Leacock, T. L., & Nesbit, J. C. (2007). A Framework for Evaluating the Quality of Multimedia Learning Resources. *Educational Technology & Society*, 10 (2), 44-59.

A Framework for Evaluating the Quality of Multimedia Learning Resources

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ABSTRACT

This article presents the structure and theoretical foundations of the Learning Object Review Instrument (LORI), an evaluation aid available through the E-Learning Research and Assessment Network at http://www.elera.net. A primary goal of LORI is to balance assessment validity with efficiency of the evaluation process. The instrument enables learning object users to create reviews consisting of ratings and comments on nine dimensions of quality: content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability, and standards compliance. The article presents research and practices relevant to these dimensions and describes how each dimension can be interpreted to evaluate multimedia learning resources.

Keywords

eLera, Learning resource, Quality, LORI; Learning object

A framework for evaluating the quality of multimedia learning resources

The number of reusable digital learning resources available through search engines and repositories is rapidly increasing. Teachers, students, and instructional developers can access large repositories such as MERLOT (Malloy & Hanley, 2001), which contained more than 15,000 resources when this article was written, and even larger meta-collections such as the US National Sciences Digital Library (Mardis & Zia, 2003), which allows users to search hundreds of repositories. However, the accelerating quantity and complexity of online resources is focusing attention on their inconsistent quality (Liu & Johnson, 2005). There are significant challenges to effective summative evaluation, in part because review processes and tools must balance assessment validity against throughput. Exhaustive and detailed instruments used by some school systems to evaluate educational software packages (e.g., Small, 1997; Squires & Preece, 1999) may not be suitable for evaluating learning objects, which tend to be smaller and more numerous. In this article we consider quality criteria specifically for multimedia learning objects, which we define as digital learning resources that combine text, images, and other media and that are intended for re-use across educational settings (Hamel & Ryan-Jones, 2002; Parrish, 2004).

We believe evaluation instruments designed specifically for these smaller digital resources are needed for three reasons. First, the design of multimedia learning materials is frequently not informed by relevant research in psychology and education (Nesbit, Li, & Leacock, 2006; Shavinina & Loarer, 1999). This has resulted in easy access to many ready-made learning objects of varying quality, making the process of sifting through repositories or the Web to find high-quality resources time-consuming and impractical. Second, to mitigate this search problem, some resource repositories use quality metrics to order search results (Vargo, Nesbit, Belfer, & Archambault, 2003). The efficacy of this technique is directly dependent on the validity of the evaluation tool used to generate the quality ratings. Third, quality criteria for summative evaluations have the potential to drive improvements in design practice (Nesbit, Belfer, & Vargo, 2002). Although our focus is on a tool for use by consumers of learning objects, we recognize that many consumers also have roles to play in the development of new learning objects. By increasing awareness of quality criteria, summative evaluations can feed-forward to improve the design and formative evaluation processes of future learning objects.

LORI: A tool for summative Discourse

The Learning Object Review Instrument (LORI) is a tool for eliciting ratings and comments from learning resource evaluators; it is available as both a web form and printable document at http://www.elera.net (Nesbit, Belfer, & Leacock, 2004). The specific purpose of LORI is to support evaluation of multimedia learning objects. While LORI can serve as a component of a program evaluation process, it is not a sufficient tool for evaluating whole educational programs in which the learning objects may be embedded. Although LORI can be used in a variety of evaluation models, we have used it primarily as part of the convergent participation model for collaborative learning object evaluation. In collaborative participation, reviewers first independently evaluate a set of objects and then discuss their divergent ratings (Nesbit, Belfer, & Vargo, 2002). For further discussion of this and other evaluation models, see Nesbit and Belfer (2004).

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In Canada, LORI is being used to teach learning resource evaluation at Athabasca University and Simon Fraser University. In the United States, it has been adopted as a learning object evaluation tool by the Southern Regional Education Board (SREB), a consortium of educational institutions in 16 states (SREB, 2005). Our research group has used the instrument to investigate collaborative evaluation and its role in professional development of instructional designers (Richards & Nesbit, 2004; Vargo, Nesbit, Belfer, & Archambault, 2003). This paper outlines the theoretical foundation of LORI.

