

# Ontology for Academic Program Accreditation

## Ontology of Accreditation Board of Engineering and Technology (ABET) Process

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**Abstract**—Many educational institutions are adopting national and international accreditation programs to improve teaching, student learning, and curriculum. There is a growing demand across higher education for automation and helpful educational resources to continuously improve student outcomes. The student outcomes are the required knowledge and skill set that graduates of any accredited program have to gain in order entry into the workforce or for to continue with their future education. To evaluate student outcomes, each assessment activities must map to a course learning outcomes which maps students' outcomes. The problem is that all course learning outcomes and student outcome mapping are placed in documents or database which requires more work and time to access and understand. This paper proposes an ontology based solution to enable visual discover of all course learning outcomes that maps to a particular student outcome and related assessments to help faculty or curriculum committees avoid over mapping or under mapping students' outcomes.

**Keywords**—Accreditation; Ontology; Semantic Web; classification; Education

### I. INTRODUCTION

Ontologies have played a major role in knowledge representation in many domains and considered one of the pillars of semantic web (Vocabulary). Semantic web is a formal conceptualization that represents new technologies used to help in web search. It provides knowledge about a real world domain and enhances understanding by using entities, relationships, and attributes [1, 2]. Furthermore, ontology use is becoming more effective in information retrieval, robots, knowledge management, and electronic commerce [3, 4]. Ontologies contributed to these domains and more due to providing shared and common understanding among people and applications. However, creating ontologies is complicated due to ambiguity of concepts and semantics heterogeneity in communication [5]. Many Academic institutions are investing in national and international accreditations to ensure the quality of educational programs. Programs or institutions accreditations have a Board of Directors (BOD). For example, The Accreditation Board for Engineering and Technology (ABET) sets policy and approves all accreditation criteria that are used to evaluate programs. To evaluate a program, the evaluation process has to establish criteria for evaluations. The criterion applies to students, program, curriculum, facilities, assessment and evaluation to increase the quality of and inspire confidence in the program. Each individual program set its own criteria with continuous improvement and institutional support [6, 7]. The Accreditation process requires mapping and defining concepts for each course in the program. The

problem is that all course learning outcomes and student outcomes mapping are placed in documents or databases which requires more work and time to access and understand. This paper proposes an ontology based solution to enable visual discover of all course learning outcomes that maps to a particular student outcome and related assessments to help faculty or curriculum committees avoid over mapping or under mapping students' outcomes. The following section will focus on the back of using ontology in diverse fields; Section III describes the semantic framework of the accreditation model and the hierarchy of the ontology.

### II. BACKGROUND

#### A. Ontology

Thomas Gruber [1] has defined ontology as “formal, explicit specification of a shared conceptualization”. This is the most common definition of ontology which means a description of concepts and relationships in a domain such as education, medicine, knowledge management, etc. The description of concept is prepared by explicitly naming the concepts and the relationship. This description is more precise structure than just being taxonomy by providing relations and constraints between concepts.

#### B. Applications

Ontologies' applications have common usages in many different fields:

- Natural language processing: There are models that support semantics for natural language expressions such as Generalized Upper Model (GUM) that are semantics for natural language expressions to arbitrate between systems and natural language technology. GUM can provide mapping structure in multilingual generation systems [8]. To enhance reasoning for deeper understanding of texts used by machine translation, SENSUS project was developed. SENSUS [9] is a framework into which additional knowledge can be added to a system. It is an extension that uses WordNet at the top level containing nodes from the Penman Upper Model. The Penman Upper Model is a class structure of concepts organized originally in three subclasses: Object, Process, and Quality [10]. WordNet is a lexical database of English developed by Princeton University.
- Educational Ontologies: Learning resources is widely available via the Web and the private network of educational institutions. Considering the constant increase of learning resources, Ontology is a key

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enabler of supporting educational systems using conceptualizations. It is becoming strongly useful in the domain of Web-based Educational Systems (WBES). Many WBES concepts were developed by [12]-[14] such as subject domain, repository of learning resources, etc. It supports the representation of a domain ontology which provides formal definition of concepts for domain knowledge representation. Ontology designed for course learning has to identify formal rules for concept representation from a given course content. Ontology allows the visualization of a course content and concepts with syntactic and semantic meaning for learners [15]. Designing ontologies based on sharing learning environment was the focus of the Ontologies for the use of digital learning resources and semantic annotations on an online (OURAL) project. This project was based on real case studies to help teachers in describing learning domain problem solving and critical analysis [16].

