Web-Based Tools for Collaborative Evaluation of Learning Resources

John C. NESBIT
Faculty of Education, Simon Fraser University
Burnaby, BC, V5A 1S6, Canada

Jerry LI
School of Interactive Arts & Technology, Simon Fraser University
Surrey, BC, V3T 2W1, Canada

and

Tracey L. LEACOCK
Faculty of Education, Simon Fraser University
Burnaby, BC, V5A 1S6, Canada

ABSTRACT

The emergence of large repositories of web-based learning resources has increased the need for valid and usable evaluation tools. This paper reviews current approaches to learning object evaluation and introduces eLera, a set of web-based tools we have developed for communities of teachers, learners, instructional designers and developers. Compatible with current metadata standards, eLera provides a learning object review instrument (LORI) and other features supporting collaborative evaluation. eLera provides limited translation of evaluations and subject taxonomies across communities using different languages and terminology. eLera is designed to assist researchers to gather data on evaluation processes and has been used to teach educators how to assess the quality of multimedia learning resources.

Keywords: e-learning, resources, reviews, assessment, eLera, LORI, convergent participation

1. THE QUALITY PROBLEM

Learning objects are digital learning resources that are often available through web-based repositories searchable with standardized metadata. Teachers, students and instructional designers can now access specialized repositories, many containing thousands of objects, that are interlinked by metadata and interoperability standards. The number of learning objects available from such repositories is expected to continue to grow for years to come [1].

However, the production of learning objects occurs in a variety of settings, many of which lack quality control procedures or guidelines. A brief survey of objects in any of the larger databases offers abundant evidence that authors frequently fail to apply design principles that have been established in the fields of instructional design, instructional psychology and the learning sciences. Further, many objects registered in repositories appear never to have been learner-tested or subjected to other processes of formative assessment. In our view, there is a quality problem that demands a multifaceted solution involving better education of learning object designers, design and development models that incorporate formative quality assessment and learner-testing, and summative review provided in association with the repository in which the object is registered. The aggregated ratings and comments produced by summative reviews should be maintained as a form of metadata that users can apply to search, sort, and select objects.

The variety of settings in which learning resources are produced and consumed suggests that no single evaluation model is sufficient for all settings. For example, chemistry teachers within a school district who have agreed to develop shared resources have assessment requirements that differ from corporate trainers who develop resources to support an industry-wide certification program. We intend the model presented in this article to cover a wide range of professional settings, but we do not claim it will fit every case in which learning object evaluation is needed.

2. EVALUATION METHODS AND MODELS

Although most repositories do not offer evaluation tools, a few different approaches to learning object evaluation have been established. Evaluation models are typically a combination of technical tools, evaluation rubrics, and community practices. In this section, three models for learning object evaluation are discussed.

CLOE

The Co-operative Learning Object Exchange (CLOE), jointly developed by seventeen Ontario universities to facilitate the design and application of multimedia-rich learning resources, operates a structured review process [2]. A learning object submitted to CLOE is first examined by the editor-in-chief to decide if it meets specified technical requirements. The object is then either returned to the author for revision, or forwarded to an instructional design reviewer and content reviewers. The instructional design reviewer gives a binary decision (go or no-go). Normally, content is reviewed by two content reviewers. When they disagree, the decision to approve the object falls to a third content reviewer. CLOE provides three broad evaluative dimensions: quality of content, effectiveness as a teaching/learning tool, and ease of use.

MERLOT

MERLOT (www.merlot.org) is a repository containing educational resources classified into seven broad subject categories: Arts; Business; Education; Humanities; Mathematics and Statistics; Science and Technology; Social Sciences. Each category is divided into sub-categories, resulting in more than

500 subjects. MERLOT provides tools for both individual member comments and peer review. In both types of evaluation, resources are rated on a five-point scale. An object may be selected for peer review by an editorial board representing one of 14 discipline-based communities within the collection. The commonly practiced peer review process in MERLOT is similar to that for CLOE, except that there is no provision for an instructional design reviewer.

DLNET

The U.S. National Sciences Digital Library is a federated repository that includes DLNET, the Digital Library Network for Engineering and Technology (www.dlnet.vt.edu). DLNET uses a subject taxonomy that was adapted from the INSPEC taxonomy of scientific and technical literature (www.iee.org/Publish/Inspec).

Like MERLOT, DLNET maintains a two-tier evaluation system allowing review by expert peers and "public review" by users at large. But it differs from MERLOT in that an object is not published in the repository until it has been approved by peer review. The function of public reviews is to provide an ongoing ranking of published objects by users.

DLNET reviewers fill out an instrument containing a single comment field and 11 items rated on a 5-point scale. DLNET currently allows members to publish multiple reviews on the same learning object and currently provides no statistical aggregation of rating data.

Models and Tools

These three examples (CLOE, MERLOT, DLNET) demonstrate a common model with variations. Each is formed from (a) a searchable database of learning resource metadata that more or less conform to the IEEE learning object metadata standard; (b) a subject taxonomy constituting one component of the metadata; (c) evaluation criteria in the form of guidelines or a structured instrument; (d) a process for conducting and publishing reviews including restrictions on who can review; (e) a structured form in which all reviews are published. We view such systems as socio-technical phenomena that can be analyzed and empirically researched.

The two tiers of individual user and peer review that we see in MERLOT and DLNET mirror the two different types of consumer product evaluation systems that have proliferated on the Web. For example, at one video game review site (www.pcgamereview.com), any user can register to rate and comment on three quality dimensions (gameplay, graphics, sound) of a video game. Similarly, at a general consumer product review site (www.reviewcentre.com), any user can rate products on the two dimensions of "quality" and "value for money", as well as record comments. In contrast to these open evaluation systems, other product evaluation sites present only expert reviews. For example, at a DVD review site (www.dvdfile.com) experts evaluate DVD movies on the quality of video, audio, supplements, interactive features, and value for money.