Unlike larger evaluative instruments that specify very detailed criteria, LORI is founded on broadly interpreted dimensions intended to support summative discourse of an object's strengths and weaknesses. This heuristic approach to evaluation is not unique. Nielsen (1994), for example, synthesized a manageable set of guidelines for evaluation of software usability, and Hedberg (2004) defined seven discourses in multimedia design. LORI's dimensions are manifested by the nine items listed in Table 1.

Table 1. Items in LORI 1.5 (Nesbit, Belfer, & Leacock, 2004).

Item	Brief Description
Content quality	Veracity, accuracy, balanced presentation of ideas, and appropriate level of detail
Learning goal alignment	Alignment among learning goals, activities, assessments, and learner characteristics
Feedback and adaptation	Adaptive content or feedback driven by differential learner input or learner modeling
Motivation	Ability to motivate and interest an identified population of learners
Presentation design	Design of visual and auditory information for enhanced learning and efficient mental processing
Interaction usability	Ease of navigation, predictability of the user interface, and the quality of the interface help features
Accessibility	Design of controls and presentation formats to accommodate disabled and mobile learners
Reusability	Ability to use in varying learning contexts and with learners from different backgrounds
Standards compliance	Adherence to international standards and specifications

In the following sections, we outline research and practices bearing on the nine LORI items and describe how each item is interpreted to evaluate multimedia learning resources. We conclude by discussing some of the larger implications of evaluation in online learning object communities and the benefits of developing a standardized, heuristic evaluation system to meet the changing demands of quality assurance and quality improvement for learning resources.

Content quality

Content quality is perhaps the most salient aspect of learning object quality and certainly the one most relevant to the expertise of subject matter experts. A learning resource is of little or no use if it is well designed in all other respects but its content is inaccurate or misleading. Indeed, in some approaches to learning object evaluation, quality is defined largely on content-related criteria. For example, MERLOT's general evaluation standards divide quality into three parts: content validity, potential effectiveness as a teaching-learning tool, and ease of use (MERLOT, 2000).

For learning materials in any medium, the importance of clear, unbiased, and accurate content is often taken to be so obvious that the detrimental effects of poor content quality are rarely analyzed. Mikk (2002), however, explained the value of conducting empirical research to measure both content quality and the impact of its absence. While his work focused on the assessment of quality in textbooks, it is equally relevant to content quality in other learning materials, including multimedia learning resources.

Sanger and Greenbowe (1999) and Dall'Alba et al. (1993) present two approaches to examining the impact that errors and biases in science textbooks have on learner understanding of course concepts. Both studies found many examples of unintentional biases in the way concepts were portrayed in the textbooks. Further, they found that learners' "understandings are incomplete in ways that parallel misleading or inaccurate textbook treatments" (Dall'Alba et al., 1993 p. 622). Often the gaps in learners' knowledge are not immediately obvious, as evaluation materials are likely to mirror the materials students are learning from. For these reasons, careful attention to content quality is particularly important.

The problem may be even more of an issue in the area of learning objects. Almost 15 years ago, de Laurentiis (1993) warned that content is often incomplete in computer-based educational materials and that this is a key factor in making learning more difficult. More recently, Hill and Hannafin (2001) observed that learning resources often suffer from lack of regulation of content validity, reliability, and credibility. We anticipate that clear and widely accepted evaluation rubrics will help potential users identify objects that do achieve high content quality standards.

To this end, both learning object developers and evaluators should take special care to consider what assumptions are implicit in learning materials and how the novice is likely to interpret the content. Gollnick and Chinn (1991), for example, identified six forms of bias that are often present in learning materials: invisibility, stereotyping, selectivity and imbalance, unreality, fragmentation and isolation, and language bias. Being aware of the types of bias that can affect content quality is an essential step towards addressing these issues.

When rating content quality using LORI, the reviewer should consider an object that is unusable as a result of serious inaccuracies, biases, or omissions to warrant a rating of 1. An object that contains accurate information presented at the right level of detail in a balanced manner, but that omits or de-emphasizes some key points in a way that could mislead learners would receive a rating of 3. Finally, an object that is free of error, bias, and omissions, that provides evidence to support claims, and that emphasizes key points with sensitivity to cultural and ethnic differences using an appropriate level of detail would receive a rating of 5.

Learning goal alignment

As evaluators of instructor-designed university courses, we have frequently found substantial mismatches between learning and assessment activities, most notably instances where students were tested on concepts and procedures that were only distantly related to the course's learning activities and presentations. According to a review by Cohen (1987), improving instructional alignment between teaching and testing in teacher-designed materials can boost student achievement from 1 to 3 standard deviations.