- **Tagging of Resources:** Represents a link between objects for future use and collaboration with other users. This type of application allows users to add their cognitive information to resolve ambiguity and have consensus by using general classification. This type of classification leads to automatic discovery of new information, and improve precision in searching. Many users use tag to attract attention, show their interest, and make contributions to an object [17, 18]. On the web, users can tag objects based on their understanding using unstructured classification. Folksonomy unstructured classification system that pretence in this type of tagging is a real challenge of information retrieval by making many semantic tags and many abstractions levels [19, 20].

### III. ONTOLOGICAL SEMANTIC ACCREDITATION FRAMEWORK

This section describes the proposed semantic framework. The accreditation framework is a knowledge-based approach that requires a comprehensive analysis of the entire domain concepts which includes course domain, institution domain, and accreditation domain. Normally, the course domain is represented by a course syllabus. This document has many concepts such as description, course objectives, course learning outcomes, topic, book, policies, etc. The institution domain has individuals, programs, facilities, technology, policies, etc. Many accreditations, such as the Accreditation Board for Engineering and Technology (ABET), support and encourage institutions to adopt and use their own terminology. Also, the accreditation domain has its own concepts. For example, ABET has defined some concepts such as program educational objectives, student outcomes, assessments and evaluations [21]. The domain's concepts have to be mapped according to the ontology model to enable machine-tractable representation and adhere to the rule. The ontology can be accessed from a knowledge acquisition system. The knowledge acquisition

system contains an ontology editor and a visualization plug-in. Figure 1 illustrates the Proposed Semantic Accreditation Model.

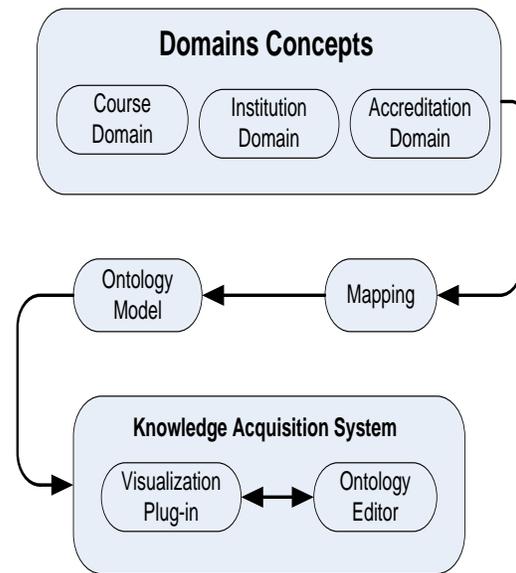


Fig. 1. Semantic Accreditation Model

Accreditation taxonomies or concept hierarchies are crucial for any knowledge-based system to structure information into categories and enable reasoning based on knowledge. These concepts hierarchies formulate relationships and rules to enable reasoning and reuse of knowledge based system.

The Accreditation model is implemented with a plug-in for Protégé 4.3. This Protégé tool has been widely used in many research projects in the area of semantic-web and modeling. Protégé 4.3.tool is extendible and fully supports the second version of the Ontology Web Language (OWL 2). The semantic web of an accreditation process helps student and faculty to understand the accreditation process. Furthermore, it promotes knowledge discovery and knowledge reuse about recruitment and evaluation. The definition of terminologies is debatable between domain experts. Therefore, the paper adopted the approach of defining accreditation terminologies based on defining relationships between terms used mosly by domain experts. This approach allows realistic understanding of terms and avoids definitions conflicts. However, ambiguity terminologies are used. For example, in writing a course learning outcome, the statement could include "Students understand" or "Students Know". This ambiguity will be discussed in the future papers. In the mean time, we focused on the terms used in this ontology by clarifying and visualizing these terms making them easy to understand. The accreditation concepts have been adopted in this model are formally used by the Accreditation Board for Engineering and Technology (ABET). Figure 2 illustrates the Accreditation Ontology Model.