As with most of the product review sites, the evaluation processes of learning object repositories provide few opportunities for interaction among expert reviewers (e.g. content experts and instructional designers), and even fewer for interactions between expert and consumer reviewers (e.g., learners and teachers). Such interactions are potentially important because, in research settings, reviewers have been consistently observed to modify their evaluation of a learning object after being presented with reviews that differ from their own [3]. This lends weight to the view that experts and consumers can affect each others' opinions and form convergent evaluations demonstrating greater validity than either could achieve independently.

Interactions among reviewers also present a powerful opportunity for professional development of teachers, instructional designers and media developers. We believe that an evaluation model that educates a significant proportion of the designer population about learning object quality will raise the overall quality of the resource pool, and is a much needed complement to models aiming for a high review throughput.

The major learning object repositories have not exploited the meta-evaluation and recommendation features that are now available on popular websites such as Amazon (www.amazon.com). We see a need to extend the current evaluation models and tools to incorporate these features.

3. ELERA

eLera is a website designed to support a distributed community of teachers, instructors, students, researchers, instructional designers, and media developers. Under development since September 2002, the initial version of eLera was publicly released in November 2003 at www.elera.net. eLera is a member of eduSource Canada, a network of interoperable Canadian repositories federally funded by CANARIE Inc.

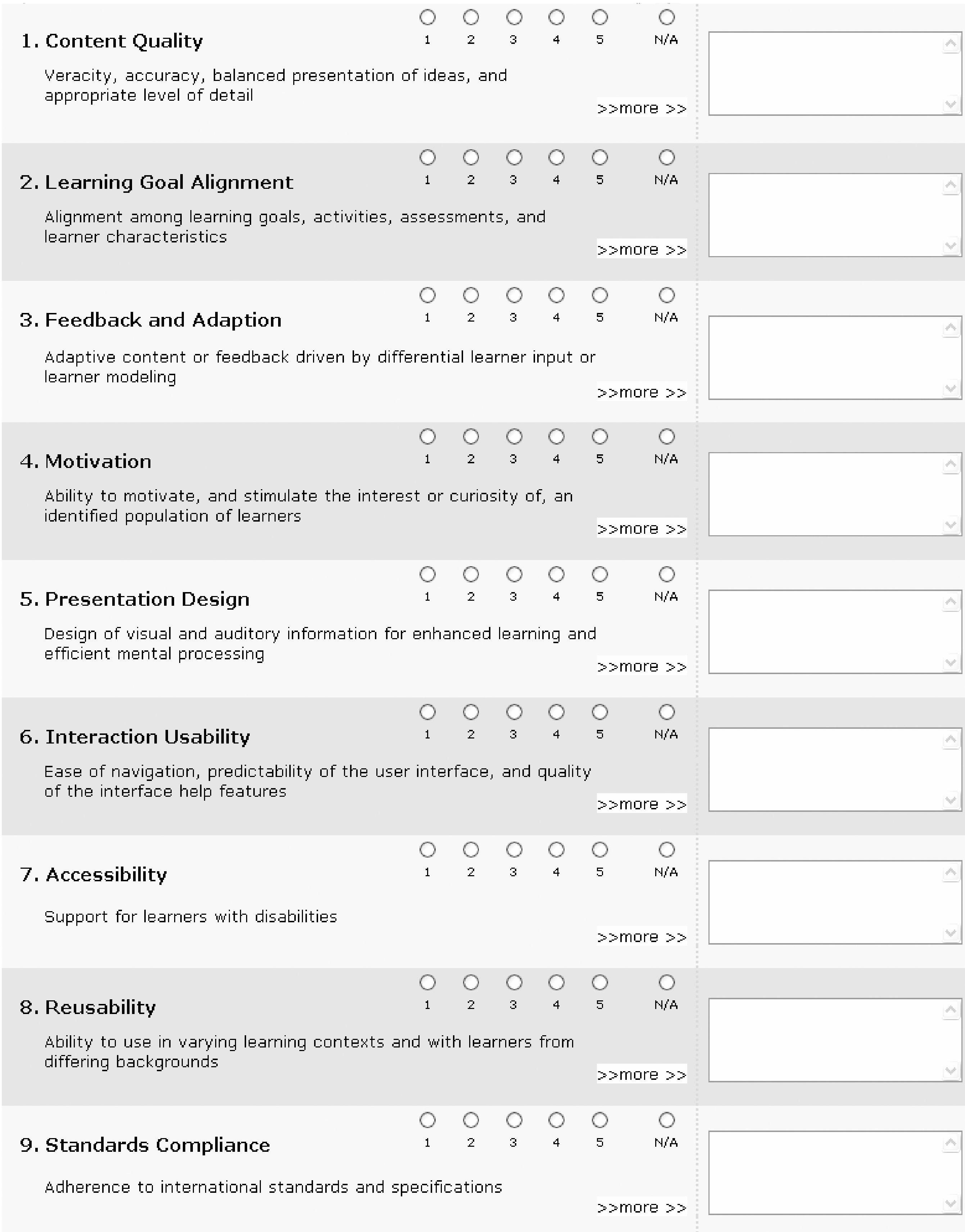
Basic Features

Like MERLOT and DLNET, eLera maintains a searchable database of learning object metadata and reviews, and provides tools and information for learning object evaluation. eLera complies with the IEEE learning object metadata standards as interpreted by the CanCore guide [4]. With permission of the Online Computer Library Centre, it uses a modified version of the Dewey Decimal Classification System as a subject taxonomy. eLera includes evaluation forms and reports, statistical aggregation of ratings, and a "my collection" feature allowing members to assemble frequently used objects. eLera is available in French and Chinese versions. It can be used to conduct a federated search of other repositories using the eduSource Communication Language [5].

