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Article

Science Information Literacy Tutorials and Pedagogy

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Abstract

Objective – This study examined information literacy tutorials in science. The goals of the research were to identify which of the information literacy standards for science, engineering and technology were addressed in the tutorials, and the extent that the tutorials incorporated good pedagogical elements.

Methods – The researcher chose for review 31 of the tutorials selected by members of the ACRL Science & Technology Section (STS) Information Literacy Committee. She carefully analyzed the tutorials and developed a database with codes for the topic of each tutorial, the STS information literacy standard(s) addressed by the tutorial, and whether good pedagogical elements were incorporated. The entire analysis and coding procedure was repeated three times to ensure consistency.

Results – The tutorials analyzed in this study covered various subjects and addressed all the (STS) information literacy standards. The tutorials presented information clearly and allowed users to select their own learning paths. The incorporation of good pedagogical elements was limited, especially in relation to active learning elements.

Conclusions – Web tutorials have been accepted as effective information literacy instruction tools and have been used to teach all elements of the STS information literacy standards. Yet, ensuring they provide a real learning experience for students

remains a challenge. More serious thought needs to be given to integrating good pedagogy into these instructional tools in order to attain deep learning.

Introduction

User instruction has been considered one of the essential functions of librarianship for many years. It has been described in a number of ways, including library orientation, library instruction, bibliographic instruction (BI), user education, and information literacy instruction. The concept of information literacy instruction has been discussed and promoted since the 1980s. Information literacy instruction goes beyond the basic need for library orientation and introduction to include research tools provided within a search strategy framework (Grassian & Kaplowitz, 2009). The movement has developed in response to the increasing amount of information available to people and the growing complexity of information technology.

Information literacy refers to a set of abilities requiring individuals to "recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information" (American Library Association, 1989, para. 3). The framework for information literacy instruction in academic settings is described in the *Information Literacy Competency Standards for Higher Education*, which outlines five standards linked to twenty-two performance indicators (Association of College and Research Libraries, 2000)**.** These standards help address the unique disciplines of science, engineering, and technology, which pose unique challenges in identifying, evaluating, acquiring, and using information. To help guide information literacy instruction in these disciplines, *Information Literacy Standards for Science and Engineering / Technology* was developed by the ALA/ACRL/STS Task Force on Information Literacy for Science and Technology. These standards acknowledge the difficulty of obtaining peer reviewed literature and grey literature, the interdisciplinary nature of science, engineering and technology, and the variety of formats that require increasing expertise in information technology (Slebodnik & Zeidman-Karpinski, 2008).

The role of libraries and librarians in helping achieve information literacy standards has been extensively researched and discussed. It is a widely shared belief that libraries, particularly those funded by educational institutions, should be the lead agencies in articulating, promoting, and developing the community's information literacy (Stanger, 2009).

While various types of information literacy instruction have been developed for library users, there has been an increasing demand for more rapid, anytime-anyplace sharing of information (Bawden, Devon, & Sinclair, 2000). In response to this demand, many libraries are now offering information literacy instruction via the Internet. Online tutorials are one of the common instructional tools for this purpose (Donaldson, 2000). Compared to other instructional modes, online tutorials have the advantage of being available 24 hours a day and 7 days a week to anyone with an Internet connection. Online tutorials combined with face-to-face (F2F) sessions can save instructors' time. "Tutorial maintenance can take time but may take less time in the long run than teaching numerous F2F one-shot sessions with a limited librarian staff" (Grassian, & Kaplowitz, 2009, p.150).

Knowing how to achieve learning goals through good pedagogy is always a main consideration for educators. In face-to-face instruction, active learning can be seen as an important pedagogical technique. While instructing asynchronously, Web tutorials seem to be at a disadvantage in incorporating good pedagogical elements. A common complaint about Web tutorials is their lack of sufficient interactivity to allow active learning experiences (Dewald, Scholz-Crane, Booth, & Levine, 2000). As early as 1999, Dewald noted

the importance of incorporating good pedagogy into such Web-based library instruction as online tutorials. She argued that with online and asynchronous instructional mode, good pedagogy and active learning should be equally important in achieving instructional objectives (Dewald, 1999b). It is believed that "real learning will only take place when students are asked to understand the material in their own terms and use it to accomplish a meaningful task" (Dewald et al., 2000, p. 38). The inclusion of active learning in a tutorial clearly improves teaching effectiveness (Hrycaj, 2005). In discussing a project to develop an online library skills tutorial at the University of Akron, Franks, Hackley, Straw, and DiRenzo (2000), also stressed the importance of active learning in their proposed tutorial.

