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Competency Proficiency Ontology

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Abstract: Expressing and exchanging competency information is a key issue to enable connections among not only different information systems, also across social and cultural systems. In order to facilitate these connections, competency information and proficiency information must be separated, but be linked together and packaged., In this paper, based on analyzing practical information, a competency proficiency ontology is designed and applied to actual competency proficiency information.

Keywords: Competency, Proficiency, Standard, Information Model, Level

Introduction

The concepts of ability or competency, as applied to human activities may be described by various terms, such as “Knowledge”, “Skill”, and “Competency”. These terms are indispensable for operating human resources (HR) management as well as for other systems, such as learning management systems, and related business information systems. In order to operate efficiently and effectively, these systems rely on the use of information and communication technologies [1].

Although in recent years improvements in methodology and technologies to support human development such as e-Learning, learning supports tools, collaborative learning technologies, and personnel data management, have been recognized, there has been debate and discussion regarding the objects of educational objectives, and specifically how competency and educational objectives may be represented within systems that rely upon information and communication technologies. The challenges of expressing semantics of competency and educational objectives have been documented in various implementation settings [2,3] including e-Portfolio studies and practice [4]. It has been suggested that semantic approaches have potential to facilitate the transfer and exchange of competency information and data across various types of systems and to support interoperability and activities such as subsequent analysis and comparison at a more granular level [5].

For a few years, several research and standards projects have tried to specify structural expressions of competencies. SkillsNET developed several sets of skill data schema, its data base and practical application. Competency is specified with knowledge, tools, indispensable resources, tasks and so on. Hirata and Brown designed a competency architecture from an ontological viewpoint for ETSS (Embedded Technology Skills Standard) a Japanese national project [6,7]. DIN (German Institute for Standardization) officially published PAS 1093: Human Resource Development with special consideration of Learning, Education and Training; Competence Modelling in Human Resource Development, which was initiated by Stracke and colleagues [8]. PAS 1093 specifies information and data models of competency by three dimensions: The first dimension defines the relation and structure between competences and activities, the second dimension focuses on the levels of competences, and the third dimension

covers the observation and measurement of competences and activities. This general framework of PAS 1093 facilitates adaptation for various applications and implementations according to given situations and needs. The European Commission has supported and funded two European projects WACOM and eCOTOOL that have developed a competence model based on PAS 1093. And also the Technical report "ISO/IEC Information technology - Learning, education and training - Conceptual reference model for competency information and related objects" will be published soon by ISO [9]. With this project, ISO/IEC SC36 has tried to develop a common view for competency information.

From these and other research projects, the finding is that the concept of level is one of several priority issues that can help to specify competency information. Essentially it has been suggested that it would be better to divide information related to level from other information used to denote competency meaning itself. To further work in this area, a competency proficiency ontology that is used within several skills standards and industry competency models in Japan is considered and applied to a European case study.

Ontology is defined as "a formal, explicit specification of a shared conceptualization" [10, 11]. A "shared conceptualization" implies an abstract understanding or model that is consensually accepted by a group, "explicit" means that the concepts and related constraints are clearly defined, and the word "formal" means that the ontology is machine-readable [11]. Using an ontological approach means that vocabularies, definitions, and structures are in place to support the exchange of queries and assertions among agents. In the next sections of this paper, a proposed competency proficiency ontology will be discussed.

