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Knowledge Representation and Ontological Model based on Software Engineering Body of Knowledge as a tool to Evaluate Professional and Occupational Profiles

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ABSTRACT

Knowledge representation is a multidisciplinary subject that needs to apply theories, and techniques from logic, ontology, and computation, for this reason the Bodies of Knowledge (BOK), contain the relevant information for an area of knowledge, and it is necessary for the development of the science, and application in the professional, occupational profiles, and the possible incidence in the industry.

This paper showed an evaluation of professional, and occupational profiles based on standard Software Engineering Body of Knowledge (SWEBOK), and ontological model as tool in order to obtain the necessary information to establish the relationship in these contexts.
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INTRODUCTION

The representation of a BOK is a complex activity. It has done through the use of guide knowledge, determining that knowledge can be often represented through Knowledge Areas (KAS), which has not met the expectations of stakeholders in BOK, this is so since BOK are quite extensive and it is not only used by engineering stakeholders but also, for instance, in government Smith, Brooks (2013).

BOK contain the relevant knowledge for a discipline. BOK must be embodying the consensus reached by the community; for this reason BOK will be of applicate. This consensus is a prerequisite for the adoption of the BOK by the community Penzenstadler et al. (2013).

A BOK may include technical terms, and theoretical concepts as well as recommended practices Taguchi et al. (2013).

A BOK is a common intellectual ground. It is shared by everyone in the profession regardless of employment or engineering discipline; for this reason; in this paper it is shown the evaluation of occupational, and professional profiles, based in the guide SWEBOK 2014, which is a popular guide in the field of Software Engineering.

The emergence of the competencies approach worldwide, it is related to productive changes because of the ongoing global change; the industries have understood the need to prevail in the market creating competitive advantages.

"The human factor is one of the strongest strategic components, the contribution made people is linked fully with the strategies of competitiveness required to be part of an organization, forcing employers to make a careful selection of profiles professionals, depending on the occupational profiles requiring" Vera (2011).

In order to evaluate occupational, and professional profiles, it was used the guide SWEBOK 2014 Bourque et al. (2003), and characterization of ontological model supported by Neon Methodology UPM (2015).

The purpose of the research it was to establish a presentation and ontological model to evaluate occupational and professional profiles taking as points of mediation BOK; also, to obtain measures of comparison between professional profiles and job offers through the BOK.

RELATED WORKS

The use of BOK has increased representatively; according to Bourque et al. (2003), and Stevens (2012) the use for developing ontological models for BOK based in Knowledge, and applied in the monitoring of networks around a community are explain; however Fazel (2014), used BOK for the conceptualization of shared knowledge between humans, and software. They also mention that the use of BOK in building ontologies for information

systems, and management development software. Moreover, a professional BOK meets the set of skills, knowledge, and attitudes required for professional domain Azuma et al. (2003).

The BOK is used as points of comparison mediation of powers between work, and academic contexts. For example in Muller, Riedlhuber, (2009), a model using DISCO II, it was proposed for the creation and comparison of profiles based on competencies.

In Garca (2007), it was proposed a model for competence and its components from SWEBOK.

In R. P. K. M (2011), SWEBOK is used as a point of mediation for the comparison of academic profiles and the labor market.

In Azuma et al. (2003), a useful model is proposed not only in academia but also in industry, where SWEBOK specifies the Knowledge Areas (KAS) necessaries in this context.

In Stevens (2012), extend the research of Azuma et al. (2003), Muller, H., Riedlhuber F., (2009), associating skill levels of Bloom's taxonomy of knowledge areas SWEBOK profiles Guide Software Engineering: New Graduate, Graduate with four years of experience, and experienced software engineer working in a software engineering process group.