Built for Research

While similar in form to other learning object repositories, eLera has unique goals that will shape its future development. eLera is intended to facilitate research on learning object evaluation and design. Evaluation data collected through eLera will be used to test the validity and reliability of instruments and evaluation models. eLera moderators can access detailed data pages for each object that present all ratings and comments in tabular form. These data have been used to study the application of Bayesian networks to learning object evaluation [6].

eLera will be used for research on collaborative evaluation and the interrelation between design and formative evaluation in e-learning development communities. To measure the effects of collaboration, eLera allows us to easily capture the distribution of quality ratings before and after discussion sessions. We expect to create versions of eLera to support successful workflow within teams that develop learning objects. For example we may create an evaluation instrument in which items become activated or deactivated as the object passes through defined stages. This enterprise leads immediately to an examin-



1. Content Quality

Veracity, accuracy, balanced presentation of ideas, and appropriate level of detail

1 2 3 4 5 N/A

>>more >>

2. Learning Goal Alignment

Alignment among learning goals, activities, assessments, and learner characteristics

1 2 3 4 5 N/A

>>more >>

3. Feedback and Adaption

Adaptive content or feedback driven by differential learner input or learner modeling

1 2 3 4 5 N/A

>>more >>

4. Motivation

Ability to motivate, and stimulate the interest or curiosity of, an identified population of learners

1 2 3 4 5 N/A

>>more >>

5. Presentation Design

Design of visual and auditory information for enhanced learning and efficient mental processing

1 2 3 4 5 N/A

>>more >>

6. Interaction Usability

Ease of navigation, predictability of the user interface, and quality of the interface help features

1 2 3 4 5 N/A

>>more >>

7. Accessibility

Support for learners with disabilities

1 2 3 4 5 N/A

>>more >>

8. Reusability

Ability to use in varying learning contexts and with learners from differing backgrounds

1 2 3 4 5 N/A

>>more >>

9. Standards Compliance

Adherence to international standards and specifications

1 2 3 4 5 N/A

>>more >>

Figure 1. LORI as seen by a reviewer

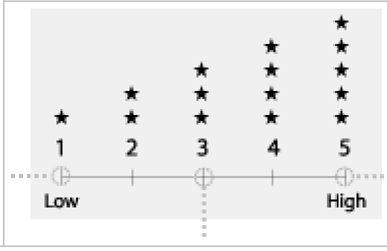
Low One of the following characteristics renders the learning object unusable. • No learning goals are apparent. • The assessments, learning activities and other content are substantially mismatched. • The learning goals are not appropriate for the intended learners.	**Learning Goal Alignment** 	**High** Learning goals are declared, either within content accessed by the learner or in available metadata. The learning goals are appropriate for the intended learners. The learning activities, content and assessments provided by the object align with the declared goals. The learning object is sufficient in and of itself to enable learners to achieve the learning goals.
Example In a learning object on heart function, seven out of ten questions on a post-test correspond to an animation showing the pumping action of the heart. The intended group of learners would be highly unlikely to infer the answer for three of the questions from information presented in the animation, even though the instructions imply that no additional resources are necessary.		

Figure 2. The detailed rubrics for Learning Goal Alignment

-tion of critical factors influencing learning object quality in design and development: What work is completed in each stage of the development process? Who should monitor quality at each stage? What information must be communicated to assure quality?

4. LEARNING OBJECT REVIEW INSTRUMENT

The eLera website allows users to evaluate resources with the Learning Object Review Instrument (LORI) [7]. Figure 1 shows how LORI appears to online reviewers. Figure 2 shows an example of the additional information about an item that reviewers can access within the review form by clicking *more*. For each item, reviewers can enter comments, and ratings on a 5-point scale. Reviewers can skip items that they are unable to assess. Each review is published as a web page in eLera. Ratings are averaged over items and reviewers to obtain a mean rating that is used to sort search results.

LORI has been iteratively developed through reliability and validity studies with instructional developers and teachers [3]. Version 1.5 of LORI is comprised of the following nine items selected to concisely specify a broad range of quality factors.

Content Quality
The single most salient aspect of quality in many discussions of educational materials is quality of content. Sanger and Greenbowe [8] and Dall'Alba et al. [9] demonstrated that biases and errors can easily slip into educational materials and cause problems for students. The content quality item in LORI asks reviewers to consider the veracity and accuracy of learning objects, in addition to assessing whether the object provides a balanced presentation of ideas and contains an appropriate level of detail.

Learning Goal Alignment
Aligning instruction and assessment can improve learning outcomes [10]. This LORI item asks reviewers to consider the degree to which the assessments and activities presented in the material accurately represent intended learning goals.

Feedback and Adaptation
Learners tend to be poor monitors of their own learning [11] and of their need for help [12]. Learning objects often provide feedback to help learners gauge their progress. The best learning objects do this adaptively. That is, they customize the learning environment, including the feedback and the content itself, to the needs to each learner [13]. This LORI item asks reviewers to evaluate learning objects on the effectiveness with which they adapt to learners' behaviors.

Motivation
According to Eccles and Wigfield [14], individuals are motivated to engage in a task if that task has value to them and if the cost of performing the task does not outweigh its expected value. Learning objects that are relevant to the learner's personal goals and offer achievable challenges will motivate learners and lead to increased interest in the topic.

Presentation Design
The visual appearance and sounds presented by a learning object, particularly as they relate to information design, affect the object's aesthetic and pedagogical impact. Decisions about presentation design should be informed by instructional and cognitive psychology, especially the theories and principles of cognitive load [15], multimedia learning [16] and information visualization [17, 18].

Interaction Usability
Learning objects that receive a high score on interaction usability are easy to navigate. They allow the learner to see what options are available, predict the outcomes of actions, and return to where they were if they make a mistake [19]. Clarity, redundancy, and system responsiveness contribute to achieving these goals [20, 21].