The problem of alignment at the course and program levels is gaining recognition (Liebling, 1997; Porter, 2002; Roach, Elliott, & Webb, 2000), and educators and administrators have several well-developed models to choose from when assessing the alignment between school programs and district, regional, or national standards (Ananda, 2003; Rothman, Slattery, Vraneck, & Resnick, 2002; Webb, Alt, Cormier, & Vesperman, 2006). However, the approaches used to assess alignment at the broad curricular level require a significant investment of time (Porter, 2002), so they are not appropriate for the smaller chunk sizes of most learning objects.

The learning goal alignment item in LORI provides a more efficient heuristic approach suitable for self-contained digital resources at a moderate level of granularity, that is, resources that are smaller than courses but large enough to contain a combination of content, learning activities, and assessments. This LORI item emphasizes the crucial role that goal-driven design plays in quality. We believe that developers should explicitly state the learning goals for an object, either within the content accessible to the student or in metadata available to the instructor (Metros, 2005). Explicit goals help the instructor to make the initial decision on whether an object is likely to be relevant to, and appropriate for, a specific context. Further, the learning activities should be aligned with the stated goals (Hodson, 2001). To complete the alignment triangle, the activities should be sufficient to provide learners with the knowledge and skills to be successful in the assessments, and the assessments should measure student achievement of the learning goals.

A learning object with a substantial mismatch among assessments and learning activities, such that the object is unusable, would receive a rating of 1. An object with clearly stated learning goals and a substantial yet incomplete match between those goals and the assessment activities would typically receive a rating of 3. To earn a rating of 5, an object must specify learning goals within the content or its associated metadata, provide content and activities appropriate to the goals and intended audience level, and include goal-relevant learner assessments.

Feedback and adaptation

Generating effective feedback and adapting to learner characteristics have been understood as important goals for educational technology since at least the early 1960s (Park, 1996). These goals are in part motivated by the belief, famously presented by Bloom (1984), that adaptive teaching strategies are the key to reproducing the very high achievement levels obtained with one-to-one tutoring. Feedback and adaptation are also important features of open-ended learning environments featuring simulations and microworlds.

Feedback is a limited form of adaptation in which the object presents information in relation to a localized action of the learner. More powerful forms of adaptation use comprehensive information about the learner such as performance history, measures of aptitude, or self-reports of preference, aptitude, or mental state to individualize the learning environment. Adaptive materials have been designed to adjust parameters such as the number of examples presented in interrogatory or expository format during concept learning (Tennyson & Christensen, 1988), the number of problems to be solved in learning LISP programming (Anderson, Corbett, Koedinger, & Pelletier, 1995), and the number and difficulty of test items (Wainer, 2000). Adaptive materials have provided individualized coaching or scaffolding for learning computer-game strategies (Goldstein, 1982), scientific modeling (Jackson, Krajcik, & Soloway, 1998), ecology (du Boulay & Luckin, 2001; Luckin & du Boulay, 1999), self-regulation of studying (Hadwin & Winne, 2001), and many other domains. Unfortunately, very few of these adaptive resources have been made available to teachers and students outside the research projects for which they were constructed.

Limited forms of feedback, such as those often used in rote learning materials, have been demonstrated to benefit post-test scores relative to no-feedback control conditions (Morrison, Ross, Gopalakrishna, & Casey, 1995; Bangert-Drowns, Kulik, Kulik, & Morgan, 1991). Compared to feedback messages that simply present correct solutions, verbal messages crafted to concisely explain the causes of specific types of error have been found to increase post-test performance and decrease learning time (McKendree, 1990). We extend the concept of explanatory feedback beyond verbal messages to include simulations or microworlds, in which the program responds to a learner's actions in a way that reveals the underlying principles of the represented phenomenon. For example in the SimCity urban planning simulation environment, road traffic and pollution increase after the learner builds a suburban infrastructure (SimCity, n.d.).

Resources at the highest level of adaptation maintain a model of the learner that offers a principled basis for guiding adaptations. For example, the LISP tutor developed by Anderson, Corbett, Koedinger, and Pelletier (1995) models the domain of LISP programming as a set of production rules. The learner model, which estimates the probability that each rule has been learned, is used to individualize the amount of practice in each section of the curriculum to ensure that the learner sufficiently masters specific production rules before proceeding to the following section. Luckin's Ecolab (Luckin & du Boulay, 1999), another example of theory-based adaptation, combines a learner model with Vygotskian principles of learning support to individualize the level of assistance, difficulty of task, and complexity of the environment.

