Designing and Evaluating User Interfaces for eLearning

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Abstract: This article describes the design and evaluation of the user interface for over 50 online modules encompassing 150 lessons, and 100+ hours of mediated instruction. We employed rapid prototyping, multiple focus groups, alpha and beta test evaluations in developing a consistent, effective, reliable and scaleable user interface. The user interface elements employ multiple navigation strategies with page arrows, a table of contents and sub-menus that support a modular design. Interactive elements include context sensitive glossary items, multiple choice and free text assessments with tailored remediation. The primary instructional components are the previews and presentations that are available in text and streaming media versions with segmented playlist links. Proactive requirements, rapid prototyping, and user-centered evaluation, contributed to the development of content rich modules, which are reliable and easy-to –use.

Requirements and Rapid Prototyping

The interface development process began with a recommended strategy of analyzing the instructional goals (Andriole and Adelman, 1995; Kovitz, 1999), the needs of the user community, the implementation plan and the criteria for evaluating success. 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 the board of governors (Meyen, Aust, Bui &. Ramp, 2002).

<u>User Interface Requirements</u>

As noted by Gardiner and Christie (1987), the user interface functions as a type of *dialogue* with the user. In this era of rapid technological innovation, there is a risk that the quest for novelty will result in user interface designs that overshadow the intended message or simply confuse the users. The key is to keep the dialogue clear and understated so the interface becomes transparent (Mandel, 1997) allowing the users to focus on the intended learning.

User interfaces that model transparency adhere to a consistent look and feel using a standardized naming scheme, graphics, orientation, navigation and other user interface elements (Shneiderman, 1998). Language use must be consistent and at the appropriate reading level. Terms must be clearly defined, highlighted, punctuated and used consistently within modules. The modules must adhere to national and international standards including relevant tagging procedures established by the World Wide Web Consortium (W3C), Advanced Distributed Learning Group (ADL SCORM), IEEE Learning Technology Group (P1484) and CAST's Bobby guidelines.

The modules adhere to pre-determined and consistent instructional components and organizational structure. There are four main levels (Orientation, Support, Lessons and Practice) in all modules. The instructional components for each level are consistent across all modules. A modular design that conforms to current trends in reusable learning objects (Wiley, 2000), was required with cohesive components at the collection, content area, module and lesson levels. Each of these levels can be used independently or integrated into locally developed online courses.

The modules were required to be accessible to a wide variety of learners, in various settings, using a broad range of equipment and network connection speeds. Initial minimum requirements include Windows and Macintosh computer platforms using Internet Explorer 4.0+ or Netscape 3.0+ browsers with 14-inch monitors. We anticipated that many universities would provide students with faster connectivity (T1 or greater). We also knew that other users would have slower speed dial up connections (28.8 K modems). All module content was required to be accessible to a wide variety of users including those with special needs who use text-readers and/or other adaptive devises.

The Online modules primary instructional components (preview and presentation) are available in two forms, text transcript with graphics and streamed media slide show with audio narration. The design of the streaming media was subject to the bandwidth constraints of dial up modem speeds (28.8 Kbps) thus limiting the presentations to an audio slide show. We required technologies capable of delivering moderately high quality audio with minimal interruptions using 28.8 Kbps modems.

Rapid Prottyping

When we developed the initial requirements in 1997, we drew on previous experience in developing educational resources that were broadly accessible on the Internet (Aust, 1994). We knew that the Internet would continue to expand at a rapid pace and that some aspects of Internet's evolution would be unpredictable. We recognized that bandwidth and access to Internet would continue to increase and that the rate of adoption by schools and teacher education institutions would vary considerably with their investments in technical support infrastructure. Given the rapid growth of the Internet, our approach was to design a scaleable and sustainable method that would quickly adapt to change.

Our design decisions were also influenced by the highly fluid nature of networking technologies. The modules require use of primary applications in the form of various computer operating systems and secondary applications (e.g., web browsers, media players, browser helper applications and plug-ins) that change frequently. The interface elements in each of these application levels are unique. In this context, optimal usability must be balanced by considering feasibility, reliability, and compatibility across multiple operating systems, browsers, hardware platforms and network capacities.

