Description of an Instructional Ontology and its Application in Web Services for Education

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1 Motivation

From an educational point of view, the potential of the Web is far from being reached. Although it offers an abundance of learning resources the search for educational resources is still tedious, and interoperability of e-learning systems only a wished-for goal. What is missing is a common ground for both human and machines. While there exist standards for describing learning resources, they fail to address the instructional purpose of a resource, for instance whether a web page provides a definition or a counter-example of a concept. However, such an explicit representation of the instructional function provides humans with a shared vocabulary and can serve as the basis for the semantic interoperability for machines. This article describes such a basis: an ontology of instructional objects (OIO) that captures the function of a learning resource. The article starts with describing several educational Web services that can benefit from it. Then, the ontology is described in detail.

2 Educational Web Services

The additional pedagogically relevant information of an ontology of instructional objects brings forth better Web services. If the resources are annotated appropriately, Web services can use this information. More specifically, it increases the accurateness of a service because at design time, a Web service developer can foresee different functionality depending on the type of the resource. For most educational services, the information whether a resource contains a definition or an example will be of use. Similarly, service composition is enhanced. For instance, a requester service can require different actions from a provider depending on the instructional type of a resource.

Examples of Web services that benefit from an OIO are for instance course generators ([3]). They assemble learning resources to a curriculum taking into account learner properties such as knowledge. If (third-party) resources are annotated by their instructional function, a course generator can include them appropriately in a curriculum, depending on the chosen pedagogical strategy. For instance, in a problem-based approach, to first present a real-world problem and the necessary definitions afterwards. A learner model that stores personal preferences and information about the learner's mastery of domain concepts can profit from the annotation, too. For instance, reading an example should trigger a different updating of the mastery of a concept than solving an exercise. Other educational Web services profit in a similar way, e.g., data mining (extracting pedagogically relevant information from the paths of a learner through the learning material), feedback in interactive exercises, intelligent assistants, adaptive hypermedia services such as link annotators, and authoring support (by providing hints to the author about missing instructional items).

3 Description of the Ontology

The goal of this work is to provide an ontology that describes a learning resource from an instructional perspective. The ontology does not describe the content taught by the learning material, e.g., concepts in physic and their structure. Instead, each class of the ontology stands for a particular instructional role a learning resource can play, for instance a paragraph in a text-book. However, it does not contradict LOM or related initiatives which operate at the domain level; all these approaches can very well be used in parallel.

For this ontology to be as broadly applicable as possible, I analyzed about 30 sources, ranging from instructional design theories and to other e-learning systems. Additionally, several instructional experts reviewed the ontology. The ontology was implemented in OWL. Figure 1 shows the class hierarchy.

Instructional object is the root class of the ontology. Its properties are a unique identifier and a subset of the IMS/IEEE LOM [2] metadata.

The class *concept* subsumes instructional objects that describe the main pieces of information being taught. A *depends-on* property represents connections between concepts.

A *fact* describes an event or something that holds without being a general rule, e.g., historical facts.

A *definition* states the meaning of a word, phrase, or symbol. Often, it describes a set of conditions or circumstances that an entity must fulfill in order to count as an instance of a class.

A *law* describes a general principle between phenomena or expressions that has been proven to hold. Its subclass *law of nature* is a scientific generalization based on observation. A *theorem* describes an idea that has been (mathematically) demonstrated as true.

