The Practice of Competence Modelling

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Abstract. A clear understanding of the organizational competences of an enterprise and the underlying individual competences and the competence development needs has become more and more important for many industrial areas as a foundation for competence supply processes and adjustment to changing market conditions. Competence modelling, i.e. the use of enterprise modelling techniques for capturing existing and describing desired organisational and individual competences in enterprises, offers important contributions to this. In the last years, the authors of the paper have performed a number of competence modelling cases, which revealed different characteristics and resulted in lessons learned. This paper presents an examination of different characteristics of competence modelling cases, and recommendations and lessons learned from these cases for the practice of competence modelling.

Keywords: Enterprise Modelling, Competence Modelling.

1 Introduction

Application of enterprise modelling can have many different purposes. Two examples of this are capturing and understanding the "as is" processes and organisational structures in an enterprise, and developing and specifying the "to be" situation as support for process improvement of organizational change processes. In such "as is" or "to be" enterprise models, organization structures and roles often are included, but detailed competence and skill descriptions for the roles are not common practice, since this aspect usually does not have priority in improvement processes. However, a clear understanding of the organizational competences of an enterprise and the underlying individual competences and the competence needs has become more and more important as a foundation for competence supply processes and adjustment to changing market conditions. Examples of relevant industrial trends are flexible supply networks, virtual supplier organizations or network-based sourcing [1], which change traditional long-term sourcing strategies to more flexible composition of teams for given projects.

Competence modelling, i.e. the use of enterprise modelling techniques for capturing and describing organisational and individual competences in enterprises, offers important contributions. Research on competence modelling so far resulted in

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languages and techniques for competence modelling (see section 2), but did not investigate practices. Which are the differences between enterprise modelling practices and competence modelling practices? In the last years, the authors of this paper have performed a number of competence modelling cases, which revealed different characteristics and resulted in experiences. The contributions of this paper are (1) an examination of different characteristics of competence modelling cases, (2) recommendations and lessons learned from these cases for the practice of competence modelling.

The paper is structured as follows: Section 2 will briefly summarize related work in relation to competence modelling. The cases of competence modelling forming the basis for the recommendations and experiences are presented in section 3. Section 4 discusses lessons learned from these cases. Section 5 summarizes recommendations for the practices of competence modelling. Section 6 summarizes the work and presents an outlook to future work.

2 Background to Competence Modelling

2.1 Definitions of Competence

The concept of competence is a rather complex one. In fact there is a large number of definitions of competence and there is none that is adopted by the whole community which spans over several research fields. This makes it important to define concepts as clear as possible. According to Coi [2] there is a distinction between the concepts of *competency* and *competence* where competence consists of three underlying dimensions (competency, context, and proficiency level). Competency represents a skill, e.g. piloting, the context represents the domain in which the skill is performed in, e.g. small civil aircraft, and the proficiency level represents the level at which the competence is mastered, e.g. expert. This makes the definition of competence more reusable since all three dimensions can be separated and reused. Thus, competence can be defined as *"effective performance within a domain/context at different levels of proficiency",* which was originally made by [3] .

There have been efforts made in order to standardise competence models, primarily from three different organisations. HR-XML (developed by the HR-XML Consortium [4]) is a library of XML schemas with focus on modelling of a wide range of information related to human resource tasks. Using such schemas it is possible to define profiles in order to use competency definitions. It specifies data sets like job requirement profiles or personal competency profiles. The former describes competences that a person is required to have. The latter describes competencies that a person has. Such profiles are composed of evidences referring to competency definitions (e.g., IEEE RCD).

The IEEE Reusable Competency Definition [5] is constructed to make it possible to define reusable competency definitions. These definitions are placed in central repositories where they can be reused by communities of competence modellers.

Simple Reusable Competency Map [6, 7] models relationships between competences using directed acyclic graphs. This is an improvement over the IEEE RCD. A map can contain information about dependencies/equivalences among competencies, including composition of simple competences into more complex ones.

2.2 Competence Modelling Approaches

Several models have been developed to provide a systematic evaluation of competences in enterprises. Concerning the evaluation of individual competences, most approaches follow a similar way: (1) the results of socio-human research are used to identify the main models linked to competencies; (2) they provide a formal and qualitative model of the concept of competence; and (3) a mathematical and/or quantitative model is proposed to generate a systematic evaluation of competence levels.