1. Features of Competency Information

The most essential feature of the concepts of ability or competency within information and communications systems is that they are represented in a variety of ways, making it challenging to support interoperability [7]. From the viewpoint of ontological engineering, which is to divide elements, to derive meanings and to make clear relationship between classes/modules, we conducted reviews of skill and competency representations and how they are expressed within various systems. There seems to be at least five representation types of skill and competency information in e-Learning and human resources management [12]. The features of skill and competency representations may be organized into the following different types:

1. **title** - a representation by only a title of competency. This type is most simple one. It is just information as only title, so it is no need to express and to deal with the meanings, not semantics, of skill and competency on information technologies,
2. **title and connection** - competency information which is expressed and defined with relationship of skill and competency titles. These relationships provide contexts and meaning rather than a single title.
3. **description** - the combination of title and descriptive explanation written in natural language. Explanation is may be simple or complex, and provides additional data about a skill or competency such as state, prerequisite requirement, result, purpose, etc.,
4. **structured definition** - defined with preliminarily configured data set. This type is eliminated from redundant description and context dependency expression, and adds structured data flame to title information. A structured data flame specifies data elements and data attributions as a format. Contents of description for skill and competency are described and implemented system by this format.

5. **application** – competency information are used with many other information in applications. Applications which are build with information technologies provide practical services. In practical, competency information are packaged and composted with deferent ways. For example. A competency are expressed by skill and knowledge information, and job or tasks in job descriptions, or course search application.

Of course there are many other ways to differentiate between various representations of competency and skill. In this paper, based on research noted above, it is suggested that it could be useful to distinguish competency information from discrete representation types and to separate out proficiency level information. At the time of exchange or migration of this information between IT systems, these disparate pieces of information should be connected and packaged together. In the next section, a preliminary review of features of skill or competency proficiency information is provided. Additionally, essential components of proficiency concepts will be discussed as a competency proficiency ontology to support interoperability. Then the ontology is applied to the European Qualification Framework (EQF).

2. An Ontology of Competency Proficiency

2.1 Categories of Measurement Types

There are many different types of measurement categories that are used to describe proficiency. Human judgment may be used to categorize, divide, or segment competency and skills and to label them using measurement types such as class, rank, degree, level, stage, grade or degree.

A skill or competency proficiency may be expressed by one or more measurement categories. A measurement category is a way of measuring that is used consistently within a system to describe a skill or competency proficiency. For example, in academic grading systems a pass-fail grading system may be used [13,14]. Typical expressions of proficiency may include values such as ““pass” or “fail”, or “distinction”, “pass”, or “fail”. This means that in different situations, systems may record two or three optional values depending on how the pass-fail grading system has been implemented. Other types of proficiency include grade or stage, such as “first grade”, “second grade”, and “third grade”.

There are various ways to express competency proficiency. In other words, competency proficiency is composed of different types of measures. As this paper focuses on a way of expressing competency proficiency from the viewpoint of ontological engineering, informational elements of a competency proficiency ontology as they are currently used within several skills standards and industry competency models in Japan are considered and applied to a 2-part European case study.

2.1.1. Measurement range

Generally, a measurement range could be formulated using an explicit set of numbers, letters, designations, etc. For example, one could have a measurement range from “1” (rank) to “5” (rank) or "beginner license" to "expert license". In the former, the competency proficiency is segmented by a total of “5” ranks, and there may be a stipulation that integers and no decimals will be used. So an instance will be a value out of “5”, in which “5” expresses the total number contained within the measurement range. In the latter case, the competency proficiency is segmented into 2 licenses. So the instance is value out of “2”, in which the number “2” expresses the total number available within the measurement range. So competency proficiency needs to

include the concept of "measurement range" which indicates the total number of ranks, grades, degrees, levels, etc. that are used for the competency proficiency that is being considered.

2.1.2. Segmentation value

It is not enough to express a competency proficiency using only measurement range. The concept of "segmentation value" corresponds to the value number as it occurs within the measurement range. A segmentation value indicates allowance of a certain number or string. In the above cases, numbers from "1" to "5" are allowable values within the former measurement range, and nominal data of "expert" and "beginner" are allowable values in the latter example.

In addition to the measurement range, the segmentation value not only indicates the relative placement of the competency proficiency within the measurement range, it also may include other attributes. For example, the measurement range may have different meanings depending on the system in which it is used. In some systems "1" may be the highest attainable level of proficiency, in others "5" may be the highest attainable level of proficiency. Therefore, additional explanation, rules, pattern information may be required and included as segmentation value attributes.