In Dunne et al. (2007), use a process based upon the IEEE-CS/ACM CE Body of Knowledge Recommendations found in the report "Computer Engineering 2005 Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering.", where the process is divided into several steps:

1) Review of the Body of Knowledge in order to further partition the Recommendations into Required and Elective categories.
2) Determination of coverage level of the BOK areas as provided by the current program.
3) Identification of inadequacies or holes in coverage of the current program.
4) Proposal of modifications to eliminate coverage holes in required areas.
5) Implementation of proposed curriculum changes.
6) Assessment and revision of curriculum changes.

METHODOLOGY

Step 1: Define ontological model.

In recent years, it has increased the interest of professionals in the development and management of ontologies to develop from scratch, with the aim of linking knowledge and providing a semantic sense Quezada, P., Garbajosa, J., and Enciso, L. (2016).

Some of the most widely used methods are as follows: METHONTOLOGY, On-To-Knowledge and DILIGENT UPM (2015). The methodologies used to development the ontological model is called NeOn. NeOn is based on nine stages, since there are several ways for building ontologies; NeOn scenarios are flexible, allowing combined scenarios, and allowing users to customize them. For the evaluation of the profiles, the following methodology of NeOn scenarios is used:

Scenario 1: From specification to implementation.

PURPOSE: To develop ontology of BOK; a vocabulary to describe the terms associated with that domain it was created.

SCOPE: The ontology was focused on domain of BOK. The proposal of this research it was study the structure of SWEBOK 2014 in order to evaluate the professional and occupational profiles Quezada, P., Garbajosa, J., and Enciso, L. (2016)

EXPECTED END USERS.

When a new ontology it was designed, it is important to evaluate possible users. In table 1, it is showed some stakeholders Quezada, P., Garbajosa, J., and Enciso, L. (2016).

Table 1. Expected end Users

Users	Description
Engineers.	People who study engineering.
Graduates.	Person who acquire an academic degree after complete the studies.

Stakeholders.	Many people, groups, companies, and other organizational or governmental entities have a stake in educational programs.	

Requirements:
- Functional Requirements:

How is knowledge described?
How to align labor or Occupational and professional profiles using SWEBOK 2014?

- Non-functional Requirements

The ontology will be developed in English.

Scenario 2: Reusing and re-engineering non-ontological resources (NORs).
The reuse of Non-ontological resources is the second activity of NeOn which is the same methodology for analyzing non-ontological resources. In table 2, the non-ontological resources necessary for the evaluation of profiles are described.

Table 2. Non-ontological resources

Class	Class Description	Properties
BOK Ontological Model with Standars	Name of Ontological Model	include
BOK	Contain the relevant Knowledge for a discipline. BOK must embody the consensus reached by the community for which this BOK will be of application. This consensus is a prerequisite for the adoption of the BOK by the community Penzenstadler et al. (2013)	id code levels Of Abstraction context structure by
Knowledge Area	Structure of a BOK, which define what a professional needs to understand and the tasks that a practitioner must be able to perform Bourque et al. (2003)	require composed by
Knowledge Unit	Each area is broken down into smaller divisions Bourque et al. (2003)	id code description involve
Knowledge Topics	Second level of knowledge structure Bourque et al. (2003)	Associate Column Matrix Matrix Topic And Reference id code description
Knowledge Subtopics	Description of Topics Bourque et al. (2003)	id code description
Profile	A set of characteristics that identify or are thought to identify a particular type of knowledge Bourque et al. (2003)	need is part of id description code typeProfile

Skills	An ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carryout complex activities or job functions involving ideas (cognitive skills), things (technical skills), and/or people (interpersonal skills) Bourque et al. (2003)	id code description
Detail-Profiles	Specific characteristics of each profile Bourque et al. (2003)	id code description

Scenario3: Reusing and re-engineering ontological resources.

For the definition of the ontological model of BOK, the basis it was SWEBOK are the same that are structured by KAS, which have several elements such as: Units of Knowledge (UK), including a hierarchy of topics Knowledge (TK), and within sub topics (KST): List of further reading, References, Taxonomies, List of acronyms and labor profiles and professionals requiring skills to define the levels of knowledge of a professional Bourque et (2003). The following ontological model has been developed based on the scenarios of NeOn methodology, which were taking for building scenarios 1, 2, and 3.

