# Combined Usage of Ontologies and Folksonomies in E-learning Environments

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## Abstract
This paper describes a working prototype which illustrates how socially constructed knowledge (specifically through collaborative tagging) can support domain experts to enrich ontological domain representations. E-learning has a particular requirement for a simple yet reliable ontology enrichment approach since domain experts usually lack knowledge engineering skills and domain representations are undergoing constant refinement. Our prototype serves to demonstrate our belief that the user interface of semantic-rich systems must be intuitive and necessarily simplistic, and provide support to the user at each step of the enrichment process.

## Keywords
Ontologies, Folksonomies, E-learning, Semantic Web, Web 2.0

## ACM Classification Keywords
H.1.2 [User/Machine Systems]: Human factors
K.3 [Computing Milieux]: Computers and Education; K.3.1 [Computer Uses in Education]: Collaborative learning, Computer-assisted instruction (CAI)
H.3.m [Information Storage and Retrieval]: Miscellaneous

## Introduction

E-learning research can be split into two main groups: the first aims at creating e-learning environments that adapt lessons and activities to the abilities and needs of an individual learner; and the second aims to overcome physical separation by better connecting learners and instructors. We generally associate two main Web-oriented approaches with these groups: semantic web technologies are often used to enable personalized learning environments; while Web 2.0 technologies are often used by educational technologists to easily connect learners with each other and their teachers. However, in light of recent research [5], we feel that these technological approaches are not fundamentally incompatible. In fact, we explain and show how socially constructed knowledge can be used to enrich ontologically engineered knowledge to facilitate new methods of personalized adaptation and instructor feedback, while still maintaining the connectedness of social software in e-learning systems. Enabling our approach is an intuitive user interface which is based on established visualizations and simple interactions. We provide a new interaction method for domain experts to manually enrich domain ontologies from folksonomy sources.

## E-Learning Research

Much of the personalization research in e-learning is focused on leveraging semantic web technologies to create semantic-rich e-learning systems. These systems rely on ontological representation of the entire e-learning process which is often logically divided into several layers representing features of the learning content, the domain of instruction, the chosen instructional model, and the characteristics of learners' and instructors [2]. Most of these ontologies are fairly persistent over subsequent offerings of web-based courses. However, course content continually evolves through the addition, removal, and refining of concepts and lessons.

*Ontologies and Collaborative Tagging in E-Learning*

The continuous changes to a course and its content have been traditionally made by an instructor without much thought on how it could impact the domain ontology or annotated content. We view collaborative tagging as providing a potential two-part solution to the difficulties of maintaining domain ontologies. First, tagging is a simple and straight-forward method which would allow more authors to become involved. Learners may be able help supply new domain knowledge, since when considering a group of taggers, common tags tend to represent actual domain concepts more accurately [7].

Secondly, collaborative tagging software has been shown to provide a source of *social support* that users may employ in their own authoring process (e.g. tag suggestions or viewing a tag cloud describing a resource) [6].

## Connecting Folksonomies and Ontologies

We see several advantages from connecting folksonomies and ontologies. First, it provides a way for learning content to be semantically annotated on an ongoing basis (i.e. if tags were directly linked to ontology concepts, the concepts would then be automatically associated with the tagged content). Given this scenario a number of new functionalities could be enabled for students, such as automatic feedback to students on concepts they may have missed in readings, indicated by the coverage of the tags in their folksonomy. In addition, the tags

associated with the domain would allow instructors to have feedback on the progression and understanding of students in the class and to use this feedback in the ontology enrichment process.

Currently there are two main approaches for linking folksonomies and ontologies. The first relies on altering the collaborative tagging process so that it creates "semantic tags". Semantic tags have either been disambiguated by a user (i.e. tags are mapped to concepts in an upper-level ontology) [2], or tag relationships have been defined by the community [4]. Neither method has proven to be overly successful. We attribute this to the fact that the additional effort required by typical taggers in creating the semantic tags, outweighs the perceived benefits.

Another approach has the ambitious goal of automatically or semi-automatically linking collaborative tags with ontologies. While, these approaches have had some promising results they have not yet revealed a general purpose and reliable solution [1].

## Ontology Enrichment using Folksonomic Support

Given our anecdotal experience we believe that e-learning instructors desire control and precision both in their interactions with students and in the process of defining and maintaining domain ontologies, but usually lack the in-depth knowledge required to use a typical ontology editor. For this reason, we have opted for an instructor controlled enrichment approach based on interactions with visualizations. We have embedded a prototype for our approach as an extension to the LOCO-Analyst system [2]. LOCO-Analyst is an educational tool which provides instructors with feedback regarding: (i) different kinds of activities their students performed and/or took part in during the learning process; (ii) the usage and the comprehensibility of the learning content and (iii) contextualized social interactions among students (i.e. social networking) in the virtual learning environment. Our extensions to LOCO-Analyst are shown in Figure 1.

The domain ontology is presented using a graph visualization. The instructor can explore the graph by zooming in and out, and reorienting the graph view by clicking and dragging nodes.

Support from the folksonomic data is presented to the instructors in the form of a tag cloud. We have two feedback variables of interest to present to the instructors for support in enriching the domain ontology. The first is the popularity of a tag, which is calculated by the number of times a given tag has been used to annotate a particular piece of learning content. The second is the measured semantic relatedness between a tag and an ontology concept. We gather the semantic relatedness scores by using the Normalized Search Similarity algorithm for Wikipedia provided by a web API for semantic relatedness [7].

We performed a pilot study of 3 alternative tag visualizations, which asked 10 participants with teaching experience to choose their preferred visualization. The goal was to inform us on which type of folksonomy visualization would work best for instructors. We alternatively mapped font size, colour, and a ranked list to tag popularity. The most highly ranked alternative was selected for our system, which used tag size. Each of the alternatives mapped

algorithm binary binary code bug class code compiler control data debug design display error errors example fourth generation guess high high-level information input instructions interpreter java javascript know language level like logic low-level machine make names need number object object-oriented operation pop portability problem process program programmer programming programming language programming process pseudo code query language runtime step syntax task testing translator use user write

A tag cloud from the prototype system: size indicates popularity, and saturation represents semantic relatedness to a selected ontology concept.

An interactive ontology graph visualization.

semantic relatedness to the saturation of the tag colour (the higher the score the darker the tag appears). Our resulting visualization is consistent with typical tag cloud displays.

As an instructor explores the domain ontology graph - by clicking on individual nodes - the tag cloud is updated, displaying the relevant tags and changing the tag saturation to reflect the semantic relatedness with the selected node. Right clicking on the node presents a popup dialog which provides options on how a tag may be used to extend or update the ontology. This form of interaction allows instructors to easily explore and link different knowledge sources for domain ontology enrichment, without a requirement for knowledge engineering skills.

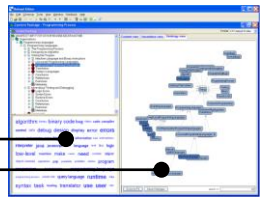

**Figure 1.** The LOCO-Analyst prototype, which provides interactive visualizations for ontology enrichment.

## Discussion

Our novel method of interactive visualizations provides an intuitive and practical way for instructors to incorporate the implicit feedback available from student folksonomies to evolve domain ontologies. Further, it allows instructors to maintain full control over the ontology enrichment process, while receiving feedback about how students are progressing (represented in the tags used) and potential similarities to the domain ontology (represented in the scores of semantic relatedness). We are currently in the process of incorporating the system into an online class, where we will conduct a case study to evaluate the usefulness, visualizations and interactions of the system.

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