correspondence between learning outcomes and industrial skill frameworks is of great importance. Moreover, accreditation institutions have their own criteria for study program assessment which usually are more general than professional frameworks. Transparent correspondence of learning outcomes to these criteria is also beneficial for achieving recognized quality of study programs. The above mentioned situation raises the following questions:

- What are the possibilities of mapping educational learning outcomes to multiple industrial frameworks: how similar are the frameworks, what is more feasible - to make direct mappings to several frameworks or to map the frameworks and then address the non-conforming areas?
- Does compliance to particular industrial frameworks ensure compliance to accreditation standards?
- What is the gap between industrial qualification frameworks and accreditation standards?
- What are the requirements, challenges and possible innovative IT solutions representation of industry oriented learning outcomes?

Answers to these questions, at least to some extent, could be provided by transparent linkage between study course descriptions, accreditation criteria and skill frameworks. The goal of this paper is to show how the linkage can be achieved by using contemporary information technologies. The paper does not discuss purely manual solutions assuming that the use of ICT is inevitable due to the conceptual complexity, diversity and great number of skill frameworks available. The work presented here builds on the authors' research on educational ecosystem [10] and information systems architecture supporting Industry-University cooperation [14], [15], [16], [17], [18]. In this paper the focus is on learning outcomes and their role in establishing the linkage between course descriptions, accreditation standards and skill frameworks.

The paper is structured as follows. Related work is briefly discussed in Section 2. Section 3 outlines the proposed solution. Learning outcomes management technology is presented in Section 4. In Section 5 future work needed for extending the existing technology is discussed. Conclusions are provided in Section 6.

The proposed approach is under the approbation for (but is not restricted to) university study programs operating in the

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field of computer science and information technology.

II. Related work: Educational informatics for curriculum management

Learning outcomes management technology presented in this paper belongs to the field of educational informatics. Educational informatics has emerged recently by bringing together aspects of information science, computing, education, instructional systems technology, and learning sciences; and building on, integrating, and extending these areas of endeavour [5]. Classroom teaching, academic advisement, course development, academic program review and course duplication review, can all be categorized as the curriculum development process [22]. One particular case combining educational informatics aspects and the curriculum development process is the curriculum management system in a narrow view meaning the management of courses, but in a broader view meaning the suite of integrated tools used for managing graduate outcomes, content, activities, and assessment in a program [24]. One vivid implementation example is *eMed* – a modular outcome-based curriculum management system including six main tools such as curriculum map, timetable, student portfolio, peer feedback tool, assessment tracking, and results tools [24]. There are other curriculum management systems supporting various aspects of the curriculum such as aligning instructions to curriculum map, individualization for helping teachers to customize the instructions to the needs of students with particular learning needs, collaboration and sharing best practices, collaboration with publishers for identification of learning resources [23]. We have identified the lack of a significant component in curriculum management systems, namely, the component for supporting the mapping of learning outcomes to qualification/competence standards. Qualification/competence standards are useful only if they help orient learning outcomes to specific professional profiles required by both industry and society [20]. The mapping component can facilitate information management and exchange between the parties involved.

III. Proposed solution outline

By learning outcome (LO) we understand skills, knowledge, and competences [6] provided by an educational institution. In this paper the management of learning outcomes is discussed in the following context:

- We consider learning outcomes of study courses which are part of a particular study program;
- We distinguish between learning outcomes of a particular study course and learning outcomes of the study program as a whole;
- We recognize that learning outcomes of a study program can be summative as well as cumulative;
- We assume that study courses and the study program are assessed with respect to particular industrial skill frameworks;
- We assume that study programs are assessed with respect to particular accreditation standards, e.g., ones defined by EQANIE [4];
- We assume that study programs are run by educational institutions such as universities;
- We consider university as a subsystem of an educational ecosystem [10]. This ecosystem consists of several interdependent subsystems, namely, *educational institutions* that provide education, *scientific institutions* that influence the content of study courses in line with new scientific findings, *industrial organizations* that seek professionally well educated employees and *administrative bodies* that support and assess educational institutions. In the paper we address the following above mentioned subsystems: educational institutions (via learning outcomes and course descriptions); industrial organizations (via skill frameworks), and administrative bodies (via accreditation criteria).