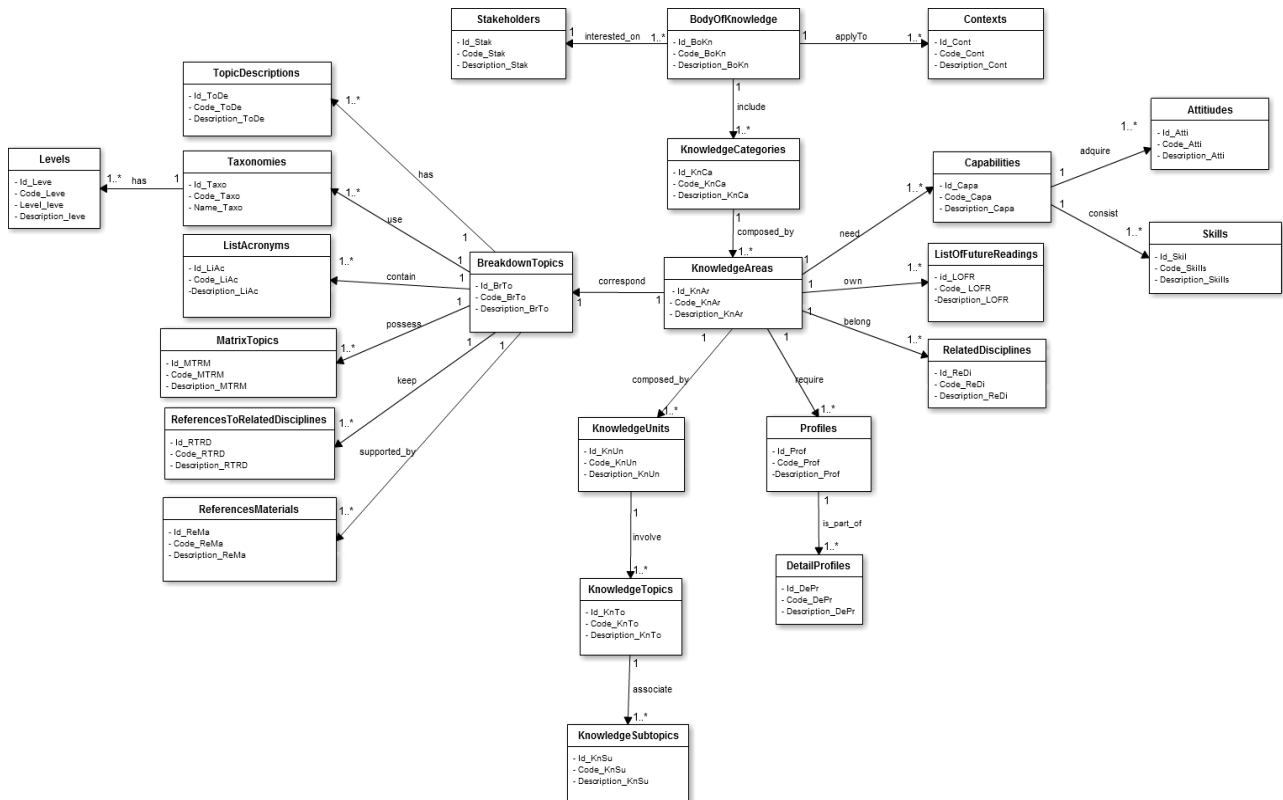In the figure 1 the UML model that support the ontology is showed.