With the understanding that the end result was required to remain reliable and widely compatible in a rapidly changing environment, we adopted a rapid-prototyping approach to design and evaluation (see Tripp and Bichelmeyer 1994). Rapid prototyping refers to a procedure that is most commonly used in manufacturing as a visualization aid to developing component parts used in product development. The technique has more recently been applied by software developers to explore various aspects of the requirements and specifications for a software system including such elements as the user interface. One of the strengths of rapid prototyping is that it allows for a participatory design approach (Schwen, Dorsey & Goodrum, 1993) where users are able to interact with the prototype and provide immediate feedback to the design team. This process is repeated as navigation functionality is added and the screen layout is modified until the users are satisfied with the design. The use of rapid prototyping along with focus group feedback can be an effective way to include formative evaluation (Northrup,1995) based upon user feedback in the design process, thus making each phase of the design process as user-centered as possible.

Our approach to rapid prototyping used focus groups and an iterative development process similar to other successful strategies used for designing user interfaces (Retig, 1994; Rudd, Stearn, & Isensee, 1996) We began by constructing a low-fidelity model of the screen layout and navigation elements then proceeded to usability testing, where user feedback was gathered and refinements were made. During the early phases of development we evaluated, refined and reevaluated the versions of the user interface in undergraduate and graduate education courses. We also conducted several focus group sessions with students and staff to discuss the effectiveness of the interface elements.

By using customized content rendering tools we were able to refine the interface throughout the rapid-prototyping phase. The module content containers were first represented as a visual map depicting the anatomy of a module. During this early phase we also considered the pedagogical devices used to create the various learning experiences (narration, lecture, case study, testimonials, modeling, guided practice, questions, activities, assessments, etc.) for users. We based many of our decisions on observations of how the users interacted with the interface. Did the users navigate using the forward and backward arrows? Could they find the table of contents? Did they click on glossary terms? Did the users refer to only one or both of the text and media versions of the presentation? Did they understand how to mail the free response and multiple choice assessment items to instructors? We followed the approach of Jacob Nielsen (2000, p. 16) who recommends, "don't listen to users...watch what they do."

Results: The User Interface

The strategies used in refining the prototype followed a user-centered approach that draws from knowledge learned in interacting with the natural world and standard conventions of computer use. Upon completion of the Instructor's Module the components and structural organization were finalized. As is true for most bodies of knowledge, the structure of the content can be expressed in a taxonomy.

We began by creating a simple outline (see Figure 1) of the content that served as a site map for developing the navigation interface. Although an outline seems an obvious first step in the design process, it is sometimes overlooked or avoided because of concerns that it may constrain users on a linear path. A more likely outcome is that an outline provides a consistent and easily understood structure that facilitates personalization.

Figure 1: Simple Content Structure Outline

- **I. Orientation**
  - A) Introduction
  - B) Critical Questions
  - C) Content Map
  - D) Structure
  - E) Help
- **II. Support**
  - A) Syllabus
  - B) Readings
  - C) Research
  - D) Directed Questions
  - E) Glossary
  - F) Assessment
- **III. Lessons**
  - **A) Lesson 1: *Lesson One Title***
    - a) Outline
    - b) Notes
    - c) Glossary
    - d) Readings
    - e) Preview
    - f) Presentation
    - g) Activities
    - h) Directed Questions
    - i) Assessment
  - **B) Lesson 2: *Lesson Two Title***
    - a) Outline …
- **IV. Practice**
  - A) Practice 1
  - B) Practice 2 …

The linear structure and navigation could be used to describe a specific path through the module, yet 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 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 (Rosenfeld & Morville, 1998). 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 if the modules also used a vertical navigation scheme.

<u>Features of the Alpha and Beta Navigation</u>

The first navigation header bar (see Figure 2) was designed for the alpha test. It appeared at the top of all pages of the module. During the Alpha testing we learned that the users easily understood the function of the Next and Previous arrows but they did not readily understand the function of the up arrow as a means of navigating up through sub-menus. They also did not readily understand the meaning of the ToC icon. Some users said that they would like to see the title of the module on every page.

We designed the second navigation bar in Figure 2 in response to lessons learned from the Alpha evaluation phase. This modified navigation bar then became part of the Beta test and was ultimately used in the modules. It appears at the top of all pages of the module except for the entry page. A simple footer bar was also added for the Beta evaluation. It appears at the bottom of most pages. Features of the footer navigation include Next and Previous linear navigation arrows and an Up arrow to the top of the page.

