

# Applying Ontology in a Project-based Learning Environment

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**Abstract:** Project-based Learning (PBL) becomes a popular teaching and learning method in recent decades. It facilitates learning by defining and solving a problem and by discussion and sharing between learners and supervisors. While ontology describes the semantics and relationship of different entities, it is desirable to explore its synergy in an environment for PBL. In this paper, we propose a new Project-Based Learning Environment by applying ontology in order to enable sharing learning resources, managing the learning process and learning outcomes for effective Project-Based Learning.

**Keywords:** Project-based Learning, Learning Resources Management, Ontology

## 1. Introduction

The ability of acquiring and managing knowledge as well as solving problems plays one of the crucial roles in learning. Project-based Learning (PBL) becomes a popular teaching and learning method in recent decades, which allows learning via various activities throughout the project, which overcomes the traditional classroom-based teaching focusing on knowledge transfer by teachers. It may also engage learners in sustainable and co-operative investigation in solving problems [1]. In a PBL environment, problems are often investigated and solved by a group of learners.

In university science and engineering programs, each student is normally required to conduct a project study and to define a project problem statement with a supervisor. After confirming the project scope and defining some initial tasks, the student starts literature reviews. For an easy kick start, the supervisor may provide some keywords to assist students in searching for relevant learning materials. Students are now, with the help of the web searches, able to gather vast amount of the information in diverse areas and directions. Those searches might result in learning materials closely related to different aspects of a chosen topic but inevitably some of them are only loosely, and some of them are even not related to the topic. In addition, some searches might appear not useful at the beginning but become important at a later stage of the project. Both the student and the supervisor face the problem of managing the collected information in a systematic manner in order to facilitate the ongoing project study. Moreover, for large-scale project which may involve a larger project team, those collected information is difficult to be shared among team members and thus, might hinder team discussion. It is also difficult for a supervisor to assess the achievements of a student or a project team. In addition, knowledge obtained throughout the project study will be easily faded without proper organization and management.

A model has been proposed in a previous study [2] in discussing the management for those learning resources throughout the project study. This model comprises of two components, namely Information Layer and Knowledge Layer (Figure 1). The Information

Layer consists of a repository of learning objects which are described and identified by corresponding records of Learning Object Metadata (LOM) [3] where one LOM record is uniquely linked to one learning object. The Knowledge Layer documents the concepts and methodology of the project where project ideas can be organized into the form of concepts by putting different keywords together. When working on a project, every learner has to follow a clear structure and methodology. This project structure may vary slightly depending on the style of a supervisor in directing a project.

This paper consolidated ideas from the previous study and develops an environment to facilitate the Project-based Learning. This environment presents the project knowledge by applying project ontology. Such project ontology is able to facilitate the management of learning resources, deliverables and learning outcomes throughout the project study in a systematic and semantic manner so that knowledge can be organized and accumulated in an evolving manner.

## 2. Conducting a Project Study in PBL

### 2.1 Defining a Project

A project may exist in various forms, for instance, a feasibility study of a technical solution, a design and implementation of a certain system, a detailed study of a certain phenomenon and so on. Although a project may be conducted in various ways, every project may consist of the following information: a project overview describing the general information and instruction; a project design containing the intended learning outcomes, learning activities with achievements; learning references collected throughout the study; and deliverables produced during the project study. Every learner may need to work out such a project design with a supervisor. Since every project contains similar project information, it is desirable to form a project structure to describe this information in a systematic manner (Figure 2). This project structure should facilitate managing the project data and learning reference collection, supporting the project design as well as helping supervisor to assess the performance of learners.