Figure 1. UML Model to Represent BOK

The model is supported by the structure of the SWEBOK 2014, with which it was possible to define the terminology of a domain of knowledge: the concepts that constitute the domain, and relationships between concepts Watterson (1999).
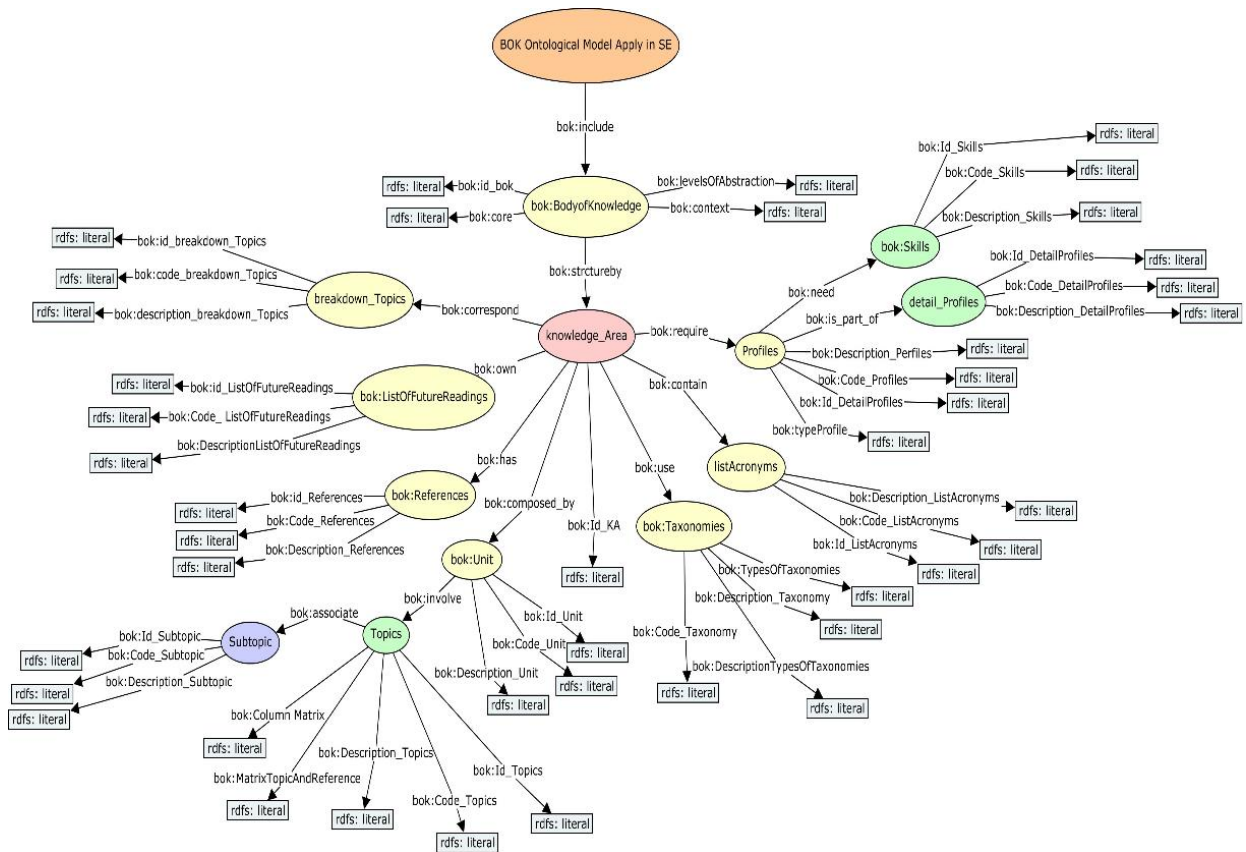
Figure 2. Ontological Model to Describe BOK (Quezada, P., Garbajosa, J., and Enciso, L. (2016))

Step 2: Evaluation of profiles through ontological models.

The ontology proposal was used to evaluate the labor and professional profiles in the area of software engineering. General ontology concepts and properties described in Scenario 2 are made, as these are needed for evaluation.