Accessibility
Accessibility is a significant issue in the digital learning environment [22]. For students to use a learning object, they must be able to access its content. Although software developers have come a long way in making computerized materials technically available to users across a range of platforms, there is still a significant access issue for learners with disabilities. For example, many learning objects provide visual information with no explanatory audio or text, thus rendering their content inaccessible to sight-impaired learners [23]. Because this LORI item is tied to detailed W3C [24] and IMS [25] guidelines, we recommend that most reviewers use a validation service such as WebXACT [26] or A-Prompt [27] to assist in determining an object's accessibility rating.

Reusability
Although reusability is frequently touted as one of the key benefits of learning objects, the reality often does not live up to the

promise [28]. This LORI item asks reviewers to consider whether an object is likely to be effective across a broad range of contexts, recognizing that no single object will be appropriate for all contexts in which particular content is taught.

Standards Compliance
As with accessibility, evaluating standards compliance requires technical knowledge beyond the preparation of most educators. Nevertheless, adherence to international technical specifications and standards is an important aspect of quality that may affect such matters as whether the learning resource can display correctly in the user's browser. Notably, this LORI item also reminds designers that providing standard metadata allows users to more easily register the object in a repository.

Figure 3. An eLera request as viewed by the moderator who created it

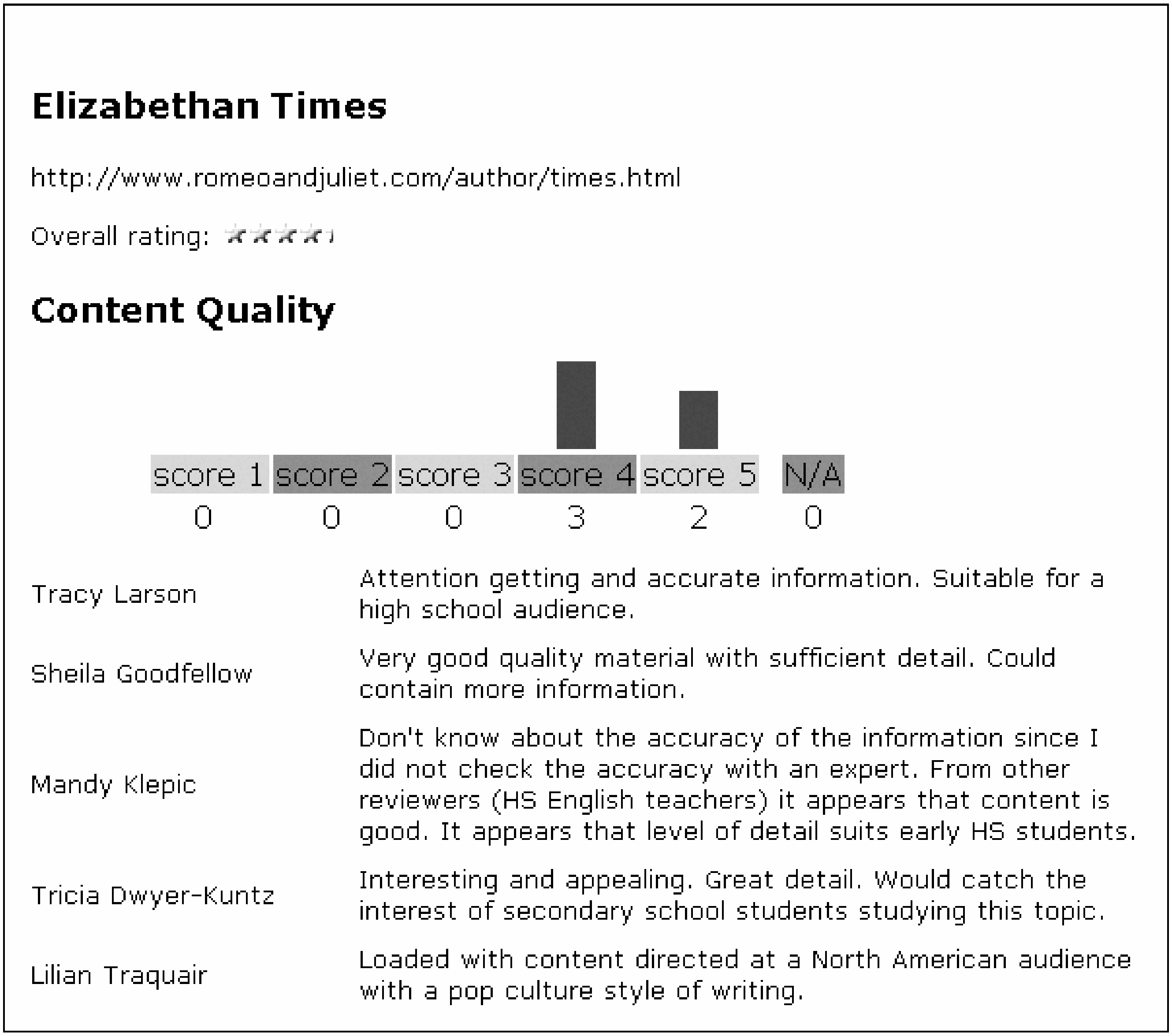


Figure 4. The distribution of ratings on a LORI item (Content Quality) as seen by collaborating reviewers

5. TOOLS FOR COLLABORATIVE EVALUATION

eLera's tools for collaborative evaluation are designed to support the convergent participation model defined and tested in previous research [3, 31, 32]. In this model, small evaluation teams are formed from participants representing relevant knowledge sets and interests (e.g., subject matter expert, learner, instructional designer). A team leader or moderator chooses objects for review, schedules the review activity, and invites team members. Currently, moderators can use eLera's request feature (Figure 3) to invite members to review an object. Members may choose to accept or reject participation.

After the team members have completed individual reviews, they meet in an online, real-time conference to compare and discuss their evaluations. In the convergent participation model, reviewers first discuss the items showing the greatest inter-rater variability. The moderator can use statistics calculated by eLera to order items for discussion. To support comparison of evaluations, eLera presents an aggregated view of ratings and comments for each item of LORI (Figure 4).