One approach by Harzallah [8] suggests the CRAI model (competence, resource, aspect, individual) associated with axioms based on set theory. The approach aims at describing formal competence in order to provide a mapping between required and acquired competence in an enterprise reengineering context. Competences are characterized by sets of knowledge, know-how and behavior associated to a context and linked to individual actors. Based on a classical evaluation of these characteristics, a mathematical aggregation is suggested to provide a quantitative evaluation of competences.

Another approach is using fuzzy logic for the evaluation of competencies [9]. An aggregated competence indicator is constructed by a fuzzy aggregation of several evaluation criteria through analysis of a work situation using formal tools. The choice of fuzzy methods is motivated by the need to clarify the reasoning of an expert in charge of competency management so that this activity can be at least partially automated. This approach is quite complex and technical but the main point is that it is impossible to define a competency independently of the work situation. This supports the view of the previously described approach where context is an important part of the competency description.

In OntoProPer [10] profiles are described by flat vectors containing weighted skills, which are expressed as labels. Weights represent importance if applied to requirements or skill level if applied to acquired skills. The system itself mainly focuses on profile matching and introduces an automated way of building and maintaining profiles based on ontologies. However, the authors also realizes that maintaining profiles from employees manually is a time consuming task, therefore metadata that is structured according to an ontology and contained in various documents is used. The crawled metadata constitute the foundation for inferences, which derive additional skill data to supplement the explicit skill data in the database.

Very few results concerning evaluation of collective competences have been reported to date. Indeed, socio-human research on collective competence is still recent and the results are not advanced enough to look for industrial engineering-oriented formalization. However, promising trends have emerged: One type of models aims at enabling decision support system to configure groups of actors (teams). Individual competences of actors are mapped against the competence requirements. The configuration of groups of actors aims at a good performance, but the collective competence as such is not evaluated.

2.3 Integrating Enterprise Models with Competence Models

Enterprise modeling is an important tool for strategic planning of any enterprise today. It consists of the process of building models of the whole or a part of an

enterprise with process models, data models, resource models, etc. It is based on the knowledge about the enterprise, previous models, reference models and/or domain ontologies. The term "enterprise model" is used in industry to denote differing enterprise representations, with no real standardized definition. Due to the complexity of enterprises, a vast number of differing enterprise modeling approaches have been pursued across industry and academia. Enterprise modeling constructs can focus upon manufacturing operations and/or business operations; however, a common thread in enterprise modeling is an inclusion of assessment of information technology.

Although this is a well known research field and there are several approaches and modeling languages available, competence modelling has not really been included in the enterprise models. To address this issue the Unified Enterprise Competence Modelling Language (UECML) has been developed [11]. UECML has integrated the concept of competence in the language at three levels; the competence itself, individual competence, and aggregated competence of a group of individuals. UECML quite unique to explicitly integrate human competence in enterprise models.

3 Cases of Competence Modelling in Practice

The research work presented in this paper is motivated by a number of real-world cases, three of them were selected for brief presentation in this section.

3.1 Team Formation at An Automotive Supplier

The first competence modelling case is taken from automotive supplier industries and connected to the EU FP6-project MAPPER [12]. MAPPER aimed at capture reusable organisational knowledge to support product innovation in a networked manufacturing organization. At the end of the project, one of the industrial partners, a first tier automotive supplier from Sweden, decided to continue knowledge modelling for certain enterprise purposes. One of the resulting activities aimed at specifically support collaboration set-up and dynamic knowledge sharing with the suppliers of key technologies for economic and ecologic product innovation. In this context, the existing enterprise knowledge models from the MAPPER project, which described the process of innovation and nine of its core tasks, like “establish material specification” or “develop new test method”, were extended and complemented.

