Some Aspects of Developing and Using the Digital Learning Environment in Alexandria Digital Earth Prototype

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Abstract

The paper describes technological (software) and instructional aspects of building an educational service that interfaces with the Alexandria Digital Library (ADL) and the Alexandria Digital Earth Prototype (ADEPT).

Introduction

The ADL is a consortium of researchers, engineers, and educators, spanning the academic, public, and private sectors, working together to develop distributed digital libraries for heterogeneous geo-referenced information. The mission of the Alexandria Digital Library projects is to complete research on issues critical for education surrounding the construction of distributed digital libraries of geospatially referenced multimedia materials; development of technologies necessary to support such a library; design, construction, and evaluation of test-bed systems based on research and development results; resolution of organizational and technological issues underlying transition from test-bed system to operational digital library (Frew, 2000, Janee, 2002). ADEPT is a next stage of the DLI2 project that The National Science Foundation has announced funding from 1999-2004.

This article continues the line of publications on ADEPT Digital Learning Environment (DLE). The description of the theoretical backgrounds and some design aspects is presented in the (Smith 2002 a-c). The recent stage of development and application of the DLE, based on an extended set of digital library collections and services, is highlighted in the ECDL paper (Smith at al. 2003).

Current educational service of the ADL/ADEPT Digital Learning Environment was designed for undergraduate education and can support the creation, search, and visual display of:

- Knowledge bases (KB) of scientific concepts records, which are based on the strongly structured model (Smith 2002 a);

- Digital library (DL) collections of learning objects that are organized and accessed by the scientific concepts from the lectures;

- Collections of presentation materials, such as lectures outlines, that are organized as trajectories through the KB of concepts records.

In this paper we focus on a practical example of using the Digital Learning Environment in the classroom with some technological comments.

Lectures Preparation Tools and Problems

There is a lack of Internet-based tools that can help an instructor add assets from a digital library or materials gathered from the Internet into an online lecture. These tools are usually separate applications, such as MS PowerPoint, FrontPage, Word Processor, Spreadsheet, Database, HyperStudio, multimedia encyclopedias, etc.; (Hurley, 2000) or general communications technologies such as Email and web-based videoconferencing, which are not integrated into the whole educational system.

Existing on-line courses share at least two common problems.

The first problem deals with using discrete lecture preparation tools. It can be difficult to integrate the output from different applications into one online lecture. During the lecture, the professor may have to switch from one presentation tool to another. This complicates students' perception and refocuses their attention from the lecture topic to the different technological instruments.

Another problem involves limitations in making changes to the online lecture presentation during class. This fact decreases the quality of teaching because it is important to incorporate class discussion, collaborative discovery and conclusions in lecture presentation materials.

Our project improves how instructors interact with the digital library learning materials and simplifies how they include those materials into lecture presentations.

Composing of DL Materials for Educational Purposes

The central tool in the Digital Learning Environment that enables lecture preparation and presentations is the Lecture (Presentation) Composer, (or Lecture Composer). The Lecture Composer provides technological support for instructors and scaffolds them with on-line instruments. General principles of the Lecture Composer are:

- Easy to use and to personalize the lecture organization processes

- Ability to create and access personal collections of lectures online

- Provide opportunities for other instructors to re-use lecture materials

The Example and Comments

The following example and comments show how the DLE works and illustrate its functionality.

> *Ms. White needs to prepare her next lecture from another university, where she participated in an annual research meeting. She opens the ADEPT DLE on-line lecture preparation interface..*

The DLE interface involves three windows:

- *Lecture Window* – a flexible, online template for displaying lecture notes and organizing the presentation of information about a topic and its associated concepts

- *Knowledge Window* – for visual manipulating science concepts from knowledge bases

- *Collection Window* – for displaying DL objects from DL collections.
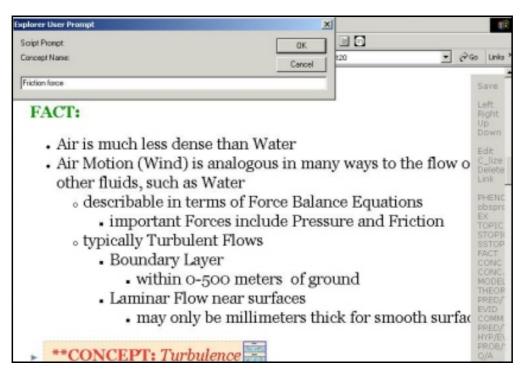
Each component is supported by corresponding services for online input, editing, searching, and display. (Table 1).