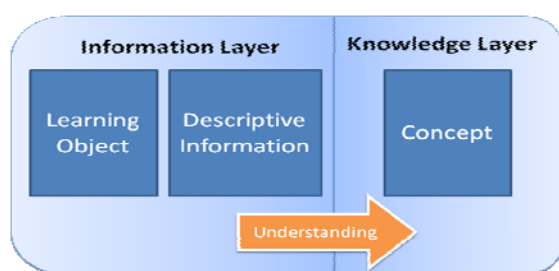


Figure 1 A learning resource management model

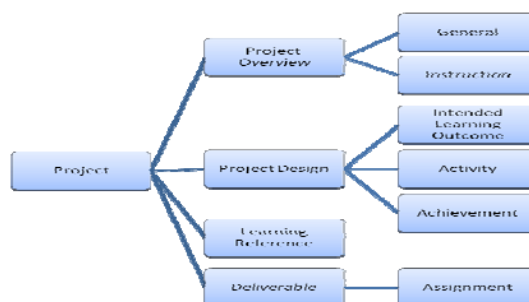


Figure 2 An initial project structure

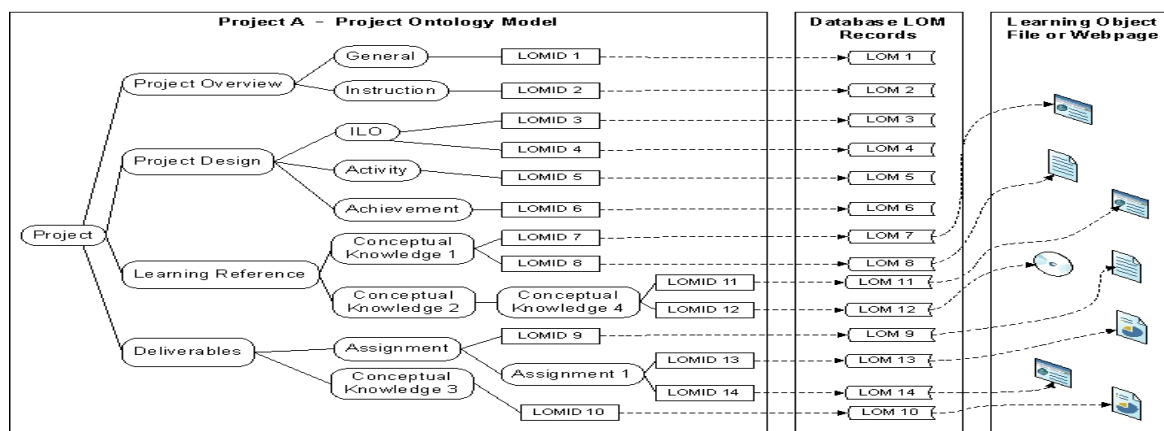
### 2.2 Managing a project

Since the initial project structure acts as a starting point in conducting a project, a learner will need to gather related learning objects by referring to those existing learning objects from previous studies, if there is any. When learners collect useful learning objects, they will use a subset of Learning Object Metadata (LOM), such as keywords, to describe these learning objects. Each learning object is identified by a corresponding LOM record. The LOM record together with learning objects, form the core components of the Information Layer. After accumulating a certain amount of keywords and the corresponding learning

objects, a learner may categorize these keywords into different concepts in the form of a keyword hierarchy, in which a concept is organized by identifying the relationships of keywords. The relationship can be in the form of parent-child, cause-effect or simply following chronological orders. These multiple views of relationships represent different perceptions or different aspects of a concept. In fact, a learner is able to manage a project by applying the Learning Resource Management Model throughout the project study.

### 2.3 Applying Ontology to facilitate Project-based Learning

In the Project-based Learning environment, a supervisor may handle a number of different projects at a specific time: setting initial project goals, providing feedback for Learning Objects collected by learners, designing project path, assessing performance of learners. It is desirable to facilitate effective management of projects for a supervisor.



**Figure 3 A Project-Based Learning environment by applying project ontology**

While different projects are being managed by a supervisor at a specific time, it is desirable to have a common representation for a project so that it can be referenced by both the supervisors and the learners structurally. Ontology can be defined as a set of knowledge terms, including the vocabulary, the semantic interconnections, and some simple rules of inference and logic for a particular topic [4]. It thus, seems that ontology is a suitable means to represent the multiple views of relationships between keywords. The project ontology model is created on the basis of the initial project structure in which, different concepts can then be organized and linked to this project ontology model (Figure 3). Learners can make use of the keywords provided in initial project ontology and group the collected learning resources under different keyword categories. Each of the collected learning objects will be identified by a LOM record and will be stored in the learning object repository. Learners may also consider selecting new keywords when existing keywords cannot suitably describe the useful learning resources that are newly identified. Different concepts can then be formed and evolved when more learning resources are collected and more keywords are selected. The organization of the keywords and the evolution of the project ontology represent the path of understanding to various aspects of a project. The project ontology thus, gives a clear description on how the related concepts are put together. In addition, it is an explicit representation of a shared understanding of important concepts in a certain domain of interest [5].