The competence modelling performed aimed at documenting the skills and competences needed for the different roles and tasks in future joint projects involving different partners. The modelling focused on competence aspects like required educational background, occupational competences, competences regarding specific design concepts and solutions, and skills of test methods and procedures. The models from MAPPER already included processes, roles, and required resources. The competence modelling extended these models by adding the above mentioned competence aspects for every role. Fig. 1 below shows a small part of the competence model developed. In the upper part, the model of the process for country-specific testing is shown. The lower left section under the process shows the roles involved in the processes; the arrows between role and task indicate the tasks the roles are involved in. For one of the roles, “test specialist (Germany)”, part of the individual

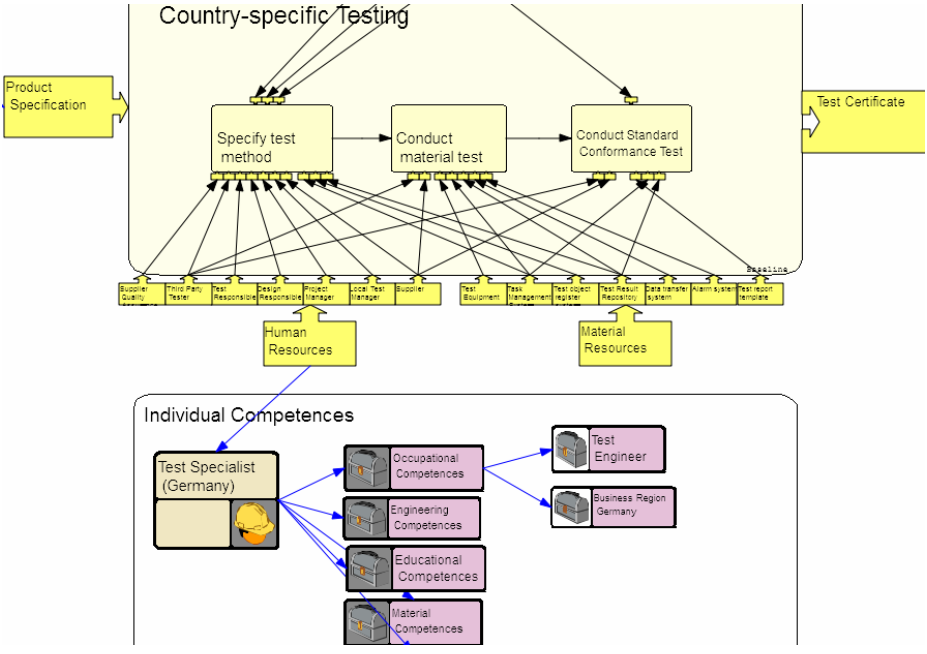

Fig. 1. Excerpt of competence model developed in automotive case

competences are shown (test engineer and business region Germany) etc. The refinements of the different competence areas are not included in Fig. 1 to maintain the understandability.

Since the MAPPER project used the enterprise knowledge modelling method C3S3P [13], we continued with this method during the competence modelling activity. More concrete, an additional iteration of the solution modelling phase was performed. In participatory modelling sessions with representatives from the first tier automotive supplier and the key sub-supplier required for the planned innovation, the activities to be performed by the different roles guided the identification of the competences aspects and skills required. The internal competence catalogues of the two companies formed a useful starting point and structural frame during the modelling, but proved to be not detailed enough and partly outdated.

During the modelling sessions, the results were documented with pen and paper, on a whiteboard or on plastic with sticky notes. After the modelling session, the tool expert and the modelling facilitator documented the modelling results in the METIS[1] tool with the MEAF[2] language. At the beginning of the following modelling session, a walkthrough of the model was used to inform all participants and validate the model.

The competence model served as input for a computerized tool for team formation, i.e. to identify suitable employees in the enterprise for participating in a planned

[1] METIS has been renamed to Troux Architect. Information is available at `http://www.troux.com`

[2] MEAF is the abbreviation for METIS Enterprise Architecture Framework.

project. However, this part of the project was not performed due to cost cutting in the economic crisis 2008/2009. Instead the model was used for documenting best practices, competence development and recruitment, and for training new employees.

3.2 Competence Demand Modelling in Higher Education

This case is one of the deliverables in the project *Competence Modelling and Competence Matching* (KoMo) where the case has served as a test bench for developing a conceptualization of how to perform and represent competence demand modelling. KoMo is a research project that was funded by The Swedish Armed Forces, in particular by the human resource management (FörbePers) and the Command and Control Systems unit (LedSysP). The tasks that we have addressed in this case are structuring, modeling and matching of individual and organizational competences for the master thesis course in higher education. This case has addressed capturing competence demands for different tasks through enterprise models. The case therefore is the base to: (i) describe an approach for competence capture through enterprise models, (ii) present a framework with constructs and relations for modelling and capturing task oriented competence demands, and (iii) describe how context will affect competence modeling.

