EdUI: A Nascent Educational Informatics System at the University of Idaho

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Abstract: The design of an educational informatics system called EdUI, currently in development at the University of Idaho, is presented. Its purposes are to improve student retention and learning, and to facilitate efficient organization and presentation of learning resources. EdUI is essentially composed of a relational database of metadata describing and linked to learning objects. The use of open source software and widely accepted standards ensures interoperability. Three viewpoints are simultaneously considered in the design: educational, technological, and sustainability.

Introduction

This paper reports on the development of a web-accessible database of learning objects (an *educational informatics* system, or EdUI) for two introductory Civil Engineering (CE) courses at the University of Idaho (UI). The pedagogical goals of EdUI are to improve learning, retention, consistency, and efficiency. Learning objects are essentially defined here as lesson-sized or smaller, self-contained electronic media. These may comprise written notes, example and practice problems, presentations, design activities, pictures and video clips in a variety of file formats, stored in a distributed file system. Learning Objects are indexed with standardized metadata cast in a relational database. The technological foundation is based on widely available open source software.

A study performed at UI showed that of 175 students entering the CE program in 1996, 37% left after their freshmen year, and 55% did not continue to their junior year. While there are numerous reasons for this loss, we believe that we will significantly increase student retention by increasing the quality of two required introductory CE courses: CE 115 Introduction to Civil Engineering (freshmen), and CE 215 Civil Engineering Analysis and Design (sophomore). Introductory courses seek to retain students by: developing students' analytical and computational skills, thus ensuring future success; relating school to Civil Engineering practice; and providing for interaction with engineering faculty. We seek to address these issues and other with EdUI, while providing for better teaching and learning through consistently documented and easily accessed learning materials.

EdUI is designed to be flexible and scalable, using open-source software and accepted standards. Once the framework is fully in place, it can be easily extended to encompass other courses and disciplines, at UI or elsewhere. All of our CE course resources may eventually be available in EdUI, but we are populating the database with learning objects on a course-by-course basis. It will be interoperable with other learning object repositories, and we will encourage connectivity with other locations, both by networking with other repository servers, and by allowing outside users to contribute to EdUI as our hardware resources permit. Our approach to creating EdUI is described herein from three viewpoints: educational, technological, and content development/sustainability.

System Description

Educational Aspects

There is a widely recognized need to improve undergraduate education (e.g., NRC, 1999). Introductory courses form the foundation required for future courses, and therefore careers. Unfortunately, few introductory resources are available to support courses intended to offer an interactive experience of real-world engineering. In

developing EdUI, we address four interrelated characteristics of learning environments important to enhancing the rate and quality of learning (NRC, 1999):

- The learning environment must be centered on the learner;
- The learning environment must be enriched with structured knowledge;
- It is essential to have on-going, or formative assessments; and
- The context in which learning takes place affects the learning process.

Learning-Centered Environments

EdUI will help reduce the emphasis on the traditional lecture by providing interactive tutorials, problem sets, and other sources of information that can be accessed by the student when convenient, and at the pace and depth required by the individual. Less reliance will be placed on the instructor for content, making more time available during scheduled "lecture" periods for in-class activities. In a computational laboratory setting, students will have access to learning materials while completing associated activities.

Structured Knowledge

Cognitive research indicates that organized knowledge supports understanding, and understanding enhances new learning, thus improving expertise (NRC, 1999). In a knowledge-based learning environment, learning resources should be appropriately structured, inter-related, and students are provided with examples of mastery (NRC, 1999). Information will be effectively organized within EdUI, in which a relational database is used for metadata, allowing the learning environment to be knowledge centered. EdUI will allow teachers to easily re-organize learning resources to improve learning based on observations of student performance. Moreover, by organizing and linking resources currently individually maintained by a group of instructors, we will improve delivery consistency and efficiency.

Formative Assessment

The continuous process of evaluating the strengths and weaknesses of both teachers and students is a challenge made more manageable with information technology, which enables a wide range of means to communicate and collaborate. While it is essential that instructors initiate feedback on a regular basis, formative assessments (instructor to student) can be incorporated into various electronic media. Students will be provided a means to assess the content quality of the learning objects, as well as to improve upon them, which will in turn provide the instructors with valuable feedback while growing the system.

Learning Context

Educational activities must promote intellectual camaraderie and build a sense of community, in part to enable effective formative assessment. While informatics alone can not create an environment in which the norms that encourage learning are emphasized, a sense of community is fostered by simply facilitating communication and collaboration. On a deeper level, however, the students themselves will help build the system, by providing feedback on the structure and implementation of EdUI, in correcting or otherwise improving existing learning objects, and by developing new components (e.g., worked example problems, presentations, etc.) that will be added to the system for future generations of students to use. A community of faculty will also develop as a result of this work.