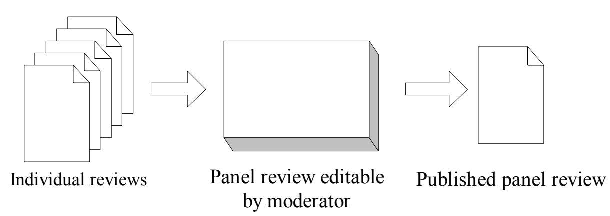


Figure 5. Individual reviews are merged to form a panel review that is published on the web.

Team members can edit their ratings and comments during the session. When the collaborative evaluation session is completed, the moderator publishes a team review by automatically aggregating individual reviews authored by team members. The tool requires the agreement of participants before incorporating their individual reviews in the team review. Figure 5 illustrates the process by which individual reviews are aggregated into panel reviews and published.

6. TRANSLATING ACROSS COMMUNITIES

With the rapid growth of global e-commerce, localization issues are becoming a significant subject of research [33]. The term localization is often used to connote the adaptation of a website to the language and culture of specific geographically or ethnically defined groups. However, our research is also concerned with translating terminology across communities of practice, such as high school biology teachers and e-learning professionals. Thus, we provide both linguistic and cultural localization of the eLera website such that users in different communities can share reviews without having to learn new terminology [34].

Localizing Language

Over the last decade, the demographics of the web have seen a dramatic shift toward a more culturally diversified, multilingual user base. The proportion of users accessing the web in English dropped from 49.6% in 2000 [35] to 35.8% in 2003 [36]. To overcome the barriers to information interchange presented by such linguistic diversity, web developers can, in some cases, create tools that will display information in a different language than it was originally entered.

We have localized eLera to French and Chinese. Although comments remain in the language in which they were entered, eLera allows, for example, scale ratings entered in French to be read in Chinese. With learning object metadata and reviews represented in multiple languages in the eLera database, users in one language community can use the information generated by another language community. We used the Canadian CanCore guidelines [4] to map the metadata between English and French, and extended this mapping to the Chinese E-Learning Technology Standard (CELTS) 3.1 [37].

Translating Subject Taxonomies

The IEEE Learning Object Metadata (LOM) standard has been adopted by most repositories, in part because the standard allows repositories to adopt and specify any subject classification system. As a result, one repository conforming to the IEEE LOM might adopt the Library of Congress system [38, another might adopt the Dewey Decimal Classification (DDC) [39], and a third might adopt a specialized classification system unique to the repository’s community. This expanding variety of subject taxonomies threatens to hamper the interoperability of learning object repositories and confuse users working across multiple repositories.

However, because users prefer to work with familiar terminology that is usually local to their community of practice, requiring all repositories and users to adopt a single standard classification system is not desirable or possible. For example, our field observations of how repositories are used in schools in British Columbia, Canada [40], indicated that teachers prefer to work with the terminology for subject matter, learning objectives, and achievement level used in the curricular materials provided by the provincial Ministry of Education. Researchers in the United States have found that U.S. teachers also prefer to link resources to the locally-defined learning outcome standards and search for resources according to a grade-specific content area [42].

In the US, each state has its own set of core education standards. The situation is similar in Canada, where each of the ten provinces establishes separate learning outcomes for a given subject in the K-12 public education system. In British Columbia (BC), the Ministry of Education has developed learning resources for K-12 known as Integrated Resource Packages (IRPs). The IRPs consist of the provincially required curriculum, suggested ideas for instruction, a list of recommended learning resources, and possible methods for teachers to use in evaluating students' progress [41].

In our research, a modified DDC, called eLera-DDC, is used as a general taxonomy into which a large number of local ontologies can be mapped. For example, Figure 6 shows the search interfaces in eLera where a user can choose a BC IRP topic for the subject field. The Local Ontology Mapping Tool enables users to pick topics from the BC IRPs by clicking the check box beside each topic. The eLera search engine transforms those concepts into eLera-DDC compliant queries using ontology mapping, which will return learning object records that matches the criteria in eLera database.

Ontology Mapping Technologies

To translate across subject taxonomies**,** we use domain ontologies [43] to represent different subject taxonomies or classification systems, and employ a mapping ontology to specify relations among taxonomies. A domain ontology is an explicit list and organization of all the terms, relations and objects that constitute the representational scheme for that domain [44]. We use the Simple Knowledge Organization System (SKOS) as well as SKOS Mapping [45] to define mapping relations among these ontologies.

Through the eLera interface, a reviewer or searcher uses the local ontology, which has a back end encoded in SKOS and a utility to match RDF/XML expressions of different ontologies. To interpret the SKOS-defined ontologies and the mapping relations, eLera uses a search algorithm developed by Gaševic & Hatala [46]. The algorithm takes a concept from the source ontology (e.g., the BC IRP) as an argument to search for concepts in the target ontology (i.e. eLera-DDC). The algorithm then generates a sequence of concepts compliant with the eLera-DDC that the eLera learning object repository can interpret when searching for learning objects. The algorithm uses the Jess rule-based reasoning engine to perform mappings and OWLJessKB to convert SKOS (RDF-based) ontologies (and mappings) into the Jess facts. The deployment of the ontology mapping search algorithm on the eLera system is shown in Figure 7.

