

Studying Educational Digital Library Users and the Emerging Research Methodologies

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INTRODUCTION

This article describes emerging methodological approaches for studying learners and educators as they interact with *educational digital libraries*. As will be described with examples, an educational digital library (EDL) is an online library specifically created to support teachers, students, and lifelong learners. An EDL typically consists of a repository of high-quality instructional resources catalogued with educator-specific metadata, along with services and tools designed to support educational uses.

These online collections can be engineered to capture fine-grained usage data. The resulting massive and longitudinal datasets contain important evidence about teacher and learner behaviors in complex online information ecologies, and their analysis remains challenging, a problem sometimes referred to as the ‘data deluge’ problem (Hey & Trefethen, 2003; Computing Research Association, 2005; Xu, Recker, & Hsi, 2010).

In response, the field of *educational data mining* (EDM) offers research methodologies for mining and discovering patterns in such data automatically. These approaches typically rely upon computational power to help reveal and visualize emerging patterns, and are intended to complement established methods such as user surveys, interviews, or observations. This article provides detailed descriptions of these research methodologies, in particular the application of clickstream, query log, social network, and text mining analysis to educational usage data.

BACKGROUND

The recent widespread availability of educational resources on the World Wide Web holds great potential for transforming education. In recognition of this potential, several large-scale initiatives are developing repositories (or, *digital libraries*) of online learning resources, sometimes referred to as *learning objects* (Wiley, Recker, & Gibbons, 2000) or *open education resources* (Smith & Casserly, 2006). These learning resources can consist of innovative curricula, teacher-created lesson plans, as well as interactive tools such as visualizations and simulations that support educational uses of real-world datasets (McArthur & Zia, 2008).

Online resources stored in digital libraries are usually catalogued and described with metadata that supports teachers’ discovery (Weibel, 1995). Education-specific metadata records for learning resources contain basic catalog information about the object, including its general, technical, semantic, and pedagogical characteristics. In some implementations, it can also include more subjective information such as teaching tips or comments.

Increasingly, this technical infrastructure is combined with the social aspects of ‘Web 2.0’ functionality to produce a collaborative network not bounded by geography, time, or educational context. The intent is to support users (especially teachers and students) to access, create, connect, and share knowledge in ways that fundamentally transform practice in order to help improve the effectiveness and efficiency of education

(Borgman et al., 2008; Computing Research Association, 2005).

The next section briefly describes several educational digital libraries and associated tools.

Example Educational Digital Libraries

The *National Science Digital Library*, or *NSDL* (<http://nsdl.org>), is the U.S. National Science Foundation's (NSF) online library of resources and collections for science, technology, engineering, and mathematics education targeted at learners and teachers of all ages. Resources range from large-granularity resources (e.g., a semester-long course in plate tectonics) to small ones (e.g., a simple graphing calculator applet) (Zia, 2001). As of August 2012, NSDL contained 123 collections and over 125,000 records (including metadata and annotations), in addition to other supporting user and technology services. The NSDL deals with the challenge of searching across heterogeneous databases (Zhang, Durbin, Dunn, Cowan, & Wheeler, 2012) by providing a unified discovery interface to assist non-specialist users such as teachers and learners. In addition to federated searching NSDL also harvests metadata from its 18 network partner libraries to allow faceted searching to further aid in educational resource discovery. Faceted searching can narrow down search results by education level, resource type, subject, audience, or educational standard, clustering research results by facet.

The *Digital Library for Earth System Education*, or *DLESE* (<http://DLESE.org>), supports Earth system science education by providing access to high-quality collections of educational resources related to Earth systems, including access to Earth data sets and imagery, and support services to help educators and learners effectively create, use, and share educational resources. DLESE contains 12,994 resources and is a close partner of the NSDL, as the latter automatically harvests metadata from DLESE so that it is discoverable by NSDL users.

The *Exploratorium Learning Resources Collection*, or *ELRC* (<http://www.exploratorium.edu/nsdl>), is a digital library of over 700 teacher-tested science activities and instructional resources inspired and created from the Exploratorium's (a science museum in San Francisco, California) exhibits, public program events, and teacher professional development programs. The

ELRC is designed for elementary and secondary school teachers as its primary audience, and informal educators as its secondary audience. Teachers can browse the collection by topic or conduct keyword searches. Search results provide a short description of the item, as well as related topics to explore. For each resource item found, a resource record is provided that includes a description of the resource as well as teaching tips where appropriate. Advanced search enables teachers to narrow a search by curricular area, grade level, and specific resource type (i.e., image, video, activity, article, web interactive, web exhibition, museum exhibit, and/or professional development resource).

The *TeachEngineering* digital library, or *TE* (<http://www.teachengineering.org/>), covers engineering content for elementary, middle, and high school teachers. TE contains 69 curricular units (built on multiple lessons and related activities), 410 lessons (containing activities), and 723 student activities. The teacher-tested engineering materials tie in to math and science classes and have a high level of detail including teaching instruction, background information, procedures, and assessments. TE content is free, aims to be directly relevant to student's lives, and incorporates low- or no-cost activities. Teachers can browse the collection by subject as well as type of material. The content is also aligned with educational standards (international, national, and state standards) facilitating searching by standard. In addition to a field specific keyword searching and standards searching, advanced search also allows users to narrow down their search by grade level, group size, length of activity, and activity cost.

Outside of the United States, several educational repositories have also gained prominence. Examples include the European-based ARIADNE educational digital library (Duval et al., 2001), the Australian National Digital Learning Resources Network (<http://www.ndlrn.edu.au/>), and EduSource Canada (<http://www.edusource.ca>).

Example Educational Digital Library Services for Teachers

This section describes two example digital library services intended to support teacher use of online resources.

The *Instructional Architect* (<http://IA.usu.edu>) supports teachers in authoring instructional activities for students using online resources increasingly avail-

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