The final thesis course case was modeled in order to try out an idea and approach for modeling organizational competence demand based on enterprise models. This means that this case had a clear activity oriented approach where the logic between activities in a process was the foundation for addressing competence demand modeling. The competence demand in this case is not defined from the view of a position or role in an organization, which is a traditional way of viewing competence demand. Instead it is defined from the viewpoint that a task has to be performed, in our case giving a final thesis course. A consequence of this view of competence demand is a focus on the organizational competence rather than on the individual competence. In this case we have not focused on finding one person for a certain job, instead what we have tried to find an organization or organizational unit that can perform a task. The size of the organization or unit is decided based on the task and its purpose. An additional consequence is that the context of task is not always the same, in fact it is very common that the context is different every time the course is given, creating different variants of the competence demand. This is something that has proven to be important to capture in order to make it possible to store this knowledge and to create a repository of competence demands. This could make it possible to externalize and reuse knowledge in the organization, i.e. a dimension of knowledge management based on competence demand modeling.

This case was mainly chosen because we as authors of this paper have expert knowledge and extensive experiences from the area (the thesis process in one of the master programs at our university). In the work with this case we have represented different roles: Domain experts regarding the thesis case, Domain experts regarding the KoMo project, Competence modeling experts, Enterprise modeling experts, and Method development experts. The approach for developing this case example has mainly been based on two major activities; modeling seminars and individual work. During the modeling seminars all actors above were involved in the process. The modeling seminars were mainly performed as interactive discussions where we

gradually, in argumentative dialogue, developed the example model that captures task oriented competence demands for the thesis process. We performed four modeling seminars and we have conducted individual work between the seminars as input for the next seminar. The individual work has mainly consisted of transforming and formalizing the evolving models into Troux Architect-models. The individual work has also consisted of finding ways to express different principles and relations in Troux Architect-models.

Without giving an exhaustive description of the constituents of the conceptual structure that were developed for this case, activity oriented competence demand modeling, Fig. 2 below at least depicts the main components and their relations.

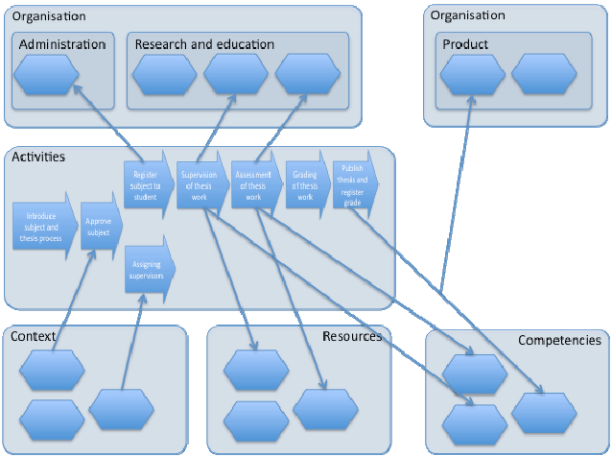

Fig. 2. The overall principle for activity oriented competence demand model

The core of an activity oriented competence demand model is of course the process with its activities. With this as a base we have also identified five other perspectives that together constitutes the whole competence demand model; Organization, Product, Competencies, Context, and Resources. Each of these perspectives represents different views of the competence demand. The activities for a certain task are described in the process view, showing the actual process with its interlinked activities, the competence perspectives provide the descriptions of the different competencies needed for a certain task. The relations between activities and competence will express what competencies are needed for performing a certain activity within a task.

3.3 Modelling Competence of Individuals

The third case is the project ICT-Support for formation of business relationships with developing countries based on immigrant competence (the SPIDER project), which was supported by the Swedish International Development Agency. In this project we aimed at supporting Swedish and Vietnamese companies searching for business

partners. The Vietnamese diaspora in Sweden was supposed to act as a business mediator and help with overcoming different obstacles in the business relationships establishment. The competence modelling in this project was thus focused on capturing individual competences of diaspora members such as personal abilities, and knowledge about the required business/industrial sector and the countries.