The feasibility of incorporating good pedagogy, such as active learning elements, into Web-based library tutorials has been discussed in the literature. According to Dewald, librarians have the opportunity to combine good pedagogy with the unique capabilities of the Web, and new technologies should allow various methods of accomplishing active learning (Dewald, 1999b; Dewald et al., 2000). Dewald proposed a set of pedagogical guidelines for Web-based library instruction (including tutorials) that included active learning elements feasible in this (Dewald, 1999b). These guidelines have been incorporated successfully in various tutorials. The design team for an online library skills tutorial at Toronto's Seneca College of Applied Arts and Technology reviewed a number of completed tutorials. They noted that many of the best tutorials consistently incorporated the use of active learning and "provided students with opportunities to interact and test new ideas as the lessons progressed" (Donaldson, 2000, p. 241). One salient feature of the Texas Information Literacy Tutorial (TILT), winner of the 2000 ACRL Instruction Section's "Innovation in Instruction Award," was its incorporation of various active learning elements, including quiz questions and exercises (Hrycaj, 2005). In the areas of science, engineering and technology, the STS Information Literacy Committee has been compiling a list of teaching ideas and techniques related to the performance indicators of the information literacy standards (http://wikis.ala.org/acrl/index.php?title=Teaching_Tips&oldid-42295; revision as of 7 Apr. 2011, at 06:26). By examining which of the science, engineering, and technology information literacy standards can be addressed by Web-based tutorials, this study sought to provide evidence that contributes to the further development of the STS Information Literacy Committee's list of teaching ideas and techniques.

Literature Review

Analysis of Web-based Tutorials

Several studies have been reported in the literature analyzing Web-based tutorials in an attempt to determine their characteristics, often based on a set of pre-established indicators. One of the earlier studies of this type was conducted by Dewald (1999a), in which she evaluated a sample of nineteen tutorials of the Library Instruction Round Table against seven pre-established fundamental indicators of good library instruction: course-related and specifically assignment-related; active learning; collaborative learning; multiple media presentations; well-clarified objectives; concept teaching; and offering a librarian's follow-up help. The study concluded that tutorials could not replace face-to-face training, and that they should be used in connection with academic classes, rather than in isolation.

Tancheva (2003) conducted another study of this type. Her study aimed at determining to what extent an online library instruction tutorial addressed the principles of accepted learning theory in distributed environments and the accepted principles of effective library instruction. Tancheva analyzed over 40 tutorials and examined the experience of creating an interactive tutorial at the Albert R. Mann Library, Cornell University. She enumerated features she considered essential

to the ideal online library instruction tutorial: preliminary assessment, branching capabilities, problem-based, concept-based, interactive, assessment, and feedback. She concluded that online library instruction tutorials were ongoing projects under constant and extensive revisions (Tancheva, 2003).

Paul Hrycaj (2005) analyzed 65 tutorials created by Association of Research Libraries (ARL) member libraries. He followed Dewald's (1999a) methodology, focusing on the active learning elements. Those elements were operationally defined as having quizzes at the end of tutorial modules, questions and exercises integrated within tutorial modules, quizzes that required use of a separate browser window, and the capability to send quiz results to an instructor. The results of the study demonstrated an increase in the use of active learning elements, as compared to those reported in Dewald's study (1999a).