In this context, learning outcomes of a study course or study program are under two systems of assessment, namely (1) education quality assessment system of accreditation bodies and (2) skill frameworks defined by professional or mixed (professional and educational) institutions. Therefore it is important to know whether the learning outcomes correspond to the assessment criteria and skill framework elements (Fig. 1).

To see the correspondence, three conceptual links are important: (1) the link between learning outcomes and skill frameworks, (2) the link between learning outcomes and accreditation criteria, and (3) the link between relevant accreditation criteria and relevant skill frameworks. It is obvious that when two of these linkages are established the third one can be derived from the existing ones.

In the next section we propose a learning outcomes management technology that is based on the possibility of establishing links between the elements of hierarchical conceptual structures. The essential feature of the technology is its capability to establish direct and indirect linkages between multiple hierarchical conceptual structures. This feature (discussed in more detail in Section V) is needed because of the variety of skill frameworks that are relevant for one and the same study program. For instance, for study programs in the area of computer science and information technology such skill frameworks as European e-CF [2] and skill frameworks based on so-called Bodies of Knowledge

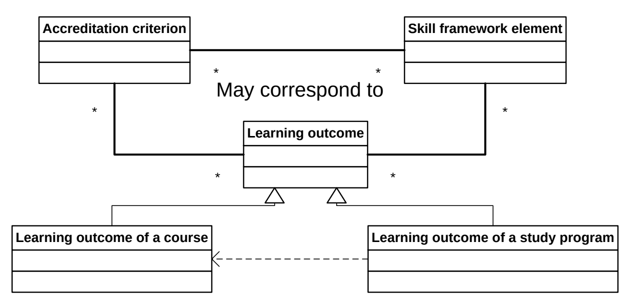

Fig. 1. Learning outcomes management context (meaning of all three binary relationships is “May correspond to”)

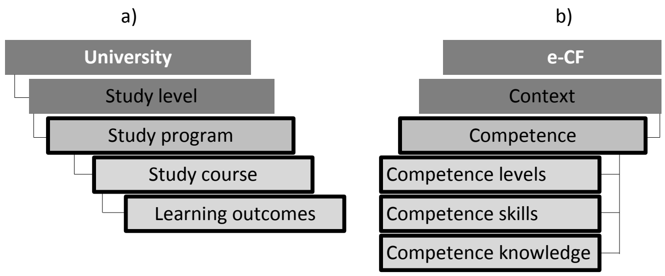

Fig. 2. The structure of study program (a) and e-CF (b).

(BOK) - Business Analyst BOK [8], Software Engineering BOK [7], Project Management BOK [13] are some examples of relevant frameworks. From the point of view of technology the accreditation criteria, study programs and skill frameworks can be considered as hierarchical conceptual structures and treated the same way.

IV. Learning outcomes management technology

A description of the technology is illustrated using e-CF – a comparatively well-known skill framework that has originated as a result of cooperation between representatives of industry and universities of several EU countries. This framework is relatively easily absorbable by industrial and educational institutions operating inside the boundaries of EU [12], [14]. We have selected a simplified structure of a study program (usually there are additional levels) to identify the possible linkage between learning outcomes and e-CF. The structure of study program and e-CF is illustrated in Fig. 2.

The study program thus is represented as a hierarchical conceptual structure with study course as one of the levels of the hierarchy and learning outcomes as a level of hierarchy with a smaller conceptual granularity. The e-CF competence levels and corresponding skills and knowledge are at the level of smaller conceptual granularity.