This tool helps you map "BC Integrated Resource Package K-7 Topic" to "eLera Subject"

Please select IRPs K-7 topic, then click "Mapping to eLera subject" :

Mapping to eLera Subject

	PROCESSES AND SKILLS OF SCIENCE	LIFE SCIENCE	PHYSICAL SCIENCE	EARTH AND SPACE SCIENCE
Kindergarten	☐Observing ☐Communicating (sharing)	☐ Characteristics of Living Things	☐Properties of Objects and Materials	☐Surroundings
Grade 1	☐Communicating (recording) ☐Classifying	☐Needs of Living Things	☐Force and Motion	☐Daily and Seasonal Changes
Grade 2	☐Interpreting Observations ☐Making Inferences	☐Animal Growth and Changes	☐Properties of Matter	☐Air, Water, and Soil
Grade 3	☐Questioning ☐Measuring and Reporting	☐Plant Growth and Changes	☐Materials and Structures	☐Stars and Planets
Grade 4	☐Interpreting Data ☐Predicting	☐Habitats and Communities	☐Light and Sound	☐Weather
Grade 5	☐Designing Experiments ☐Fair Testing	☐Human Body	☐Forces and Simple Machines	☐Renewable and Non-Renewable Resources
Grade 6	☐Controlling Variables ☐Scientific Problem Solving	☐Diversity of Life	☐Electricity	☐Exploration of Extreme Environments
Grade 7	☐Hypothesizing ☐Developing Models	☐Ecosystems	☐Chemistry	☐Earth' s Crust

Mapping to eLera Subject

Figure 6. The eLera interface in which a British Columbia school teacher can choose a BC Instructional Resource Package (IRP) topic

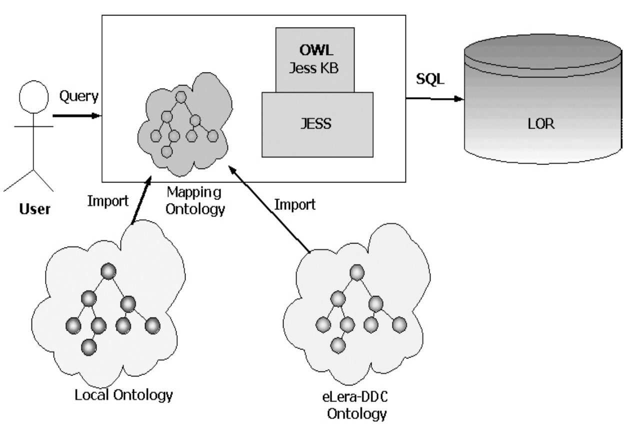


Figure 7. Using SKOS-based ontologies and ontology mappings in the eLera system: When a request comes from a user who uses a selected local ontology (in our case BC IRP), the system translates the query argument to eLera-DDC ontology in run time. Then eLera generates an SQL query to search its learning object repository.

7. RECOMMENDATION AND TRUST

Through eLera we are researching models for supporting e-learning communities of practice. This research asks how online communities should be structured to foster norms of reciprocity, collective action, identity, and information flow [47]. Key questions at this stage are: How can community members recommend resources and reviews to others? How can they find and be introduced to other members with similar or complementary interests? How can they build the identity, interpersonal trust and reputation that are prerequisites to effective collective activity?

At present, eLera provides only rudimentary facilities for recommendation and trust. By default, search results are ordered by average rating so that the most highly rated objects are presented at the top of the list. Users can also choose to order objects by *popularity*, a metric that is incremented whenever an object is placed in a personal collection. To support trust and alliance building, eLera members can create personal profiles detailing their interests and areas of expertise. Thus, decisions about whether to trust and collaborate with a reviewer can be based on the combined knowledge of his or her profile and previous reviews.

As we build on these features, we are researching more advanced models of trust and recommendation that will contribute to the nascent research base in this area [48, 49, 50, 51]. For example, we are implementing a "web of trust" for eLera in which members can create a list of highly trusted others. eLera will be able to recommend new members for one's trust list by chaining forward through the network of trust lists.

8. ELERA WORKSHOPS

Earlier versions of eLera have been used in professional development workshops for local teachers [40]. These have been helpful in refining the usability of the site and identifying deeper community design issues. We will continue to work with teachers and will extend this field-based component of our research to include instructional design and development teams. eLera will evolve as a product of the identified needs of e-learning communities and our ongoing research on learning object evaluation models.

9. USES IN PROFESSIONAL DEVELOPMENT

Although eLera was originally developed to facilitate the production of reviews, its most significant benefits may lie in the professional development of those who design, develop and select learning resources for educational curricula. We believe that most teachers, and even many of those who create learning materials, receive little education in the principles of instructional design that are summarized by the nine dimensions of LORI. The exposure they do receive is often presented as theory, with little opportunity to apply or enact design principles.

Richards and Nesbit [52] studied the use of eLera during two 2-hour sessions in an instructional design course required for a masters degree in distance education. Because the course was itself delivered at a distance, students communicated through long distance teleconferencing while collaborating in groups of four through the eLera website. During the first session the students, most of whom were teachers or instructional designers, were taught how to use eLera and LORI to collaboratively evaluate learning resources. During the second session the groups collaboratively evaluated five online learning resources. The students submitted written reflections on their experience with eLera, and approximately six months later completed a questionnaire in which they evaluated the effect of the eLera sessions on their professional practice as teachers and designers. In general, the students believed that the collaborative evaluation activity using the convergent participation model was a highly effective component of the course, and that they were able to apply what they had learned from the activity to better design online learning resources.

Collaborative evaluation may be a particularly effective way for learners to be introduced to principles of instructional design because it allows relatively immediate and repeated application of those principles, combined with a significant amount of feedback from peers. Unlike the practice of instructional design, which can be a difficult and lengthy process for novices, evaluation is relatively free from distracting technical complications, allowing learners a more continuous focus on design principles.

Of course, the idea of evaluation as a learning goal or activity is not new. Evaluation is defined as a higher-level cognitive process in Bloom's taxonomy of educational objectives [53]. Within that category, the convergent participation method matches most closely with the critiquing subcategory:

> Critiquing involves judging a product or operation based on externally imposed criteria and standards. In critiquing, a student notes the positive and negative features of a product and makes a judgment at least partially on those features. Critiquing lies at the core of what has been called critical thinking. [53, p. 84].

Collaborative evaluation may be especially appropriate as a pedagogical method in design disciplines, such as architecture, engineering and instructional design, because it allows novices to work with professional-level quality criteria and standards before they are able to complete a professional-scale product.

