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International Journal of Web-Based and Teaching Technologies
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This journal focuses on the dimensions of reporting about developing new WBLT technologies and uses, and also sharing educational experiences and situations including (but not limited to) distance learning, collaborative work, constructivist approaches in on-line class-rooms, designing blended learning and programs, importance of dialogue in distance education programs, CSCL, network learning, etc. This journal also covers aspects such as models and frameworks for the pedagogical design of courses including or supported by WBLT technologies, and for issuing and evaluating educational policies in institutions, and for organizing and managing training policies or departments in companies. Issues in methodologies for the training of teachers and trainers, for the building of multidisciplinary teams for distance and on-line program administration and delivery are also included in the coverage. Among topics to be included (but not limited to) are the following: WLT implementation; models, methods and frameworks; Web-based Technologies enabled pedagogical scenarios; Web-based Technologies enabled pedagogical systems and programs; Management side of Web-based Learning and Teaching; Building multi-disciplinary teams for WBLT; Learning and Teaching Network; and much more! Visit www.idea-group.com/ijwltt

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State author’s name and year of publication where you use the source in the text. See the following examples:

Example 1: In most organizations, information resources are considered to be a major resource (Brown, 2000; Smith, 2000).

Example 2: Brown (2002) states that the value of information is recognized by most organizations.

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Example 1: Brown (2001) states that “the value of information is realized by most organizations” (p. 45).

Example 2: In most organizations, information resources are considered to be a major organization asset” (Smith, 2002 p. 36-36) and must be carefully monitored by the senior management.

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One of the main challenges we face is to evaluate the learning process, its role in our working environment, the relationship between e-learning and traditional learning, and the impact of new technologies on education. Let us consider this topic in more detail.

As is now common, the learning environment takes place in a networked or multimedia tool. Mobile phones, TV ROMS, software, specialized devices, and the integration of these devices with traditional educational tools create new opportunities for learning. A learning situation is considered as an interaction within the network.
Evaluating Learning Management Systems:
Leveraging Learned Experiences from Interactive Multimedia

Katia Passerini, New Jersey Institute of Technology, USA

ABSTRACT

This paper maintains that the use of multimedia content in Web-based instruction — facilitated by the proliferation and standardization of learning management systems (LMS) — calls for the extension of traditional multimedia design and evaluation guidelines to the Web. The compliance with these guidelines needs to be thoroughly evaluated by any institution using (or planning to use) Web-based learning management systems. In addition to providing criteria and examples for the evaluation of these systems, the paper includes a survey instrument that can be used for university-wide assessments of the design effectiveness of technologies that support learning. As an example, the proposed evaluation instrument is applied to a learning management system developed at a large university in the United States. While the assessment refers to one system, the model, the instructional and design evaluation criteria, and the questionnaire are built for use in any organization conducting a formative and summative evaluation or a selection of learning technologies.

Keywords: assessment; formative and summative evaluation; instructional design; learning management systems; multimedia design; Web-based instruction

INTRODUCTION: LEARNING MANAGEMENT SYSTEMS

Learning Management Systems (LMS) are Web-based applications that support online teaching or supplement face-to-face instruction. Typical functionalities of LMS include Web course design, Web course collaboration tools, and Web course management (Hall & Hall, 2004; Hills, 2003c).

The course design features provide templates for course organization. Instructors control the content and have some impact on the screen layout (changing...
features such as color and screen placement). Students can post information on personal Web pages or can create areas to post assignments and discussion topics. Search tools are available for quick access to materials.

The collaboration tools include synchronous (chat) and asynchronous components (discussions and threaded listservs). Faculty can use bulletin boards to post course-related announcements. Electronic messaging within the LMS provides a repository for course-related messages. Whiteboards are used especially with mathematical and visual information. File sharing and workgroups are particularly useful for team-based activities enabling simultaneous file editing by several users.

The course management features enable student grading, performance tracking throughout the course, and the calculation of time spent using the software applications. They also enable instructors to design online quizzes, randomize questions from a database, and assess response time.

In addition to the above, a number of administrative features provide security and technical support for faculty and students. Table 1 lists typical LMS areas contained in many commercial and open-source applications such as WebCT, Blackboard, and Lotus LMS.

EVALUATING LEARNING MANAGEMENT SYSTEMS

Stoner (1996) defines a learning technology as any application of technology for the enhancement of teaching, learning and assessment. This definition includes the use of network communication systems and embraces a large number of multimedia and Web applications. Learning management systems that enable classroom instruction on the Web and/or support face-to-face instruction with access to online learning repositories of course materials fall within this definition of “learning technology.” When integrating a learning technology into a traditional curriculum, a thorough evaluation of its design and instructional characteristics is a wise pre-requisite for its implementation (Bersin, 2005; Stoner, 2004).

Stoner proposes an approach to the integration of technologies into the classroom (see sections thereof). He begins with a review of methodologies, design and implementation, and instructional design (Alavi and Wagner, 1988). Stoner states that careful data collection, analysis, and resource allocation are key factors in the design of LMSs. He concludes that when selecting an LMS, “These will need to be carefully planned in detail, identifying the need for the technology [courseware] to be used and integrating it into the curriculum being considered.”

This paper presents some factors for the assessment of LMSs. The LMS evaluation system design approach is discussed. Particularly, it relies on a process used in the design of instruction that applies the design and development of a specific LMS designed by the School of Business at Washington University. This system, to introduce, was designed for use in the evaluation protocol.