Technological Aspects

Each learning object within EdUI is a collection of files that address a particular topic, with accompanying metadata. EdUI manages a collection of learning objects, and provides methods to easily access, create, search, and manipulate those objects. EdUI is being developed using widely available, open software. By using industry standard open source software we gain access to a wealth of existing tools, accelerating development and allowing others to emulate our model. Moreover, we are using two currently accepted metadata standards, including suggested vocabularies and languages, ensuring interoperability with other open systems. Metadata standards are described in a following section. Figure 1 shows the general layout of EdUI.

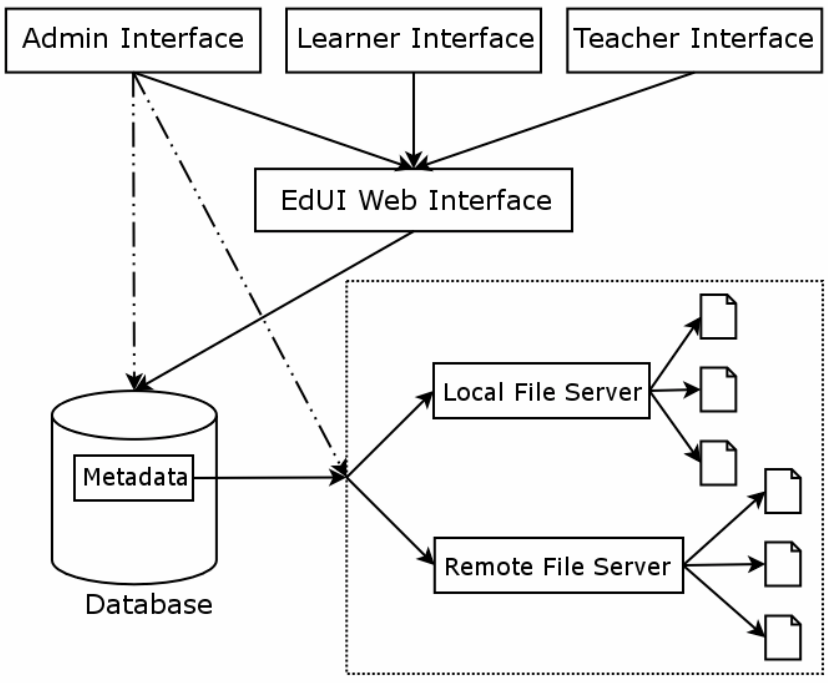

Figure 1: General Structure of EdUI

Implementation

The actual software behind the EdUI system (not including the learning objects themselves) consists of three major components, as shown in Figure 1. These are:

- A relational database responsible for storing metadata,
- An underlying file system responsible for storing the learning object files, and
- A web based user interface to interact with the system.

The relational database is constructed using MySQL, but is designed to be easily adapted to use other database systems. The database contains over 50 tables that model the metadata standard(s), incorporates the various vocabularies recommended to be used with the standard(s), and controls modification permissions. The database is designed to be extensible. The database is designed to be consistent with existing standards, but will be extended based on our needs. For example, the suggested vocabularies suggested for use the metadata standards have already been found lacking in the area of engineering, thus vocabulary extensions will be incorporated and documented.

The file system is not necessarily local to EdUI, although it is first developed that way to facilitate testing and control. There are many situations where it is logical for a learning object to reference a remote file or resource. EdUI is designed with this in mind, allowing for remote files to be associated with local metadata. File locations are tracked by unique identifiers, such as Uniform Resource Identifiers (URI), which are stored for each learning object

as metadata in the appropriate database table. Any file format can be used for learning objects, but use of common file formats are encouraged. While this approach requires that users have appropriate software, and there will be instances that users may not be able use a particular object, it will allow developers to use whatever software that they are familiar with.

The web interface is being served by Apache HTTP and is written in PHP. For the learner, several interfaces are available to find learning objects of interest. The learner has the ability to browse by collections of learning objects. This could be by discipline, by class, or by some other grouping as constructed by the teacher. A search interface is also provided, allowing the learner to quickly find specific learning objects by keyword or by searching on specific metadata fields. For the teacher, interfaces are provided to create, modify, and otherwise manage the learning objects that they create. Teachers have the ability to finely delegate control over their objects, so that others can assist in maintaining those objects, or contribute to them. At first, only system administrators and teachers are allowed to insert and modify learning objects. Interfaces that allow learners to modify learning objects will be developed later.

Metadata Standards

EdUI has been designed to encompass two distinct but related metadata standards, the Dublin Core Metadata Initiative (DC; ISO 2003) and the Institute of Electrical and Electronics Engineers (IEEE) Standard 1484.12.1-2002 (IEEE 2002) for Learning Object Metadata (LOM). The DC is a smaller, more general standard, designed to facilitate creation of "intelligent information discovery systems." The IEEE LOM standard is more comprehensive, designed specifically to describe learning objects. The IEEE LOM standard defines a mapping to the DC, which provides a mechanism for interoperability between systems using either of these two metadata standards. Figure 2 shows how the IEEE LOM "classification" category is implemented in the relational database.