The modelling process consisted of the following steps. The first one was study of existing approaches to structuring and modelling of individual competences as well as analysis of the case with identification of abilities and skills relevant for the domain. Then we created a semi-structured questionnaire and conducted interviews with diaspora members. After analysis of the interview and structuring of the competences, we constructed a competence model and created personal profiles. The last step was creation of formalization (machine-readable representation) of the model and profiles. The modelling activities were carried out by two modelling experts and one domain expert. The formalization was performed by one knowledge engineer.

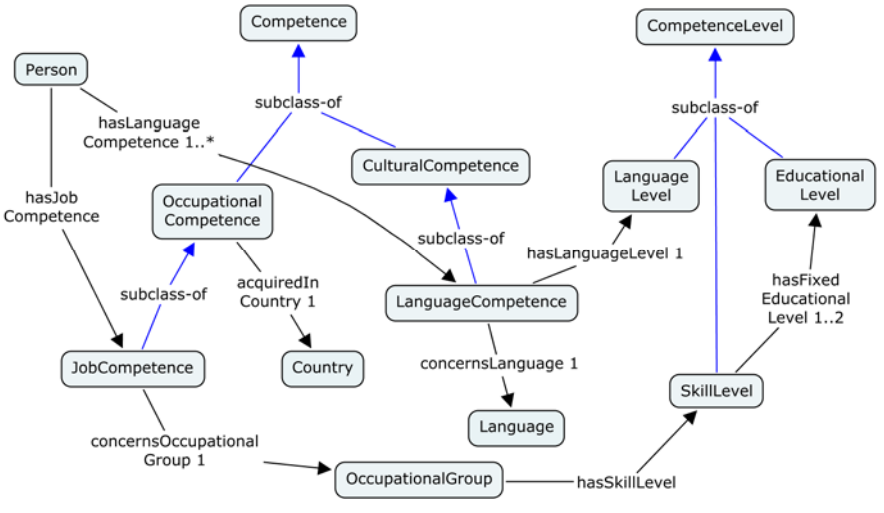

Fig. 3. A fragment of the competence model from the SPIDER project

The core area of modelling was qualification and skills of individuals. The created model includes three major parts: general competences like ability to inform or plan, cultural competences, e.g. command of English, and occupational competences. The latter represents educational background and work experience. All abilities and skills were graded against a scale. A fragment of the model is shown in Fig. 3 above. Competences of each diaspora member were described as a profile created based on the individual competence model (an example is shown in Fig. 4 below).

The model and profiles were implemented as an ontology [14]. During the ontology development process we initially followed Noy & McGuinness's methodology and used the Protégé frame-based ontology language. Recently, the initial competence model has been redesigned to take into account the experience accumulated after the project end. We added the conceptualization steps from the

METHONTOLOGY methodology. The model implementation was also reengineered and the ontology language was changed to OWL (Web Ontology Language) because of good tool support. The ontology was intended to use as a basis for development of an add-in for the existing web applications in Sweden and Vietnam to support companies by suggesting diaspora members who could be of help. Several experiments were made but the applications were not fully completed due to organisational changes and lack of technical competence related to this technology on the Vietnamese side. However, the competence model was used as a basis for competence modelling in another area – collaborative engineering design [15].

4 Lessons Learned and Recommendations for CM

4.1 Comparison of the CM Cases

Table 1 compares the three cases, including the focus of modelling, method, modelling language and application of the results.