A. Linkage

One of the goals of the learning outcomes management technology is to link LO to a particular competence of e-CF and determine the overall competence level according to study program. The following linkage options should be considered between two linkable conceptual structures (namely study program and e-CF):

1) *One-step linkage*. One or multiple LOs of courses could be linked to the competence, competence level, competence skill or competence knowledge. Skills and knowledge provided in e-CF 4th dimension are just examples and are not limited to, in particular, competence [2]. Therefore LO linkage to the skills and knowledge defined in e-CF is not provided. The direct linkage of LO to a particular level of competence is not always obvious because there is no way of assuring that one LO could be linked to only one competence and only one level of competence. Usually the level of a particular competence is obtained by a group of LO. There can also be situations where one LO could be linked to several levels of competence. Therefore the two-step linkage case is introduced.

2) *Two-step linkage*. In this case one or multiple LOs of courses could be linked to competence and re-linked to competence level. The first step (linkage to competence) is described in this and B subsection, the second (re-linkage to competence level) is described in subsection C.

The following relationship types are used to link LO to the competence: *part-of* and *instance-of*. *Part-of* relationship is representing the contribution of a particular LO (in terms of skills or knowledge) to a particular competence, i.e., LO is *part-of* the competence. The "part-of" relation is frequently used when linking a LO to competence; meaning that multiple LOs should be obtained in order to achieve some particular competence. *Instance-of* relationship is used when the LO is described as a competence (not skill or knowledge) and linked to e-CF competence. LO linkage to competence is illustrated in Fig. 3 (see "Step 1").

B. Weighting

Usually educators evaluate LO significance with respect to one or more competences. This could be done by weighing the relationship between LO and competence. Significance to the

