

Development of Ontology Based Competence Management Model for Non-Formal Education Services

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Abstract – Competence management is a discipline that recently has regained popularity due to the growing demand for constantly higher competences of employees as well as graduates. One of the main implementation challenges of competence management is that, as a rule, it is based on experts' implicit knowledge. This is the reason why the transformation of implicit knowledge into explicit knowledge practically is unmanageable and, as a consequence, limits the ability to transfer the already existing knowledge from one organisation to another.

The paper proposes an ontology-based competence model that allows the reuse of existing competence frameworks in the field of non-formal education where different competence frameworks need to be used together for the purpose of identification, assessment and development of customers' competences without forcing the organisations to change their routine competence management processes. The proposed competence model is used as a basis for development of competence management model on which IT tools that support a competence management processes may be built up. Several existing frameworks have been analysed and the terminology used in them has been combined in a single model. The usage of the proposed model is discussed and the possible IT tools to support the competence management process are identified in the paper.

Keywords – Competence management model, competence model, non-formal education, ontology.

I. INTRODUCTION

The necessity to manage competences as a measurement of ability to complete assigned tasks has been introduced in [1] and later supported in [2]. Since then there have been numerous efforts to define what the term really means. The definitions of competence tend to be understood by experts in cases of human resource management or subject matter experts in a particular field but even then, their understanding is frequently challenged by other experts and even more frequently by people who are subjects of the competence assessment processes. The reason of such uncertainty is the fact that usually competence management is based on experts' implicit knowledge, which practically is impossible to transform into sound definitions that are characteristic for explicit knowledge that may be identically interpreted by all users.

Empirical findings often indicate that both employees and managers of companies consider competence assessment to be

entirely subjective and linked to the individual interpretation of the assessment maker. They also indicate that there is certain dissatisfaction within the ranks of employers who expect a certain level of competence from the graduates of schools and universities that could be readily applicable to work situations, yet the graduates show inability to complete their tasks which is attributed to the lack of required competence. This facilitates the belief that some education institutions are unable to prepare employees for their tasks, and in extreme cases raises questions whether the education is valuable at all. This forces the education institutions to rethink their strategies in order to provide the best service possible. From this viewpoint, there is a significant difference between the so-called formal education institutions as we shall call government founded and private schools and/or universities that follow the predefined curricula and non-formal education institutions that provide specifically selected courses on request mainly for employees coming from different organisations operating in diverse fields. The latter are much more flexible concerning requirements of rather wide spectrum of customers.

Non-formal education providers have been seen as a quick fix for the development shortages of employees. The training that such education providers provide usually is shorter and should be directly related to tasks at workplace. As such the training is expected to show instant results. Non-formal education providers are under even more pressure to provide improvement of competences after the training than schools and universities.

Recent trends in the European Union (EU) indicate attempts to standardise competence management by developing appropriate frameworks for specific needs and requirements. These frameworks tend to be industry specific or related to specific sets of skills prioritised by certain groups like employers of particular field of business or strategic priorities set by countries. Competence frameworks like e-Competence Framework [3], DigComp [4], EntreComp [5] have been established to act as a guideline for managing competences in respective fields. On a smaller scale, competence frameworks have been formulated more or less successfully on the country level. For example, in Latvia there are competence frameworks developed for certain positions in government institutions.

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Large companies also develop their own competence frameworks that are limited to their own needs.

All these frameworks tend to have typical characteristics. They cover a limited number of competences that are subject specific, e.g. e-Competence Framework (eCF) includes competences that are essential to ICT professionals, while DigComp includes competences that are related to the use of digital tools in everyday life and thus are beneficial for the EU citizens. This corresponds to the idea of core competences introduced in [6] and has allowed the creators to build smaller and more specialised frameworks. These frameworks have not been necessarily built to be used together with others and there are difficulties to apply them to situations where someone would want to apply parts of several existing competence frameworks at the same time. For example, if a non-formal education provider wishes to offer competence development solutions that would integrate IT and entrepreneurship competences, they would need to figure a way of how to treat them in the same way. This is why a clearly formulated basis for the use of different competence management approaches and different frameworks at the same time is needed. It will help a non-formal education provider reuse different existing competence frameworks and lists of competences together as a unified system by establishing a common description of concepts that could be applied to the existing frameworks not forcing the organisations to change the language used for competence management, but at the same time still providing relevant competence management services. This is the motivation to create in some sense the universal ontology-based competence model as well as the ontology-based competence management model on which the paper is focused.