Table 1. Comparison of the competence modelling cases

Criteria/Aspect	Automotive Supplier	Higher Education	Migrant competences
CM purpose	Team Formation	Perform task	Competences of individuals
Core area	Product knowledge	Task/activity oriented competence demand	Qualifications and skills
Method / process	C3S3P	Participative modeling	Noy & McGuinness's meth., METHONTOLOGY
Modelling language/ notation used	Metis Enterprise Architecture Framework (MEAF)	Metis Enterprise Architecture Framework (MEAF)	Protégé-Frames, OWL
Application of the results	Documenting best practices, plan competence development, teaching employees	Documentation of action oriented competence modelling, teaching in master course	Use of the model in several other projects as the basis for further modelling

4.2 Lessons Learned

Team Formation at an Automotive Supplier. A lesson learned from the various competence modeling cases is the importance of understanding the core area of the competence modeling as early in the process as possible, i.e. the decisive competence perspective is the activity to be performed, the individual's competence or the product knowledge. The core area affects the further modeling process, the stakeholders to be involved and to some extent other prerequisites of the modeling process. When product knowledge is in focus, like in the automotive case (see section 3.1), understanding product composition, dependencies and commonalities between components, relevant technical parameters and other engineering aspects are of importance and ask for the involvement of product managers and technical experts in

the modeling process. Furthermore, the modeling can benefit from knowledge in product data management and product lifecycle management and of knowledge about the industrial domain under consideration. With individual competence as core area, the consistency of the competence model with established enterprise-internal or international competence description "standards" gains importance. This requires an introduction of relevant standards for the modeling team and the involvement of experts in this area. An activity focus often begins like a conventional process modeling, but requires a strict perspective on activities as representation of organizational competences rather than on activities as what is ongoing in an enterprise. In practice, additional validation of the enterprise models and sometimes individual competence focus as continuation of activity focus can be the consequences.

Experience and knowledge in enterprise modeling is an excellent basis. Enterprise modeling requires an understanding of the domain under consideration, which can be achieved by including domain experts in the modeling team. Competence modeling requires also an understanding of different competence modeling traditions, which can occur during the modeling exercise, as experienced in the cases discussed in section 3. In the automotive case, a catalogue with core competences and skills for the automotive supplier under consideration existed. This catalogue had been developed at the Swedish location of the supplier during a period of more than a decade and was updated or changed whenever a new recruiting was planned which showed shortcomings in the catalogue. Compared to this "local" competence structure, other larger enterprises require the use of catalogues defined company-wide, often including different countries of operation. In the thesis case (section 3.2) there is a local formal requirement at the university that the examiner, course manager and tutor should have a PhD degree. This personnel category carries a lot of knowledge and experiences about the thesis process and therefore they need to be involved in the competence demand modeling process. In the case for the Swedish development agency (Section 3.3) the compatibility with international standards was important, aiming at categorizing internationally accepted qualifications and occupation descriptions. As a consequence, the competence modeling team should include at least one member with expert knowledge in how to capture and express competences.

When establishing a competence modeling project, management support and acceptance in the organization is of high importance – like in enterprise modeling projects. But competence modeling requires from our perspective additional efforts in preparing the organizational setting since both, line management, division and human resource management have to be involved. Competence supply, selection and preparation of qualification measures, recruitment and promotion processes, and description of the tasks and responsibilities of a role usually are located in the human resource department. Even though organizational competences often are the responsibility of the line management (or not allocated to any specific role in the organization at all), the human resource department will be able to provide valuable contributions to competence modeling projects.

We observed in many projects that international standards or company internal standards for structuring and representing competences are seen as starting point and as a means to guarantee compatibility. However, these standards were not always of value for the project but sometimes turned out to be rather a "curse" than an asset.

International standards offer from our experience a rather high level categorization of competences, since they form the common denominator for various education traditions worldwide. The attempt to use the standard as basis and add refinement levels might lead to the problem that some competences have be considered as refinement in different categories, which will lead to ambiguities in the categorization. Similarly, company-internal standards can turn out to be inconsistent, outdated, incomplete or all of the before. Cleansing and improvement of such standards can cause more efforts than the actual modeling project.

Competence Demand Modelling in Higher Education. A lesson that can be drawn from this case is the need for both domain experts and modeling experts during the modeling process. The domain expert(s) must, naturally, have sound knowledge and experiences from the domain that is in focus for competence modeling. It is also important that there is coverage of domain knowledge for the whole process. The domain experts must therefore cover the whole process with all tasks and hierarchical representation if this is relevant for tasks in focus. There is also a need for the modeling expert(s) to expand their situational knowledge in relation to the domain in focus. There is some kind of threshold for the modeling expert to climb over in order to be able to ask generative question about the competence demand in relation to a certain task.