Fig. 2. ABET Ontology Hierarchy

The hierarchy of ABET in the ontology is debatable among domain specialist. Some specialist suggested that all this domain classifications should be listed under the super class Program. Their justification is that accreditation process applies to program. Others, argue that domain classifications should be separate because in real world education institutions are using these classifications for another purposes than ABET Accreditation. Therefore, this ontology adopted this hierarchy shown in Figure 1. It consists of seven classes: Evaluation, Assessments, Knowledge Domain, Person, Program, Report, and Facility. Figure 2 illustrates the ABET ontology hierarchy.

A. *Evaluation*: Consists of processes for interpreting a course data and evidence to determine the attainment level which a program educational objectives and student outcomes has improved. The data and evidence collection come from the assessment practices during the course period. Before initiating the evaluation process of a program, the program must have met the eligibility requirements [29] of ABET and apply for Request for Evaluation (RFE). The accreditation of a program may be granted to students who graduated before the on-site visit if their samples work and transcripts have been evaluated. There are two types of RFE:

- Requesting Initial Accreditations: The program must submit the RFE with one official graduate’s transcript.
- Renewing Existing Accreditations: The program must submit the RFE to renew the existing accreditation.

B. *Assessment*: A valuable assessment uses relevant method (direct, indirect, qualitative, and quantitative) to the objective or outcome being measured. The result of the evaluation processes is used as a base for the decisions to improve the program [21]. Figure 3 illustrates the assessment class hierarchy.

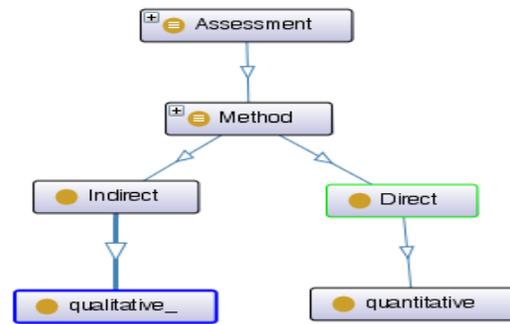


Fig. 3. Assessment Class Hierarchy

C. *Knowledge Domain*: It has teaching material (textbooks) and topics to be covered, assessed, and evaluated to determine the attainment level of the program educational objectives and student outcomes as shown in Figure 4.

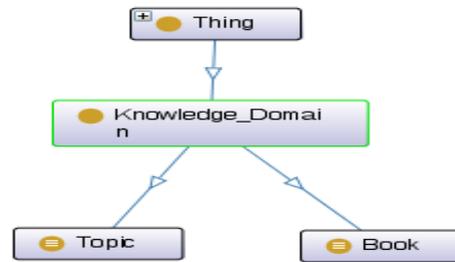


Fig. 4. Knowledge Domain Class Hierarchy

D. *Person*: This class hierarchy is evaluator, faculty (lecturer, teaching assistant), staff, and student. The main focus of the ABET accreditation process is the students in a program and their continuous improvement. Figure 5 illustrates the hierarchy of a person.

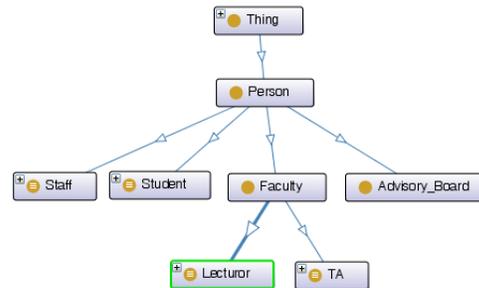


Fig. 5. Person Class Hierarchy

E. *Program*: ABET defines it as “An integrated, organized experience that culminates in the awarding of a degree” [25]. It has courses, objective, Student Outcome (SO) to be measured and evaluated, and a status. A course has key performance indicators (KPI) or course learning outcomes

(CLO), sections, syllabus, and samples. A course can have at least one section which is related to a knowledge domain. At most the course has exactly one syllabus which has many key performance indicators, teaching material, and covers some topics. A course also has samples to measure a particular KPI or CLO and it belongs to exactly one student. Program education objective statements are a description of what students are expected to attain within a few years of graduation. This objective should be carefully written based on the program constituencies [21] and it is related to an evaluation. The Student Outcomes statements are descriptions of what students are expected to know and able to do by the time of graduation such as skills, knowledge and behaviors and also related to an evaluation. Each program has status includes the followings:

