Linking learning technology with agricultural knowledge organization systems

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In the agricultural domain there exist already several mature controlled vocabularies, such as FAO's AGROVOC Thesaurus, the CAB Thesaurus, and the National Agricultural Library Thesaurus in the United States. These knowledge organization systems provide the required support for indexing , annotating or classifying documents according to the terminology of the domain. In recent years, this has been complemented by ontology versions of some of these controlled vocabularies or newly created ontologies. Learning technology can benefit from such systems by linking to them via learning resource metadata. However, when annotating learning resources, there is a need to consider some requirements that are not usually accounted for in typical indexing tasks. Learning objects about agriculture can be annotated with existing KOS with idioms that enable better integration with advanced learning technology.

***Index Terms*— Agriculture, ontologies, thesauri, classification, knowledge organization systems, learning objects.**

I. Introduction

KNOWLEDGE ORGANIZATION SYSTEMS (KOS) are schemes for organizing information. According to [1], KOS include classification and categorization schemes that organize materials at a general level, subject headings that provide more detailed access, and authority files that control variant versions of key information such as geographic names. Knowledge organization systems also include highly structured vocabularies, such as thesauri, and less traditional schemes, such as semantic networks and ontologies.

In the area of agriculture, FAO [2] has collected a list of relevant KOS [3], including ontologies and less formal terminologies. These are being used for information search today, used for the indexing of documents in general. One particular indexing or annotation context is the annotation of learning objects, which are essentially learning resources devised for modularity and reusability [4]. The indexing of such learning resources has distinguishing requirements, since searching for learning resources in many cases includes user needs related to the educational properties of the resources, and not only the topic or general concepts dealt with in them. Several evolving standards and specifications have been crafted for that specific purpose. Further, learning technology systems attempt to retrieve learning objects based on advanced pedagogical criteria, and some of them attempt to compose some of them into higher levels of instruction. This calls for revisiting learning object annotation practices in the light of the requirements of such systems. In the case of agriculture, the KOS are considered to be mature, however when annotating learning resources there is a need to follow some specific guidelines to come up with the best annotations possible for their exploitation by means of advanced learning technology. This short paper sketches some of the guidelines that have been identified in the context of the Organic.Edunet project [5].

II. Linking Agricultural KOS with LT

Current learning object metadata schemas as IEEE LOM actually provide room for annotating resources with elements in KOS. Concretely, the `Classification` category in IEEE LOM is targeted for that use. This can be combined with specifications for the mapping of heterogeneous KOS as SKOS. Then it is possible to link a learning object with elements in several KOS or with unified terms that cluster together the terms in several KOS. Using `Classifications` in IEEE LOM would actually entail an indexing of the resource in a traditional Information Science philosophy. However, learning resources are specific kinds of information resources, and there are additional desirable requirements on KOS used for annotation and on the way the annotations or indexing is carried out. These include the following:

I. *Predication of pedagogically relevant intentions* of the indexing.
II. *Consistent degree of granularity of the terms.*
III. *Separation of content indexing and pedagogical intention.*
IV. *Pedagogical interpretability of relations*, i.e. that the relations between the terms represent useful relations for representing learning chunks or relations among learnable elements.

Also, the use of KOS related to pedagogical properties have a special, separate role, as they affect the processing of the resource by LT in a very distinct dimension.

These requirements can be interpreted as quality criteria, so that a KOS or a way of annotating can be judged to be better for learning technology if it is closer to the attributes presented. In addition to them, there are other process- or technical- attributes that should be considered, as the maintenance process of the KOS or the availability of tools for the KOS, but here we deal only with those related to the annotations of the resources.

Each term or concept used for indexing a learning resource should ideally be connected via a predicate as concrete as possible, so that it is possible to decide on the pedagogical usages of the resource. For example, if we have the resource

R1: "*Types and Uses of Nitrogen Fertilizers for Crop Production*" [6], a typical indexing may use the `Nitrogen fertilizers` term, which is code 5195 in AGROVOC (which has not narrower terms). The addition of a predicate like `discussesApplicationOf` provides an added value for the search process, by differentiating other resources as R2: "*Economics of Nitrogen Fertilizer and Crop Production*" [7], which could in turn be linked to the same AGROVOC term but through a predicate like `discussesEconomicsOf`. This is a typical example for practical subjects, in which typically both economic and technical constraints are important from a learner's perspective. If different kinds, parts or constituents are important for learners, the granularity of the terms in the KOS is an important issue. Following with the example, narrower terms of nitrogen fertilizer should be used. While this is a common guideline in indexing, when annotating learning resources, some KOS may be inappropriate if they have not enough level of detail to match the instructional objectives. For example `Ammonium Fertilizers` in AGROVOC is a term used for `Nitrogen Fertilizers`, and this may prevent the selection of ammonium fertilizers resources for separate learning activities.

In addition to the differentiation of the predicates that relate the resources to the concepts, there is a need to differentiate the predicates that describe the topics from those that describe pedagogical properties. In the second case, pedagogical applications depend on *contexts targeted* [8], and there may be different of them. For example, a resource with quantitative data on the effect of nitrogen fertilizers in the soil will have an unambiguous context indexing, but it may be used in two different learning contexts either as a vehicle to learn about the importance of organic agriculture techniques, or simply as a way to know facts on these kinds of fertilizers.

The pedagogical interpretability of relations in the KOS is essential for systems that use those relations to reason about instructional sequences. For example, Reigeluth's elaboration theory [9] uses relations as "broader/narrower" between concepts to derive sequencing. The Plant Ontology (PO) [10] is an example of a KOS with clear part-of relations that can be effectively used for that purpose. For example, if a resource is annotated with a PO term as "`explainsConcept meristem[PO:0006085]`", learning object composition can safely proceed to compose with resources about other terms that are related with `part_of` to the term `root` (a *plant structure* in the PO).

III. Outlook

Indexing Web resources for functions related to learning technology requires a critical examination of the current practice of indexing, which need to be tailored to the specific needs of search and combination of learning objects. There is a need for idioms and methods for annotation, which tailor existing standards and specifications for the possibilities of learning technology that exploits annotations for selection and composition of learning objects.

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