Types of Evaluations

There are several types of evaluations: formative, summative, and diagnostic. Formative evaluations should be conducted periodically to ensure that the technology used does not interfere with student performance. Summative evaluations may be conducted at the end of a course or academic year. Diagnostic evaluations are conducted to identify problems that may be occurring in a specific area or course.

Four main approaches for evaluating technologies are:
characteristics is a critical element and a pre-requisite for its successful implementation (Bersin, 2005; Hills, 2003b).

Stoner proposes a system design approach to the integration of learning technologies into traditional courses (or sections thereof). This approach draws on methodologies widely used in the design and implementation of computerized-information systems (Lucas, 1994; O’Brien, 2005) and in systems approaches to instructional design (Gagné, Briggs, & Wagner, 1988). Stoner’s model suggests a careful data collection on course type, students, and resources available. He encourages the research of alternative solutions: “These will need to be formulated in some detail, identifying the learning technology [courseware] to be used and how it might be used and integrated within the course(s) being considered.”

This paper presents a framework for the assessment of LMS leveraging the system design approach suggested by Stoner. Particularly, it relies on lessons learned in the design of interactive multimedia. It applies the design evaluation criteria on a specific LMS developed at the George Washington University, the Prometheus system, to introduce a specific example of the evaluation protocol here presented.

**Types of Evaluations**

There are several approaches to conducting evaluations (Johnson & Ruppert, 2002; Hills, 2003b). Ideally, several types of evaluations should be implemented. In reality, financial, temporal, and human resource constraints limit the options (often in favor of “late” summative evaluations). Four main approaches to evaluating learning technologies are seen in Table 2.

**Formative Evaluation**

Formative evaluation is testing conducted on selected samples of the user population while the product is still being developed (prototypes). Formative evaluation uses open-ended methods, survey questionnaires, or confidence logs (users’ self-assessment of their knowledge). The key constraint of this method of evaluation is its timing. Authors describing the planning efforts of formative evaluations note that it is difficult to plan and implement testing early enough so that changes can be made (Alessi & Trollip, 1991). Often, resource constraints do not enable the administration of formative evaluations.

**Summative Evaluation**

Summative evaluation is a process that concerns the final evaluation. This evaluation usually focuses on the user (rather than the application) because it is conducted after the product release. It is used to inform decision on future developments, as a product review, and as a user-satisfaction data collection instrument. Traditional surveys or assessment tests can be used, as well as observations, interviews, and other qualitative and quantitative data.

**Illuminative Evaluation**

The aim of illuminative evaluations is to discover what factors and issues are important to the participants in a particular learning situation, which may differ with the developer’s judgment. Draper, Henderson, Brown, and McAteer (1996) state that “illuminative evaluation has a systematic focus on discovering the unexpected, using approaches inspired by anthropology rather than psychology,” and that these approaches have a significant effect on the users.
Table 2. Types of evaluations

<table>
<thead>
<tr>
<th>Evaluation Type</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formative</td>
<td>To help improve the design (conducted during development)</td>
</tr>
<tr>
<td>Summative</td>
<td>To assess the product and its functionality (conducted after release)</td>
</tr>
<tr>
<td>Illuminative</td>
<td>To uncover important factors latent in applications</td>
</tr>
<tr>
<td>Integrative</td>
<td>To help users extract all the benefits of a learning technology</td>
</tr>
</tbody>
</table>

Integrative Evaluation

Integrative evaluation is “aimed at improving teaching and learning by better integration of the learning technology into the overall situation. It is not primarily either formative or summative of the software, as what is both measured and modified is most often not the software but surrounding materials and activities. It is not merely reporting on measurements as summative evaluation is, because it typically leads to immediate action in the form of changes” (Draper et al., 1996). For example, if all the students in a classroom complain about the use of the technology for a particular learning outcome, the instructor and the developers need to reevaluate the tool and its current application. “Is the feature able to achieve its intended purpose?” If it is not, the developers should promptly modify the system, based on user feedback.

This paper focuses only on the first two types of evaluation: the formative and summative models. The scope of the discussion is limited to two models in consideration of space limitations and to present examples of LMS evaluation models actually run at a large university. It describes the content and assessment procedures for applying these evaluations to learning management systems. The paper draws from the interactive multimedia literature to identify frameworks and criteria for LMS assessments.

CRITERIA TO EVALUATE LEARNING MANAGEMENT SYSTEMS: BORROWING FROM INTERACTIVE MULTIMEDIA

Interactive multimedia instruction is traditionally grounded in several years of experience with interface design, human-computer interaction and computer-supported mediated learning. In the mid-and late nineties, instructional multimedia was partially replaced by LMS systems (Taylor, 2003). New applications competed in emerging as tools to facilitate transfer of in-class materials to the World Wide Web. Initially, these systems failed to leverage the design lessons from interactive multimedia because of the then clear hiatus between the Web and multimedia systems. Today, pervasive broadband access has brought about the possibility of delivering multimedia content in a Web space with a relatively low bandwidth impact. Finally, several multimedia applications have started to be transferred online (Watson & Hardaker, 2005) through Macromedia Flash and Java programs, lowering the pressure on interactive multimedia.

