

THE DESIGN AND DEVELOPMENT OF A SCALEABLE E-LEARNING AUTHORING SYSTEM

Ronald J. Aust
The University of Kansas
e-Learning Design Lab
3061 Dole Human Development Center
1000 Sunnyside; Lawrence, Kansas 66045
785-864-3466; aust@ku.edu

Edward L. Meyen
The University of Kansas
e-Learning Design Lab
3061 Dole Human Development Center
1000 Sunnyside; Lawrence, Kansas 66045
785-864-0675; meyen@ku.edu

Abstract

This flexible and scaleable e-Learning Resource Authoring (ERA) system is designed to support the rapid development of content structures, instructional features and user interfaces. By separating content from design, we execute rapid global refinements to the user interface while maintaining reliability in large-scale e-Learning resource development. The user interface elements include multiple navigation strategies with pagination and position indicators, a main table of contents and sub-menus that support a modular design allowing lessons to be used independently. Interactive features include: multiple choice and open-ended assessments with tailored remediation and hyperreference links to context sensitive glossaries and other instructional features. The primary instructional components are the lesson previews and presentations that are available in a text format and streaming media versions with segmented play lists. Over fifty e-Learning modules have been developed with ERA. Modules can be easily mirrored on remote servers using commonly available web and streaming media software.

Key Words: online instruction, e-learning, e-learning systems, online production, scalability, interface design

Introduction

We began developing systems for authoring and distributing e-Learning resources in 1992 [1] [2] as part of projects sponsored by the Office of Educational Research Initiatives (OERI) in the U.S. Department of Education (DoE). Our first wide scale implementation of the e-Learning Resource Authoring (ERA) system described in this paper was for a project sponsored by the DoE's Office of Special Education Programs (OSEP) in 1997 [3]. As a consequence of evaluation and application, the ERA system has subsequently undergone a series of refinements. The initial development effort produced 22 content rich short courses in the form of online asynchronous modules in teacher education. These included 72 lessons, 300 hours of streaming media, 13,800 graphics and over 50,000 files. The instructional design allows for the modules to be used as self-contained interactive units or as part of an instructor led course. The first set of 22 online modules were adopted by over 180 universities using a phased distribution model where the universities install (mirror) the modules on their local

servers. An additional 30 courses have been developed using enhanced versions of the production tool. The content generation, production and tool refinement have involved interdisciplinary teams from education, engineering, computer science and design departments.

There were many processes and experts involved in developing the online instructional system, content and deliverable modules. Writing teams and national boards of jurors [4] were engaged in the initial conception and writing of the content. The content was developed to meet the specification requirements of the production tool. The design of the production tool itself resulted from a series of processes aimed at determining user needs, optimal instructional features, instructional requirements of the content, and validated advanced technologies capable of delivering the instruction at scale. Scaling and sustaining this level of production required software tools and systems designed to maintain high quality and consistency across a large amount of information. A reliable distribution architecture was used by system administrators to move the modules to a variety of technical settings that accommodate integration of resources in diverse instructional management systems.

Instructional management systems, such as Blackboard and WebCT encompass a range of capabilities for managing e-Learning including: enrollment, synchronous communications among students and faculty and grading. Our system centers on developing feature rich interactive content that compliment and can be readily integrated within instructional management systems. We focus on such capabilities as assisting authors in structuring and writing effective content, interactive instructional features and user interface designs that support learning.

The users' experience with the content is influenced significantly by the design of the general user interface characteristics that apply across all modules. As Neilson [5] explains, the page layout is the most immediately visible part of an online design that sets the stage for how users will interact with the content. We use the term general user interface in referring to major design characteristics, such as page layout, that are used consistently across modules to describe the structure of the content, make it easy to use, improve interaction and contribute to understanding. The general user interface characteristics include: the page layout, graphics,

navigational aids, help messages, cues, highlighting, interactive elements and media.

Structuring Content for e-Learning

The design of our interface and authoring system is influenced in part by the structure of the e-Learning content. Our initial e-Learning modules adhered to consistent instructional components and organizational structure. There are four main levels (Orientation, Support, Lessons and Practice) in all modules (see Figure 1). The design conforms to current trends in reusable learning objects [6]. Each of the levels can be used independently or integrated into locally developed online courses. Because most of the products that we have produced are targeted for staff development as well as pre-service programs nationally the system is designed to be accessible to a wide variety of learners in various settings, using a broad range of equipment and network connection speeds. The design of the streaming media was subject to the bandwidth constraints of dial up

modems thus limiting the robustness of the audio presentations.

Each level in the instructional model serves a specific function for the learner. An instructional unit may be a single module or there may be three or four modules configured as a course.

Levels in Organizational Structure

1: The learner accesses the orientation level as they begin a module or course. The introduction and critical question features provide information specific to the modules whereas as the content maps detail the content to be covered in each lesson within the module or course. The structure defines each feature in the system.

2: The learner accesses the support level largely for review purposes where many of the instructional level features are aggregated. The exception being the syllabus, which approximates a comprehensive traditional syllabus, in that it details all learner responsibilities.