The next lesson is that the competence model is modular; parts of the model are optional, although all of them contribute with valuable information. The only parts that cannot be left out, which also are the core in task/activity oriented competence demand modelling, are *the task*, *competence* and *organization*. Without these focal areas it is not possibility to express the needed competencies for a certain task. With these three modules we can express what competencies are necessary to fulfill a task. This is the minimal way of doing activity oriented competence modeling, the benefit is that it is fast and almost immediately gives a task related competence model.

Context is an important perspective to be covered during activity oriented competence modeling. The main reason for this is that there always are a number of situational aspects that will affect the competence demand even if the formal task(s) is the same. It is therefore important to try to characterize the context in terms of different frame conditions. This is also a way to identify different scenarios for a certain task where the competence might differ depending on the frame conditions. The context and frame conditions need to be addressed during the modeling session but they will not be really validated until the task is really performed.

Finally we have formulated some procedural recommendations for the activity oriented competence demand modeling process. The modeling should be an incremental and iterative process where different activities will be generative interdependent to each other. The first modeling task will be to capture the process. What are the activities that will constitute the task, how are the activities interlinked, and what are the main results in the process. The next step should be to address what competences that are needed to perform these activities and where these competencies are located both existing ones and competencies that don't exist in the current situation. These competencies need to be related to the organizational dimension, which usually is done through roles. It is important to note that the relation between roles and competencies is expressed through the activities and not directly between

each other. This is important since we can define and evaluate roles, existing and needed ones, based on requirements that are needed to be able to perform an activity. This is also a way to define requirements on how to organize and to set up a team. These three parts (competence – task – organization) define the core of competence modeling. In order to be able to meet situated dimensions the next step is to address the context. The frame conditions that are identified in the context will be an important source for refinement of the other three core perspectives; competence, task, and organization. Finally, there is a need to deal with the recourses that are needed to perform a task, both existing resources and demand for new or changed ones.

Modelling Competence of Individuals. The first lesson learned from the modeling of individual competences (section 3.3) is that abilities/skills assessment is difficult. In most cases it is not enough to state that a person has certain ability, it is necessary to model the level of this ability. In our project we used combination of self-evaluation and assessment through indirect interview questions. But this approach turned out to be error-prone and inaccurate. More elaborated methods for competence assessment are needed and this calls for contribution of professional psychologists.

The second lesson is that a clear and distinct phase of design is necessary during development of a competence model. The design documentation helps very much in revisions of the competence model, especially when the model is implemented in a computerized language to be part of an application. That is why we utilized the conceptualization steps from the METHONTOLOGY methodology.

One more lesson is that if a competence model is supposed to be a basis for a software application, it is better to use such an implementation language, which has more extensive tool support. Protégé-Frames was flexible for implementation of competence models but the lack of tool support made retrieval of needed competence profiles difficult. When we switched to the Web Ontology Language for implementation of the competence model, we found that existing tools like ontology classifiers (e.g. Pellet) and SPARQL processers simplify search for needed competences significantly. For example, if a person is needed who has experience of repairing cars in Sweden and speaks some Swedish, then it is enough to classify the ontology (model implementation) and run this SPARQL query:

```
SELECT ?person_id
WHERE {
 ?person :hasJobCompetence ?job_comp .
 ?job_comp :concernsOccupationalGroup :OccupationalGroup7231 .
 ?job_comp :acquiredInCountry :Country-Sweden .
 ?person :hasLanguageCompetence
                    [:concernsLanguage :Language-Swedish] .
 ?person :hasPersonID ?person_id .
}
```

The answer found will be “Person C”. The corresponding part of person C’s competence profile is shown in Fig. 4 below (experience of repairing cars is represented by occupational group 7231, Motor vehicle mechanics and repairers).