> *Step 1. Ms. White clicks on the starting granule to begin her lecture preparation. A Control Panel appears at the right side of the Lecture Window.*

A granule is a component of the lecture (Fig. 1). In contrast with educational portals, where the minimal element is basically a page, each lecture file is built up from granules. A granule can be viewed as a "bit" of educational content, for instant: a concept, topic, subtopic, question, problem, hypothesis, or just piece of text. Each granule has associated objects from the Knowledge Base and one or more associated items from the Learning Objects collection. Granules form a hierarchical tree-like structure, and can be visible or hidden on the screen in the display time and organized in the format of rich textual outline. This feature significantly improves navigation through the lectures materials: the instructor does not need jump from page to page, which can confuse students. Instead, he/she controls one compact lecture page by turning on and off visible or hidden granules.

Table 1. Composition and services of the ADEPT DLE

	Collection of DL Learning Objects	Knowledge Base of the Scientific Concepts	Lectures Presentation
Create/Edit Service	ADN Metadata Input	Concept Input/Edit	Lecture(Presentation) Composer
Search Service	ADL Middleware Search	KB Search	Presentation Search
Display Service	ADEPT Client (s)	Concept Display	Presentation Display

Figure 1. Lecture Composer interface

Step 2. *She investigates the Control Panel.*

The Control Panel includes three zones: Position at the Screen, Editing, and Template (fig. 1, right column).

Position at the Screen has options such as LEFT, RIGHT, UP, and DOWN. These options allow the user to quasi-automatically build indented lists and hierarchically arrange the granules.

Editing consists of EDIT, CONCEPTUALIZE, DELETE, and LINK. This area supports the user with:

- Editing granules using standard editing functions such as save, font, color, indentation, alignment, etc (Fig.2).

- Automatically creating the lecture's concept maps;

- Inserting new and deleting old granules; and

- Hyper-linking the text with DL collections items.

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Step 3. *Keeping the cursor on the start granule, she clicks on Topic in the control panel (template part) and makes the lecture outline in the format of an*

indented list. Then she uses the representation option in the template and prepares the lecture context, which consist of granules of key concepts.

The *Template* can be easily created by the user and automatically included into the Control Panel. It could be the template for all the course lectures, the template for laboratory experiments, or the template for exams or assessments. The Template can be redesigned any time and saved online when it is necessary. This very flexible simple tool helps the instructor integrate different learning tools and. simplifies the process of the lecture preparation. In demo version, the Lecture Composer uses the template from the Physical Geography 3 course, which includes following:

a. *Identification* of the scientific phenomena with: TOPIC, SUBTOPIC, AND SUBSUBTOPIC; OBSEVATIONAL PROCEDURE, and EXAMPLE. These represent high-level views of lecture materials.

b. *Representation* of the scientific phenomena with: FACT, CENCEPT, and THEORY options. This connects to the DLE Knowledge Base.

c. *Understanding* of the scientific phenomena with: QUESTION/ANSWER, PROBLEM/SOLUTION, HYPOTHESIS/EVALUATION, STATEMENT/DERIVATION, PREDICATION/TEST, COMMENT.

The Template itself is a dedicated document in the lecture format, and is created/modified with the Lecture Composer.