The rest of the paper is organised as follows. In Section II, the overview of related works is given. In Section III, the background for the development of the universal competence model is discussed and the proposed model is presented. Section IV concerns the proposed ontology-based competence management model. The paper ends with some conclusions and the outline of future work.

II. RELATED WORKS

Competences as a concept have been used by several authors starting from the introduction of the idea by McLelland in 1973 [1]. At the same time, it is worth stressing that often this concept is considered as a fuzzy concept [7]. Slightly different definitions of the concept have been used in publications [8]–[11] and adopted by the competence frameworks built for specific needs [3]–[5]. A common agreement is that competence as a concept includes knowledge and skills, but the opinions differ on what other elements are parts of competence concept. There are also arguments about the relationships between a competence itself and other elements. In [8], the idea of competence as an aggregate sum of other elements is introduced. Yet more, competence descriptions are often considered to be industry specific [12] or it is even advised to make them specific to the individual organisation [10]. This is based on the idea that such competences will be better accepted by employees of each individual organisation.

Competence-based management, in its turn, is considered as a valid approach to human resource management in different organisations [13]. Best practice for applying competence management principles to human resource management in organisations has been described in [10]. If competence management is introduced at an organisation, a competence management system might be used as part of tools for human resource management [9]. Building of a competence management tool or system often is based on the needs expressed by the management of the organisation acquiring the tool as suggested by [14] for a competence management tool for manufacturing small and medium-sized enterprises (SMEs).

Modelling competences by using ontologies has been considered to be a valid approach in [15] and attempts to define competence ontologies have been performed in several works. Using competence ontologies as a means to facilitate common understanding of the concepts and their relations has been supported by [16] when defining their ontology for the competence gap analysis for education purposes. Professional learning ontology has been proposed in [15] using the idea of learning opportunities. Competence ontology for the use with e-learning and integration with human resource applications has been described in [13]. Competence object library and a model of competence management as a production process have been done in [12]. A model of linking competences to proficiency levels and context of use has been created in [17].

However, there is an issue of a very dynamic environment of managing competences of several organisations at once (some with already adopted competence frameworks) by a non-formal education service provider that requires the ability to interpret the different approaches and still provide competence management services. According to World Economic Forum, 54 % of all employees will need to change and increase their existing skills that will require additional training. According to the study, these employees will need training in competences related to new technologies as well as ‘human’ skills. Approximately 42 % of all skills possessed by employees will have to change by year 2022. The amount of training required will measure up to 6 months for 35 % of all employees and even longer for 19 % of them [18].

It can be expected that some kinds of required training will be performed outside of formal education institutions due to the dynamism of demands. Non-formal education is institutionalised, intentional and planned by some education provider [19] that provides this type of education, which can be considered part of life-long training that is an alternative to formal education. Non-formal education provides additional qualifications that are needed by employees to be successful in the labour market, usually not recognised by education authorities but acknowledged by employers as being beneficial for their organisations.

Non-formal education provided by a provider company is related to vocational training. Vocational education and training (VET) aim at providing people with knowledge, know-how, skills and competences required for particular occupations [20]. Successful completion of vocational education is acknowledged by the labour market [19]. Important

characteristics of VET are that the programs are less standardised, benefit from competence-based education and rely on competence-based standards [21].

III. THE ONTOLOGY BASED COMPETENCE MODEL

The goal of the study is to create a universal competence model for the integration of selected competence frameworks and company specific competence models. Thus, it can be used as a basis for competence management services at non-formal education institutions. The competence model in question should be able to allow for a better understanding of the subject of competence itself and serve as a starting point for the development of IT supported competence management tools.

A. The Background

Usually a team of researchers who need to reach a common understanding of the specific domain knowledge for its analysing, sharing and reusing, as well as for making domain assumptions explicit propose an ontology [22]. The role of ontology is to establish a common language between problem domain experts [23] and to represent it in a form that is shareable both between experts and software agents [24]. The competence management field is populated by various competence frameworks that are based on experts' opinions. It often lacks a means to easily link competences from one framework to another. There already have been attempts to define competence ontologies [9] but usually they are built with a specific goal in mind. Thus, these attempts are not suitable for integration of different selected competence frameworks.