The distinction of interactive multimedia and learning systems is “blurry” (Hedberg, 1997). If interactive multimedia is perceived to be bound by a physical container (the Web, other delivery capabilities, downloadable content and navigation applications), then, And where interactive multimedia is seen as self-contained, it may suffer from the same constraints along with the self-contained (closed) system where both instructors and students interact with the instructor and reorganize content to coherently navigate multimedia documents (whether interactive multimedia or not) (Hall & Hall, 2003). In areas of coinciding multimedia design guidelines, lines increase. As discussed earlier, both multimedia frameworks can be used to evaluate the same features (before its curriculum) (James, 2003).

As discussed, interactive multimedia and learning systems principles further the close mapping of the multimedia design guidelines with instructional systems design principles (multimedia design guidelines by Reeves, 1993) to the LMS.

Designing multimedia content requires major attention to the coherence and context (Short, 2003). Coherence is an important element of composition and the construction of meaning.
programs, lowering the gap between interactive multimedia systems and LMS.

The distinction between interactive multimedia and the Web is becoming “blurry” (Hedberg, Brown, & Arrighi, 1997). If interactive multimedia was perceived to be bound to the shell of a physical container (the cd-rom), today’s online delivery capabilities enable hyper-linking and navigation as in a Web-based system. And where interactive multimedia systems are still constrained by the boundaries of a self-contained application, also LMS suffer from the same limits. As in interactive multimedia products, LMS rely on a self-contained (online) shell within which both instructors and students (and only the instructor and registered students) coherently navigate to organize and retrieve documents (within the available templates) (Hall & Hall, 2004). In this context, the areas of coincidence among interactive multimedia design and Web-design guidelines increase. As the coincidence grows, lessons learned and validated interactive multimedia frameworks can be leveraged to evaluate the effectiveness of an LMS (before its curriculum integration) (Coates, James, & Baldwin, 2005).

As discussed next, an examination of multimedia and Web development principles furthers these statements eliciting a close mapping of interactive multimedia design guidelines with Web-based instructional systems design guidelines. It extends multimedia design principles (for example, Reeves, 1993) to LMS models.

Designing multimedia for instruction requires major attention to two main factors: coherence and cognitive load (Yi & Davis 2003). Coherence of screen design is a key element of comprehension as it facilitates the construction of the mental models for the learner. The higher the coherence, the easier it is for the learner to comprehend.

- **Coherence** needs to be reached at a small scale, linking pieces of information together for local coherence, and on a large scale, reminding the user about the relationships between the current screen and the learning domain.

- **Cognitive load** is defined as any effort in addition to reading that affects comprehension (i.e., navigation efforts or adjustment to the user interface). The higher the cognitive load the more difficult it is for the learner to comprehend. Strategies for reducing the cognitive load include creating a good balance on “distance”, “focus”, and “proportion” (Szabo & Kanuka, 1999). For example, key elements on the screen can be placed or given a different layout or shape based on importance. Cognitive load is also reduced by using clear navigational strategies. For example, hyperlinks/buttons need to be user-friendly and easily understandable also by a novice user.

Multimedia applications should follow screen design, navigation, and interactivity design guidelines that are informed by cognitive load and coherence principles:

- **Ease of use**. The perceived ease/difficulty of user interaction with a multimedia program: the more intuitive the application user interface, the less impact on the user cognitive load.

- **Screen design**. Screen design in multimedia relates to the coordination of text and graphics to present a sequenced content. This content facilitates un-
derstanding (Mukherjee & Edmonds, 1993) with each screen providing effective instruction, appropriate navigation tools and pleasing design/visual aesthetics (Milheim & Lavix, 1992). Each screen must display a navigation toolbox at the bottom, title and instruction areas at the top of the screen, with the body area containing media clips in the center (Stemler, 1997).

Information presentation. Visual clues and information on the screen cannot be cluttered: too many representational clues (icons) or too much declarative text in one screen creates confusion and overwhelms the user (Overbaugh, 1994).

Level of interactivity. Interactivity is a key distinctive feature of interactive multimedia and should be provided frequently, at least every three or four screens (Orr, Golias, & Yao, 1994).

Navigation. Navigation should occur through simple interfaces, using facilitating metaphors and familiar concepts (Gurak, 1992). The icons should clearly show whether they are hyperlinks to other screens (by color, form, or mouse-over effects).

Quality of media/media integration. Individual media (text, sound, video, and animation) within a multimedia application need to be combined in a way that is integrated based on content, space, and time of the animation.

Mapping. Thuring et al. (1995) suggest several hyperlinking guidelines. They include the clear identification of hyperlinks, the visualization of the document structure, the inclusion of navigational tools, and so forth.

Web design guidelines are closely related to design principles identified in interactive multimedia. In the following list, design principles identified by Jones, Farquhar, and Sury (1995) are mapped to interactive multimedia guidelines. For example, well-designed Web-based application systems need to:

1. Provide structural clues: Coherence in interactive multimedia. Information needs to be presented in a consistent manner with clear identification of the structure (Elges, 2003). Strategies include providing overview areas, maps, fixed display formats, and consistent placement of section titles.

2. Clearly identify selectable areas: Navigation in interactive multimedia. Clarity is accomplished by following standard Web conventions (i.e., underline and blue for active hyperlinks) or using icons that clearly indicate alternate navigation paths. A sub-principle to this guideline is to clearly indicate selections made, so that the users have a contextual understanding on where they have been and their current location.