Anderson, Wilson, Livingston, and LoCicero (2008) evaluated 274 tutorials used by the medical libraries of the Association of American Medical Colleges. The pre-established indicators for their analysis included whether the tutorials were created by the libraries or by third parties, the subjects of each tutorial, the software used to create them, active learning elements, including the level of interactivity (i.e., whether users were required to perform searches, complete exercises, click on appropriate boxes for additional information, open up the database or software product in a new window, and follow along with the steps in the tutorial), the availability of quizzes or tests, requests for feedback or an evaluation survey, as well as having user profiles. The study found that in spite of the existence of many self-produced Web tutorials, few of the tutorials incorporated active learning elements.

Somoza-Fernández and Abadal conducted a recent tutorial analysis (2009). They analyzed 180 academic library tutorials using 30 indicators grouped in 5 main areas: general characteristics, content, educational features, browsing and design, and technological features. The indicators for educational features were timing (whether there was a statement of the time estimated for studying each section), pretest, teaching methodology (e.g., presentation of content, guided demonstration, or problem-solving), presence and type of exercises, evaluation or feedback for the exercises, contact with the librarian, a method to evaluate the tutorial (i.e., whether the tutorial could be evaluated or provided the possibility to suggest improvements). Results of the study revealed that only 12 of the 180 tutorials satisfied most of the indicators. The authors concluded that Web-based tutorials offered by academic libraries are still at an early stage of development (Somoza-Fernández & Abadal, 2009).

Pedagogical Elements

Elements of good pedagogy have been proposed by a number of authors. According to the guidelines proposed by Dewald (1999b), Web-based library instruction combined with good pedagogy should allow users to select their own paths through information, should provide clearly presented information to help learners develop their own understanding of material, and should provide interactivity for learning and assessment.

Among the previous studies of online tutorials, Hrycaj's research (2005) specifically focused on the extent of the use of active learning in online "stand-alone" library skills tutorials. Hrycaj used Collins and O'Brien's (2003) definition of active learning, describing it as "the process of keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving". This definition fits well into Dewald's (1999b) proposed pedagogical guidelines for learning and assessment interactivity and is practical for the analysis and evaluation of Web tutorials.

However, there is a lack of research to establish how Web tutorials address information literacy standards using good pedagogy, especially in the area of science,

engineering, and technology. This study sought to address this gap by determining which of the *Information Literacy Standards for Science and Engineering/Technology* were addressed by science information literacy tutorials and by determining the extent to which good pedagogical elements are incorporated in those tutorials.

Methods

Sample

The sample was created from the list of tutorials selected by STS Information Literacy Committee members (http://wikis.ala.org/acrl/index.php?title=Science_Information_Literacy_Tutorials&oldid=42110; revision as of 7 Apr. 2011, at 02:17). Each tutorial in this list was selected to address one or more of the *Information Literacy Standards for Science and Engineering/Technology* (ALA/ACRL/STS Task Force, 2006).

The list was carefully examined; those that fell into the following categories were excluded from the final sample:

- Tutorials where the sole purpose was to demonstrate or instruct in the use of a specific resource (e.g., how to search PubMed or CINAHL).
- Resources in the format of guides, handouts, "traditional" Web pages, or (most) TILT-based tutorials
- Collections of tutorials that cover diverse topics or have multiple instructional purposes
- Tutorials that were no longer accessible
- Tutorials created outside North America.

The final sample was comprised of 31 tutorials, of which 28 were from the United States and 3 from Canada.

Information Literacy Standards for Science and Engineering/Technology

This study used the information literacy standards developed by *the ALA/ACRL/STS Task Force on Information Literacy for Science and Technology*:

- *Standard One: The information literate student determines the nature and extent of the information needed.*
- *Standard Two: The information literate student acquires needed information effectively and efficiently.*
- *Standard Three: The information literate student critically evaluates the procured information and its sources, and as a result, decides whether or not to modify the initial query and/or seek additional sources and whether to develop a new research process.*
- *Standard Four: The information literate student understands the economic, ethical, legal, and social issues surrounding the use of information and its technologies and either as an individual or as a member of a group, uses information effectively, ethically, and legally to accomplish a specific purpose.*
- *Standard Five: The information literate student understands that information literacy is an ongoing process and an important component of lifelong learning and recognizes the need to keep current regarding new developments in his or her field.*