Figure 2: Alpha and Beta Navigation Headers

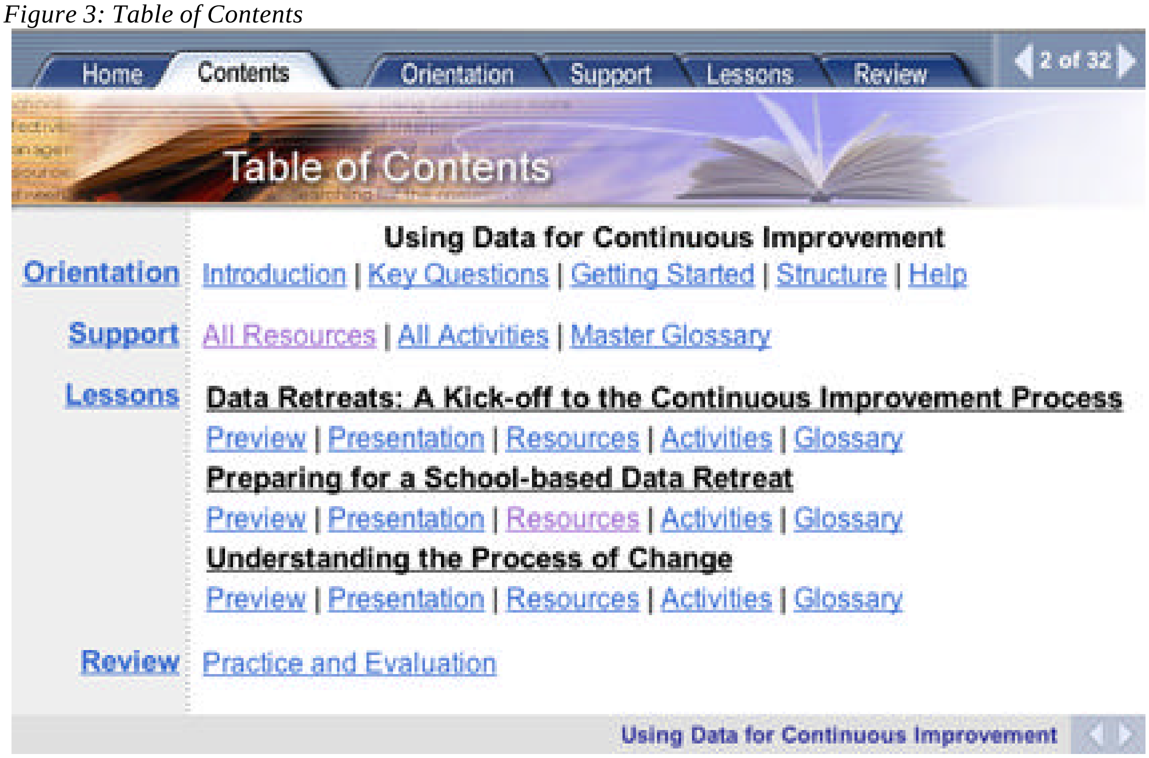
<u>Alpha Navigation features (left to right)</u>
- Table of Contents link (left icon)
- Page Title
- Page numbers (23 of 27)
- Next, Previous and Up navigation arrows

<u>Beta Navigation features (left to right)</u>
- Link to Home, Contents nd Sub--Menus
- Next and Previous navigation arrows
  Page numbers (13 of 32)

<u>Table of Contents</u>

An improved ToC (see Figure 3) was designed for the Beta evaluation. Titles for the main levels incorporate illustrative graphics that are repeated in the sub-menus. Because all main components are in the ToC, and a link to the ToC is on all main pages, users can use this spoke and wheel navigation to get from any main page to any other main page in only two clicks.