3. Indicate progress made: Interactivity in interactive multimedia. This is an option particularly important when users are navigating through instructional material or taking an online assessment. Feedback on the status of the lecture or progression on the quiz cases navigation and favors cognition.

4. Provide multiple versions of instructional material: Information Presentation. This includes offering a text-only option, a text and graphics option, and a video, which is possible through Java (Fleming, 1996), important for users with reduced access (van Beurden, 2002).

5. Offer context-sensitive help. Context-sensitive help is vital (Zhang, 2001). It provides a meaningful experience for users with educational materials, and configures the user interface.

6. Keep page length manageable. Scrolling can be distracting and decrease user satisfaction (del Galdo et al., 1994). A complete discussion or lesson should be packaged for each page, providing a complete discussion or lesson on the first instance.

7. Link to other topics in a meaningful way. Long documents with broken down topics will provide users with easy access to other sections through meaningful links.

8. Select links that are contextually relevant. Too many links can overwhelm the user (del Galdo et al., 1994). On the first page of the document, it is important that the links be placed with clearly labeled text, contextual information for the link.

9. Label links appropriately. Some textual links may not clearly indicate what the link contains.
Guidelines are closely incipient identified in dia. In the following s identified by Jones, / (1995) are mapped media guidelines. For ned Web-based append to:

5. Offer contextual help: Ease of use. Contextual help facilitates navigation and ease of use (Tarafar & Zhang, 2005). For example, if users experience difficulties in retrieving materials, specific browser options and configuration ease progress.

6. Keep pages short: Screen design. Scrolling may not be enjoyed by users (del Galdo & Nielsen, 1996). Information should be presented on sequential pages, providing the option to print the complete document through a single packaged file, conveniently placed in the first instructional screen.

7. Link to other pages, not to other points in the same page: Mapping. Long documents and text should be broken down in sequential pages. The users will have the ability to “jump” to other sessions or go back to the same paragraph by simply using back buttons and “breadcrumbs.”

8. Select links carefully: Cognitive load. Too many links in the same page may overwhelm the student and disorient (del Galdo & Nielsen, 1996). Links should be placed only at the bottom of the page or at the end of the text that they refer to. Links conveniently placed within the paragraphs offer contextual information and clarification for the learners.

9. Label links appropriately: Navigation. Some textual links or icons may not clearly indicate the destination area. Particular attention needs to be paid to content synchronization.

10. Keep important information at the top of the page: Screen Design. As dynamic text, such as “flying” or moving effects, lower attention and focus (Yi & Davis, 2003), and are not supportive of learning. Important information should be static and placed at the top of the page.

11. Links and information must be kept updated: Information Presentation & Mapping. Both content and links to other material need to be tested on a periodical basis to check the availability of the link (“active” links).

12. Limit overly long download times: Interactivity. As “traditional human factor guidelines indicate 10 seconds as the maximum response time before users lose interest” care should be used to decrease file size and download times (del Galdo & Nielsen, 1996; Tarafar & Zhang, 2005).

In summary, the principles above map and extend guidelines applicable to interactive multimedia. These principles can provide guidance on how LMS supports learning by decreasing the cognitive load and increasing coherence. The next section presents an example on how these guidelines can be applied to uncover limitations with existing systems and systems under-development.

Examples of Evaluation: Prometheus Formative Evaluation

Having reviewed design principles and instructional objectives set forth in the literature, this section of the paper applies these principles to the evaluation of an...
online courseware application, Prometheus (Johnson & Ruppert, 2002). Prometheus was developed at the George Washington University starting in 1997. The Prometheus LMS evolved during its development through a series of formative evaluations (similar to the model presented in this section) and summative evaluations (described in the next section). The assessment process benefited the design of the system. It was conducted by a team of instructional designers at the Center for Instructional Design and Development of the university, including the author. The formative evaluations informed the development team of improvement needs. An example of the design guidelines is discussed below. The evaluation is conducted on a 5-point level (using Harvey balls to represent Very Low to Very High levels) and is summarized in Table 3.

Prometheus’ main menu (navigation toolbox) identifies the structure of the course and the key course content. The main menu display is fixed, and coherently placed on each screen (see Figure 1).

Hyperlinks within pages are labeled with text descriptions and standard colors for visited/unvisited links are used. Additional hyperlinks that enable editing and interactivity are clearly identified by consistent yellow boxes placed at the top of each frame (see Figure 1).

Prometheus does not provide feedback on the progress made in the completion of the coursework. In the communication section of Prometheus, the discussion area, the provision of feedback on the navigation of the threaded/unthreaded messages is lacking. The user does not know how many messages are left to read when navigating sequentially through each discussion response. Figure 2 shows the navigation screen in the discussion area. Help on the contextual position of the user is missing (How many messages have been read? How many yet to read?).

Prometheus enables the integration of video and audio to any type of text and/or PowerPoint presentation. Faculty can deliver their lectures using a variety of media. A re-sizeable pop-up window with a multimedia presentation is available to students (see Figure 3). This window enables learner control (play, pause, and stop buttons) and self-paced learning.

Although Prometheus is a particularly user-friendly interface, for example, no formal directions and Frequently Asked Questions (FAQ) responses to configure users’ browsers are available. Contextual support with instructions on download could be easily integrated into Prometheus, rather than being handled individually and redundantly by each instructor.