10. CONCLUSION

The tools available in the eLera website for evaluation of learning resources enable a form of computer-supported collaborative work in which participants converge on more accurate evaluations through a combination of ratings, comments and discussions. Through language and subject terminology translation, reviewers can share objects and ratings across communities. When used to teach principles of instructional design, the tools foster an innovative brand of computer-supported collaborative learning. Convergent participation, the collaborative method around which the eLera tools were designed, can potentially be applied to domains other than learning object evaluation. We anticipate that software similar to eLera, supporting forms of collaborative evaluation similar to convergent participation, will be developed to produce reviews and educate professionals in design domains such as engineering, architecture, and computer science.

11. REFERENCES

[1] J.M. Saylor, **Why Every Digital Science Collection Builder Should Contribute Catalog Information to the National Science Digital Library**, 2002, retrieved February 26, 2006 from http:// collections.comm.nsdlib.org/cgi-bin/wiki.pl?WhyJoin

[2] M. Clarke, **CLOE Peer Review**, 2003, retrieved February 26, 2006, from Co-operative Learning Object Exchange: http://cloe.on.ca/documents.html

[3] J. Vargo, J.C. Nesbit, K. Belfer, A. Archambault, "Learning Object Evaluation: Computer Mediated Collaboration and Inter-Rater Reliability", **International Journal of Computers and Applications**, Vol. 25, No. 3, 2003, pp. 198-205.

[4] N. Friesen, S. Fisher, L. Tozer, A. Roberts, S. Hesemeier, & S. Habkirk, **CanCore Guide for LOM Implementation**, CanCore Initiative, 2003, retrieved January 7, 2004 from www.cancore.ca

[5] M. Hatala, G. Richards, T. Eap, & J. Willms, **The EduSource Communication Language: Implementing Open network for Learning Repositories and Services**, 2003, retrieved January 7, 2004 from www.sfu.ca/~mhatala/pubs/sap04-edusource-submit.pdf

[6] V.S. Kumar, J.C. Nesbit, P.H. Winne, A.F. Hadwin., & K.N. Han, "Quality Rating of Learning Objects", in S. Pierre (Ed), **E-Learning Networked Environments and Architectures**, Springer, in press.

[7] J. Nesbit, K. Belfer, & T. Leacock, "Learning Object Review Instrument (LORI)", **E-Learning Research and Assessment Network**, 2003, retrieved January 7, 2004 from www.elera.net

[8] M.J. Sanger, & T.J. Greenbowe, "An Analysis of College Chemistry Textbooks as Sources of Misconceptions and

Errors in Electrochemistry", **Journal of Chemistry Education**, Vol. 7, No. 6, 1999, pp. 853-860.

[9] G. Dall'Alba, E. Walsh, J. Bowden, E. Martin, G. Masters, P. Ramsden, & A. Stephanou, "Textbook Treatments and Students' Understanding of Acceleration", **Journal of Research in Science Teaching** Vol. 30, No. 7, 1993, pp. 621-635.

[10] S.A. Cohen, "Instructional Alignment: Searching for a Magic Bullet", **Educational Researcher,** Vol. 16, No. 8, 1987, pp.16-20.

[11] B.J. Zimmerman, "Self-fulfilling Cycles of Academic Regulation", In D. H. Schunk and B. J. Zimmerman (Eds.). **Self-regulated Learning: From Teaching to Self-Reflective Practice,**1998, pp. 1 – 19. New York: Guilford Press.

[12] V. Aleven, E. Stahl, S. Schworm, F. Fischer, & R. Wallace, "Help Seeking and Help Design in Interactive Learning Environments", **Review of Educational Research**, Vol. 73, No. 3, 2003, pp. 277-320.

[13] A.F. Hadwin & P.H. Winne, "CoNoteS2: A Software Tool for Promoting Self-regulation and Collaboration", **Educational Research and Evaluation: An International Journal on Theory and Practice**, Vol. 7, 2001, pp. 313-34.

[14] J.S. Eccles, & A. Wigfield, "Motivation, Beliefs, Values, and Goals", **Annual Review Psychology**, Vol. 53, pp. 2002, 109-32.

[15] R.E. Mayer, **Multimedia Learning**. New York: Cambridge University Press, 2001.

[16] J.J.G. van Merriënboer & J. Sweller, "Cognitive Load Theory and Complex Learning: Recent Developments and Future Directions", **Educational Psychology Review**, Vol. 17, 2005, pp. 147-177.

[17] P.E. Parrish, "The Trouble with Learning Objects", **Educational Technology Research and Development**, Vol. 52, No. 1, 2004, pp. 49-67.

[18] E.R. Tufte, **Visual Explanations: Images and Quantities, Evidence and Narrative**, Cheshire, CN: Graphics Press, 1997.

[19] D. Norman, **The Design of Everyday Things**. New York: Basic Books In. Pub, 1988.

[20] C.D. Wickens, J.D. Lee, Y. Liu, & S.E Gordon Becker, **An Introduction to Human Factors Engineering (2nd ed),** Upper Saddle River, NJ: Prentice Hall, 2004.

[21] P. Selvidge, B. Chaparro, & G. Bender, "The World Wide Wait: Effects of Delays on User Performance", **International Journal of Industrial Ergonomics**, Vol. 29, No. 1, 2001, pp. 15-20.

[22] **Section 508 Standards** (1998). Retrieved February 22, 2006 from http://www.section508.gov

[23] M. Paciello, "Preface", **Web Accessibility for People with Disabilities**, Norwood, MA: CMP Books, 2000, retrieved February 22, 2006 from Books 24x7 database.