Some learning resources provide options that allow learners to customize the behavior of the resource. For example in Emile, an environment for learning kinematics (Guzdial, 1994), learners are able to select the level of instructional support they receive. An important question for learning object evaluators is whether a particular learner control feature constitutes effective adaptation to the learners' needs. The mixed research record on learner control offers little guidance in this respect except to indicate that learners make better decisions about their learning when provided with relevant information or advice (Williams, 1996; Eom & Reiser, 2000). While theories of self-regulated learning suggest that well-designed learner control features can promote metacognitive engagement (Hadwin & Winne, 2001), there is evidence that many students are unable to accurately self-monitor progress toward learning goals (Zimmerman, 1998) or their need for assistance (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003). For these reasons we argue that learner control features should only be regarded as adaptive if it is plausible that learners are well enough informed to use them effectively.

For this LORI item, an object that is essentially expository and provides little or no feedback receives a rating of 1. An object that consistently explains why a response is incorrect or demonstrates the entailments of actions in a constructivist environment might be assigned a rating of at least 3. A learning object that provides such feedback and builds a learner model to individualize the learning activities and environment would earn a rating of 5.

Motivation

The motivational quality of a learning object affects the amount of effort a learner will be willing to invest in working with and learning from the object. Expectancy-value theory (Wigfield & Eccles, 2000) offers a useful framework for understanding issues of learner motivation. According to expectancy-value theory, motivation is a function of the value one places on a task, one's expectations about the task, and the perceived cost of the task. For example, tasks that are inherently enjoyable will have high intrinsic value, and those that help a learner to achieve more distal goals such as passing a course will have high utility value; both types of value will increase motivation. Learners' expectations about success or failure on a task will also impact motivation, as will perceptions of what the learner must give up (e.g., lost opportunities to do other tasks or effort expended to complete the task at hand). A learning object that is perceived to be too difficult or too easy may result in low motivation because learners expect it to be boring, not possible to complete, or not worth completing.

Multimedia-heavy interfaces are sometimes introduced in an attempt to bolster learner motivation, but such interfaces may squander and misdirect cognitive resources if their use is not integral to the learning goals of the resource (Mandel, 2002; Squires & Preece, 1999). Squires and Preece (1999) use the term superficial complexity to describe attention-grabbing gimmicks such as flashing banners, non-instructional animated characters, and irrelevant audio-tracks. These devices can initially capture a learner's attention, but their use in learning objects rarely leads to substantive motivational benefit. As their novelty dissipates, they soon become distractions that interfere with learning (Garris, Ahlers, & Driskell, 2002). Instead, developers should focus on aspects of learning objects that can be designed to foster intrinsic motivation, which Ryan and Deci describe as a "natural wellspring of learning and achievement" (2000, p. 55).

Gaining and retaining attention by presenting highly relevant material and authentic activities that are meaningful to learners are two approaches that can increase intrinsic motivation (Keller, 1987; Keller & Suzuki, 2004; Schraw, Flowerday, & Lehman, 2001). Objects that allow learners some control over their own activities and learning (Martens, Gulikers, & Bastiaens, 2004), that provide opportunities for high levels of interactivity and encourage learner participation (Tsui & Treagust, 2004), and that present game-like challenges (Garris, Ahlers, & Driskell, 2002) will have high motivational value. Objects that partition content into discrete components or levels matched to the ability of the learner lead to increased self-efficacy and motivation (Keller & Suzuki, 2004). Finally, the multimedia possibilities afforded by learning objects, which help learners to visualize complex information and processes, have also been shown to increase student motivation (Tsui & Treagust, 2004).

In the LORI rubric for motivation, a learning object that is not relevant to a learner's goals, that is too easy or too difficult for its intended level, or that seeks to draw attention primarily through superficial complexity would receive a score of 1. An object that provides sufficient interaction to hold learners' attention as they work through the content but that is not designed to build confidence or help the learners to see the relevance of what they are learning would receive a rating of 3. An object that is perceived as relevant by its target audience, that offers appropriate difficulty levels for learners to gain confidence and satisfaction from the learning activities, and that is able to get and hold learners' attention would receive a rating of 5.