The length of the pages in Prometheus vary depending on the amount of information each instructor uploads into the system. Prometheus pages may remain short, become very lengthy, depending on the instructor’s preference for typing a lecture in Prometheus or simply uploading a document file that the students can download.

Prometheus does not enable hyperlinking within the same page (thus burdening the cognitive load). A new window will open if a file is being downloaded or a hyperlink has been selected.

Prometheus enables hyperlinking in specific and coherent areas. Although users can always create links in any area by using HTML commands, Prometheus fill-in forms enable posting of URLs and other class materials only in selected areas (see “required reading for session x” or “files associated with session x” in Figure 4).

Links in Prometheus use text that is explanatory of the function that the selected area will accomplish, provides an overview of the text, and available on selected areas and accurate.

Faculty has little control of the placement of information (files, projects, and text) on the page (files, projects, and text) on time of the page (files, projects, and text) on time of the page.
Table 3. Summary LMS evaluation

<table>
<thead>
<tr>
<th>Web Design Guideline</th>
<th>Interactive Multimedia Equivalent</th>
<th>Prometheus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide structural clues</td>
<td>Coherence</td>
<td>●</td>
</tr>
<tr>
<td>2. Clearly identify selectable areas</td>
<td>Navigation</td>
<td>●</td>
</tr>
<tr>
<td>3. Indicate progress made</td>
<td>Interactivity</td>
<td>○</td>
</tr>
<tr>
<td>4. Provide multiple version of instructional material</td>
<td>Information presentation</td>
<td>○</td>
</tr>
<tr>
<td>5. Offering contextual help</td>
<td>Ease of use</td>
<td>○</td>
</tr>
<tr>
<td>6. Keep pages short</td>
<td>Screen design</td>
<td>●</td>
</tr>
<tr>
<td>7. Link to other pages, not to other points in the same page</td>
<td>Mapping</td>
<td>●</td>
</tr>
<tr>
<td>8. Select links carefully</td>
<td>Cognitive load</td>
<td>○</td>
</tr>
<tr>
<td>9. Label links appropriately</td>
<td>Navigation</td>
<td>○</td>
</tr>
<tr>
<td>10. Keep important information at the top of the page</td>
<td>Screen design</td>
<td>●</td>
</tr>
<tr>
<td>11. Links and information must be kept updated</td>
<td>Information presentation</td>
<td>○</td>
</tr>
<tr>
<td>12. Limit overly long download times</td>
<td>Interactivity</td>
<td>○</td>
</tr>
</tbody>
</table>

Legend:  
- Very Low  
- Low  
- Medium  
- High  
- Very High

Note: Permission of Idea Group Inc.

Faculty has little control of the placement of information in Prometheus. Most of the placement in the interactive areas (files, projects, and discussion) is based on time of the posting and cannot be rearranged in different order. The forms in Prometheus can be used or left blank. If they are left blank, they do not appear on the screen. If filled, the order cannot be rearranged by the instructor by level of importance for the specific subject matter.

This criterion applies only to the information that is pertinent to the functioning
Figure 1. Navigation and information presentation areas

Figure 2. Feedback on navigation

Figure 3. Multiple formats integration

Figure 4. Hyperlinks in selected areas
of the system (and not the material posted by the instructor). A control mechanism to verify the "active" links and restores backup files is a needed improvement.

Although downloading time will vary depending on type of connection, modem speed and location (U.S. or abroad), the communication areas of Prometheus (i.e., discussion) suffer from long wait times to navigate through messages. Improvements in iterative releases of the software have decreased this problem, although it still remains substantial for users outside the campus.

Areas for improvement: the evaluation shows that Prometheus could be improved in:

- Interactivity features: Re-designing the discussion areas to provide contextual feedback and better navigation.
- Technical support: Offering users printable manuals and additional help on how to address the technical problems associated with browser configurations.
- Screen customization (alias "spatial" and "temporal" synchronization): Allow faculty and content developers to manipulate the layout and place the information that they consider most relevant in the top portions of the screen. A layout that constructs hierarchies of information based on the time of the posting is cumbersome. Allowing users to manipulate placement and order of uploaded information helps in the accomplishment of the learning objectives and guarantees that important information is not overlooked.

The implementation of the above recommendations, and iterative designs conducted from 1997 to 2003, enabled Prometheus to compete with commercial courseware applications and expanded its reach beyond the George Washington University community, for which it was originally intended. In 2003, Blackboard purchased the Prometheus system to integrate some of its developed features in their product offerings. A key factor in the decision to purchase the product was its high response to the needs of the teaching and learning community. This community was better served by using the results of the formative and summative evaluations described here. An evaluation guide for the assessment of LMS systems and their integration within a curriculum is included in the remainder of this paper to encourage an informed review of commercial applications. Suggestions for criteria and survey administration options are also included.

**SUMMATIVE EVALUATION: ADMINISTRATION AND CRITERIA**

While the formative evaluation was used as part of a process to improve the software during the development, it represented only a selected group of power users. Broader summative evaluations of the user population (faculty and students) enable corrective and developmental maintenance to comply with user expectations.