The paper proposes a new ontology-based competence model that can be used as a basis for providing competence-based education and other competence management services. The model is defined so that it can be reused in existing competence frameworks that are industry or company specific. The model provides a clear understanding of existing competences defined in the frameworks, offers guidelines for the establishment of competence management process description at non-formal education provider and acts as a basis for development of competence management system and support tools for competence management services. All concepts that have been included in the model were acquired from three types of sources – scientific publications, results of analysis of three competence frameworks recognised by the EU and results of analysis of descriptions of competence frameworks and competence management approaches by several organisations in Latvia. The initial list of concepts related to competence management was discussed at expert workshops. In total, 10 experts were invited to participate – 4 experts from the education field, 4 experts from the ICT field and 2 experts from business management.

The frameworks under analysis were the European Framework for ICT Professionals or e-Competence Framework [3], Digital Competence Framework for Citizens or DigComp 2.1 [4] and the European Entrepreneurship Competence Framework or EntreComp [5]. The organisation specific competence management approaches were based on a study of 26 organisations that included public service organisations, ICT companies and selected small enterprises

from various fields as part of project supported by ERDF (see acknowledgment at the end of the paper).

An ontology-based competence model has been formulated in order to represent the understanding of the concept as it is related to the needs of non-formal education provider that is involved in competence management process for their customers. After that a competence management model has been created to establish the main concepts that are related to the service, in which a non-formal education provider is involved.

B. The Competence Model

At the very beginning of competence model building, the definition of competence per se is needed. The definition used in the paper is based on the existing definitions used by different authors, though with some modifications. Usually competence is described as consisting of knowledge, skills and attitude or KSA, in brief [10]. There are variations in the definition, which suggest that the competence also includes personal beliefs, character traits and other attributes [9], [10], [11], but the authors of the present paper interpret them as being related to characteristics of human being. Since attitude is also related to these characteristics, it is reasonable to combine all other things into the concept of attitude.

Another aspect of competence is that it typically is viewed as something that needs to expose itself in action or in the behaviour of a person that possesses the competence [13], [25]. However, it must be taken into account that a specific action may depend on the level of competence possessed by the employee of an organisation.

It is also worth mentioning that the proposed competence model (see Fig. 1) has been based on the idea that there are many different competences in various fields that could be beneficial to the employees of various organisations.

For the purpose of the competence model, the concept of competence has been defined as a composite concept that consists of three parts, namely, Knowledge, Skill and Attitude. Thus, in the competence model depicted in Fig. 1 there are four concepts, three pairs of which are linked using the relationship PartOf (see Competence – Knowledge, Competence – Skill, and Competence – Attitude). It is needed to stress that in practical applications there may be cases when each competence may have some number of each KSA. There are several reasons behind this. Knowledge, Skill and Attitude which are assigned to a Competence can act as additional description that explains what the Competence is in essence. In other words, this idea helps describe a competence better. In addition, these parts of Competence may help in employee's assessment as well as in the development of sub-processes as guidelines.

The approach used in the paper is not the only one that is possible. Separate concepts for competence and KSA have been incorporated in ontologies by [16] and the need to process knowledge and skill has been acknowledged by [12]. Contrary, some authors seem to use the concepts of competence and skill more as substitutes and their considerations for ontologies do not necessarily consider the need to separate them [14]. Instead, they use the idea of sub-competences.