(ALA/ACRL/STS Task Force, 2006)

Good Pedagogical Elements

The pedagogical elements used for the analysis of tutorials in this study were derived from the studies described in the literature review above (Dewald, 1999b; Hrycaj, 2005; Anderson, Wilson, Livingston, and LoCicero, 2008; Somoza-Fernández and Abadal, 2009). They include:

- An option for users to select their own paths through information
- Information presented clearly to help learners develop their own understanding of material
- Active learning elements
    - Quizzes at the end of tutorial modules

- Questions integrated within tutorial modules
- Exercises used within tutorial modules
- Quizzes requiring use of a separate browser window
- Option to send quiz results to an instructor
- Surveys for feedback

Analysis of the Tutorials

For each tutorial the researcher used an Excel™ coding sheet to indicate the presence of the standards outlined above. The columns of the coding sheet indicated the name of the institution that created the tutorial, the tutorial's URL, its subject areas as identified by STS Information Literacy Committee members, STS information literacy standard(s) addressed by the tutorial, and whether each of the selected pedagogical elements was incorporated. The entire coding and analysis procedure was repeated three times to ensure consistency, a research procedure recommended by Babbie (2007).

Results

The project analysis included a total of 31 tutorials in various subjects (Table 1).

Table 1
Tutorials by Subject

Subject	Number of Tutorials
Science, General	9
Biology	5
Biomedicine	4
(Public) Health	3
Medicine	2
Nursing	2
Engineering	2
Patent	2
Pharmacy	1
Chemistry	1

The categorization of the subject areas followed the original practice of the ACRL Science & Technology Section (STS) Information Literacy Committee. Results showed that there were comparatively more general science tutorials than other subjects.

Table 2 illustrates that the majority of tutorials aimed to address Standards I, II, and III - relating to information needs, acquiring information, and critically evaluating the sources of information.

Further analysis of the tutorials addressing Standard I showed that their focus was identifying an information need and the variety of potential sources for information. One clear example of this was the tutorial on finding online health statistics created by University of Michigan School of Public Health (http://www.sph.umich.edu/mi-info/03-hs/index.html). One of the three learning objectives of that tutorial was to "identify the types of statistics and data sets that are available on the Internet." It instructed users on the categories of statistical information available on the Internet, and it also provided specific guidance in showing users how to define their information needs and formulate their questions.

The majority of tutorials in the sample addressed Standard II, the effective and efficient acquisition of needed information. An example was a tutorial for nurses, "Nursing: Refining searches"(http://www.lib.ua.edu/Content/tutorials/nursing/GES/?id=200), created by Rodgers Library at the University of Alabama. This tutorial examined the basic ways to refine searches and the use of Boolean logic. Similar objectives were addressed by the tutorial created by the University of Hawaii's Leeward Community College library (http://wwwleeward.hawaii.edu/lib/tutorials/bioskills/Biolibraryskills_files/v3_document.htm). The Leeward tutorial also taught keyword search strategies and use of Boolean operators to narrow or broaden search results.

Many of the tutorials in the sample addressed Standard III - how to critically evaluate information and its sources. The tutorial (http://www2.roosevelt.edu/library/libraryureloaded/introduction.htm), created by Chicago's

Table 2
Standards Addressed by Tutorials

Information Literacy Standard Addressed	Number / Percentage Tutorials
I – determining information need	24 - 77.42%
II - acquiring information effectively and efficiently	25 - 80.65%
III – evaluating the procured information and its sources critically	24 - 77.42%
IV – understanding the economic, ethical, legal, and social issues	12 - 38.71%
V – understanding the ongoing process of information literacy	2 - 6.45%

Note. Percentages do not total 100%, as each tutorial could address multiple standards.

Roosevelt University library, presented training on the evaluation of Web information.