The evaluation instrument presented is developed on the basis of the interactive multimedia design principles earlier described. Each question in the scale (item development) is based on a set of related criteria for the evaluation of interactive multimedia products (Reeves, 1993). All the items in the scale are related to specific related domains. The survey measures attitudes and opinions on a self-reported
5-point Likert scale. Criteria for evaluation are based on the perception of interface design and the perception of usefulness of the application by users (students and faculty).

**Administration**

The survey questions (see Appendix 1) should be administered to two groups of users (faculty and students). Timing of the survey administration is an important factor — it should take place preferably at the end of an academic semester. In order to enable the evaluation of features that were used in the classroom, respondents should be enabled to access only questions relative to the features they used.

Participation in the survey questionnaire may vary. Different strategies could be used to encourage all system users to complete the online survey. For example, incentives could be offered, such as a drawing of free computer software could be conducted for all student respondents. Similarly, faculty participation could be encouraged. Alternatively, participation in the survey could be required of all users (as long as anonymity is guaranteed). For example, users may not be able to access any of the features before they complete the online questionnaire. To avoid user frustration or disruption of user’s work schedule, users could be warned that they will be able to access only 10 additional working sessions, before the system will prompt them to complete the survey in order to be able to proceed. They may choose to take the survey earlier, but they should be informed and given enough time to complete important tasks, before the system locks them out.

Both approaches have pros and cons. A survey that is completely voluntary may not get enough responses, or may suffer from a response bias. A compulsory survey may frustrate some users, but will engage the entire user population.

**Summative Evaluation Criteria**

Reeves’ evaluation criteria (1993) focus on the user interface of interactive instructional products, such as multimedia programs. As mentioned earlier, these criteria extend to LMS. If the user interface is not well designed, users will have little opportunity to learn from the program. Examples of a student survey instrument are included in Appendix 1 and key criteria used to define the survey questions (based on Reeves, 1993) are presented in this section. Continuing on the description of the earlier example, the sample questions are referred to a specific LMS system (Prometheus).

**Ease of Use**

“Ease of Use” is concerned with the perceived ease of a user interaction with the program. Figure 5 illustrates Reeves’ dimension as ranging from the perception that the program is very difficult to use to one that is perceived as being very easy to use.

**Navigation**

“Navigation” is concerned with the perceived ability to move through the contents of an interactive program in an intentional manner. Figure 6 illustrates Reeves’ dimension of interactive multimedia ranging from the perception that a program is difficult to navigate to one that is perceived as being easy to navigate. Possible options for navigation include evaluating the clarity of navigation icons.
Figure 5. "Ease of Use"

<table>
<thead>
<tr>
<th>Ease of Use</th>
<th>Difficult</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Easy</td>
</tr>
</tbody>
</table>

Example on a 5-point Likert scale:
- I was able to learn Prometheus on my own .............................................
  - Strongly Agree: o
  - Agree: o
  - Neither Agree Nor Disagree: o
  - Disagree: o
  - Strongly Disagree: o
  - Not Applicable: o
- Prometheus menus are intuitive .............................................................
  - Strongly Agree: o
  - Agree: o
  - Neither Agree Nor Disagree: o
  - Disagree: o
  - Strongly Disagree: o
  - Not Applicable: o

Figure 6. "Navigation"

<table>
<thead>
<tr>
<th>Navigation</th>
<th>Difficult</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Easy</td>
</tr>
</tbody>
</table>

Example on a 5-point Likert scale:
- The navigation options in Prometheus are clear in each section .............................
  - Strongly Agree: o
  - Agree: o
  - Neither Agree Nor Disagree: o
  - Disagree: o
  - Strongly Disagree: o
  - Not Applicable: o

Figure 7. "Cognitive Load"

<table>
<thead>
<tr>
<th>Cognitive Load</th>
<th>Unmanageable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Manageable</td>
</tr>
</tbody>
</table>

Example on a 5-point Likert scale:
- I do not need to remember several commands to use Prometheus ..........................
  - Strongly Agree: o
  - Agree: o
  - Neither Agree Nor Disagree: o
  - Disagree: o
  - Strongly Disagree: o
  - Not Applicable: o
Cognitive Load

The cognitive load is defined as any effort in addition to reading affects comprehension (i.e., navigation efforts or adjustment to the user interface). The higher the cognitive load, the more difficult it is for the learner to comprehend. In terms of "cognitive load," Reeves states that the user interfaces can seem unmanageable (i.e., confusing) or easily manageable (see Figure 7).

Mapping

"Mapping" refers to the program's ability to track and graphically represent to the user the navigation path through the program. This is a critical variable because users frequently complain of being lost in an interactive program. Evaluations of interactive programs vary from containing no mapping function to an appropriately powerful mapping function (see Figure 8).

Screen Design

Screen design is a dimension of interactive programs that evaluates elements such as text (font layout and type), icons, graphics (placement), color (balance), and other visual aspects of interactive programs. "Screen design" ranges from substantial violations of the principles of screen design to general adherence of these principles (see Figure 9).

Knowledge Space Compatibility — [Content]

Refers to the compatibility of the product content with the layout of the learning space in the software application. When a novice user initiates a search for information in an interactive program, s/he could perceive the resulting information as compatible with his/her current knowledge space (see Figure 10). If the search results are not compatible, the application is weak in integrating content and technical features. This criterion is mostly applicable in interactive multimedia, where the content placement is static. In LMS systems, it can be used as "content" evaluation instruments.