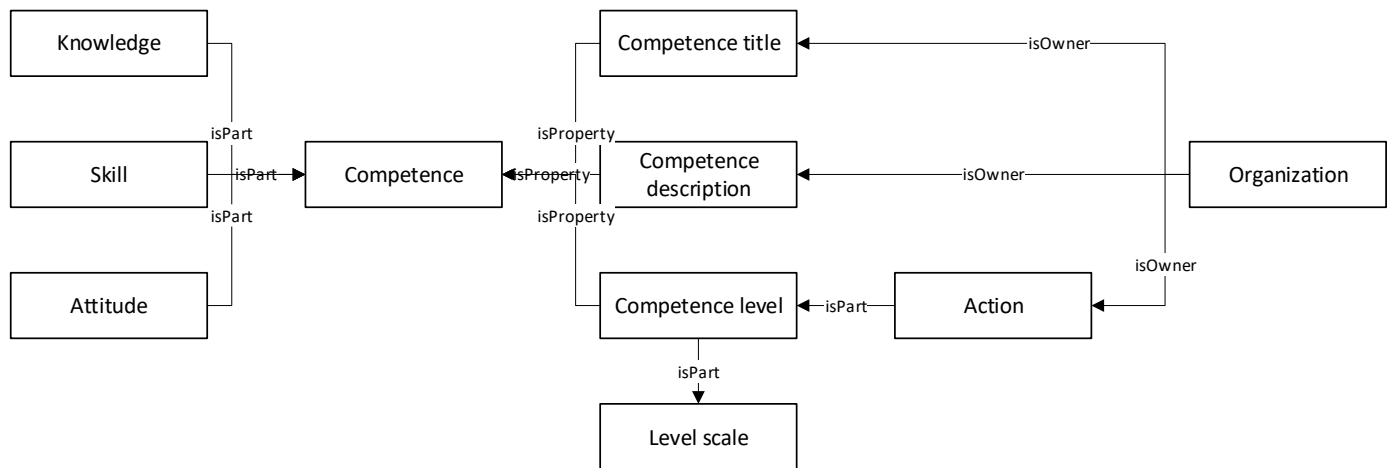


Fig. 1. The universal competence model.

The model also includes the identified attributes of a Competence – CompetenceTitle, CompetenceDescription and CompetenceLevel. The need to identify CompetenceDescription and CompetenceLevel has been expressed by several authors, too [13], [15]. The CompetenceTitle usually is not considered to be part of ontology. However, for the purpose of using this competence model for the support of competence management process, CompetenceTitle is important as the same competence may be called differently by the organisations and some of the titles may be used simultaneously by competence management service provider.

CompetenceLevel is used as a means to grade better or worse performance of the person that has the Competence. This is represented by defining Action as being part of CompetenceLevel. CompetenceLevel, in turn, is part of LevelScale. Some authors have stressed the need to define CompetenceLevel within the boundaries of some levelling scale. For example, authors of [9] have defined a concept of skill description level that has values for a fixed set of competence levels. The proposed model uses LevelScale in a slightly different manner. It is made under assumption that there may be more than one LevelScale used at the same time for different or even the same competences depending on the organisation's requirements. Assignment of a CompetenceLevel to a LevelScale serves the purpose of managing different instances of competence levels into different sets of level scales.

Organisation is a concept that is included in the model to represent the situation where every organisation that uses competences uses them according to their individual needs. This idea has been identified as context by several authors [12], [17]. For the purpose of the present study, Organisation acts as a context for the application of Competence and determines the definition of CompetenceTitle, CompetenceDescription and Action that corresponds to CompetenceLevel.

IV. THE ONTOLOGY BASED COMPETENCE MANAGEMENT MODEL

The competence model in Fig. 1 has been used as a basis for the competence management model (see Fig. 2) discussed further on. The competence management process is divided in three sub-processes, all of which use Competence as a building block. These sub-processes are competence identification, assessment and development.

The model takes into account that competence management is related to other human resource and business management processes in the organisation as well. Some notable processes are goal management, performance management and human resource management. These processes can be viewed as separate but for the purpose of competence management as a service offered by a provider, they are closely related to competence management. Therefore, they are interpreted as part of the competence management concept in the proposed model. At the same time, it must be mentioned that goal management is sometimes considered as a separate process from competence management. For instance, the authors of [10] also recognise the need to adjust the competence management to the specific needs of an organisation and its goals. In the developed model, concepts of Goal and Task are interpreted as the context of being involved in the competence management process. Both Goal and Task are considered as a trigger that initiates management of specific competence.

Below the competence management model is discussed in three parts according to the sub-processes of identification, assessment and development. For all three sub-processes, five general relationships have been defined between the classes:

- PartOf – the first class is part of the second class;
- isReason – the first class is the reason why the second class exists;
- isAuthor – the first class is the creator/author of the second class;
- isOwner – the first class uses the second class in the process, the first class claims ownership over the second class;
- isPerformer – the first class performs the second class.

