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AN ONTOLOGY FOR SOFTWARE ENGINEERING EDUCATION

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ABSTRACT

Software agents communicate using ontology. It is important to build an ontology for specific domain such as Software Engineering Education. Building an ontology from scratch is not only hard, but also incur much time and cost. This study aims to propose an ontology through adaptation of the existing ontology which is originally built based on a qualification framework.

KEYWORDS

Ontology, Agent, Malaysian Qualification Framework

1. INTRODUCTION

Software agent is the popular technology used today. How do software agents communicate with each other? They communicate using ontology. The definition of ontology is diversed. Tom Gruber (1993) defines the term ontology as "*an ontology in a specification of a conceptualization*", conceptualization refers to "*an abstract model of how people think of things in the world, usually restricted to a particular subject area* " (Gruninger, 2002). The results of the works of Welty, Lethmann, Gruniger and Uschold reported in 1999 with regards to the definition of information systems ontology are: an ontology is a catolog, a glossary, a collection of taxonomies, a set of general logical constraints, a set of text files, a thesaurus and a collection of frame (Smith and Welty, 2001). Based on statement made by Smith and Welty in 2001, ontology in the information systems would continues to flourish. Yes, today it is flourishing in many application domains such as business enterprises as they continue to make effort using ontology as common ontology in order to provide a shared framework of communications (Uschold et. al., 1998, Obrst et. al., 2001; Puustjarvi & Puustjarvi, 2010). Application of ontologies in the application domain of medicine and traffic control have been successful in 2000's. The idea of common ontology has been proven useful when applied in smaller scale (Viinikkala, 2003). In this study, it is believe building a common ontology in Software Engineering Education is necessary and useful. As automation requires a higher degree of accuracy in the description of its procedures and ontology is a mechanism for helping to achieve this. Ontologies are designed in order to enable knowledge sharing with and among agents (Gruber, 1993).

Why ontology is developed? One of the reasons of developing ontology is sharing common understanding of the structure of information among people or software agents (Musen 1992; Gruber,1993). For example, suppose several web-sites contain medical information, if these web-sites share and publish the same underlying ontology of the terms they all use, then software agents can extract and aggregate information from these web-sites. Software agents can use this aggregated information to answer user queries or as input data to other applications. Once aggregation or integration of several ontologies of large domain, it is considered as large ontologies. Another example, developing a small ontology in the domain of Software Engineering (SE) Education for Instituition of Higher Learning. Once SE ontology is developed, software agents used it as data and this ontology can be used as a basis for application such as curriculum design support system which can create suggestions for designing learning outcomes or answer queries of curriculum designers.

Developing ontology from scratch is hard, however Ra et. al. (2012) note that reuse of pre-developed ontology save time and cost. The idea of reusing pre-developed ontology triggers the effort of this study which adapting the pre-developed ontology developed by Lilian et. al. (2007) in their work group project. The proposed ontology may be used as a shared framework by a group of curriculum designers who are designing software enginerring programmes for Instituition of Higher Learning in Malaysia.

2. RELATED WORK

There is a different in object-oriented design such as designing classes and relations with ontology design. Object-oriented programmers makes design decision based on operational properties of a class whereas an ontology designer makes these decisions based on structural properties of a class (Noy et. al., 2001). Referring to the definition presetned earlier, in this study is: ontology is a formal explicit description of concepts in a domain of discourse. In ontology, classes sometime is called concepts, properties of each concept describing various features and attributes of concept i.e slots sometimes is called roles or properties and restrictions on slots i.e. facets sometime is called role restriction. An ontology together with a set of individual instances of classes constituite a knowledge base. In reality, there is a fine line where ontology ends and the knowledge base begins.

2.1 The Computing Ontology and It Application in Education

It is recalled that this study adapted the work of a workgroup which has set up and progressively working on Ontology of Computing Project (Cassel et. al., 2007). The purpose of the Working Group is to extend the community of individuals contributing to the development of the ontology and to validate or modify partially completed sections. The group also considered issues related to visual presentation of the ontology for the purpose related to curriculum development and the overall structure of the ontology. Accreditation criteria such as Eurpean Qualification Framework is used as guidelines and reference.