Information Presentation

A dimension concerned with whether the information contained in an interactive program is presented in an understandable form. A well-designed user interface is ineffective if the information it is intended to present is incomprehensible to the user. (see Figure 11).

Media Integration

Deals with the question on whether the various media (text, graphics, audio, video) work together to form one cohesive program. The media integration dimension is defined as ranging from uncoordinated to coordinated (see Figure 12).

This criterion is not applicable in the context of LMS because the integration of media and their quality will be dependent primarily on the quality of the application that the individual content developers (faculty) will upload in the courseware. This criterion can be substituted with questions relative to "class interaction" and collaboration tools, key components of LMS tools that support interaction in multiple ways (audio, voice, and text interaction).

Aesthetics

"Aesthetics" deals with a subjective evaluation of the user of the screen layout ranging from displeasing to pleasing (see Figure 13).

Overall Functionality

"Overall Functionality" is related to the perceived utility of the program to
application is weak in inter-technical features. This applicable in interactive content placement systems, it can be used as on instruments.

presentation concerned with whether attained in an interactive and in an understandable manner user interface is comprehensible to the user.

The question on whether text, graphics, audio, etc. to form one cohesive via integration dimensioning from uncoordinated (Figure 12).

not applicable in the sense. the integration of applicability will be dependent on the application content developers (facing the courseware. This instituted with questions interaction and collaboration components of LMS tools in action in multiple ways text interaction).

deals with a subjective user of the screen layout pleasing to pleasing (see

Figure 8. “Mapping”

Example on a 5-point Likert scale:

Prometheus navigation layout is consistent.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree Not Applicable

Figure 9. “Screen Design”

Example on a 5-point Likert scale:

The text layout on the screen makes it easy to read.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree Not Applicable

Figure 10. “Knowledge Space Compatibility”

Example on a 5-point Likert scale:

I can understand the meaning of all the instructions on any Prometheus page.

Strongly Agree Agree Neither Agree Nor Disagree Disagree Strongly Disagree Not Applicable
Figure 11. “Information Presentation”

Example on a 5-point Likert scale:

Prometheus enables me to access class materials in an organized way.

Strongly Agree | Agree | Neither | Agree | Disagree | Strongly Disagree | Not Applicable
---------------|-------|---------|-------|----------|------------------|-----------------}
              |       |         |       |          |                  |                 

Figure 12. “Media Integration”

Example on a 5-point Likert scale:

Prometheus enables me to easily interact with my instructor.

Strongly Agree | Agree | Neither | Agree | Disagree | Strongly Disagree | Not Applicable
---------------|-------|---------|-------|----------|------------------|-----------------}
              |       |         |       |          |                  |                 

Figure 13. “Aesthetics”

Example on a 5-point Likert scale:

Prometheus screen design is pleasing.

Strongly Agree | Agree | Neither | Agree | Disagree | Strongly Disagree | Not Applicable
---------------|-------|---------|-------|----------|------------------|-----------------}
              |       |         |       |          |                  |                 

Additional Criteria

Since Prometheus features (course management tools) that enhance interaction, evaluation of the individual user requires a complete summation of the user's perception, whether the user is functional or not. The combined features are essential for ease of access and being familiar with the system. Features at the beginning of Appendix 1 [Lectures, Videos, and Utilities] questions...
Figure 14. “Overall Functionality”

Example on a 5-point Likert scale:

The technical quality of Prometheus is satisfactory......

achieve what its intended purposes are. It will include an evaluation of the factors that affect the perceived quality of the application. Figure 14 illustrates a dimension of the user interface of interactive programs that ranges from dysfunctional to highly functional.

Additional Criteria

Since Prometheus contains a series of features (course design tools and collaboration tools) that enable different types of class interaction, evaluation of the usefulness of the individual feature (as perceived by the user) is an important component of a complete summative evaluation. Questions evaluating user’s perception of usefulness of the system will vary depending on whether the user is a student or a faculty member. The questions will cover each of the features available to the users, but will be accessed by the user only if s/he reported being familiar with or having used the feature at the beginning of the survey (see in Appendix 1, Syllabus, Outline, Projects, Lectures, Files, Email, Discussion, Chat, Utilities questions).

The deployment of the survey to a large population of LMS users can provide a better understanding of how LMS supports learning.

CONCLUSION

This paper presents a framework for the evaluation of LMS based on the criteria set forth by the literature on interactive multimedia. It claims that the convergence between multimedia and Web-based learning environments enables the extension of design guidelines to LMS. As in interactive instructional multimedia systems, an effective LMS strives for coherence and focuses on the reduction of the learner’s cognitive load. LMS systems are currently consolidating, but variations and customizations still exist, especially in emerging open-source products representing lower cost solutions (Hall, 2005).

Evaluating LMS systems remains a key prerequisite and a first step for evaluating Web-based instruction effectiveness (Hills, 2003a). To address this assessment need, an evaluation protocol for LMS was proposed in this paper based on the
integration of interactive multimedia and Web-evaluation criteria. Different types of evaluation and evaluation criteria were presented. Sample questions for each evaluation and strategy for the survey administration were also briefly discussed. These questions may constitute a useful reference tool for LMS evaluations. The survey questionnaire presented in the Appendix could be reviewed, changed, and integrated beyond the issues discussed in this paper. In any event, it could serve as a starting point for a serious effort to evaluate instructional software that has not yet been assessed by the majority of its users before, during, or after its integration in the curriculum. As Stoner (1996) and other authors (Carman & Haefner, 2002) point out, evaluation is a key element of any proper curriculum implementation.