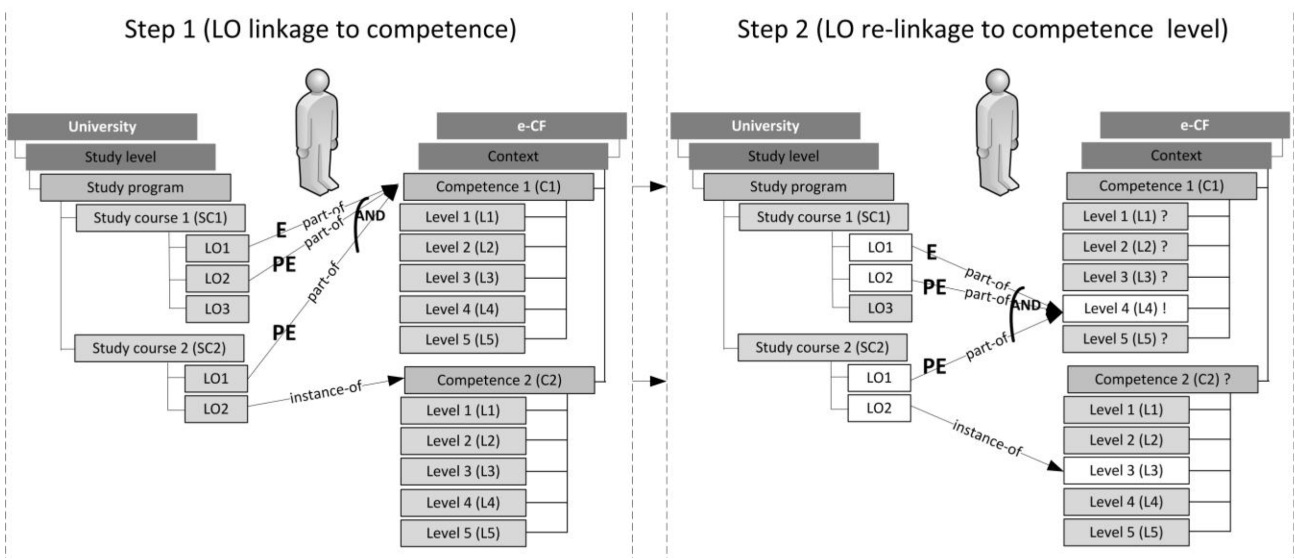

Fig. 3. Two-step weighted learning outcome linkage to e-CF

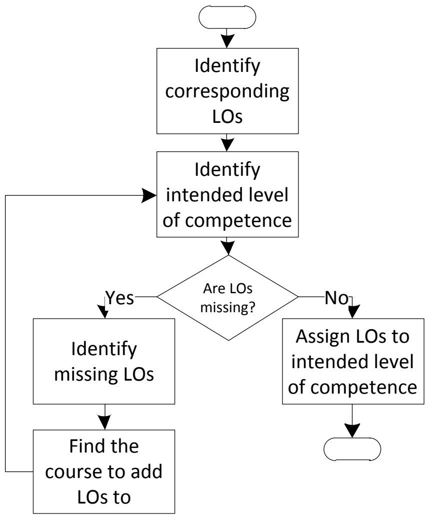

Fig. 4. Process for LOs linkage to intended level of competence

competence could be weighed subjectively as *essential (E)* or *partially-essential (PE)* (see Fig. 3). This weighting become important when identifying the LOs linked to a particular competence – it clearly shows how significant the LO is in acquiring a particular competence (competence level). A short description to the link could be added to obtain more details about the linkage. Linkage of two nodes thus has such attributes as node from, node to, type and weight (*essential* or *partially-essential*), and description.

C. *Determination of competence level*

In evaluation of a set of LOs linked to a particular competence with a *part-of* relationship, the next step is to determine the LOs' correspondence to a particular level of competence. Firstly, an expert should evaluate LOs according to three components of the level of e-CF competence [3]:

- autonomy (ranges between "responding to instructions" and "making personal choices"),
- context complexity (ranges between "structured - predictable" and "unpredictable - unstructured" situations) and
- behaviour (ranges between "the ability to apply" and "the ability to conceive")

Secondly, the expert should re-link the set of LOs to the chosen level of competence (see Step 2 in Fig. 3). Thus each available level of competence is considered and linkage to the most suitable one has to be obtained. If it is not possible to find a suitable level of competence the necessary LOs (skills and knowledge) have to be identified; then the course should be found to add new LOs in order to achieve the intended level of competence (the process model in Fig. 4)

Relationships of *instance-of* type should also be checked and assigned to a particular level of competence. In order to assign one LO to a particular level of competence it is necessary to determine whether the LO includes useful skills and knowledge satisfying the whole level of the competence.

The second step of linkage (re-linkage) usually has to be repeated, because the set of LOs linked to competence (competence level) can change – new LOs can be added to the competence and existing LOs can be updated or deleted.

D. *Usage*

By exploiting the two-step linkage method, benefits could be viewed from two perspectives, namely e-CF and study program/course perspectives.

From the *e-CF perspective* finding LOs supporting a particular competence or competence level becomes possible. Because of relationship weighting evaluating the significance of linked LOs becomes possible, thus identifying the most significant courses to be obtained. Linking LOs to e-CF competences could result in e-CF adjustment for university needs because skills and/or knowledge included in LOs could be added as new skill or knowledge examples to the 4th dimension of e-CF. When linking new LOs it would be easier to select the particular competence by firstly evaluating the extended set of skill and knowledge examples.

From the *study program/course perspective* finding competences and competence levels corresponding to study program/courses based on LOs becomes possible. Thus the coverage of e-CF by a particular study program can be monitored and used for decision support in the curriculum development process.

V. Extending current technology

Currently we have developed a tool for supporting the linkage between hierarchical structures, such as study programs and competence standards (not limited to these two). Initially we have defined the study course as a leaf level of the hierarchy in the study program and linked courses to levels of competences. Evaluation of this approach revealed the necessity to obtain the linkage between competences and study program elements (nodes) of a smaller granularity such as learning outcomes. The first results of using the tool showed also that linking the course to a whole level of the competence is not correct because one level of the competence usually is not obtained in one only course. This has also motivated the use of learning outcomes instead of courses as leaf elements in the study program conceptual hierarchy and linking them to particular competences of e-CF by using the two-step weighted linkage method described in Section IV.

