Metadata is an odd word, and the process of creating it is even more outlandish. To those who work in the digital world, the word metadata and the process itself may not seem so foreign. But to those who have not worked in organizing the abundance of information available, it sounds quite obscure. With the swift growth of the Internet, information is exploding even faster than the growth rate of computational power. This computational power in part is the human capability to communicate about this formidable source of information. The word metadata arises from this building of vocabulary, and is defined as “data about data.” In traditional libraries, metadata is found in the card catalogue and assists patrons in finding what they need. In a digital collection, metadata plays the same type of role. It denotes structured, descriptive information about a resource, a way for users to decipher useful information from the abyss that results from a typical Web search. Metadata saves time and relieves the frustration of sifting through the sheer volume of search hits. Other words like proxy, matrix, portal, and gigabyte induce a similar feeling of nausea when heard.

We first encountered this intimidating vocabulary when we ventured into the digital world of the Digital Library for Earth Systems Education (DLESE). Through the Global Climate Change and Society (GCCS) Program funded by the National Science Foundation Research Experience for Undergraduates at the University of Colorado at Boulder we were given the opportunity to explore the digital world for six-weeks
internship. During this time, our tasks consisted of finding and cataloging quality web-based resources at the intersection of earth systems education and the history, philosophy, and policy issues surrounding science and technology. These were subject matters that were not well represented and served to enhance the DLESE collection. We will begin, then, with a more detailed description of DLESE and its goals.

The dryness and discomfort reminds me that it has been awhile since I have last blinked. Staring at the computer screen for extended periods of time, with only occasional movements of eyes to read and hand to move the mouse, is a task of endurance. The physical constraints are not the only challenges, however. The tangled mess of the Web that glows in front of me is equally a test of stamina.

For the past hour I have been sifting through search engine results and links off of links in order to find a reputable, well-designed website about the natural environment to add to the digital library collection. It does not help that I find myself sitting in a scratchy chair in a small gray closet of an office where the only light is fluorescent and the only air is recycled.

The moment finally comes, though - I find a usable resource. The sense of discovery and interest is fleeting, however, as I begin to parse my thoughts into constrained metadata bits. I now must enter the data about the data into the inflexible resource cataloger. Required fields about the audience and URLs, concisely bland descriptions - after my style-less piece is added to the emerging digital library entry, it goes down the production line to the next stop, where it is further tapped and trimmed into shape to match the other 4,500 entries.

What is DLESE?

The Digital Library on Earth Systems Education is a grassroots, community-based effort involving teachers, students, and scientists (dlese.org, 2003). This interdisciplinary group is working together to develop and govern a library of earth system science educational resources and services for students, teachers, and informal learners. The DLESE library is composed of electronic materials, such as lesson plans, maps, images, data sets, visualizations, assessment activities, curricula, online courses, and more.
DLESE is funded by the National Science Foundation (NSF) through the NSDL (National Science Digital Library) for $26 million over the course of five years - an amount that increases to nearly $40 million for five years when contributions from collaborators are also taken into account (correspondence with Holly Devaul).

DLESE was initiated through an award that supported a national meeting of key leaders and educators in Earth and Space Science in order to establish a digital library to support education in their field (John T. Snow). The meeting participants developed an action plan that resulted in the Portal to the Future conference in August of 1999. The outcome was the development of a steering committee for a Digital Library for Earth System Education (DLESE) effort. Today the library has grown into a community-owned, community-governed digital library with over 4,000 resources. The DLESE headquarters are located within the NSDL office at the UCAR Foothills laboratory in Boulder, Colorado. From here information is cast onto the World Wide Web.

DLESE is reliant on its community members to contribute educational resources and collections. Their “users as contributors” philosophy encourages users to participate in library governance, planning, and evaluation. There are several opportunities for community members to become more involved with DLESE. For example, all are invited to participate in the DLESE Annual Meeting. Additionally, the DLESE steering committee has developed a strategic plan in order to provide both support services to help educators and learners effectively create, use, and share educational resources. The communication network facilitates interactions and collaborations across all dimensions of Earth system education. The DLESE scope is intended to be multidisciplinary and international, in order to reach many levels of scientific sophistication.
Funding from NSF and a close partnership to the existing NSDL library gave rise to the DLESE website (www.dlese.org). The dynamic site is designed to communicate the full scope and to support the efforts of the diverse participants. The site design includes the following: related community projects, collaborating partners, an email discussion group, the navigational structure, community posting tool for news and opportunities, a calendar of events, critical policy development and governance. Most relevant to our work is the library development information and resources that allow for collections building, metadata, services, user interface, technical infrastructure, and evaluation. The Search and Discovery System allows browsing of entire collection based on topic, grade level, or resource type. The metadata interfaces provide users with detailed metadata information on any resource. Part of our internship responsibility was to create metadata in the DLESE Catalog System (DCS) for the resources we collected. Each record's framework contains controlled vocabularies to describe educational resources and a minimum level of description (required data) in order to facilitate community-generated metadata. DLESE conducts introductory and advanced metadata workshops for community members to encourage and facilitate participation.