2.1.3. Segmentation value character

Segmentation value is expressed not only as integer numbers, it may also be expressed as continuance number, and nominal characters, including rate, interval, order, and so on. So it may be necessary to provide explicit information regarding allowable segmentation value characters.

2.1.4. Proficiency composition

There are some of special cases which have 2 or more continuums. For example, "Judo", which is one of the fighting sports, has 2 continuums, "Kyu (級: class)", and "Dan (段: stage)". Kyu begins from 10 to 1, Dan begins from 1 to 9. A lower number of Kyu means more skilled, and a lower number of Dan means **less** skilled. The flow from 10 Kyu to 1 Kyu, and 1 Dan to 9 Dan follows two continuums that are ordered differently. In this case the measurement range is "19" grades. However, in such a case the attribute of "composition" is useful as it can indicate 2 different but related grading continuums.

The license of skiing in Japan is more complex. There are ranks from 5 to 1. A lower number means more skilled. Above rank 1, there are two additional ways to indicate skill level. One way is "Technical expert" and "Crown expert" from the viewpoint of competitive and practical technique, the other way is "Semi instructor" and "Instructor" from the viewpoint of variety and completeness of technique. In this case, there are two or three continuums, so the composition of two or three grades needs to be accommodated. The instance are "3" components, and the respective components have a measurement range of "5", "2", and "2" grades. This means that the competency proficiency concept needs to allow for multiple components, and to respect "cardinality".

2.2 Metric

Metric information is used to specify differentiation in the competency proficiency of learners, trainees, students, etc. A metric is used to help specify how a measurement category (e.g., for grade, degree, level, etc.) for a competency proficiency is being applied. ISO/IEC 19796-3 is useful to chose and define metric type [15]. Each metric corresponds with a measurement

category that is being used. If a certain competency proficiency uses two different measurement categories, then it may have at least two metrics.
It is easy to define and to specify attributions of a measurement category from an initial observation of information related to the competency proficiency in question. However, it may not be as easy to elicit and to define the metric being used, because more detailed information related to the metric that is being used may be hidden or implicit, and complex.
The concept of metric for competency proficiency may be composed of two elements at least, which are criterion and discrimination.

2.2.1. Criterion
Criterion specifies a condition statement used for measuring and judging a competency proficiency. When criteria are grouped together, they can provide an overview useful for assessment and benchmarking.
Criterion can be used to specify dimensions/factors and how they are combined. For example, a driving license may include several different components such as a paper test and an in-person practical exam of driving skill. Criteria may be combined under at least three different dimensions including knowledge regarding driving (knowledge of laws, regulations, etc.), practical knowledge regarding cars and how they work, and driving skill. For this type of situation criteria may be grouped with the condition that all criteria must be met in order for a driving license to be issued.

2.2.2. Discrimination
Discrimination is used to specify how the content of dimension outlined in the criterion will be measured and judged to arrive at a level, degree, grade, etc. of competency proficiency. Discrimination can be used to provide a specific view for scale and assessment.
Discrimination specifies all the dimensions that are used for making differentiations for the metric being used to measure competency proficiency. There may be more than one discrimination item for each criterion and one discrimination item may be used for more than one criterion.

2.2.3. Segmented level
There may be variations in the measurement categories, metrics, criterion, and discrimination information across the different levels that are used to define a competency proficiency. The concept of segmented level is intended to allow for the exchange of information to support these possible variations.
For example, if a competency proficiency has three levels, such as beginner level, intermediate level, and expert level, each level may be measured differently. However, information for all levels is required in order to exchange and share information regarding a competency proficiency.

3. Use case for EQF

The competency proficiency ontology outlined above was applied to the European Qualifications Framework (EQF) concept of levels. Two types of use cases were considered, one use case is for the whole concept of EQF level. In other words, EQF proficiency structure is expressed by the

competency proficiency ontology. The other use case employs the competency proficiency ontology to express one level (the 3rd) within EQF.