Thus the study program hierarchy was extended by learning outcome level (see Fig. 2 a). Physically the learning outcomes are represented in the university study program and course management system. Therefore import procedures were carried out in order to make them available in the tool. The tool currently supports direct linkage between any two hierarchical structures and the definition of the following relationship attributes: node from, node to, and description (see Fig. 5). The following further extensions are possible: introduction of advanced information representation capabilities, new analytical operations, inclusion of additional skill frameworks and use of indirect linkage.

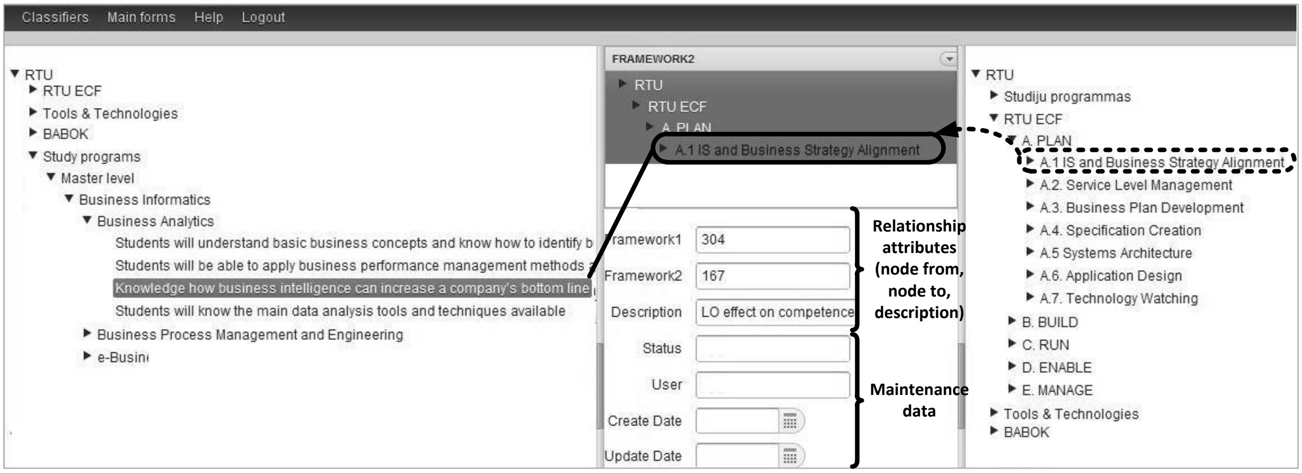

Fig. 5. Prototype supporting linkage between LO and e-CF

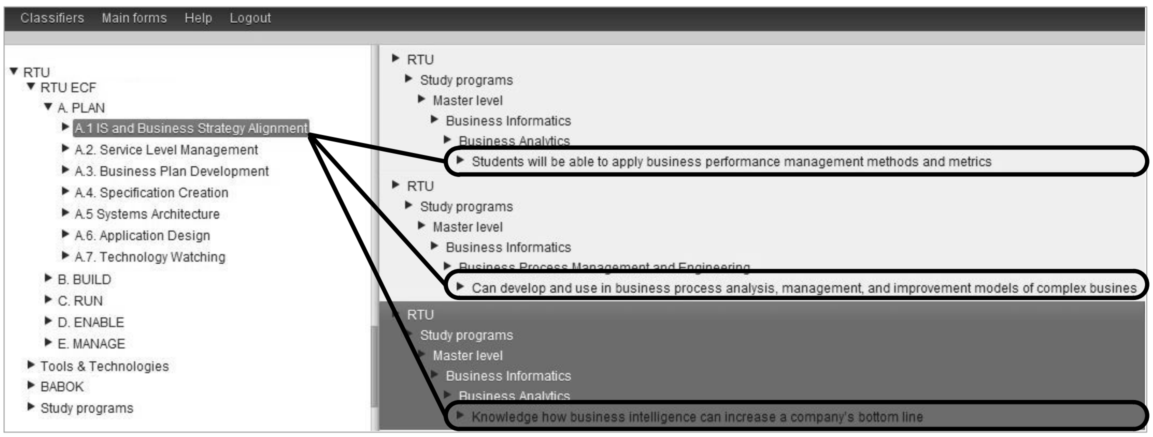

Fig. 6. e-CF perspective (LOs corresponding to competence)

A. Information representation and operations

Currently the tool supports direct representation of linked nodes (as in Fig. 6 – e-CF perspective), i.e., the option of displaying child and parent level linked nodes is not possible. Thus obtaining a full view on competences and levels of competence covered by a study program is hindered. For instance, if a course is clicked then all competences linked from the course learning outcomes cannot be presented to the user of the tool (also identifying cases when competence is composed of learning outcomes from different courses).