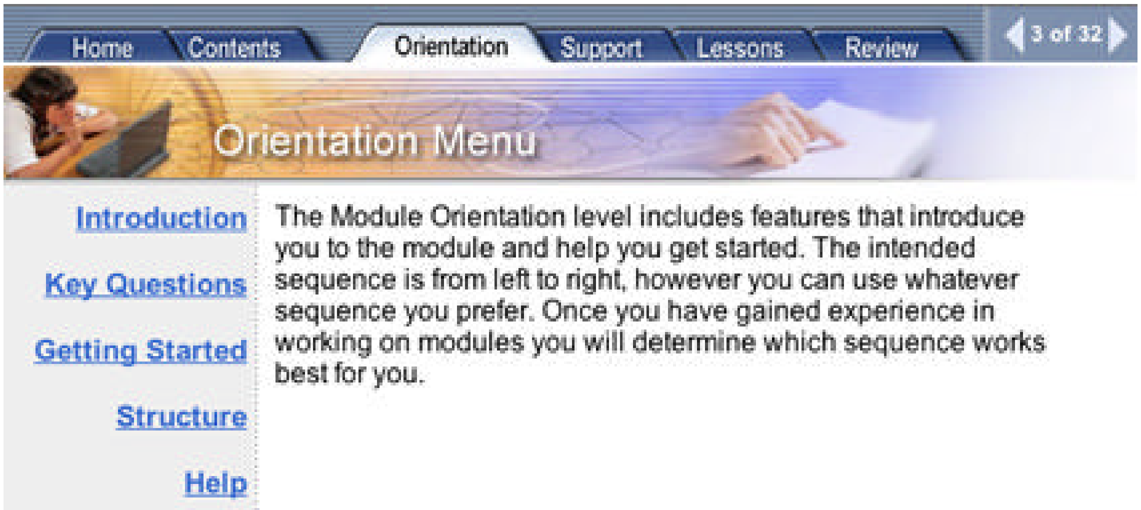
Figure 3: Table of Contents



<u>Sub-Menus Organize Smaller Chunks of Information</u>

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 Contents. The use of sub-menus is an effective strategy for dividing content into smaller cohesive chunks (Lynch & Horton, 1999). Users who prefer to work with smaller chunks can use the sub-menu to navigate directly to content within that category (see Figure 4).

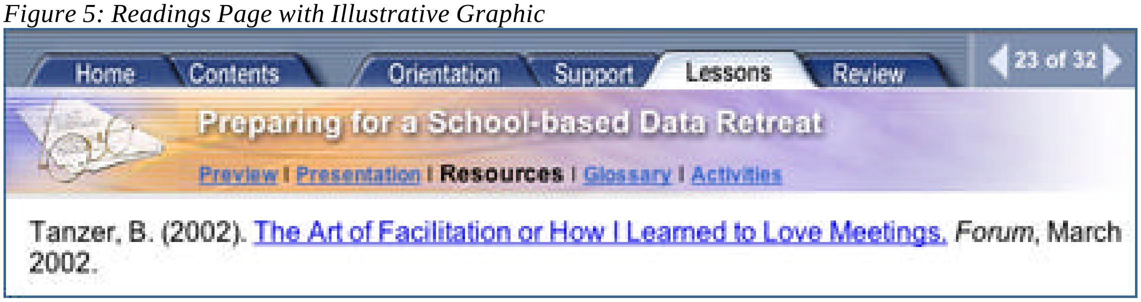
Figure 4: Sub-Menu Navigation



Illustrative Graphics

Graphic illustrations are used consistently across the modules to identify the major instructional components (see Figure 5). Graphics were developed for each of the four main levels (Orientation, Support, Lessons and Practice) and they appear in both the ToC 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 chunk of information.

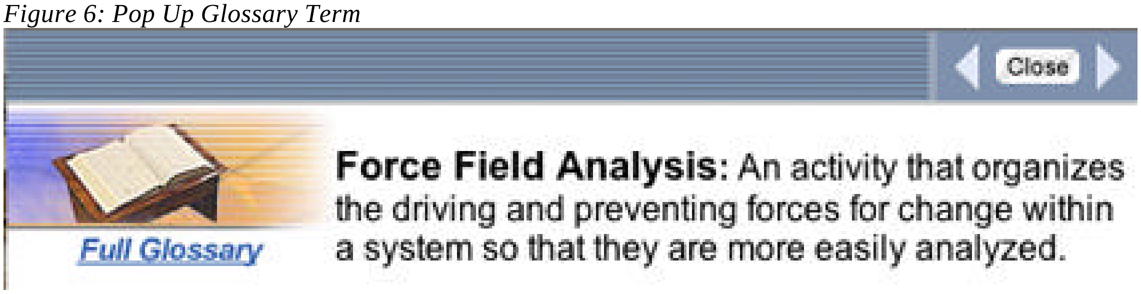
Figure 5: Readings Page with Illustrative Graphic



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 (Aust, Kelly & Roby, 1993) with the term's definition appearing in a pop-up window (see Figure 6) that maintains the context within the document. Users may then click the Full Glossary to see a list of all glossary terms.

Figure 6: Pop Up Glossary Term



Interactive Free Response and Multiple Choice Assessments

To minimize server installation challenges, interactive assessment components are embedded in the web pages. Thus, no special server software is required and the modules can be saved to CD with interactive components intact. There are two forms of interactive assessments: free response and multiple choice.

The free response items allow users to write a response, compare their response to an exemplary response and mail the response to an instructor. Authors of free response items have the option of including an exemplary response for any item. The exemplary responses are seen by the user after they have entered their response but before they mail the responses. Free response items are used in the modules for such items as the Directed Questions, Activities and Practice Items.