Presentation Design

In LORI, presentation design refers to the quality of exposition in a digital resource. This item applies to all expository media including text, diagrams, audio, video, and animations. High-quality presentations incorporate aesthetics, production values, and design of instructional messages in ways that are consistent with principles from research and theory in cognitive psychology and multimedia learning (Mayer & Moreno, 2003; Parrish, 2004) and with established conventions for multimedia design (e.g., Pearson & van Schaik, 2003). The essence of the presentation design item is represented by the principles of clear and concise expression advocated by Tufte (1997) for data graphics and Strunk (Strunk, Osgood, & Angell, 2000) for writing style.

Much of the science behind presentation design follows from the properties of human working memory, as addressed in cognitive load theory (CLT) and Mayer's principles of design for multimedia learning (Mayer, 2001; Mayer & Moreno, 2003; Reed, 2006; van Merrienboer & Sweller, 2005). In CLT, intrinsic cognitive load is described as being an inherent part of the learning task that results from the interactivity among the elements of to-be-learned material; this component of cognitive load cannot be reduced without impacting the learning objectives (Mayer & Moreno). Designers have more flexibility over two other components of cognitive load. Effective presentation design can increase germane cognitive load, which can contribute to learning and schema development. Poor presentation design can lead to increased extraneous cognitive load, which will reduce the capacity available for other cognitive processing. Mayer's design principles form an effective guide to minimizing extraneous cognitive load. They include coherence principles that recommend excluding unneeded or irrelevant materials, contiguity principles that recommend presenting elements that the learner must mentally integrate close together in space and time, and a modality principle that recommends explaining animations with audio narration rather than text. Consistent with Mayer's modality principle, there is strong evidence that, in comparison with text-only formats, displays that combine graphics with text often greatly benefit learning (Vekiri, 2002).

The advantages of graphic representations for representing verbal concepts, as distinct from their more obvious uses in presenting inherently spatial information, are also becoming better understood by researchers and designers. Knowledge maps, consisting of concept nodes connected by links labeled with relational terms, have been shown to work as powerful adjuncts or alternatives to expository text (Lambiotte, Dansereau, Cross, & Reynolds, 1989; Hall, Hall, & Saling, 1999; Nesbit & Adesope, 2006). Evaluators should question whether learning resources make the best use of text, conceptual diagrams, audio, and other formats to effectively communicate verbal concepts.

For rating learning objects on this item, we suggest that objects suffering from problems such as illegible fonts, distracting colour schemes, or poor audio or video should receive a rating of 1. Objects showing professional presentation design that is concise, clear, and aesthetically pleasing should receive a rating of at least 3. To obtain higher ratings, objects should also demonstrate designs that effectively integrate text, graphical, video, or audio media in a manner that is appropriate for the content and consistent with research-based principles of multimedia learning.

Interaction Usability

Usability has long been recognized as a critical issue in software quality (e.g., Norman, 1998; Nielsen, 1994) and in educational software in particular (Tselios, Avouris, Dimitracopoulou, & Daskakaki, 2001). Typically, usability efforts focus on error prevention, yet instructional activities are often designed to encourage students to make and learn from mistakes (Lohr, 2000). This tension between the demands of good usability and the demands of effective instructional design can be resolved by clearly distinguishing between two types of interactions that occur when a student uses a learning object: interaction with the interface and interaction with the content. In LORI, *interaction usability* is the term used to describe how easy or difficult it is for learners to move around in a learning object — to navigate their way through the options that the object provides and to participate in the activities the object offers. Other LORI items (e.g., feedback and adaptation) focus on interaction with the content, per se. Because learners must split limited cognitive resources across these two types of interaction, designers should strive to ensure that interaction with the interface will not get in the way of learning and that any errors the learner makes will be related to meeting the learning goals of the object, not to navigation (Laurillard, Stratfold, Luckin, Plowman, & Taylor, 2000; Mayes & Fowler, 1999; Parlangeli, Marchigiani, & Bagnara, 1999; Squires & Preece, 1999).

To reduce the effort learners must invest in learning and manipulating the interface, usable designs build on learners' prior knowledge of common interface patterns and symbols and require recognition, rather than recall, in navigational tasks. A learning object that rates highly in interaction usability will present a clear conceptual model that provides consistency in presentations and outcomes and simple mappings between actions and results, and it will implicitly inform users how to interact with it without overloading them with extraneous information (Mandel, 2002). While a learning object should allow the learner some flexibility in how to proceed through activities, it is critical to recognize that a certain amount of consistency in layout and structure can actually lead to more effective individualized explorations (Fleming & Levie, 1998; Kearsley, 1988; Tognazzini, 2001).