REFERENCES


APPENDIX 1. SUMMATIVE EVALUATION QUESTIONNAIRE

Sample Student Survey

Please indicate how many courses you took on the LMS

______________ (number)

Please indicate which features of the LMS your courses used (check all that apply)

☐ Syllabus
☐ Projects
☐ Lectures
☐ Files
☐ Email
☐ Discussion
☐ Chat

Please evaluate the LMS based on your overall experience with this Web-based courseware and your experience with the individual features used. Remember that this is an evaluation of the LMS as a software application, and not an evaluation of how well your instructor used the LMS.

Thank you for your time!
**QUESTIONNAIRE**

[Ease of Use]

<table>
<thead>
<tr>
<th>The LMS menus are intuitive.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If I have any problem, The LMS help menu provides useful information.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I was able to learn The LMS features on my own.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If I needed help, I had plenty of opportunities to learn additional LMS features through:</th>
</tr>
</thead>
</table>
| - The LMS team support ...

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree/Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neither Agree/Disagree</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>-</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neither Agree/Disagree</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

[Navigation]

<table>
<thead>
<tr>
<th>The navigation options in the LMS are clear in each section.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

[Cognitive Load]

<table>
<thead>
<tr>
<th>I do not need to remember several commands to use the LMS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hyperlinks within The LMS clearly indicate what each section is designed for.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
**[Mapping]**

The sections in which the LMS is organized are appropriate for my needs.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Which other sections would be useful to you?
1.  
2.  
3.  

**[Screen Design]**

The text layout on the screen makes it easy to read.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

**[Content]**

I can understand the meaning of all the instructions on any of the LMS page.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Which instructions are unclear?
1.  
2.  
3.  

**[Interactivity]**

The LMS enables me to interact with my inst

The LMS enables me to easily interact with classmates.
[Information Presentation]

The LMS enables me to access class material in an organized way.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please, indicate which type of documents you accessed on The LMS (check all that applies).

- [ ] Plain Text
- [ ] Word documents
- [ ] HTML files
- [ ] Video files
- [ ] Sound files
- [ ] PowerPoint presentations
- [ ] Portable document format (.PDF)
- [ ] Streaming media files (narrated PPT, audio, video)

The media (video, sound, graphics or text) used by my instructors on The LMS enabled me to better understand class information.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The LMS is a useful supplement in my courses.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Interactivity]

The LMS enables me to easily interact with my instructor.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The LMS enables me to easily interact with my classmates.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
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</table>
[Overall Technical Functionality]

The technical quality of The LMS is satisfactory

Using a modem, I find that The LMS runs at an acceptable speed

Please indicate your Internet connection characteristics

Using a network connection, I find that the LMS runs at an acceptable speed

Which sections of The LMS gave you the most technical problems when accessing them?

1.

2.

3.

Which type of problems did you have?

1.

2.

3.

Have you used any other LMS?

☐ Yes (please specify ____________________________)

☐ No

If yes, how does it compare with The LMS?

☐ Better

☐ The same

☐ Not as good

Section Specific Questions

[note: Questions selected that he/she used]

Syllabus

The way the syllabus is organized is very useful

Projects/Assignments

The project area enables me to access information coherently

Lectures

The lectures are engaging and class notes coherent

Files

The files area enables me to effectively deliver a variety of files to my classmates

The files area enables me to distribute files/information to my classmates coherently

I can easily edit any information that I include in the files area

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**Section Specific Questions**

[note: Questions in this section should appear in an online survey only if selected that he/she uses the specific LMS feature]

**Syllabus**

The way the syllabus is organized is very useful

<table>
<thead>
<tr>
<th>Strongly Agree</th>
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<th>Neither Agree Nor Disagree</th>
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**Projects/Assignments**

The project area enables me to access information coherently

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I find the project area very useful

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**Lectures**

The lectures area enables me access class notes coherently

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I do not need extra explanations to access class materials in the lectures area

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**Files**

The files area enables me to effectively deliver a variety of files to my classmates

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The files area enables me to distribute files/information to my classmates coherently

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I can easily edit any information that I include in the files area

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E-Mail

The broadcast e-mail function is very useful to communicate with my classmates

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<tr>
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The log of the e-mails sent to my colleagues and instructor is useful

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The group-e-mail feature enables me to effectively manage communication with classmates

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Discussion

The discussions board effectively enable me to interact with my classmates

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<tr>
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The different discussions levels (threads) make the discussion easy to follow

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The speed associated with accessing each discussion reply is acceptable

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Chat

The chat area effectively enables me to communicate with my classmates

<table>
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<tr>
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The chat room enables me to obtain information coherently

<table>
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I do not run into any technical problem when participating in discussions in the chat room

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Katia Passerini is an assistant professor of MIS at the School of Management of the New Jersey Institute of Technology (NJIT) where she teaches courses in MIS, knowledge management and IT strategy. She has published in refereed journals and proceedings, particularly in the area of computer-mediated learning, IT productivity and mobile communications. Her professional IT experience includes multi-industry projects at Booz Allen Hamilton and the World Bank. Dr. Passerini earned both an MBA and a PhD in information & decision systems from the George Washington University in Washington, DC.