To evaluate profiles it was used SWEBOK 2014, where only the Quality Knowledge Are (QKA) was taken account. The area is divided into Knowledge Units (KU), Knowledge Topics (KT), in order to deepen the concepts of knowledge and identify sub-topics.

On the other hand, it was necessary to consider another level in the structure of BOK, where the topics will be more detailed Knowledge Subtopic (KS). The KS has addressed different knowledge and skills. In the same way, to develop a BOK it is necessary to take into account: Process Model, Deliverables, Organization, Technology focus, Tools, Assignment focus and Exercise domain Han, J. (2011). The sub-topics were extracted by experts Software Engineering, each sub-topic considered the breakdown of QKA.

Table 3. Shows the breakdown of the subtopics found in the topics of QSKA are presented.

SWEBOK 2014 Quality Knowledge Area

KA	KU	KT	KS
Software Quality	1. Software Quality Fundamentals	1. Software Engineering Culture and Ethics	Features and concepts of software quality Software development Software Maintenance Software Requirements
	2. Software Quality Management Processes		Measurement methods and acceptance criteria for evaluating the quality
	3. Practical Considerations		
		Value and Costs of Quality	Software Product Product requirements

	Prevention cost
	Cost of appreciation
	Cost of internal failure
	Cost of external failure
	Software Projects
	Scope of the software project
	Software Requirements
	Software life cycle
Models and Quality Characteristics	Quality Software
	Taxonomy or Software Quality model
	Software quality attributes
	Characteristics models of software quality
	Negotiation of the quality of Software product
	Planning of Software product quality
	Transaction of the quality of Software product
	Software Product
	Models of quality of the Software Product (internal, external, and job quality)
	Quality of the software engineering process
	Quality of software product
Software Quality Improvement	Software Product
	Software life cycle Process
	Process of detection error/defect
	Quality improvement process
	Quality construction, through prevention and early detection of errors
	Software Engineering Process
	Product evaluation
	Scope of the software project
	Project management
Software Safety	Software applications
	Develop safety-critical software.
	Software test environments
	Software functional requirements
	Software performance requirements
	Development processes
	Software quality assurance
	Controlling software risk
	Software Product
2.	Software life cycle Process
	Software Requirements
Software Quality Management Processes	Planning of Software product quality
	Software development
	Quality plan
	Software Maintenance
	Plans of Management, Development, and Maintenance for the software.
	Quality standards
	Activities and tasks of quality
	Software Configuration Management
	Software Projects

Verification & Validation	Planning verification and validation of product Software life cycle Process Software development Software Maintenance Verification and Validation of Product Techniques and tools for verification and validation of the product.
Reviews and Audits	Management reviews Technical reviews Inspections Walk-throughs Audits
3. Software Quality Requirements	Influencing factors Reliability Software integrity levels Process quality software Design methods Programming languages Software Technologies Software development Software Maintenance Taxonomy or Software Quality model
Defect Characterization	Reliability models built based fault collected Software Testing Software Engineering Process Implementation of management techniques software quality
Software Quality	Static techniques Intensive techniques of personnel Analytical Techniques Dynamic techniques Quality testing Software quality models Metrics software quality Software Product Software Quality
Management Techniques	Software life cycle Process Quality processes and software improvement Cost of quality processes Cost generic quality models Development processes Software Engineering Process Software Engineering Management Reports of the software quality management
Software Quality Measurement	Software quality metrics Software life cycle Process Software Engineering Process Software Engineering Management Development and maintenance processes

Step 3: Selection of the occupational and professional profiles.

Given a corpus of both occupational offers and professional profiles, it was obtained from of universities and employment platforms of Ecuador, two samples were taken for evaluation with SWEBOK 2014 profiles, considering among them the naked eye that may have greater alignment with a possible minor alignment with the samples to be worked, are:

1. Possibly aligned

Engineering in Computer Systems and Computer

Computer Engineering and Computer Science

2. Not aligned

Career Computer Education

Electronic and Computer Engineering Quezada, P., Garbajosa, J., and Enciso, L. (2016)

Experimentation. - To test our theory, an experiment in which 2 profiles were used. It is based on a macro algorithm that includes the following steps:

Manual description experimentation. - Manual testing is performed based on the SWEBOK 2014 guide, by reference to the area of knowledge subtopics Quality. To get the result 1, the following comparisons were performed using a matrix intersection.