The multiple-choice items provide users with forced choice options for each item. Users respond to each item by clicking their "correct response" for a list of items. The scored multiple-choice responses may then be mailed to an instructor. Authors of the multiple-choice items have the option to provide comments (remediation or extension) for each of the items. The scored responses are seen by the user after they have entered their response but before they mail their response to an instructor. Multiple-choice items are used in the modules as assessment components at the Support and Lesson levels.

Streaming Media Usability Features

The Real Media with synchronized multimedia integration language (SMIL) was used to deliver the streaming media lesson presentations. SMIL is a version of extended markup language (XML) designed specifically for the integration of various types of media such as animation, audio, graphics, photographs, and video. A key usability feature of SMIL when interpreted by robust players such as the RealOne Player' is the play list indexing capability. This allows the media presentations to be indexed so that users can use the playlist links to navigate to specific sections of the media presentation for review. The RealOne Player also has a multiple screen option that provides a three-pane interface environment using the metaphor of "play/more/explore." This multiple screen option integrates the streaming media presentation with HTML pages, and playlist index features thus allowing users the option of navigating the module in an integrated web browser environment that eliminates the need to switch between a separate web browser application and media player.

Lessons Learned

Proactive Requirements and Specifications

The effort spent developing clear specifications and requirements saved time in development efforts and minimized the need for later revisions. Common reference points in the form of requirements and specifications were beneficial in creating a universal understanding among a diverse group of team members engaged in a collaborative design process.

Ownership Benefits User-Centered Design

As was true with our other recent development and evaluation activities (Aust et.al., 2005) we found that users with ownership in the process provided some of the richest feedback that served to shape revisions in the instructional 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. The processes of developing effective user-centered designs benefit from:

- A collaborative team effort;
- Clearly identified requirements and specifications at the early conceptual stages of the design process;
- Rapid-prototyping incorporating focus group alpha testing to determine proof of concept prior to final implementation;
- Development environments that are capable of separating the content from the user interface so as to allow for rapid refinement;

- Alpha and beta testing of user interface that is extended to all phases of production from the initial prototyping to final distribution.

The Interface Ecosystem

Interface design considerations for the web-based delivery must identify how best to present the instructional content within the constraints of the transmission media. Today's instructional interfaces exists within a complex "user-interface ecosystem" involving the operating system interface, web browser and plugin interfaces, and media player's interface. Components of the interface ecosystem are evolving rapidly and their evolution influences what is feasible and desirable in an instruction interface. The design of the instructional user interface should compliment not compete with the other interfaces within the ecosystem. One way of achieving a complimentary instruction design is to replicate or at least avoid dramatic departures from the basic functionality features used by components within the user-interface ecosystem. This includes using the standard types of pull down menus, navigation aids and positioning found in the operating systems, browser and media players that you anticipate the users will be using. In this way the user interface becomes more transparent and the focus is on the elements most critical to learning and understanding the content.

Separate the Content from the Functional Design

Separate the content from the user interface, navigation and design elements. This will allow more flexibility in refining the user interface and 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.

Addressing the Accessibility Challenge

The Technical Application Group was committed to developing modules that were accessible and easy-to-use for a diverse group of users. The modules needed to be reliable and ease-to-use across a broad range of hardware and software platforms. Over the past five years, the Internet and computer hardware and software have changed exponentially. We learned that developing a user-interface that works reliably across most hardware, software and network configurations was substantially more challenging than designing software that only works on the latest configurations. Maintaining broad accessibility requires:

- A multi-platform development environment with a broad range of hardware and software configuration covering the past 5 years of use. Many users will stay with the configuration that was on their machine when they purchased it.
- A realistic balance between features and reliability. Expanding features must be tempered by a rational comparison of need, impact on accessibility and available resources.

Rapid Prototyping and Evaluation

We adopted a rapid prototyping approach to design and development. The prototypes advanced through Alpha (features are evolving), and Beta (features are fixed and bugs are addressed) phases before they achieved release status.

- Rapid-prototyping methods that incorporate focus group during the alpha testing phase are effective in establishing consensus for proof of concept prior to final implementation;
- Development environments that separate content from the user interface allow for rapid refinement of the interface while maintaining contextual perspective for the designers and content developers.
- Alpha and Beta testing of user interface should be extended to all phases of production from the initial prototyping through final distribution.

Communication and Coordination

We learned the importance of consistent communication with all members of our design and development team as well as with our constituent groups. Factors that contribute to effective and consistent communications include:

- A collaborative team effort;
- Regular weekly meetings of the Technical Applications Group

- An internal web site for internal communications including: project goals, guidelines, internal and external standards, personnel schedules and meeting minutes.

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