Of the few tutorials that focused on Standard IV, most aimed at presenting an understanding of intellectual property, copyright, plagiarism, and how to appropriately cite information sources. An example was a tutorial "Searching the Pharmacology Literature" created by McGill University's library (http://mmiweb.mmi.mcgill.ca/dev/LorieKLODA/HealthLib-Instruction.htm). The McGill tutorial had a section, "Academic Integrity & Citing Sources" that focused on the importance of ensuring that the content in a paper should be original material, and if not, attribution to its original source must be made clear to the reader. The tutorial instructed users on ways to reference information sources in a paper and how to follow the Vancouver style for writing in the biomedical sciences. The "Science Information Tutorial," developed by the libraries of the University of California – Irvine (http://www.lib.uci.edu/How/tutorials/science_info_tutorial/tutorial.html) is another example of a tutorial focusing on Standard IV. An entire section of this tutorial focused on "Reading, Evaluating and Citing Information," where the importance of citing sources, recognizing and avoiding plagiarism, basic citation elements, and citation styles were clearly explained.

Only two of the tutorials examined in this project addressed Standard V, which emphasizes the importance of maintaining current awareness of information literacy through lifelong learning. A tutorial developed by the Massachusetts Institute of Technology (MIT) Libraries addressed this standard. "Scientific Publication Cycle" (http://techtv.mit.edu/collections/mitlibraries/videos/3636-scientific-publication-cycle) focused on the scientific publication cycle and scientific research process. It emphasized the value of keeping current with new developments in the literature of the field. Another example of a Standard V tutorial was "MI-INFO" (Michigan Informatics), created by the University of Michigan Public Health Library. The section "Staying Informed" (http://www.sph.umich.edu/mi-info/01-si/) aimed to identify strategies and resources to help users stay informed of news and developments related to their area(s) of interest within public health. The tutorial also helped learners develop an action plan for incorporating these current awareness strategies and resources into their regular work routines.

The tutorial analysis also disclosed the incorporation of pedagogical elements in the tutorials (Table 3) and the extent to which active learning elements were integrated (Table 4).

To determine whether a Web tutorial provided information clearly, the researcher followed Dewald's guidelines (1999b) to determine whether the instructional design of

Table 3
Pedagogical Elements in Tutorials

Pedagogical element		Number of tutorials having the element	Percentage
Provision of clearly presented information		31	100.00%
Option for users to select their own paths through information		27	87.10%
Active Learning Element	Quizzes/exercises at the end of tutorial modules	15	48.39%
	Questions integrated within tutorial modules	12	38.71%
	Exercises used within tutorial modules	15	48.39%
	Quizzes requiring use of separate browser windows	2	6.45%
	Options to send quiz results to instructor	3	9.68%
	Surveys for feedback	5	16.13%

Note. Percentages do not total 100%, as each tutorial could incorporate multiple pedagogical elements.

the tutorial followed a logical progression of step-by-step skills needed to accomplish the learning objectives. The specific techniques for this purpose included use of page design elements such as arrows, color, highlighting, white space, small icons, and various font sizes used to structure information for better learner understanding; text that was succinct, broken up, and arranged for maximum clarity; and graphics used to clarify points or to maintain the student's interest (Dewald, 1999b).

To decide whether a Web tutorial provided the option for users to select their own paths through information the researcher carefully examined the tutorial to determine whether a linked table of contents would be available for users to have a continual overview of the material, and whether there were internal navigational aids (e.g., buttons, icons, or text links) to allow users to review material, move between and within sections as needed, and to receive additional explanations if desired (Dewald, 1999b).

For Hrycaj (2005), the use of a quiz at the end of a module or instructional unit was one of the most common types of active learning in an online tutorial, and the results of this study correspond to Hrycaj's (2005) observations. Fifteen tutorials analyzed in this study contained this active learning element. One example was the tutorial, "How Do I Find … Science Information" created by the University of California, Irvine (UCI) libraries - (http://www.lib.uci.edu/how/how-do-i.html). This tutorial had a brief quiz at the end of each module, and users could immediately see if their answers were marked correctly. If the user gave a wrong answer, the reason was given. Another tutorial with self-assessments was developed by the library at the University of Hawaii's Leeward Community College. Their tutorial, "A Guide to Biological Information and Resources" (http://www.leeward.hawaii.edu/lib/bioguide/index.html) provided a snap quiz at the end of each module. The users were encouraged to answer the questions on their own before going to the answer page at the end of each tutorial.