Figure 1:
Table of Contents for an e-Learning Module

Level	Content
Orientation	Introduction Critical Questions Content Map Structure Help
Support	Syllabus Readings Research Directed Questions Glossary Assessment
Lessons	<u>The Development of Literacy: As Reading Instruction Begins</u> Outline Notes Glossary Readings Preview Presentation Activities Directed Questions Assessment
	<u>Learning About Phonemes</u> Outline Notes Glossary Readings Preview Presentation Activities Directed Questions Assessment
	<u>Teaching Phonological Awareness</u> Outline Notes Glossary Readings Preview Presentation Activities Directed Questions Assessment
Practice	Practice 1 Practice 2

3: The learners will spend most of the time at the lesson level where the core content is available. While the intent is that the users will progress through each lesson in the sequence that the features appear, they are free to vary the sequence once they gain experience with the user

interface. The preview is a two-minute presentation reminding the learner of what was covered in prior lessons and introducing them to the objects and content of the current lesson. The presentation is equivalent to a lecture in a face-to-face course where content is

specifically structured to meet instructional objectives. The presentations are in a multi media and a text format. The content and the graphics are the same. A multimedia presentation is typically 30 to 40 minutes. Students are able to print hard copies of any feature in the system including relevant graphics.

Other lesson features include: outline, notes, activities, directed questions, handouts and assessments. The assessments include integrated feedback for self-evaluation. Icons in the presentation transcript allows the learner to access any of the lesson features from the relevant portion of the text. For example, a user may click an icon to complete assessment over the content that they just read. They can also work from a feature menu to access content. That is, when reading a note or assessment item learners can click an icon and be taken to the relevant text in the presentation.

4: The practice level is designed for use after the learner has successfully completed all lessons in the module. The practice activities allow the learner to demonstrate an application of what they have learned. Learners may be asked to complete practice activities in an applied setting. Criteria are included for self-correcting but there is no integrated evaluations of practice activities.

A User Interface for e-Learning Resources

Our interface development began with a review of the literature, an analysis of instructional goals, user needs, the implementation plan and criteria for evaluating success [7], [8]. This information served as the foundation for establishing the requirements and specifications. We refined the requirement drafts through internal reviews and early meetings with the content team jurors and a board of governors. As noted by Gardiner and Christie [9], the user interface functions as a type of dialogue with the user. We sought to establish a clear, consistent and understated look and feel [10] using standardized naming scheme, graphics, orientation, navigation and other user interface elements [11].

We began by creating a simple outline of the content that served as a site map for developing the general navigation interface. Although the outline structure may describe a specific path through the module, the primary intent is to aid users in knowing where they are, not to constrain users on a prescribed path. The navigation interface allows multiple and direct paths to any content so that the users are free to choose their own linear or nonlinear path. The multiple navigation approaches are designed to allow users quick and easy access to all information. For example, if users choose to use the Figure 1-Table of Contents (ToC) navigation they are only two or three clicks away from all information in the module.

We selected a horizontal top navigation bar to minimize use of valuable screen real estate. This is an effective approach used by many sites with linear or hierarchical content [12]. The use of horizontal navigation accommodates integration of the modules in comprehensive learning environments such as Blackboard

or Web CT. These systems often use vertical navigation that would compete with a vertical navigation scheme.

Sub-Menus Organize Smaller Chunks of Information

The table of contents (see Figure 1) provides a view of all elements in a module. The navigation features also include sub-menus for each of the main levels. The sub-menu offers navigation within a shorter list of links than the table of contents. The use of sub-menus is an effective strategy for dividing content into smaller cohesive chunks of information [13]. Users who prefer to work with smaller chunks can use the sub-menu navigation links to go directly to any page within the sub-menu.

Illustrative Graphics

Graphic illustrations are used consistently across the modules to identify the major instructional components. Graphics were developed for each of the four main levels (Orientation, Support, Lessons and Practice) and they appear in both the table of contents and each of the sub-menus. Icons were also developed for several of the instructional components. We understood that some users would read information directly on the screen while other would print the pages. Whenever feasible we designed the pages to maximize use of screen real estate and minimize scrolling. For some pages, such as the transcripts and readings, scrolling is required because the content is logically connected as a unit and because it can be printed as a coherent body of information.

Glossary Features

The glossary included a comprehensive master glossary at the support level, context sensitive glossaries at each lesson level and interactive glossary terms across the modules. Glossary terms that appear in the body of the text are underlined. The interface employs a hyper-reference design [14] with the term's definition appearing in a pop-up window that maintains the context within the document. Users may then click "Full Glossary" to see a list of all glossary terms.

Interactive Assessments

To support easy server installation, interactive assessment components including: multiple choice, matching and open-ended questions are embedded in the web page's javascript. Thus, posting modules on servers requires only readily available Web HTTP and streaming media software. The modules can also be saved to permanent media (CDs) with interactive elements intact.