In cases where navigational information cannot be conveyed implicitly, the learning object should provide clear instructions and user interface help, allowing the learner to quickly grasp the directions and return to the content (Kearsley, 1988). According to Ryder and Wilson (1996), users see the computer — or in our context, the learning object being presented via the computer — as their partner in a conversation. In keeping with the norms of conversation (Grice, 1975), instructions should say true things (quality); they should say neither too much nor too little (quantity); they should be relevant to the topic at hand; and they should be clear. Thus, a learning object that is high in interaction usability will have easy-to-follow directions available at all points where a learner may need such help.

Delay is another important factor in interaction usability. The generally recognized maximum acceptable delay for web-page loading is 10 seconds (e.g., Nielsen, 1997; Ramsay, Barbesi, & Preece, 1998). However, Mayhew (1992) provides a figure of two seconds for intermediate steps in a process, and moving from one task to the next within a learning object would be seen by most users as an intermediate step. These numbers can be expected to drop, as more users come to rely on high bandwidth connections and faster machines. If a step within a learning object takes too long too load, learners will experience frustration and may choose to exit the object (Selvidge, Chaparro, & Bender, 2001).

Using LORI, objects that lack interactivity or have problems with navigation due to high cognitive load, poor screen layout, broken links, or inconsistencies in system response would receive a 1. Objects which contain working interactive elements but pose some problems for learners attempting to learn the interface would typically receive a 3. To earn a 5 in interaction usability, navigation through the object must be intuitive, predictable, and responsive.

Accessibility

People with disabilities may be inadvertently excluded from the potential benefits of online learning if learning object developers do not consider and accommodate issues of accessibility in the design of learning objects. Paciello (2000, Preface: Who are you?) claims that the increasing prevalence of graphical user interfaces has produced a situation in which "blind users find the Web increasingly difficult to access, navigate, and interpret. People who are deaf and hard of hearing are served Web content that includes audio but does not contain captioning or text transcripts." While these comments reference the web in general they are equally applicable to web-based learning objects. They correspond to a widespread disregard for accessibility among developers of educational software. A survey of major providers of instructional software (Golden, 2002) found that none of the 19 companies responding to the survey provided accessible products, and only 2 companies were enacting plans to address accessibility issues in product development and marketing.

Learning objects that present content only in text or graphical formats, with no audio voice-over, may exclude learners with visual impairments; objects that are designed specifically for students with ADHD may be ineffective for autistic learners (Kalyanpur & Kirmani, 2005). As Palmeri (2006) notes, good design should provide multiple means of accessing educational content. In some countries accessibility is being fostered through public policy. In the United States of America, for example, Section 508 of the *Rehabilitation Act* requires that federal agencies make their information technologies accessible to people with disabilities. Section 508 provides a detailed set of standards for ensuring that reasonable and effective accommodations are provided. The standards for web content, for example, include the requirement that "when pages utilize scripting languages to display content … the information provided by the script shall be identified with functional text that can be read by assistive technology" (Section 508 Standards, 1998). The 2004 *Individuals with Disabilities Education Improvement Act* imposes similar responsibilities on educators by requiring materials to be made accessible to learners with mild disabilities (Peterson-Karlan & Parette, 2005).

At the international level, accessibility is being advanced by the 14 Web Content Accessibility Guidelines established by the W3C (World Wide Web Consortium, 1999). A central theme in W3C accessibility is "graceful transformation," that is, the ability of a web page to offer consistent meaning when users interact with it through a wide range of browsers, screen types, assistive technologies, and input devices. Each of the W3C guidelines includes a set of checkpoints, and each checkpoint is categorized as Priority Level 1, 2, or 3. Conformance to the guidelines is then determined by whether the checkpoints at each priority level have been met.

More recently, the IMS Global Learning Consortium has provided *Guidelines for Developing Accessible Learning Applications* (IMS, 2002). In dealing specifically with online learning, these guidelines address accessibility issues in tests, interactive exercises, presentation tools, repositories, schedule organizers, threaded message boards, and synchronous collaboration tools such as text chat and video conferencing. They recommend the use of standard technical formats, especially W3C's Extensible Hypertext Markup Language (XHTML).