The project ontology does not only organize the concepts that learners explored but also create a structure for all projects. Each concept is able to link up with a LOM record describing the corresponding learning object. These artifacts include objects that a learner may collect and create during the project study. By introducing the project ontology in the Project-based Learning environment, a supervisor is able to define a clear project structure

for all students, manage the learning resources, assessing learning outcomes as well as controlling the project progress in a systematic and effective manner.

### **3. A new PBL Environment**

#### *3.1 The Design Rationale*

The project ontology acts as a common platform to facilitate discussion among supervisors and learners; and manages both the learning resources and learning outcomes throughout the project study in order to facilitate knowledge building, knowledge sharing and knowledge preserve. A new PBL environment was developed to demonstrate that new Project-Based Learning perspective. As mentioned in section 2, the environment should facilitate the entire project study by managing the project information, managing the learning process, managing the learning resources and managing the learning outcomes.

#### *3.2 System Design*

The new environment consists of four functional areas: Project Information Management, Learning Process Management, Learning Resource Management and Learning Outcomes Management.

In *Project Information Management*, the essential project information such as project title, background and objectives are to be maintained and evolved.

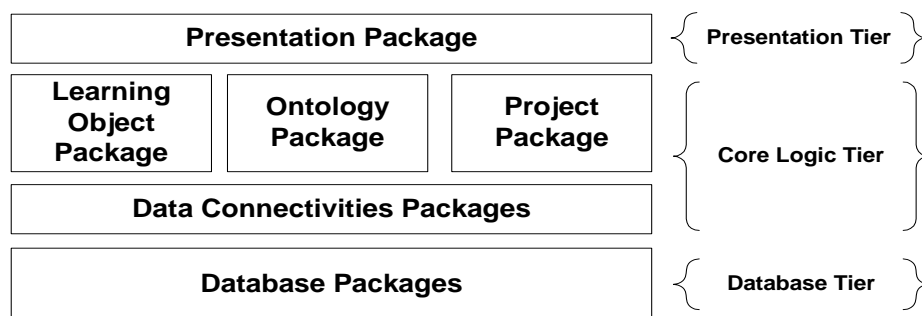
In *Learning Process Management*, a supervisor may design initial learning instructions, which include defining the project structure; setting up project schedule according to project objectives; defining deliverables, etc. Further instructions such as suggesting new search directions in literatures, requesting a summary or comparison between certain existing methods, or creating a forum for discussing a collected learning object collaboratively and so on. Intended learning outcomes may be checked by requesting the provision of outcomes at various stages of the project so that a supervisor may be able to monitor the learning progress of a learner.

In *Learning Resource Management*, learners may add a learning object by creating a corresponding LOM record. Each LOM record is described by some keywords. This LOM record will be stored in the learning resource repository and the LOM record will be linked to relevant concepts or deliverables under the project ontology. Learners may also provide summary, critique, comments, etc. linked to a learning object and thus, learners can make use of this collective wisdom in nourishing their own project ontology.

In *Learning Outcomes Management*, learners may deposit their deliverables against the intended learning outcomes and the learning instructions. A supervisor may check whether a learner has produced a piece of deliverable on time with the desirable quality. A supervisor is able to provide feedback to a learner or a project team so that further improvement can be made.

#### *3.3 Implementation*

The environment is implemented under an enterprise architecture design (Figure 4). The database tier stores learning resources in binary formats. The core logic tier manipulates the Learning Objects, their corresponding LOM records and the project ontology. The presentation tier handles user interface and presents the project ontology and other necessary data to a learner.



**Figure 4** System architecture of the new Project-Based Learning environment

The development of the Project-based Learning environment has applied various semantic web technologies: Resource Description Framework (RDF) [7] and Web Ontology Language (OWL) [8] for project ontology representation; Protégé [9] as the ontology editor for the initial project ontology; Jena API [10] for manipulating the project ontology persistence; Ext API [11] for rendering the ontology data for human interventions.

#### 4. Conclusion

A common platform in managing learning resources as well as assessing the learning performance of learners is essential for Project-based Learning environment. This paper described the design rationale of such an environment and a development of a prototype. Web 2.0 technology is selected to implement the environment because of its collaborative nature. The prototype assists various stages of the Project-based Learning. It is able to manage project structure by organizing the project information into project ontology, to provide a common platform for learners to collect, discuss, update the learning resources, and to allow supervisor to assess the deliverables submitted by learners. This newly developed PBL environment also helps in preserving the project knowledge for future reference. The next step of the study is to have a trial run on project students and evaluate the efficiency and effectiveness of the environment.

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