If the Template is used for K-12 lesson preparation, it can include other items, for example:
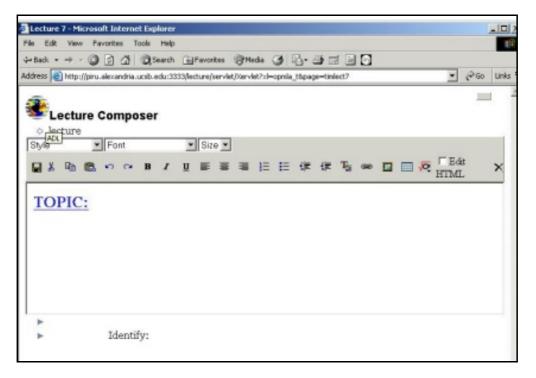
a. Teachers' Name

b. Grades and Subject

c. Lesson Title

d. Main, Auxiliary, and other Curriculum Standards/Objectives

f. Activity Description: Organization, Reading, Research, and Computing

e. Student Product or Performance

g. Assessment

Figure 2. Granule Design

Step 4. To illustrate each scientific concept, she uses the instructional materials from the Alexandria Digital Library. She makes search in ADEPT collection; finds appropriate objects, such as figures, movies, and simulations. Using the LINK option in the Control Panel, she incorporates the items into the lecture.

The search for collection objects is accomplished within the framework of ADN joint metadata. ADN metadata is mapped to the ADL bucket schema, which enables the use of the ADL web-based client for object search and retrieval.

Design.

The digital library items are displayed during the lecture in the Collection Window. A number of display services have been developed and are under development, including dynamic resizing/panning of the graphical objects for optimal viewing by the audience in the classroom.

The object collection consists of individual examples of items a lecturer may want to incorporate into a lecture. Currently, the objects consist of any web viewable data, such as maps, images, illustrations, web pages, QuickTime and Flash animations. These can be thought of as concrete examples of concepts and are designed to loosely reference the concept they relate to.

Implementation

Currently, the object collection is implemented in MySQL with a PHP interface for adding and editing objects. The actual objects are stored in a web-accessible location on the server with references in the form of URLs that are stored in the database. One

of the advantages of this design is that once the lecture has chosen the content of the lecture there is no longer any need to access the database.

Testing

The current object collection was implemented to support the ADEPT Physical Geography Class in the fall of 2002. It was extensively used in each lecture and proved to be a useful and stable tool.

Status

Currently, the object collection tools are fairly stable while the collection itself is under continual development.

The Future

Like the Knowledge Base, the design of the tools in this section must promote the growth of the Object Collection rather than merely use of existing objects. Although a base collection of objects is critical for the usability of the system, lecturers must be free to add specific examples and supporting objects unique to the particular point they are trying to make. In this way, the Object Collection shares many of the bigger design issues the Knowledge Base is facing, such as user and group interaction with items.

Features planned include expansion of the types of data stored in the collection. The possibility of more interactive and robust simulations on varying datasets has been a driving idea behind the creation of the object collection tools as well as most of the ADEPT systems.

Display.

Currently, the display of the items in the object collection is implemented through a web browser. Under the current design, the objects are all in a format handled by a standard web browser with a reasonable set of installed plug-ins (e.g., Java, QuickTime and Flash).

Future design enhancements include research into web services to manipulate and view other types of data. For instance, one web service may take a reference to a digital educational material (DEM) and render a browser-viewable image from a specific view of the DEM. The reference to the DEM would be stored in the database with a standardized web service description and possibly default parameters. This allows a lecturer or lab designer to easily understand the types of interactions possible with the service.

Another possibility for expanding the types of objects possible is through helper applications on the client side. For most stand-alone applications, this is less desirable due to the fact it would require additional installations on the lecture or lab computer prior to the viewing of a lecture. A better design would be the development of browser-based helper applications in Java or Flash with a generic interface accepting a reference to the desired data as part of their URL. An example of one such application is the Java 2DGraph tool under development as part of the Knowledge Base. Although this tool is designed with a specific purpose in mind, it has a generic, easy-to-understand interface, which allows the display of any kind of data with a node/relationship structure.