3.1 Instance of proficiency structure

Category of measurement type is "EQF level". Measurement range is "8". Segmentation value is "from (lowest) {1} to {8}". Segmentation value character is "order" and "integer". Proficiency composition is "none".
Metric is "EQF_Metric_01". Criterion is "d01, d02, d03, d04, d05, d06, d07, d08, d09, d10". Discrimination is "d01: width of general knowledge", "d02: range of domain specific knowledge", "d03: purpose of action in tasks", "d04: theoretical knowledge for operation" etc. For this use case, 8 segmented levels would be linked to this information, because EQF has 8 levels.

3.2 Instance of a specific proficiency level

The following is an example of EQF "level 3". Category of measurement type is "EQF 3rd level". Measurement range is "3rd". Segmentation value is "{3} by {8}". Segmentation value character is "order" and "integer". Proficiency composition is "non".
Metric is "EQF_Metric_01_03". Criterion is "and {d01, d02, d03, d04}". Discrimination is "d01_3: broad knowledge", "d02_2: industry field range of knowledge", "d03_1: to undertake simple tasks", and "d04_1: basic theory etc.

4. Future Works as a Consideration

A competency proficiency ontology that has been used within several skills standards and industry competency models in Japan has been applied to two use cases of the European Qualifications Framework. Next steps will be to apply what has been learned to a database environment and to experiment with further application of the ontology including exploration of a competency proficiency information architecture and data coding in the near future.

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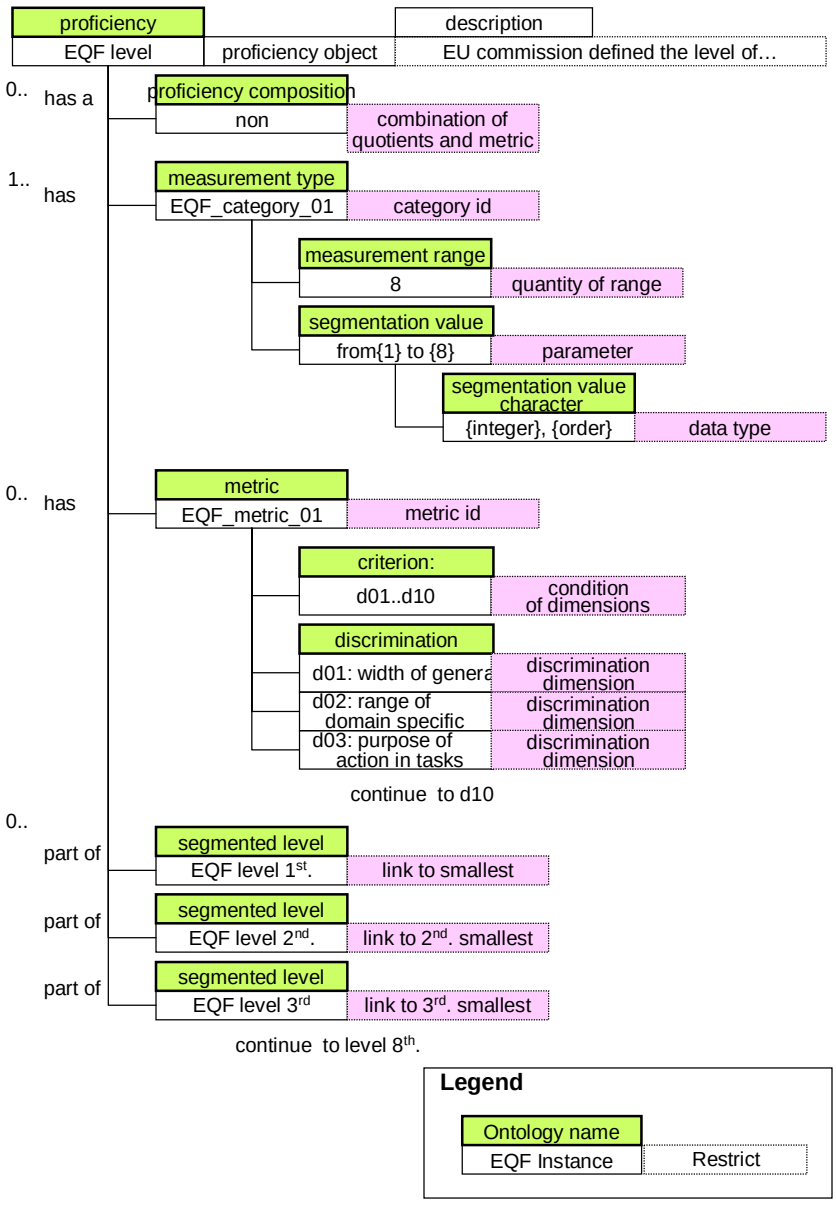