Twelve tutorials analyzed for this research had embedded questions within the modules. For example, the engineering students' tutorial "GES131 Library Tutorial" (http://fc.eng.ua.edu/GES/) created by Rodgers Library for Science and Engineering at the University of Alabama, included several self-

assessment questions throughout each of the tutorial modules. Another example was the tutorial on reading scientific papers developed by Purdue University Libraries (http://www.lib.purdue.edu/phys/assets/SciPaperTutorial.swf). Questions in this tutorial were integrated throughout, to initiate users' deep thinking and to advance the lesson.

Exercises in tutorials often give users a search exercise. Some of them involve a dual screen - one screen provides directions and the other screen provides the resource for the user to carry out the directions (Hrycaj, 2005). An example of the dual screen approach was the tutorial created by the University of Massachusetts Amherst libraries, "Herbs, Spices & Medicinal Plants" (http://umalws1.library.umass.edu/instruction/tutorials/herbs/index.html) (see Figure1).

According to Hrycaj (2005), quizzes that require use of a separate browser window test users' skills, because the user is expected to complete a research exercise in a separate window, find the results, and then return to the tutorial to enter the answer. Among all the sample tutorials analyzed, only two had this element. One was the tutorial "Evaluating Web Sites" created by Chicago's Roosevelt University library (http://www2.roosevelt.edu/library/libraryureloaded/introduction.htm). Users were instructed to follow the link to a site (which opened in a new window), view the site, close the new browser, and return to the page when they were finished in order to take the quiz (http://www2.roosevelt.edu/library/libraryureloaded/siteone.htm).

An option to send quiz results to an instructor may not be active learning technique in itself,

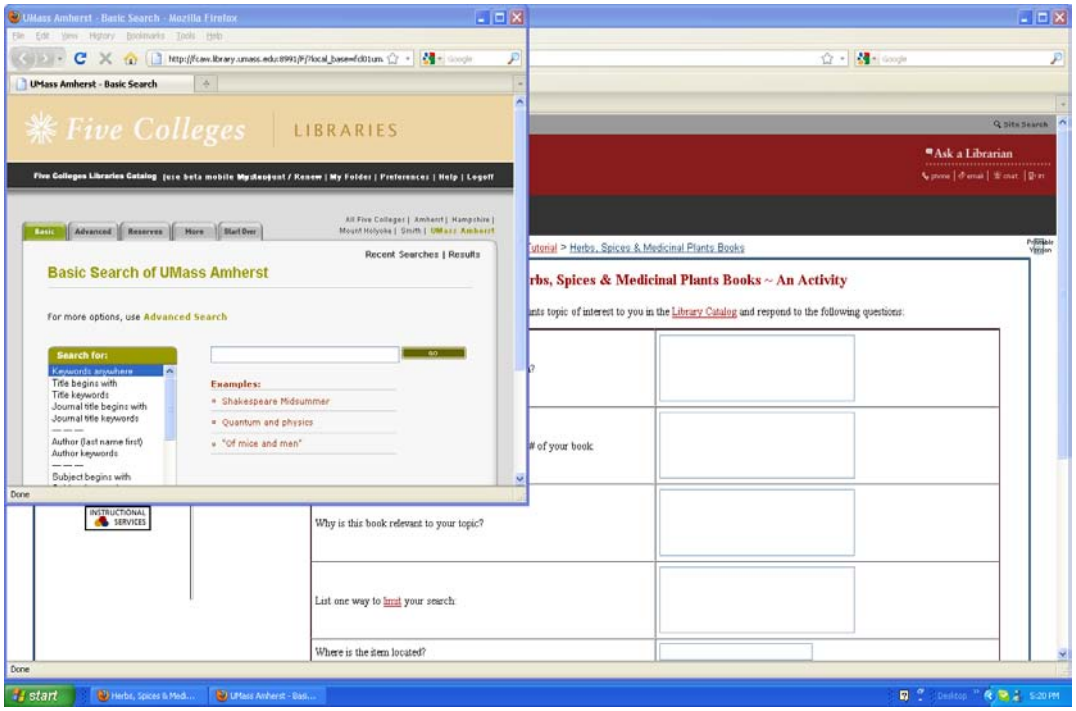

Figure 1
Example of dual screen for exercises in tutorials.
(http://umalws1.library.umass.edu/instruction/tutorials/herbs/books/activity.html#).