> **Step 5**. *She checks the information from the Knowledge base that represents each concept.*

In the DLE knowledge base, each concept represents an XML record, which is based on the Strongly Structured Model of the scientific concept (Smith '02 a-c, '03). Key points of the SSM can be displayed on a screen for each requested. The instructor can use this information for further explanation. The concept basis forms the "backbone" of the lecture, forming the lecture as a trajectory in the concept space. This trajectory can be built textually in the Lecture Composer. Alternatively, the instructor has an option to build it graphically with the Concept Grapher. These are two ways that might be used alternatively, leading to the ultimate goal—building the conceptualization of the educational content, served by the DLE.

The Knowledge Base

Two initial designs for the Knowledge Base have been implemented to support the initial ADEPT Physical Geography class in the Fall Quarter of 2002. Both share the common goals of a centralized Knowledge Base with client access through a web browser for both creation and viewing of concepts.

Design 1

The more robust design is centered on multiple facets or types of concepts. An extensive relationship structure has been implemented to allow for interaction between the concept types. Specific relations are permitted only within certain concept types. Concepts are well structured and must be complete to exist in the Knowledge Base.

The pros of this design include strict adherence to a defined XML structure, guaranteeing that each concept in the Knowledge Base is complete—an

extensible relationship structure (programmatically, not end user).

This design has a few shortcomings, which become apparent after actively designing lectures based upon it. The strict adherence to constraints that makes this structure so attractive requires a large investment of time when adding a concept and all of its supporting relations. Individuals designing a lecture based upon existing concepts has a wealth of information at their fingertips. However, for the long-term growth of the Knowledge Base, the goal would be to accept contributions from instructors in varying Knowledge Domains as they use the system to build new lectures. To this end, adding the required concepts must be viewed as an ongoing, organic growth rather than an initial all-inclusive tome. To promote this growth, adding new concepts should be as flexible as possible and should be promoted as a part of designing lectures and visualizations based upon the Knowledge Base.

Design 2

Design 2 was created to allow the rapid development of the Knowledge Base in conjunction with the design of the lectures. It requires a bare minimum of effort to add a concept and a relationship, but it does not support the robust concept descriptions and relationship types of the initial design.

The advantage of this design is, of course, rapid Knowledge Base development. Where the initial design required a specific effort to develop the concepts required for a group of lectures prior to the lecture design process. This implementation allows lecturers to expand the Knowledge Base easily while developing their lectures.

This design was implemented to support the development of classroom tools and to teach the initial ADEPT Physical Geography class in Fall 2002. It is by no means considered complete however, it has been an extremely useful tool for evaluation of usability of the ADEPT systems from the perspective of the lecture designer.

Implementation

The current designs have been implemented using MySQL. In addition, the more robust design returns an XML document by way of a PHP script.

Basic input and editing features have been implemented in PHP and JavaScript, with additional, capabilities integrated into the Java visualization client still under development.

Visualization of the concept space has been implemented in two clients: an OpenGL graph visualization tool and a lightweight Java applet.

The OpenGL tool was written as a generic graph visualization tool to explore the possibilities of spatially viewing concepts and other library materials in 3D. Data is acquired via an XML structure. The visualization research with the OpenGL client led to the development of a lighter weight 2D Java applet based upon a similar force springs algorithm (Smith, Ancona, 2003).

The Java Graph Applet has the advantage of a live database connection through a PHP script on the server. Aside from applet security concerns, this design was implemented to allow complete abstraction of the data layer, in turn allowing simultaneous access to both of the current implementations of the Knowledge Base. Currently the applet is used mainly for visualizations of the relationships between concepts. The visualizations currently center on a specific user-selected concept and show a view of the Knowledge Base from that concept.

The Java Graph client allows for the fine-tuning of a graph with the ability to change the number of relationship levels visible, and to even hide individual nodes to focus on the specific topic at hand. Conversely, many parameters can be passed to the applet via a PHP script, allowing for links to dynamically generated graphs centered on any concept in the Knowledge Base. It also has the ability to save a graph to a database so it can easily be retrieved via a URL as part of a lecture. The applet is currently driven by a force springs algorithm, but it is designed for the easy addition of new graphing algorithms.