For the application of ontology to educational purposes, IFIP working group in 2002 has identified seven critical components of a curriculum development effort (Cassel et. al., 2003). The seven components are: Body of Knowledge (BOK), Foundation Materials, Application Context, Social Context, Breadth and Depth, Thematic Coherence and Outcomes. This study focuses on two components which are relevant to the research objectives i.e. BOK and Outcomes. BOK is topics that define the field to be studied. Outcomes refer to learning outcomes for any proposed curriculum, it is a clear set of goals essential for determining a realistic, collection of topics and activities that will form the students' experience (Cassel et. al., 2007). The ontology addresses questions of BOK and contributes to the understanding the issues of foundational knowledge and depth and breath. The relationship between outcomes and BOK information are also included in the ontology.

Cassel and other researchers (2007) in their project also note that in relating learning outcomes to topics in ontology, the context is not always clear; therefore as a consequence, the ontology related learning outcomes have to be generic and on high level of abstraction. They recommended that these learning outcomes could be a starting point or point of reference for more specific educational based learning outcomes. As learning outcome is about tasks that have to be performed by a person, it has to be clear what level of performance is expected. The European Qualification Framework where the ontology project of Cassel and her colleagues proposes possesses eight levels (refer Appendix). In order to contribute to a better international understanding of mutual programmes, educational instituition is strongly advised to earmark their programmes according to the eight levels. The ontology proposes in this research is adhered to Malayian Qualification Framework (MQF) which contains the eight learning outcomes domains.

To begin with, the components of learning outcomes are to be speicified. In Cassel's project, the components of learning ourcomes are: 1) level of performance (EQF level 5 & 6 are choosen); 2) issue (choose from ontology, one or two layers below the main chapter identification); 3) knowledge (describe using a verb in and agreed format); 4) skills (describe using a verb and an agreed format); and 5) personal competence (describe using an agreed classification system for personal competence). Cassel et. al. (2007) suggested before associating learning outcomes with ontology topic, definitions and interpretation of learning outcomes components need to be made. Knowledge as third component of learning outcomes are explored based on: IT ontology, the topic space, relation between IT ontologies topics and pre-requisites for performance of learning outcomes dependent on specific topics. (specific areas of ontology). Some specific ontology sections, for example, computing history area and sub-area are presented in Table 1. Knowledge at cognitive level is the scope of the proposed ontology.

In fact, the terminology used in designing learning outcomes must be clear and meaningful. In classifying the educational objectives would help curriculum designers clarify and tightened the "language" of educational objectives (Krathwhol et. al., 1964). There are three major parts of a complete taxonomy – the cognitive, the affective and the psychomotor domains. The affective domain includes objectives (this study applies it in learning outcomes) which describes changes in interest, attitude and values; and the development of appreciations and adequate adjustment. The psychomotor domain is the manipulative or motor-skill area (Bloom et. al., 1956). Among the three domains stated above, most of the work of curriculum development has taken place in cognitive domain. This domain is also the focus domain of this study. The taxonomy was further qualified as intellectual behaviours that represented the intended outcomes of the educational process. Bloom's taxonomy of cognitive domain comprises six level of intellectual behaviour: knolwedge (K), comprehension (C), application (AP), analysis (AN), synthesis (S), and evaluation (E) (Bloom et. al., 1956). These six level can further categories learning outcomes to lower level learning outcomes and higher level learning outcome. Later on, learning outcomes need to be refined based on each level's key terms.Bloom's is well known for cognitive domain. This research uses teaching and learning taxonomy such as Bloom's Taxonomy as a vehicle for specification of learning outcomes in SE courses. The SE courses follow the specification of SWEBOK in 2004 (Bourque & Dupus, 2004). The research illustrates how a faculty may express and document programme objectives through learning outcomes at course level. As such, the problem of designing curriculum to cover measurable keywords and a particular topic in learning outcomes become less nebulous, making the learning outcomes more measurable and clearly specified.