Figure 1 Use case of EQF (for whole level expression)

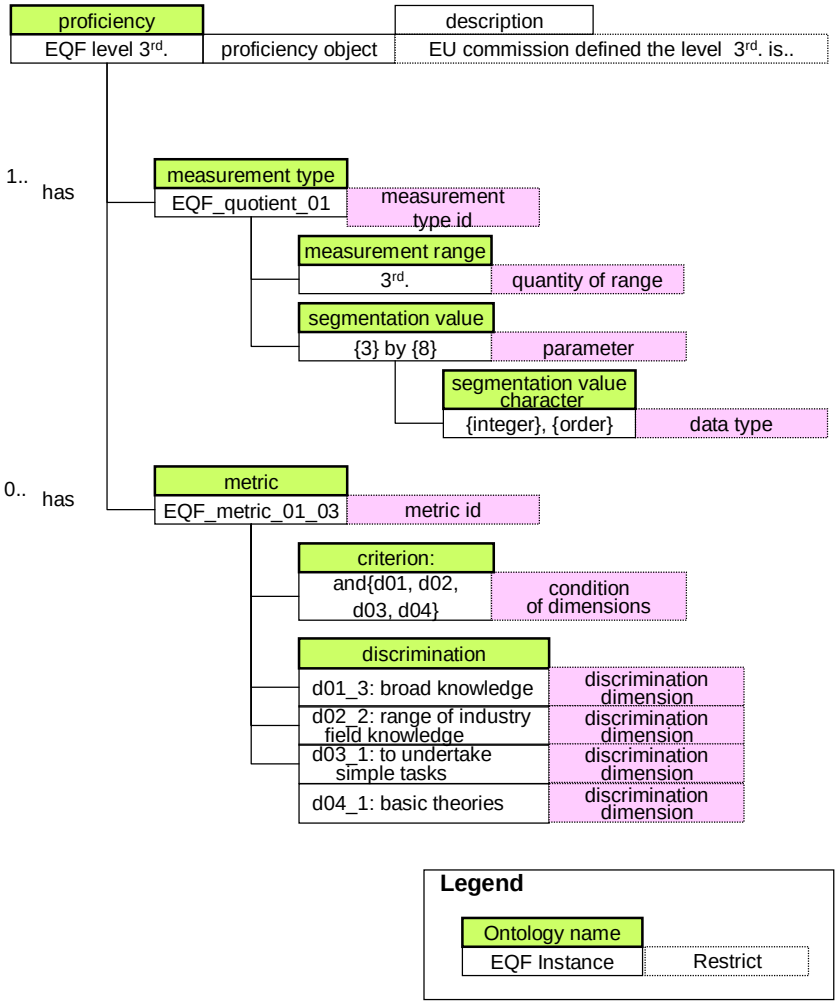

Figure 2 Use case of EQF (for the third level)