As proposed above such relationship attributes as weight and relationship type should be added to support weighted linkage. Functionality of the tool such as re-linkage of groups of LOs to levels of competencies should be implemented to support the second step in the proposed technology. It could be facilitated by the implementation of filtering operations (see Fig. 6 – e-CF perspective) that allow information representation based on weights and relation types.

B. Additional frameworks and indirect linkage

Taking into consideration the emerging usage of various qualification and competence standards additional frameworks could be added to the tool and linked to course learning outcomes. The frameworks themselves could be interlinked, thus also facilitating the indirect linkage of hierarchical structures. Indirect linkage becomes possible because of usage of some frameworks as mediating structures. The framework can serve as a mediating structure if it has links to at least two other hierarchical conceptual structures. Then these structures can be linked indirectly on the basis of their linkage to the mediating structure.

Study program when evaluated by industrial enterprises can be linked directly or indirectly to several frameworks. Fig. 7 illustrates the situation when study program (1) as a hierarchical conceptual structure is linked to other hierarchical structures, namely competence framework e-CF (2); job position framework (3) which represents conceptual structure of job descriptions of a particular enterprise; tools and technologies framework (4) that reflects the taxonomy of ICT tools and technologies that can be used in different ICT job positions and also in university courses; and IIBA competency model [9] (5).

Table I shows how different frameworks can serve as mediating structures to obtain indirect linkage between study program and job position frameworks. For instance, it is very hard to obtain direct mapping between study courses and job descriptions, however both university representatives and industry representatives can map study courses and job descriptions to e-CF. Thus indirect mapping (linkage) of study

TABLE I
EXAMPLES OF PATHS AND MEDIATING STRUCTURES FOR STUDY PROGRAM TO JOB POSITION FRAMEWORK INDIRECT LINKAGE

Nr.	Path length	Path	Mediating structures
1	2	1→2→3	Competence framework (2)
2	2	1→4→3	Tools & Technologies (4)
3	2	1→5→3	Qualification framework (5)
4	3	1→2→4→3	Competence framework (2), Tools & Technologies (4)
5	3	1→2→5→3	Competence framework (2), Qualification framework (5)
6	3	1→4→2→3	Tools & Technologies (4), Competence standard (2)
7	4	1→2→4→5→3	Competence framework (2), Tools & Technologies (4), Qualification framework (5)
8	4	1→2→5→4→3	Competence framework (2), Qualification framework (5), Tools & Technologies (4)
...	...	...	...

courses and job descriptions can be maintained (row 1 in Table I).

In general the following options of linkages are possible:

- Direct linkage between source and target conceptual hierarchies;
- Indirect linkage through one mediating structure;
- Indirect linkage through a set of related mediating structures.

Accreditation criteria can be represented as a hierarchical conceptual structure, too. Thus learning outcomes of study program's study courses can be linked to the criteria directly or indirectly via a non empty set of mediating structures, which are mutually linked if there is more than one structure in the set (Fig. 7).