Testing

The development of our current set of tools has been centered on the goal of teaching the first ADEPT Physical Geography class which was taught using most of the aforementioned tools. Although this has been a controlled environment test, many improvements have already been implemented in the systems.

In addition, the ADEPT Education and Evaluation team at University of California Los Angeles (UCLA) has given thorough feedback on their testing efforts in a more neutral environment.

Status

We have followed an iterative design process with all of the ADEPT tools, implementing test environments to further our understanding of the needs of various types of users. We are currently evaluating results from our recent classroom experience. We have identified several areas where improvements are possible, and we have several new features planned for our next ADEPT course.

The Future

The Knowledge Base has grown in two directions. Ideally, we would like the best of both worlds. That is exactly what we are designing. We will have a robust structure expanding upon our best relationship models, while still allowing rapid development of the content. This will be achieved by easing constraints on our current robust concept model and by giving visual cues to the user as to the completeness of a given concept. This allows a user to add just as much information as necessary for a given lecture, while still maintaining the integrity of the Knowledge Base. A future user will have the ability to add to the "thinner" concepts as needed for their purposes.

This structure introduces new issues with user tracking and the possibility of conflicting "views." All elements of the new structure will be built with varying users and gr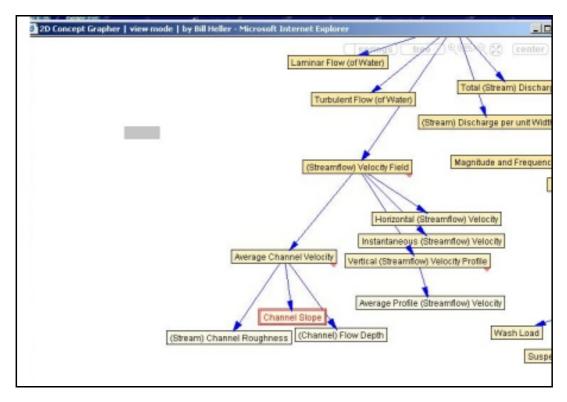oups of users in mind. A revision tracking system, as well as a "new entry" authorization systems are planned for the next iteration of this design.

Further development of the Java visualization client will allow lecturers to add to the Knowledge Base from within the applet and to view a full concept record alongside the graph of its relationships. In the very near future, it will be possible to perform any desired interaction with the Knowledge Base in this one place.

An active list of saved graphs and available concepts is planned for creation of drag and drop panels in other applications like the lecture composer. This will allow easy integration for quick access to the Knowledge Base content. Most importantly, this will be designed to promote use of the existing Knowledge Base in new applications by third party designers.

Figure 3 (Fig. 3) is a Screenshot of the Java Concept Grapher focusing on a specific concept and an individual type of relationship. The pink node (Channel Slope) is the selected concept. Grey nodes represent parent concepts. Child nodes are in fading shades of yellow based upon the distance from the selected concept.

Figure 3. Knowledge Base representation

Conceptualization is initially done in the Lecture Composer by hierarchically structuring the relationships between concepts in the lecture. Although the KB provides a variety of concept relationships, the Lecture Composer allows the lecturer to create a custom framework of concept relationships for this particular lecture instance. This relationships schema is picked up by another component of DLE—the Concept Grapher—to be displayed and manipulated at the lecture time as an interactive lecture concept map in the Knowledge Window.

Future 4. A Classroom presentation. Left to right: The Knowledge window, the Lecture Window, The Collection window.

Step 7. *Finally, Ms. White checks the whole lecture architecture and saves it into her personal ADL collection on the department server.*

Teaching the Physical Geography 3 course with ADEPT DLE was implemented during Fall and Spring quarters in years 2002 and 2003. (Fig. 4) Future applications are being planned for other domains of science.

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