yet it can motivate users to be learning actively. Three of the analyzed tutorials offered this option. One example was the University of Alabama Rodgers Library tutorial "GES131 Library Tutorial" (http://fc.eng.ua.edu/GES/). This tutorial included homework quizzes at the end of some modules. The users were instructed to record their responses to each question and then submit the responses to the instructor.

A survey for feedback is a technique that can initiate users' critical thinking. Five tutorials analyzed for this project offered this option. An example was the tutorial "Introduction to Evidence-Based Medicine" from Duke University Medical Center library. This survey included both close-ended and open-ended questions to collect user feedback (http://www.hsl.unc.edu/services/tutorials/ebm/EvalThis.htm).

Table 4 demonstrates the extent to which active learning elements were incorporated into the science, engineering, and technology information literacy tutorials analyzed.

The majority of the tutorials incorporated some active learning element(s). Indeed, 50% contained one or two active learning elements. Almost a quarter of the tutorials analyzed contained three or four active learning elements, but none contained more than four. Seven (almost a quarter of those studied) did not contain any active learning element.

Discussion

The results of this study show that these tutorials address the STS information literacy standards, particularly standards I, II, and III - relating to information needs, acquiring information, and critically evaluating information sources. Those that illustrate these features particularly well have been noted as examples, where appropriate, within the text.

Designers of Web tutorials in science, engineering, and technology have generally seen the importance of good pedagogy. The tutorials presented information clearly, and in most cases they provided the option for users to select their own paths through information. Over three quarters of the tutorials in the sample contained some sort of active learning component. Yet the level to which good pedagogy and especially active learning elements were incorporated into Web tutorials was unsatisfactory. Almost one quarter of the sample tutorials disregarded the need for active learning elements and another quarter had only the minimum of such elements.

Science, engineering, and technology disciplines are rapidly changing, and the body of knowledge in these fields is carried by a wide variety of information sources and formats (ALA/ACRL/STS Task Force, 2006). The study showed that libraries are able to design instructional materials to help improve users' critical thinking and lifelong learning

Table 4
Number of Active Learning Elements in Tutorials

Number of Active Learning Elements Incorporated	Number of Tutorials	Percentage of Tutorials
0	7	22.58%
1	8	25.81%
2	8	25.81%
3	4	12.90%
4	4	12.90%
5	0	0%
6	0	0%

skills, instead of solely demonstrating or instructing in the use of a specific resource. Web tutorials, while teaching asynchronously, can be available 24 hours a day and 7 days a week. They should especially appeal to those who cannot come to campus for face-to-face instructions.

Good pedagogical elements are the basis for effective information literacy instruction. With Web tutorials, clearly presented information and the provision of the option for learners to select their own paths for information can help learners develop their own understanding of material and acquire deep learning of the content (Dewald, 1999b). Active learning elements are critical to the successful achievement of the instructional purpose, and real learning cannot possibly happen without these elements (Dewald et al., 2000).

This study provided examples of Web tutorials that address information literacy standards with satisfactory incorporation of good pedagogical elements. One example is the "Science Information Tutorial" created by the University of California, Irvine Libraries (http://www.lib.uci.edu/how/tutorials/science_info_tutorial/tutorial.html). It was one of the best among the tutorials evaluated here in terms of addressing information literacy standards by incorporating good pedagogical elements. Aiming at addressing STS Information Literacy Standard I, II, III, and IV, it clearly stated its purpose and objectives in observable behaviors from the beginning. It provided the option for users to select their own paths through information via a main menu on the left frame of the screen on all the Web pages and used "Previous" and "Next" buttons at the bottom of each page. It provided clearly presented information via various techniques, e.g., color, highlighting, white space, small icons, different fonts and font sizes, text that was succinct, broken up, and arranged for maximum clarity, and used graphics to clarify points or to maintain students' interest. For each module, it had a pre-test, review, and a quiz at the end. Questions and activities were integrated in all the tutorial modules to initiate users' critical thinking. Users were motivated by a completion certificate and were encouraged to give their feedback and comments when successfully completing each module.