- Accredited: The program is granted ABET accreditation since it satisfies accreditation criteria.
- Not to Accredited: The program is denied ABET accreditation since it has deficiencies that are not compliance with the accreditation criteria. This decision is taken only after a Show Cause Report or a Show Cause Visit to review the status of a new and unaccredited program. The accreditation is not extended as a result of this decision which is the only decision that can be appealed.
- Observations: The suggested statements offered by ABET to assist the institutions in the continuous improvement of the program. These statements are not related directly to the accreditation process.
- Concern: The program's current situation satisfies ABET's criterion, policy, or procedure, but the possibility exists for this situation to change negatively.
- Weakness: The program lacks strength of not being in compliance with the accreditation criterion, policy, or procedure. The institution is required to respond to this weakness with the corrective of actions to show the compliance before the next review.
- Deficiency: A Statement that indicates that the program is not in compliance with the ABET criterion, policy, or procedure.
- Satisfactory: A Statement that indicates that the program is in compliance with the ABET criterion, policy, or procedure.

Figure 6 illustrates the hierarchy of the Assessment Class.

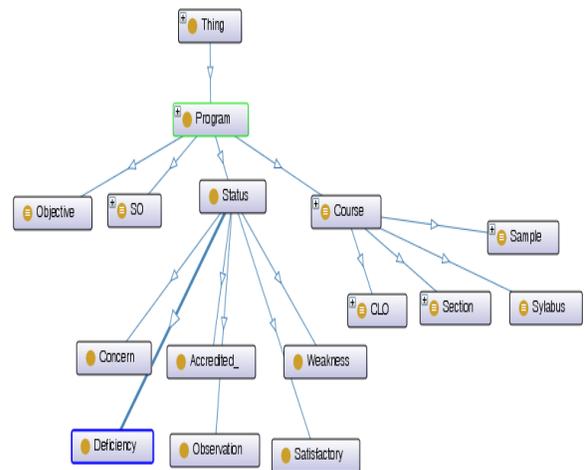


Fig. 6. Program Class Hierarchy

F. Report: According to the business dictionary a report is a document containing information about events, occurrences, or subjects.[26] In Figure 1 report class has four subclasses:

- Show Cause (SC): Is an action which indicates that the currently accredited program has one or more deficiencies.
- Show Cause Visit (SCV) action indicates that a currently accredited program has one or more deficiencies. Therefore, the deficiencies require an on-site visit to make sure a corrective of actions has been taken by the institution within typical duration of two years. This action cannot be for the same deficiency.
- Interim report (IR): Is an action which indicates that the program has one or more weaknesses. The institution is required to take a corrective of actions to these weaknesses typically within duration of two years.
- Report Extended: Is a satisfactory action taken by the institution with respect to weaknesses identified IR. This report has typical duration of either two or four years which extends accreditation to the Next General Review.
- Self Study: Is the "Primary document that a program prepares to demonstrate compliance with ABET criteria" [27].
- Show Cause Report (SCR): Is an action which indicates that a currently accredited program has one or more deficiencies but this action cannot follow previous SC

action for the same deficiency. The institution is required to take a corrective actions to these deficiencies typically within duration of two years [21].

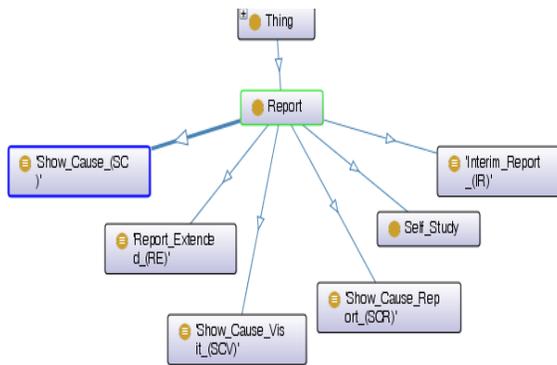


Fig. 7. Report Class Hierarchy

#### IV. CONCLUSIONS AND FUTURE WORK

The development and implementation of an ontological model allows the integration of all available data into a specific and unique information system. The ontological approach allows improving the decision making process to improve the quality of education and information management. The future work will focus on fuzzy ontology to define terms used by the accreditation process to eliminate conceptual and terminological confusion and come to a shared understanding.

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