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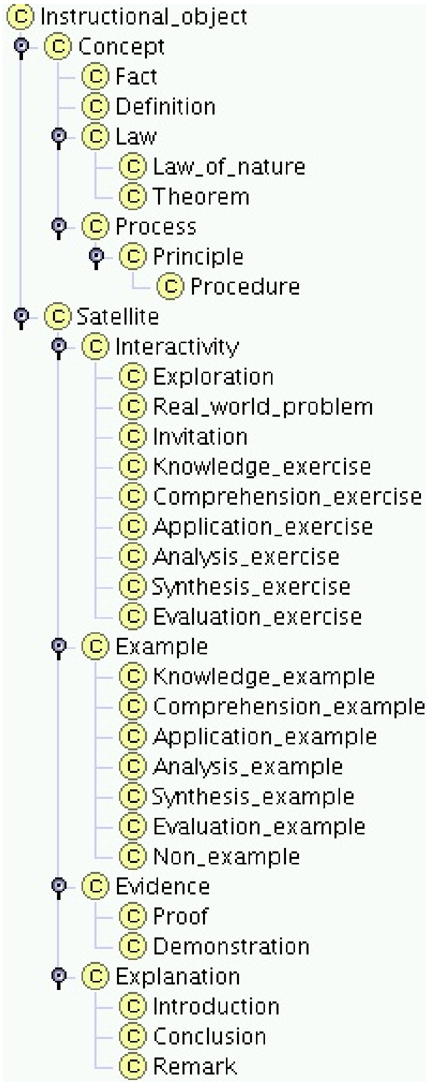

Figure 1: Class hierarchy of instructional objects.

Process and its subclasses describe a sequence of events. The deeper in the class hierarchy, the more formal and specialized they become. A process provides information on a flow of events that describes how something works and can involve several actors (e.g., "how is someone hired in a company"). A *principle* describes a fixed or predetermined policy or mode of action. One principal actor can employ it as an informal direction for tasks, or a guideline (e.g., analyzing a work of literature). A *procedure* consists of a specified sequence of steps or formal instructions to achieve an end and can be as formal as an algorithm.

Satellites are not the main building blocks of the domain, but elements that provide additional information about the concepts. A satellite offers information about one or several concepts, enumerated in a *for* property.

An *interactivity* offers some kind of interactive aspect, more general than an exercise as it does not necessarily have a defined goal that the learner has to achieve. It is designed to train an ability related to a concept. The difficulty of an interactivity is represented as a property. The subclasses of *interactivity* do not capture technical (forced choice, multiple choice questions) but instructional aspects.

Using an *exploration* the user can explore aspects of a concept without a specified goal (e.g. simulations).

Real world problems describe a situation from the learner's daily life that involves open questions or problems.

An *invitation* is a request to the learner to perform a specific activity, e.g. , a call for discussion with other students or meta-cognitive hints.

Knowledge, Comprehension, Application, Transfer, Synthesis Exercises/Examples correspond to typical exercises / examples found in learning materials. They differ in the educational objective they aim to achieve, e.g., whether a learner can recall or apply a concept.

An *example* serves to illustrate a concept. Similar to interactivities, it has a *difficulty* slot. A *non-example* is not an example of a concept but is often mistakingly thought of as one.

An *evidence* provides supporting claims made for a law or one of its subclasses. Therefore, the *for*-property of an evidence has a range the class *law*. A *proof* is a more strict evidence. It can consist of a test or a formal derivation of a concept. A *demonstration* consists of a situation in which is shown that a specific law holds (e.g., experiments in physics).

An *explanation* provides additional information about a concept. It elaborates on some aspect, points out important properties. An *introduction* contains information that leads the way to the concepts. A *conclusion* sums up the main points of a concept. A *remark* provides additional, not obligatory information about an aspect of a concept.

4 Related Work and Conclusion

While there exist standardized ways of describing learning resources (i.e. IMS/IEEE LOM), these approaches fail to address the instructional purpose of a resource. They can not represent, for instance, that a web page provides a definition or a counter-example of a concept. Work regarding instruction and ontologies was done by [1]. They describe how an assistant layer uses an ontology to support content authoring.

This article described an ontology of instructional objects which captures the educational "essence" of a learning resource. This ontology is supposed to serve as a shared and common understanding that can be communicated between people and applications. A number of Web services were described to illustrate how they benefit from the ontology. It is the hope of the author that the ontology is one step forward to bring the web to its full e-learning potential.

References

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