$R1 = (C3 = ((C1 = STQ$ vs $PP) + (C2 = STQ$ vs $OP)/2)$

$C1 = \sum comparations/Nro. l$ of comparations

$C2 = \sum comparations/Nro.$ of comparations

$C3 = (\sum C1 + \backslash \sum C2)/\backslash Nro.$ Of Subtopic

Where:

$R1$ = alignment between professional and job profiles

$C1$ = Quality and Profiles (Skills)

$C2$ = Quality Subtopic and Jobs offerts

$C3$ = Results C1 and C2

STQ = SWEBOK Topic Quality

PP = Professional Profile

OP = Ocupacional Profile Quezada, P., Garbajosa, J., and Enciso, L. (2016)

In both crosses (C1 and C2), in order to obtain numerical data, if there is any similarity it is assigned one (1), otherwise, the field being analyzed is left in blank. Upon completion of the comparison result C1 and C2 in percentages for each subtopic, versus the professional profiles and occupational, respectively bids are obtained. Once the percentages obtained, we proceed to C3, which consisted on comparing the total percentages of the C1 and C2. Quezada, P., Garbajosa, J., and Enciso, L. (2016). In the figure 3, show the experimentation, and application of the evaluation.

Figure 3. Experimentation and application of evaluation

KNOWLEDGE ASSESSMENT BETWEEN LABOR OFFER AND SKILL				
skill / labor offer	ENGINEERING IN COMPUTER SYSTEMS AND COMPUTER	COMPUTER ENGINEERING AND COMPUTER SCIENCE	EDUCATIVE INFORMATIVE	ENGINEERING IN ELECTRONICS AND COMPUTERS
Multitrabajos - IT Solutions Architect	47%	50%	38%	34%
Multitrabajos- Systems Engineer	41%	45%	32%	29%
Multitrabajos- .Net Developer	35%	38%	26%	22%
Software Developer, Web and/or Mobile Applications	38%	42%	29%	26%

CONCLUSIONS

The definition of BOK in the context of software engineering is important to respond the training needs of future professionals, so they in order to they acquire the competencies in the social, business, educational, and industrial.

The Body of Knowledge as Standard is the sum total of our human understanding of the world around us. Studies in the area of strength and conditioning make up one of the many fields of knowledge, and strength and conditioning professionals must understand how our understanding is created to successfully use it to optimize their professional practices, approaches, and exercise prescriptions and applied them in occupational context.

A general structure of BOK in the software engineering it was established. This structure begins with the set of KA, continues with KU, KT and ends with KST according to the research area.

A BOK generally uses a tree structure to represent knowledge, and a certain limit is set to its height to help its understandability and readability. In the same context the main objective of a BOK is to provide classification of knowledge and its detailed explanation.

BOK provides the basis for curriculum development and maintenance and supports professional development and any current and future certification schemes. Lastly, it promotes integration and connections with related disciplines.

A SWEBOK 2014 can fulfill to stakeholders role in supporting education, certification, professional stature, professional development, and organizational improvement.

FUTURE WORK

Contribute to improving the overall structure of the BOK where Knowledge Area includes both the area of engineering, science.

Joining the IEEE and ACM efforts in improving the SWEBOK Guide.

Adapting the curriculum of software engineering to the current needs of science and industry. Deploying the SWEBOK guide in improving the curriculum in undergraduate and graduate programs in Ecuador.

Analyze the skills, abilities, competencies of Software Engineering and the possible application in the professional profiles.

Analyze the professionalism and code of ethics of the Software Engineering to improve the ontological model.

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