[24] World Wide Web Consortium, **Web Content Accessibility Guidelines 1.0**, 1999, retrieved February 22, 2006 from http://www.w3.org/TR/WCAG10

[25] "IMS Guidelines for Developing Accessible Learning Applications, Version 1.0", **IMS Global Learning Consortium**, 2003, retrieved February 22, 2006 from http://www.imsglobal.org/accessibility

[26] **WebXACT** (n.d.), retrieved, February 21, 2006 from http://webxact.watchfire.com

[27] **A-Prompt Web Accessibility Verifier**, (n.d.), retrieved February 22, 2006 from http://aprompt.snow.utoronto.ca/

[28] D.A Wiley, "Learning Objects Need Instructional Design Theory", in A. Rossett (Ed.), **The 2001/2002 ASTD Distance Learning Yearbook**, New York: McGraw-Hill, 2002.

[29] IEEE **Learning Object Metadata,** 2005, retrieved February 22, 2006 from http://ltsc.ieee.org/wg12/

[30] **IMS Global Learning Consortium Specifications**, 2001-2006, retrieved February 22, 2006 from http://www.imsglobal.org/specifications.cfm

[31] J.C. Nesbit & K. Belfer , "Collaborative evaluation of learning objects", in R. McGreal (Ed.), **Online Education Using Learning Objects**. London: Routledge/Falmer, 2004.

[32] J.C. Nesbit, K. Belfer, & J. Vargo, "A Convergent Participation Model for Evaluation of Learning Objects", **Canadian Journal of Learning and Technology**, Vol. 28, No. 3, 2002, pp. 105-120.

[33] D. Cyr & H. Trevor-Smith, "Localization of Web Design: An Empirical Comparison of German, Japanese, and U.S. Website Characteristics", **Journal of the American Society for Information Science and Technology**, Vol. 55, No. 13, 2004, pp. 1199-1208.

[34] J. Li, J.C. Nesbit, & G. Richards, "Evaluating Learning Objects Across Boundaries: The Semantics of Localization", **International Journal of Distance Education Technologies**, Vol. 4, No. 1, 2006, pp. 17-30.

[35] J.D. Haynes, "International User Interfaces", **Internet Management Issues: A Global Perspective,** Hershey, PA: Idea Group Publishing, 2002.

[36] Global-Reach, **Global Internet Statistics,** 2004, retrieved March 28, 2004, from http://www.global-reach.biz/globstats/index.php3

[37] X. Xiang, Z. Shen, L. Guo, & Y. Shi, "Introduction of the Core Elements Set in Localized LOM Model. Learning Technology", **IEEE Computer Society**, Vol. 5, No. 1, 2003, retrieved February 27,2006 from http://lttf.ieee.org/learn_tech/issues/january2003/#6

[38] Library of Congress, **Library of Congress Classification Outline**, 2005, retrieved August 11, 2005 from www.loc.gov/catdir/cpso/lcco/lcco.html

[39] OCLC, **Dewey Decimal Classification System**, 2005, retrieved July 22, 2005 from http://www.oclc.org/dewey/about/worldwide/default.htm

[40] T. Leacock, G. Richards, & J. Nesbit, "Teachers Need Simple Effective Tools to Evaluate Learning Objects: Enter eLera.net", **Proceedings the 7th IASTED International Conference on Computers and Advanced Technology in Education**, Hawaii, USA, 2004, pp. 333-338.

[41] BC Ministry of Education, **Integrated Resource Packages (IRPs)**, 2005, retrieved July 22, 2005 from http://www.bced.gov.bc.ca.proxy.lib.sfu.ca/irp/irp.htm

[42] M.M. Recker, J. Dorward, & L.M. Nelson, "Discovery and Use of Online Learning Resources: Case Study Findings", **Educational Technology & Society**, Vol. 7, No. 2, 2004, pp. 93-104.

[43] T.R. Gruber, "A Translation Approach to Portable Ontology Specifications", **Knowledge Acquisition**, Vol. 5, No. 2, 1993, pp. 199-220.

[44] J.H. Gennari, S.W. Tu, T.E. Rothenfluh, & M.A. Musen, **Mapping Domains to Methods in Support of Reuse**, 2005, retrieved August 11, 2005 from http://smi-web.stanford.edu/pubs/SMI_Reports/SMI-93-0497.pdf

[45] A. Miles, & D. Brickley, "SKOS Core Vocabulary Specification", **W3C Working Draft**, 2005, retrieved February 27, 2006 from http://www.w3.org/TR/swbp-skos-core-guide

[46] D. Gašević, & M. Hatala, "Ontology Mappings to Improve Learning Resource Search", ***British Journal of***

Educational Technology, Vol. 37, No. 3, 2006, pp. 375-389.

[47] R.D. Putnam, **Bowling Alone: The Collapse and Revival of American Community**, New York: Simon & Schuster, 2000.

[48] J.C. Nesbit, & P.H. Winne, “Self-regulated Inquiry with Networked Resources”, **Canadian Journal of Learning and Technology**, Vol, 29, No. 3, 2003, pp. 71-91.

[49] D.A. Wiley & E.K. Edwards, **Online Self-organizing Social Systems: The Decentralized Future of Online Learning**, n.d., retrieved January 4, 2004, from http://wiley.ed.usu.edu/docs/ososs.pdf

[50] M. Recker & A. Walker, “Supporting Word-of-mouth' Social Networks via Collaborative Information Filtering”, **Journal of Interactive Learning Research**, Vol. 14, No. 1, 2003, pp. 79-98.

[51] M. Recker, A. Walker, & K. Lawless, “What Do You Recommend? Implementation and Analyses of Collaborative Filtering of Web Resources for Education”, **Instructional Science**, Vol 31, No. 4/5, 2003, pp. 229-316.

[52] G. Richards, & J.C. Nesbit, “The Teaching of Quality: Convergent Participation for the Professional Development of Learning Object Designers”, **International Journal of Technologies in Higher Education**, Vol. 1, No. 3, 2004, pp. 56-63.

[53] L.W. Anderson, & D.R. Krathwohl, **A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom’s Taxonomy of Educational Objectives.** New York: Longman, 2001.