Table 1. Example of Computing History Areas and Sub-area (Source: Cassel et. al., 2007)

Area	*Sub-area*
Early Methods, Devices and Machines	Numeration Systems Early Calculation Devices Abacus Mechanical Calculating Devices Babbage Machines Analog Computers Mechanical Computers Early Electronic Machines
HARDWARE – NON- SYSTEM	Logic Design Basics Hardware Control Machine Instructions Computer Arithmetic Computer Performance Datapath and Control Pipelining Memory Hardware Networks Multiprocessors Different Architectures

3. SOFTWARE ENGINEERING ONTOLOGY

This research adopted the following format of learning outcomes statement (Soulsby ,2009). The format adopted in this study is as follows:

To (action verb) *(object) (target) (modifiers)*

With the basic format stated above, the components of learning outcomes need to be specified (in this study, it is referred as *(object) (target) (modifier)*). The definition and interpretation of the components of learning outcomes is adopted according to MQA: "*The curriculum ….address learners' needs as individuals and citizens. It identifies outcomes relating to knowledge, skills, personal attitute and attributes. It is underpinned by clear values*". (MQA, 2010,p.5). The structure adopted is later formed based on MQA.

According to MQA (2010), knowledge is the first domain used in MQF, it is demonstrated by mastery of the subject matter, the knowledge of major idea, observing and recalling information and recognising concepts. Skills is the second domain used in MQF (known as practical skills), it is demonstrated by carrying professional task, reading and undestanding instruction, perceiving and responding effectively and applying learnt skills in a safe environment. Personal attitude and attributes are interpreted as competence in this research. Competence is described in terms of students' responsibility and autonomy as of the decriptor defining qualification level stated in MQF appendix 1 (MQF,2007). this research focuses on cognitive domain i.e. knowledge which is described as the theoritical and/or factual stated in BOK in which the ontology is built upon.

The details of the structrue of the proposed ontology is not discussed in details in this study as it only presents the overall idea of proposed ontology.

4. SUMMARY AND STATUS

The work undertaken in this study is an intial work and it is ongoing. It is hope that it shed some lights on ontology adapation based on a pre-developed ontology. It is believe that the proposed ontology is able to help curriculum designers who need to applies ontology in their work specifically in the area of software engineering education.

Figure 1. Structure of the Proposed Software Engineering Ontology (Cognitive domain)
(Adapted from: Malaysian Qualification Framework Domain (Level 1), Software Design Areas and Sub-area (Bourque & Dupus, 2004) and Taxonomy Level (Cognitive Domain))

MQF Domain	**Learning Outcome**	**Area**	**Subarea**	**Taxonomy Level**	**Action Verbs**
Knowledge	Course learning outcome	Software design fundamental	General design concepts Context software design Software design process	Comprehension	Classify, convert, defend, describe, discuss, distinguish, estimate, explain, express, extend, generalise, give examples, identify, indicate, infer, locate, paraphase, predict, recognize, rewrite, report, restate, review, select, summarise, translate
			Enabling techniques	Analysis	Analyze, appraise, break down, calculate, categorize, compare, contrast, criticize, diagram, differentiate, discriminate, distinguish, examine, experiment, identify, illustrate, infer, model, outline, point out, question, relate, select, separate, subdivide, test
		Key issue in software design concurrency	Concurrency Control & handling of events Distribution of components Error & exceptional handling & fault tolerance Interaction & presentation Data persistence Functional-oriented(structured) design	Application	Apply, change, choose, compute, demonstrate, discover, dramatize, employ, illustrate, interpret, manipulate, modify, operate, practice, predict, prepare, produce, relate, schedule, show, sketch, solve, use, write
			Object-oriented design	Analysis	Analyze, appraise, break down, calculate, categorize, compare, contrast, criticize, diagram, differentiate, discriminate, distinguish, examine, experiment, identify, illustrate, infer, model, outline, point out, question, relate, select, separate, subdivide, test
			Data-structure centred design Component-based design Other methods	Comprehension	Classify, convert, defend, describe, discuss, distinguish, estimate, explain, express, extend, generalise, give examples, identify, indicate, infer, locate, paraphase, predict, recognize, rewrite, report, restate, review, select, summarise, translate

REFERENCES

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: Handbook I: Cognitive domain*. New York: David McKay, 19, p.56.

Cassel, L. N. et. al. (2007) . The Computing Ontology: Application in Education. In *ACM SIGCSE Bulletin* (Vol. 39, No. 4, pp. 171-183). ACM.