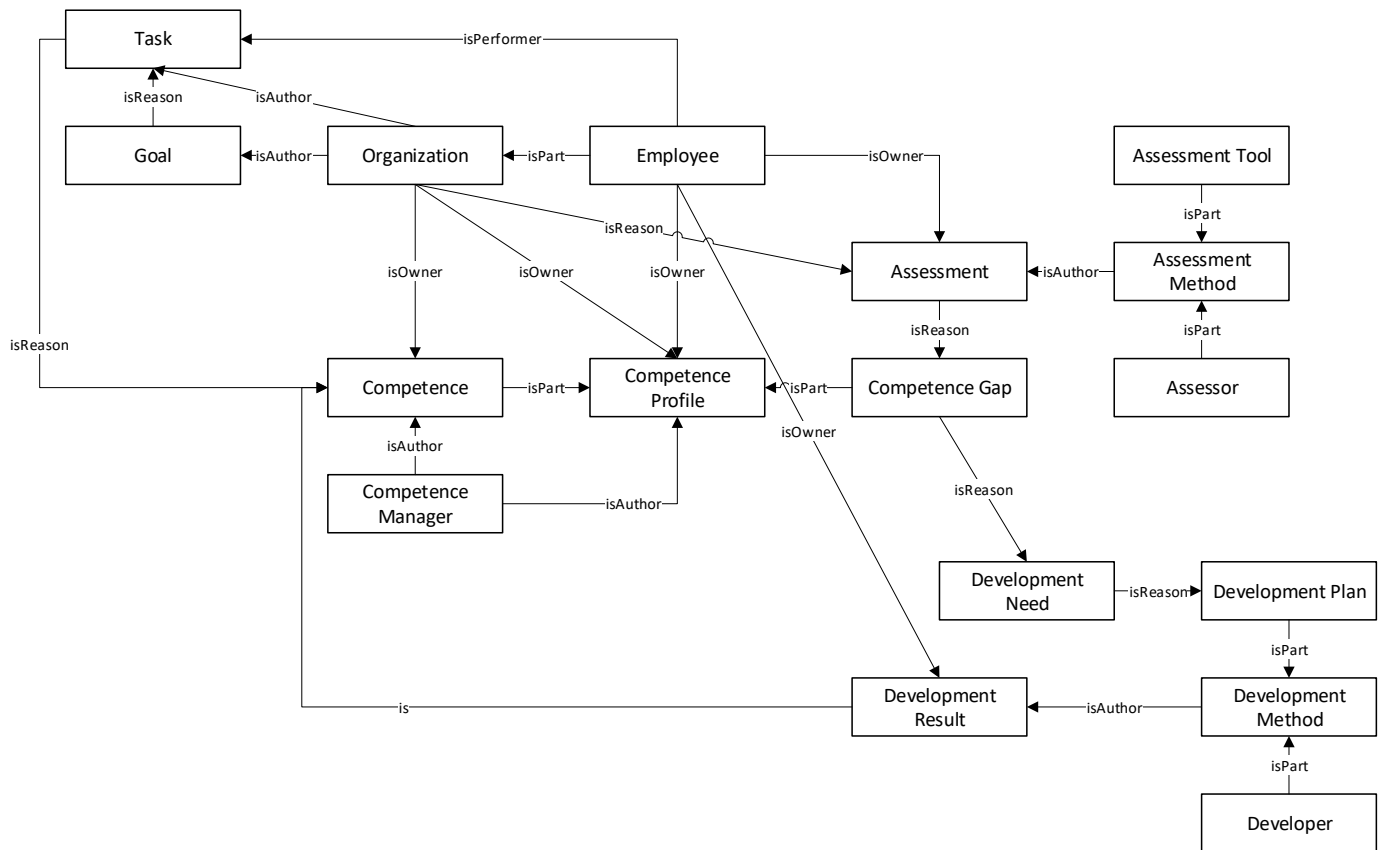


Fig. 2. The ontology based competence management model.

Competence identification part of the model is explained as follows. Any Employee is part of Organisation that determines the Goal to be reached. The Goal is the reason why the Task must be completed. The Organisation determines which Task must be completed. The Employee completes the Task because he/she has the required Competence. Therefore, the Task that is identified is the reason why the Organisation needs to be involved in the Competence management of the competence that is assigned to the Task. The Organisation is the owner of Competence because it has identified the Task that requires this Competence. The Organisation is also the owner of all CompetenceProfiles that are required for Tasks to be completed. The Employee is the owner of the CompetenceProfile that is required for the Tasks that are specific for this Employee. In [12], [17] the idea of required and acquired competence profiles is presented and its interpretation is discussed later on.

Competence assessment part of the model may be explained in the following way. The Organisation initiates the Assessment of Employee competence. On an occasion the Employee as the part of Organisation can initiate the Assessment of competence. This, for example, would manifest when an employee performs self-assessment, e.g., the Employee performs the Assessment by applying the AssessmentMethod, which in this case has an individual instance – Self-Assessment. Assessor and AssessmentTool are part of AssessmentMethod that produces Assessment. Each Assessment that is created by AssessmentMethod belongs to Employee. Employee is the

owner of his or her Assessment. Assessment is the reason why CompetenceGap is created. CompetenceGap is the difference between the required and acquired competence level that is part of CompetenceProfile (or required and acquired competence profiles, respectively). Therefore, CompetenceGap may be interpreted as Assessment, which is expressed in a specific form and as such is part of CompetenceProfile. Finding competence gaps is considered to be one of the functions of a competence management system [25]. Competence gap (by the way, sometimes the term of skill gap takes the place of this term) is a subject of analysis and a basis for decision making [13]. In case if the competence gap is identified, it becomes the starting point for competence development.