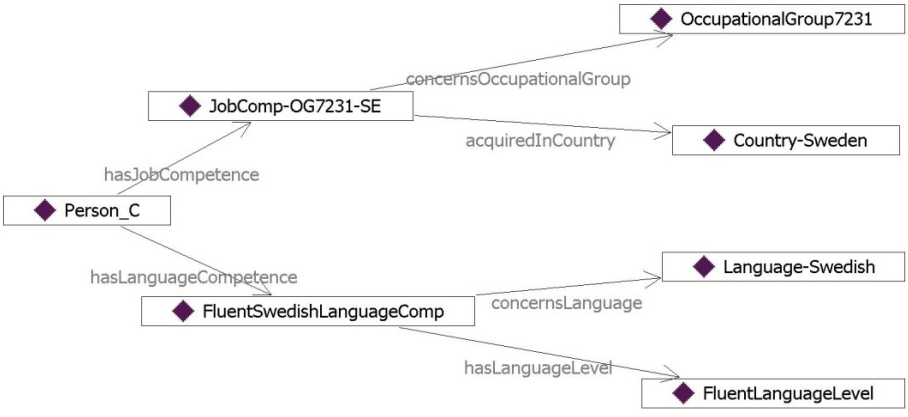

Fig. 4. A fragment of person C's competence profile (the SPIDER project)

The last lesson from this project is that if a competence model is intended to be part of a software application, it is necessary to make sure that needed technical skills exist on site. The lack of such skills was one of the reasons for incomplete use of the model in the SPIDER project. Use of competence models in applications requires advanced technical skills. If such skills are missing, it is necessary to arrange for relevant training for developers.

5 Summary of Recommendations

Recommendation 1: Identify the core area of the competence modeling as early in the modeling process as possible: Activity, product knowledge or individual competence focus?

As a rule of thumb, we recommend the following. If organizational competences are the core interest of the project: chose an activity based perspective first and keep an open mind for individual competences. If the purpose of the project is strongly related to products or their lifecycle, select a product knowledge focus first and try to understand the activities to be performed. If the human resources are of specific interest for the project, start with individual focus of the project and observe the importance of product knowledge in case of manufacturing enterprises.

Recommendation 2: Investigate what ways of structuring and describing competences exist in the scope of the competence modeling project

We recommend involving the human resource department or the responsible manager for this issue. Questions to investigate are ways of describing and structuring competences (local scope, global definition, integration of standards, etc.), existing task and responsibility descriptions for roles, and competence development plans and their basis.

Recommendation 3: Check quality and suitability of competence catalogues or classifications before deciding to apply them

As a simple initial check, we recommend to express the competences for one selected role or activity with the standard under consideration. If such standards shall be applied, the motivation for this requirement has to be analyzed. A requirement regarding compatibility between the competence model to be developed and the existing standard can turn out as severe constraint for the projects, where the effects have to be analyzed. Standard as starting point, without compatibility constraints, can be beneficial for the modeling project.

Recommendation 4: If assessment of individual abilities/skills is necessary, find out reliable methods for doing this beforehand

Assessment of abilities/skills through self-evaluation and interviews is error-prone and inaccurate. More reliable measures are needed that can be created with the help of professional psychologists and human resource departments.

Recommendation 5: Include both domain experts and modeling experts in the modeling process

The domain expert has knowledge and experiences from the domain that are needed for competence modeling. The modeling expert can through this expand their situational knowledge in relation to the domain in focus.

Recommendation 6: Include in a competence model the task, competence, organization, and context.

As soon as a competence model is modular, other parts of the model are optional. The first three mentioned modules are necessary to express what competencies are necessary to fulfill the task. A context can represent a number of situational aspects that will affect the competence demand even if the formal task(s) is the same.

Recommendation 7: Conduct modeling in an incremental and iterative way

The modeling should include several steps addressing the process with activities, competences that are needed to perform these activities, relation between roles and competencies, and recourses that are needed to accomplish a task.

Recommendation 8: When a competence model needs to be implemented in machine-readable form, it is advisable to follow a distinct design phase, choose an implementation language that has good tool support, and make sure that technical specialists skilled in the chosen technology exist on place

The design documentation is needed for revisions of the competence model. If a competence model is supposed to be a basis for a software application, extensive tool support of the implementation language simplifies application development. Lack of relevant technical skills will be an obstacle for application deployment.

6 Conclusions

This paper describes three cases of competence modelling with different core areas: product knowledge, task/activity oriented competence demand, and qualifications and skills of individuals. The cases are analysed and lessons learned are presented. Based on this, several practical recommendation are formulated that can simplify competence model development. These recommendations can be applied to other cases of competence modelling.

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