Accessibility evaluation for LORI requires a detailed understanding of the W3C and IMS guidelines. LORI ratings are closely tied to the scores objects would receive if evaluated on standard accessibility metrics. In the case of web pages, we recommend that evaluators who are not experts in this area use one of the validation services, such as WebXACT (http://webxact.watchfire.com), A-Prompt (http://aprompt.snow.utoronto.ca), or UsableNet (www.usablenet.com), that automatically checks for conformance to the W3C accessibility guidelines and returns a report on the level of compliance. Learning objects that contain Flash, Java, and other media or plug-ins must be manually checked, meaning that evaluators not yet familiar with this area may choose to mark the item as Not Applicable. For non-web-based objects, we recommend that evaluators interact with materials using assistive technologies, and base ratings and comments on IMS guidelines. Ratings can be calibrated using equivalent or similar W3C requirements.

Reusability

A key benefit of developing learning objects is the potential for reuse across courses and contexts (Harden, 2005; Hirumi, 2005; Koppi, Bogle, & Bogle, 2005). The possibility of creating digital learning objects that are more granular and more adaptive to different contexts and learner needs than conventional materials increases the opportunities for reuse. The ESCOT project is one example of a successful project that has made reusability a priority (Roschelle & DiGiano, 2004). While their primary definition of reusability focused on using existing materials to create their objects ("curriculets"), they also note that, once developed, curriculets "could be used by teachers in many different ways [including]… a computer lab exercise … whole class discussion … [or] the basis for [a] whole curriculum" (80–81).

The LORI reusability item focuses on a practical definition of reusability that will help to make the issues and approaches to reusability more salient to learning object developers and users. We hope that this, in turn, will help to promote the development of more portable learning objects, thus furthering one of the main goals of the learning object enterprise — reduction in the duplication of effort and cost across institutions. The LORI rubric values learning objects that are effective for a broad range of learners, but recognizes that no single learning object will be effective for all learners in all contexts.

At the most basic level, learning objects should not contain reference to specific contextual information such as instructor names, class locations, or course dates; this information should be housed in the overall course structure. Going beyond this fundamental requirement, designing reusable learning objects demands a thoughtful balance between reusability and fit to context, or as Campbell (2003, p. 38) puts it, "learning objects need to be produced in such a way that they are large enough to make sense educationally, but small enough to be flexibly reused." Certainly designers must keep the needs of learners in their target context in mind when developing new learning objects. However, this also includes considering the needs of diverse learners in that context — those with different backgrounds, abilities, and disabilities. For example, providing a glossary of key terms or a summary of some of the prerequisite knowledge that students should already have in order to complete the current learning object makes the object more accessible for those who might be coming to it from a learning path quite different from the one envisioned by the original object developer. Designing for a diverse population will make it more likely that the learning object will be reusable in a range of contexts (Treviranus & Brewer, 2003).

The LORI rubric for reusability describes some of the approaches that learning object developers can take to maximize reusability without sacrificing usefulness. An object containing instance-specific information, such as assignment due dates, would typically receive a rating of 1. An object that has restricted reusability due, for example, to reliance on specific prior knowledge that is not accessible via adjunctive content would receive an intermediate rating. An object that embeds sufficient situational context to be meaningful, provides adjunctive or alternate content useful to learners of varying skills and abilities, and is usable in multiple contexts would earn a rating of 5.

Standards compliance

"The requirement for standards is incontrovertible. From baseballs to railroad tracks, standard dimensions and approaches to design are essential if the cogs of today's technological world are to intermesh" (Bush, 2002, p. 5). The standards-compliance item in LORI addresses relevant technical standards and specifications, including those for HTML and XML (World Wide Web Consortium, 2006), object interoperability (IMS, 2006), and packaging (SCORM, see Advanced Distributed Learning, 2003). In the context of learning objects, the primary thrust of standardization efforts has been in the area of metadata — a term used to describe data about the learning objects. It is this metadata that potential users search when looking for learning objects, yet there are often discrepancies in approaches to metadata across objects and repositories. Different names may be used for the same element (e.g., "author" vs. "creator"), the same name may be used for different elements (e.g., "date" may refer to the date an object was created or the date that it was last updated), and elements used in one repository may simply have no correlate in other repositories. Even when a consistent metadata template is used, there can be variation in the quality of the information entered into each field. Some fields may be left blank or only partially completed due to lack of time, interest, or understanding on the part of the person entering the metadata (Krull, Mallinson, & Sewry, 2006). All of these issues directly impact the searchability and reusability of learning objects.