CompetenceProfile is a set of Competences that is owned by Organisation or by Employee. The distinction is made here because of required and acquired CompetenceLevel. Organisation sets the required Competence and the required CompetenceLevel, while Employee is the owner of acquired Competence and acquired CompetenceLevel. CompetenceProfile can also be interpreted as a set of CompetenceGaps that have been created by applying Assessment to Competences owned by Employee.

Now let us discuss the third part of the proposed competence management model, that is, competence development. A CompetenceGap that is found during the competence assessment process is the reason for identification of DevelopmentNeed. Any DevelopmentNeed causes creation of the DevelopmentPlan, which together with the Developer are

two parts of DevelopmentMethod that defines the DevelopmentResult. DevelopmentResults are reached by an Employee who develops his/her Competence using the DevelopmentMethod. The DevelopmentResult is Competence that is defined in accordance with needs of Organisation. The last statement declares the idea that the objective of competence development is to acquire or to improve the competence.

At the end of description of competence management model, there is a necessity to mention that it is common to use the term of learning objective or learning object [26] to describe the result of competence development or training in general. Authors of [15] have included the terms of learning object and learning opportunity in their competence ontology, in which both concepts represent the signal that there is a possibility to develop a competence. Since one of the objectives of building the competence management model presented in the paper is the provision of the explanation of competence development subprocess at institutions of non-formal education providers, the concept DevelopmentResult is considered equivalent to the concept learning objective when such tasks as defining the objectives for competence development must be solved.

The ontology-based competence model described here has been applied so far to three case projects that are related to competence management. The goal of the first project included the improvement of an existing competence framework for the employees of a public service organisation. For this case, competences were redefined using clear indicators of competence levels. These indicators are planned to be used for assessment of competence gaps as part of employee evaluation and motivation, and for creation of competence development plans with measurable development results. The project also implied the need to reorganise the existing competence framework for the use with possible competence management tools in the future.

The goal of the second project was to define competence profiles for ICT related positions in various companies that could be used for creation of competence development plans. For this case, required competences, skills and knowledge were defined and competence profiles for several positions were developed. Competences were referenced to existing competence frameworks for ICT professionals based on the clear description of the competences.

The main goal of the third project was to define training modules for competence-based training that would be based on the need of employees of various small enterprises. An additional challenge was to identify development needs and create development plans based on development needs. In this case, existing competence descriptions from two frameworks were used to develop competence profiles for 10 general positions at small enterprises based on the need identified by the market survey. Development plans were defined referencing the competence profiles and development solutions were described using competence descriptions as indicators for development results.

In all three cases, the proposed model could be applied for the needs of supporting the competence management process in non-formal competence-based education.

V. CONCLUSION

The ontology based universal competence model proposed in the paper has been developed for the purpose of the use by a non-formal education provider being involved in competence-based training and offering other competence management services. The model is intended as a usable tool for the non-formal education and competence management service company without compromising the existing procedures defined by its customer companies. As a result, the model may be used as a reference model. This, however, requires the service company to process a list of competences from different sources. Ontological approach to building a competence model was chosen to establish clear links between the possible concepts of competence management and to decrease the chance that a new competence model used by an individual customer company would require changes in the model.

The competence model establishes a means for interpretation of various concepts that may be encountered in individual frameworks. This interpretation is used for competence management model that facilitates the offering of competence management services. It covers competence identification, assessment and development sub-processes and thus enables the non-formal education providers to establish new services related to competence management without forcing customer companies to change their already existing competence management frameworks.

The main interest of this paper has been the description of competence management in non-formal education from an education provider's point of view. This does not however mean that the same idea cannot be applied to formal education environment in general and management of teacher competences in secondary schools in particular. In fact, the same competence model has been applied to describe competence management for teachers in schools as a part of the same research project (see Acknowledgment at the end of the paper). Similarities between the management of competences in both formal and non-formal education environments have been identified when interpreting the education providers as organisations that themselves have employees with possible competence development needs.

The obtained results will be used for the purposes of automation of some of the tasks that are related to competence management. The future research will focus on two areas. First, by formalising the description language of competence management process and establishing links between concepts it will be possible to develop competence management tools that enable efficient support of competence management process as a whole. Second, the developed models will be integrated with competence assessment tools and support tools for competence development process.

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