Cassel, L. N., Davies, G., Kumar, D., & Zorzo, F. (2003). Computing: the shape of an evolving discipline. *Informatics Curricula and Teaching Methods, LN Cassel and RA Reis, Editors*, pp.131-138.

Gruber, T.R. (1993). A Translation Approach to Portable Ontology Specifications. *In Knowledge Acquisition*, 5, 1993, pp. 199-220

Gruninger M. and Lee J., (2002). Ontology Application and Design. *In Communication ACM 45,2(2002)*, pp. 39-41

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). *II: Handbook II: Affective domain*. New York: David McKay.

Malaysia Qualification Agency (MQA) (2010). *Guidelines to Good Practices: Curriculum Design and Delivery*. Panel of Experts, Malaysia, Kuala Lumpur.

Malaysian Qualification Agency (MQA) (2007). The Malaysian Qualification Framework.

Musen, M.A. (1992). Dimension of Knowledge Sharing and Reuse. Computers and Biomedical Research 25, pp.435- 467

Noy, N. F., & McGuinness, D. L. (2001). Ontology development 101: A guide to creating your first ontology.

ObrstI., Wray R.E. and Liu, H. (2001). Ontological Engineering for B2B E-commerce. Formal Ontology in Information Systems. *Proceedings of Second International Conference (FOIS '01),* October, 17-19, Ogunquit Maine, New York, ACM Press, 2001, pp. 117-126

Puustjarvi, J. and Puustjarvi, L., 2010. Exploting Learning Object Ontology in Building Personal Curricula for Pharmacists. *Proceedings of the 12th International Conference on Information Integration and Web Applications & Services*. Paris, France, pp. 367 -372. ACM.

Ra, M., Yoo, D., No, S., Shin, J., & Han, C. (2012). The Mixed Ontology Building Methodology Using Database Information. In *Proceedings of the International MultiConference of Engineers and Computer Scientists* (Vol. 1).

Smith, B. Welty C (2001). FOIS Introduction, Ontology: Towards a New Synthesis, Formal Ontology in Information Systems. *Proceedings of the Second International Conference (FOIS '01)*, October 17-19, Ogunquit, Maine, New York, ACM Press, pp. iii-ix

Soulsby, E. P. (2009). Assessment Notes.

Bourque, P., & Dupuis, R. (2004). Swebok: Guide to the Software Engineering Body of Knowledge (2004 Version). *IEEE Computer Society*.

Uschold M., King M., Moralee S., and Zorgois Y: The Enterprise Ontology, The Knolwedge Engineering Review, 13, 1998.

Viinikkala, M. (2003). Ontology in Information System. Disponible en.

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APPENDIX

Descriptor Defining Levels in the European Qualification Framework (extracted from: Cassel et. al., 2007)

Level	Learning outcomes relevant to the Level		
	Knowledge	Skills	Competence
	In the EQF, knowledge is described as theoritical and/or factual	In the EQF, skills are described as cognitive (use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, tools and instruments)	In the EQF, competence is described in terms of responsibility and autonomy
Level 1	Basic general knowledge	Basic skills required to carry out simple tasks	Work or study under direct supervison in a structured context
Level 2	Basic factual knowledge of a field of work or study	Basic cognitive and practical skills required to use relevant information in order to carry out tasks and to solve routine problems using simple rules and tools	Work or study under supervision with some autonomy
Level 3	Knowledge of facts, principles, processes and general concepts, in a field of work of study	A range of cognitive and practical skills required to accomplish tasks and solve problems by selecting and applying basic methods, tools, materials and information	Take responsibility for completion of tasks in work or study adapt own behavior to circumstnaces in solving problems
Level 4	Factual and theoritical knowledge in broad contexts within a field of work or study	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities
Level 5	Comprehensive, specialised, factual and theoritical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Exercise management and supervision in contexts of work or study activities where there is unpredictable change review and develop performance of self and others
Level 6	Advanced knowledge of a field work or sutdy, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredicatble problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts take responsibility for managing professional development of individuals and groups
Level 7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	Manage complex technical or professional activities or projects, taking responsibility for managing professional development of individuals and groups
Level 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or professional practice	Demonstration substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contects including research