Achieving consistent and effective use of metadata standards is critical to overcoming the technical barriers to learning object reusability (Duval & Hodgins, 2006; McClelland, 2003). The quality of the metadata description and how closely it matches the learning object's characteristics are key factors in helping users "evolve from searching to finding" (Duval & Hodgins, 2006, p. 97). As the number of learning objects continues to grow, the importance of functional, sharable, and consistent metadata grows as well. With consistent usage of standardized metadata schemes, the interoperability of learning object repositories will increase significantly (Robson, 2004). According to Sampson & Karampiperis (2004), with consistent metadata, "*searching* becomes more specific and in-depth; *managing* becomes simpler and uniform; and *sharing* becomes more efficient and accurate" (p. 207).

There are several organizations involved in the development of usable metadata standards (CanCore, see Friesen & Fisher, 2003; DublinCore, 1999; IEEE, 2002; IMS, 2002 & 2005; and SCORM, see Advanced Distributed Learning, 2003, for examples). These agencies must balance the need for thorough descriptions of learning objects (e.g., the IMS standards include approximately 70 separate elements) with realistic time expectations for data entry. Too few elements and the metadata won't be effective in aiding learning object discovery even when complete. Too many elements and fields will be left empty, which will also defeat the goal of making the objects accessible and reusable through searches.

Evaluators using the standards compliance item in LORI as part of their assessment of the quality of a learning object should examine whether the metadata fields associated with the learning object follow the international standards and whether the creator has completed them with sufficient detail and accuracy to enable others to use the information to assess the relevance of the learning object. Objects that fail W3C and SCORM compliance tests or that do not provide sufficient metadata would receive a rating of 1. Those that pass some of the compliance tests would receive an intermediate rating, depending on the level of compliance. To receive a rating of 5 in standards compliance, an object must adhere to all relevant standards and specifications and must have metadata that is available to users.

Conclusion

In the preceding sections, we have described each of the nine items that make up the learning object review instrument and reviewed arguments and evidence that support the centrality of these categories in considerations of learning object quality. Outside this review, the utility of LORI has been examined in empirical work (e.g., Leacock, Richards, & Nesbit, 2004; Li, Nesbit, & Richards, 2006; Richards & Nesbit, 2004). These studies demonstrate that LORI is useful within a collaborative evaluation model and, when used in an educational setting, is perceived as helping participants to acquire instructional design and development skills.

Methods for assuring quality in learning resources are changing. The traditional labor- and time-intensive approaches, such as pre-publication expert peer review, are routinely bypassed as publishing and data-sharing technologies enable individuals to share their work directly with wide audiences. As with any emerging social practice, development brings standards, conventions, and new traditions. We believe that heuristic approaches to evaluation and quality control will form an important part of these new traditions.

The time required to use some of the more highly detailed approaches to evaluation is a significant barrier to their implementation (Jones et al., 1999). LORI strikes a pragmatic balance between depth of assessment and time. With a few minutes of effort, an evaluator can provide a meaningful learning object review that will be informative on its own and can also be aggregated with the reviews of others who have evaluated the same object.

Although some evaluators may initially not be comfortable using every item in LORI, the heuristic approach helps ensure that almost all experienced designers and users of learning resources can use the instrument effectively. Our experience is that most evaluators become comfortable with LORI items after rating a few learning objects. Further, compared with instruments that present more detailed criteria, LORI's relatively open structure better affords collaborative evaluation through discussion and argumentation. This characteristic is important in growing and sustaining shared knowledge among developers and users of multimedia learning resources.

It may seem that very few of the learning objects that many of us have encountered would earn top ratings in LORI. In these early days of improving knowledge and developing conventions around learning object quality this is to be expected. Without clear benchmarks, it is difficult for new developers to know how to ensure that their objects will be of high quality. Clear, visible guidelines for assessing quality will help both users and developers in this emerging field. With time, and with the wide adoption of evaluation tools such as LORI, we believe a greater proportion of learning objects will earn top ratings.

Acknowledgement

We thank our colleagues for contributions to this effort: Karen Belfer, British Columbia Institute of Technology; Natasha Boskic, University of British Columbia; Marek Hatala, Simon Fraser University; Griff Richards, Simon Fraser University; and Paul Stacey, BCcampus.

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