The open-ended items allow users to write a response, compare their response to an exemplary response and mail the response to an instructor. Authors of the multiple-choice and matching items have the option to provide comments (remediation or extension) for each of the items. Similarly authors often provide an exemplary response for a open-ended item. The users see the remediation and exemplary responses after they have entered their response.

e-Learning Resource Authoring System

The e-Learning Resource Authoring (ERA) system consists of a suite of software tools that perform a number of functions supporting the production of modules. These include holding the content for processing, combining the content with the design templates, creating a consistent and flexible navigation system, and controlling technical functionality through the rendering of special tags. When the content is designated as being in the final delivery state it is imported into the module processing tools. Once the content is tagged and imported into the ERA, the processing software marries the original text content with the user interface design template to publish the module in a format that is viewable using commonly available web browsers. The design templates are created using standard HTML, XML and customized markup tags. The rendering tools interpret these custom markup tags and apply processes that install such items as the navigation elements, interactive glossary and assessment items. Each unique tag represents a content marker or defines the boundaries for a particular set of functions that are used to marry the content with the design templates to produce the completed module.

The ERA tools for creating e-Learning modules were specifically engineered to ensure that the user interface would be separate from the instructional content. The user interface is defined by a series of templates that describe the look and feel of the modules. The template design allows for rapid global modification of the user interface. Modification can be made within template suites in response to field-testing that suggest user interface improvements. This approach also provides the opportunity for multiple user interfaces that reflect alternative instructional models tailored for different applications or audiences.

Module creation begins with a standard set of default pages that represent a generic module structure. These default pages form the structure upon which all other content connects to the module. The modules structure, as defined by the default pages, serves as the foundation for the navigation interface. Additional pages are added to the module as needed and in practice each module has a different number of these optional pages. These optional pages are configurable in a variety of ways. Optional pages may be inserted or deleted as needed at any point in the module creation. For example, an author might initially identify seven readings for a lesson and later change the number of readings to nine. The module rendering tools permits this flexibility while at the same time ensuring accurate, stable and similar navigation features for all modules with a unique navigation interface dynamically generated for each module.

When the structure of the modules is established, content is entered into the individual pages in the content processing web site. Entering content data into the pages is achieved through a text box in a standard web browser. For ease of use, instructions and samples of the pages are provided and the editable fields are labeled with HTML comments such as "add content here." The custom tags may be entered by the authors or by technical editors at a

later time. When the document is saved, the template tags are automatically rendered to "rebuild" a page preview.

The internal tags which are added to the content control and support unique functions and processing by the module rendering tools. Specific functions supported through internal tags include: glossary, open-ended questions, multiple choice questions, matching, outline and transcript storyboard. The module rendering tools interpret these internal tags and then produce the standard HTML coding for the web-ready modules.

Evaluation

A series of alpha and beta testing strategies have been employed with the development and subsequent revision of the e-Learning Resources Authoring tool. The staff typically carries out alpha testing internally. This process also involves observing others working through online instructional units produced with the ERA. Beta testing involved a series of processes including the maintenance of journals by users, focus groups, and responding to detailed instruments online. The national beta test on the first 22 modules involved engaging teacher educators and students from 32 pre-service teacher education programs nationally. The emphasis in this beta test was to engage individuals who were inexperienced in online instruction. A follow-up beta test was carried out with instructors and students at 10 institutions where the participants were experienced in online instruction [15]. The beta test for professional development entailed the engagement of 31 professionals from 9 states. Each completed an online module and responded to an instrument, plus participation in two face-to-face sessions [16].

Conclusions: Lessons Learned

Creating a production system that integrates commercial software, custom software and procedures for producing e-Learning modules provides significant challenges and opportunities. Following are some lessons that we learned which may be helpful for designers of large e-Learning content production initiatives.

Establish Clear Communication and Specifications.

Specifications and requirements are essential to the success of the system. Delays in developing or communicating specifications only hampered production, while the initial development of clear specifications ultimately saved time in developing the production tools and technical infrastructure.

User-Centered Design

Focus group interviews conducted during alpha testing encouraged a collaborative approach to development and engaged users in the early phases of the design process. User feedback increased the likelihood of success in creating a user interface that matched the needs of the targeted audience.

Addressing the Accessibility Challenge

The resources should be accessible to a wide array of hardware, software and network configurations for wide scale implementation. The resources must also be compliant with current accessibility standards as identified by CAST and the Bobby standard.

Group Collaboration Contributes to Innovation.

Creating a dynamic multidisciplinary team requires effort and consideration. The process of encouraging each team member to offer their best ideas involved them in the project and contributed to a productive design and development environment.

Maintain Version Control and Standardization.

Standardization of file handling procedures and naming systems helped the group keep track of changes needed to create the complex e-Learning modules. One of the most challenging aspects of any large-scale development process is maintaining a common group understanding of the status of all design components and processes.

Separate the Content from the Functional Design

Separating the content from the user interface, navigation and design allowed for more flexibility in refining the user interface as well as ensured the stability of the final product.

Automate Repetitive Processes to Improve Reliability

Simplifying the download and installation procedures through automation helped to ensure ease of installation of the e-Learning resource at the end users' site.

Preserve Use and Distribution Options

Because the resources require no special server interaction, they can be distributed in CD-ROM and other permanent media formats or readily integrated into a wide variety of server-based learning architectures such as WebCT or Blackboard.

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