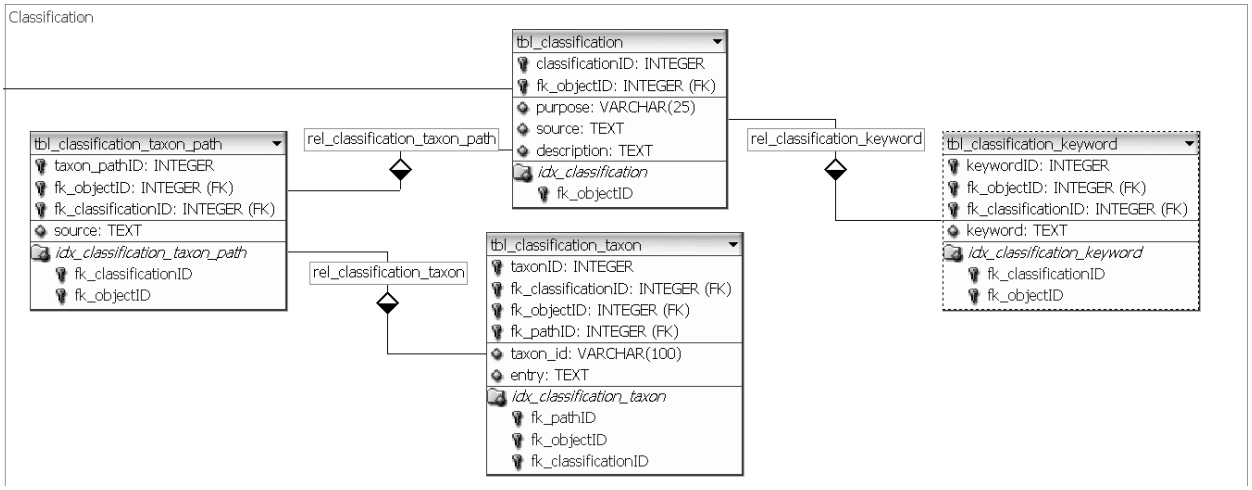

Figure 2: Relational Database Implementation of the IEEE LOM "Classification" Category

Because the IEEE LOM standard is a superset of the DC, an incremental development model can be used. The relational database has been designed to include the entire IEEE LOM standard from the very beginning. However, in the first stages of development only the DC elements are being used in the interfaces available to the end-users. As development of EdUI progresses, additional elements of the IEEE LOM standard will be included in these interfaces (and the metadata associated with the learning objects cataloged earlier will be updated), until ultimately the entire IEEE LOM standard will be accessible. One goal of this incremental design strategy is to initially keep the software components of EdUI small and mobile, making design changes and refactoring easier to accomplish. Ultimately this will enable EdUI to be a more polished, useable, application early in its lifecycle. Moreover, it will enable faculty unaccustomed to working with metadata to be introduced slowly, resulting in more participation.

Development Approach and Sustainability

To a large extent, content development is driving the creation of EdUI. From our perspective, there is a clear need for students to have access to electronic learning media that adequately supports an undergraduate education. There is also a clear need for there to be a means for instructors to consistently deliver these media such that entire courses and curricula are covered, without having to search through numerous sources using disparate technology. Rather than concentrating on the technological aspects and sparsely populating the system with a few learning objects in many different discipline areas, we are building EdUI course-by-course. This should ensure that a "critical mass" is rapidly reached for each discipline area and the system is used repeatedly by students and instructors of the completed courses.

At UI, CE 115 and CE 215 are, to a large extent, "community taught" classes, as they are not specific to any one discipline area in CE. All UI CE faculty are expected to contribute lectures and learning materials. Faculty will learn about and develop the system together initially, enabling extension to other classes without extensive "training." In extending EdUI, we will request that for each new course, a near-complete set of learning objects be created; modifications and growth will naturally follow once functionality is reached for each course. While use of a common "suite" of software and associated file formats is encouraged, EdUI allows learning objects to comprise any file formats.

This approach is inherently sustainable at the local level. At the global level, we are striving for sustainability by using open source software and widely accepted standards. In fact, by using common tools with little customization, keeping the system as simple as possible while allowing rich organization capabilities, and providing a full "map" of the system so others may emulate it, we hope to spur creation of a network of linked educational informatics systems.

Summary

The development approach to EdUI considers three distinct aspects of an educational informatics system, each critical to the overall success of implementation. The system is technologically rooted in open source software and widely accepted standards. Learning objects are being created that address important pedagogical issues and adhere to the tenets of object-oriented design (small, self-contained, and re-usable). Both the development approach and use of readily available tools are intended to ensure sustainability.

Because there is a dearth of appropriate resources for introductory engineering courses, considerable time must be spent preparing and providing traditional lectures. EdUI will make more classroom time available for active learning approaches that generate student excitement and stimulate critical thinking. In other words, we seek to make more effective use of the instructor's time while making the student experience more relevant and meaningful, thus increasing both student learning and retention.

References

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