Another tutorial that successfully incorporated good pedagogical elements was one created by the University of Massachusetts Amherst Libraries (http://umalws1.library.umass/instruction/tutorials/herbs/index.html). That tutorial instructed users to search for, evaluate, and find information in the field of herbs, spices, and medicinal plants. It shared various features of the "Science Information Tutorial" from the University of California, Irvine Libraries. Both provided the option for users to select their own paths through information via a main menu on the left of the screen on all the Web pages and the "Previous" and "Next buttons" at the bottom of each page. They clearly presented information via various techniques. The Amherst Libraries tutorial offered exercises that involved dual screens (Figure 1). It used both pre-assessment and post-assessment tools. Users were encouraged to contact librarians for more ideas on how to find the precise data or resource that they needed. They were urged to join in an anonymous evaluation of the tutorial and could even receive a response if they provided an email address.

It is both important and feasible to base information literacy instruction on the STS standards with the incorporation of good pedagogical elements. Although there are several successful examples in this area, there is clearly more work to be done, particularly in relation to STS standards IV and V which cover ethical and legal issues and the need for keeping up to date with lifelong learning skills

There are two distinct approaches to learning: surface learning, in which the learner memorizes the information, and deep learning, in which the learner tries to understand the information or to seek meaning (Alexander, 1995). Surface approaches are generally associated with poor learning outcomes, while deep approaches

tend to yield higher quality learning outcomes (Entwistle & Ramsden, 1983; Watkins, 1983). Numerous Web tutorials have been designed to address STS information literacy standards, which have gone beyond the teaching ideas and techniques compiled by the STS Information Literacy Committee (http://wikis.ala.org/acrl/index.php?title=Teaching_Tips&oldid=42295; revision as of 7 Apr. 2011, at 06:26). However, it is important to have active learning elements integrated into all Web tutorials, to ensure that users will acquire deep learning from them.

This study achieved its objective of identifying which of the STS Information Literacy Standards were addressed by Web tutorials. Future research is needed to expand the findings of this study and to determine which performance indicators of specific literacy standards are addressed by Web tutorials. This recommended study might provide a better idea of what Web tutorials can do to help learners acquire information literacy skills and become lifelong learners.

Feedback from learners themselves may provide a more realistic picture of how Web tutorials are accepted as information literacy instruction tools in science, engineering, and technology. It may also reveal what content and pedagogical elements appeal to learners as truly effective in helping them develop their information literacy skills. A survey is needed to elicit constructive comments and suggestions from users of Web tutorials in these disciplines.

This study excluded tutorials that focused on the usage of a specific resource, collections of tutorials covering diverse topics, and those with diverse instructional purposes. The tutorials included in this project originated only from North America and excluded many tutorials from other countries. These exclusions ensured that the study was feasible, however they may have led to bias or skewing of the research findings. The focus on Web tutorials addressing the Information Literacy Standards in science, engineering, and technology also meant that the study was narrow in scope. Future research may be needed to analyze the Web tutorials that deal with the *ACRL Information Literacy Competency Standards for Higher Education*. Such studies could provide insight into a broader picture of academic libraries' efforts in teaching information literacy standards via Web tutorials and the extent to which they demonstrate the importance of good pedagogy in this kind of instruction.

Conclusion

Many librarians have accepted Web tutorials as effective information literacy instruction tools for science, engineering, and technology. Yet ensuring that they are real learning experiences for learners remains a challenge. The study shows that previous guidelines on good pedagogy and standards for information literacy have been integrated into Web tutorials. However, there is still work to be done, particularly with regard to standards that focus on ethical and legal issues, using information literacy as a component of lifelong learning, and ensuring that a range of active learning elements is incorporated. If tutorial developers further considered employing these pedagogical techniques, learners might better experience deep learning.

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