This way the study program is linked to accreditation criteria directly. It can also be related indirectly in case the criteria are linked to one of the mediating skill frameworks, e.g., e-CF. This shows that the linkage of learning outcomes and skill frameworks can make the accreditation process more transparent and easier due to automatically obtainable

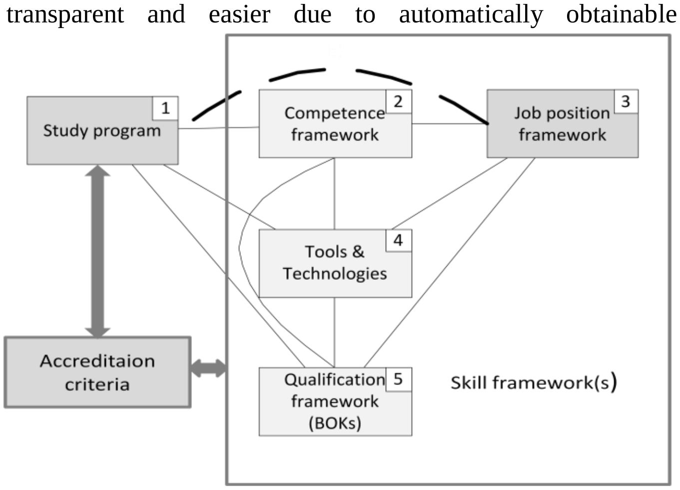

Fig. 7. Linkages between study program and accreditation criteria

correspondences between learning outcomes and evaluation criteria. The evaluation criteria themselves can be related to particular frameworks of knowledge, skills, and competences such as national qualification standards [11], International Standard Classification of Education ISCED-1997 [21], and The European Qualifications Framework for lifelong learning (EQF) [1]. These linkages can be utilized in learning outcomes management technology, too.

VI. Conclusions

The existing research shows that not only universities but also companies and professional organizations are players in the education sector. Companies and professional organizations have developed and promoted widely known and generally accepted standards and skill frameworks for specific areas that differ from conceptual frameworks of Universities' study programmes in terms of ease of understanding and extent of applicability. In order to ensure correspondence among all players learning outcomes management technology can be applied that gives a possibility to link directly or indirectly study programs, skill frameworks, and accreditation criteria.

One particular study program can be related to several skill frameworks. It is a matter of choice how mappings are made, i.e., whether the learning outcomes of the study program courses are linked to all of these frameworks directly or mediating structures are used. Frameworks differ one from another in terms of the level of abstraction with respect to particular concepts as well as the scope of conceptual coverage. In case some linkages between frameworks already exist it is easier to establish new linkages. However it has to be taken into consideration that due to the areas that do not map in mediating structures some links to indirectly related hierarchical structures may be missed.

Compliance to particular industrial frameworks may ensure compliance to particular accreditation criteria if they correspond to these frameworks. Therefore the learning outcomes management technology discussed above may help to transparently see the correspondence between learning outcomes and accreditation criteria.

Accreditation standards, on one hand, are less specific than skill frameworks; however, they also include issues that are not part of skill frameworks. This leads to the conclusion that learning outcomes management technology can be helpful but cannot replace all manual accreditation procedures. Industry related learning outcomes representation is possible and can bring the following benefits:

- University can control the relationship between knowledge provided and knowledge requested by the industry;
- Students can see how the courses they are taking relate to their potential job contents;
- It can facilitate continuing education and on-demand course development;
- It helps to maintain transparency in cooperation of the different subsystems of the educational ecosystem.

Nevertheless, achieving a highly precise linkage is a matter of further research. Some directions of future research were already outlined in the paper, such as link weighting that shows learning outcome significance in obtaining a particular competence; identification and representation of relevant competence levels; indirect mapping management, etc. With respect to study program evaluation only additive learning outcomes are currently taken into considerations. Specific algorithms are to be included in the learning outcomes management technology to detect cumulative learning outcomes that emerge as a result of synergetic effects among the study program subjects.

First results of using of technology showed that industrial representatives appreciate transparency in skill framework and study course correspondence representations. Taking into consideration the steady growth of a number of skill frameworks, the application of above mentioned technology may help universities to manage in a jungle of different skill frameworks and quality assessment criteria that are related at different levels of abstraction and to a different extent in each of these levels. This ability to manage the learning outcomes can help universities to be responsive to different needs of individuals and organizations that use and assess knowledge, skills, and competences provided by the educational institution.

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