Another Digital Library

There are other digital libraries focusing on earth system education on the Internet as well, and these may serve as a point of comparison for DLESE. A notable example is the GB-Explorer, the Georgia Basin Digital Library Project (http://www.georgiabasin.info). Similar to DLESE, the GB-Explorer's goal is to provide access to useful educational information about earth issues via the Web. However, the GB-Explorer narrows its scope to a much greater extent than DLESE. Their goal is
specifically to “develop the necessary conceptual framework for a Web-based digital library that will seamlessly integrate natural and social science information (GIS maps, images, and text) into a comprehensive information resource to support sustainability research, community-focused decision making and public consultation activities in the Georgia Basin region of western Canada” (Journeay, 2). Not only does the GB-Explorer limit its geographical area of concentration; it also limits its subject matter exclusively to issues surrounding sustainability.

With this specific focus, the GB-Explorer maintains a much more local frame of reference than DLESE. Local stories about the Georgia Basin authored by those who know the area coexist with formal reports and news stories. While DLESE depends upon the community for resource contribution, GB-Explorer attempts to engage the community in different ways. For example, users are invited to post their personal stories on the local page, and local educational outreach programs are organized through the site as well.

Additionally, while it deals only with a limited subject matter (only pro-sustainability), GB-Explorer takes a more creative and interdisciplinary route for its design. Georgia Basin's various interactive future scenarios, some functional and some in the process of development, have the potential to allow users to have a very different kind of educational experience that cuts across traditional disciplinary lines. The website format is highly visual, unlike the largely text-based DLESE. Although less eye-catching, DLESE does provide a greater density of directly linked resources on a wider variety of scientific environmental issues.

During our experience at DLESE, several questions captivated our interests. How effective are digital libraries, taking the demands of users, the goals of the designers, and
the cost to society into account? Are there ways to improve the digital library experience? How does DLESE address the fact that students and teachers alike are overwhelmed with information? The purpose of this paper is to investigate these questions. First, we will provide an overview of DLESE's chief methods of evaluation. Secondly, the investigation will proceed with anecdotal evidence and facts and figures from traditional libraries. We will also present an idea for a new kind of digital library called CONTEXTS. Finally, we will use the findings of the investigation, along with pertinent Science, Technology, and Society education research, to critique the digital library.

An Investigation

Facts and Figures from Digital and Public Libraries

In order to begin to address the efficacy of digital libraries, we can first look at how they compare to the system we already have – traditional, hard copy libraries. There are the obvious physical differences between the two types of information repositories. Traditional libraries are confined by the limits of space (serving one particular town) and time (closing and opening with business hours) in a way that does not apply to the digital world. The librarians of the digital world, however, are faceless, and the other patrons are nowhere to be seen. The list of experiential differences between the two types of libraries could continue at some length.

Another way to compare traditional and digital libraries is through the facts and figures available to the public about both – the number of items checked out or used, the number of patrons, the amount of funding, etc. In comparing the amount of money used to support the given library to the number of people actually using and benefiting from
the library’s resources, a valid argument about the usefulness and efficacy of each library type can arguably be made.

To pursue this argument, facts and figures were collected from three traditional libraries – Denver Public Library, Boulder Public Library, and the University of Colorado at Boulder’s Norlin Library – and three digital libraries – DLESE, NSDL (National Science Digital Library, of which DLESE is a part), and GBDL (Georgia Basin Digital Library). The findings are displayed in Figure 1 below.

**Figure 1. Funding and Use Statistics for Traditional Libraries and Digital Libraries**

<table>
<thead>
<tr>
<th>Digital Libraries</th>
<th>Name</th>
<th>$ Funding/yr</th>
<th># Patrons/mo</th>
<th>Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSDL</td>
<td>$25 Million*</td>
<td>5140**</td>
<td></td>
<td>more than 4500</td>
</tr>
<tr>
<td>DLESE</td>
<td>$5 Million^</td>
<td>6000^^</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GBDL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Traditional Libraries</th>
<th>Name</th>
<th>$ Funding/yr</th>
<th># Patrons/mo</th>
<th>Items checked out/mo</th>
<th>Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Denver Public Library</td>
<td>$5.6 Million***~</td>
<td>100,000*~</td>
<td>854,600***</td>
<td>4,646,769**~</td>
</tr>
<tr>
<td></td>
<td>Boulder Public Library</td>
<td></td>
<td></td>
<td>99,000*~</td>
<td>441,656***~</td>
</tr>
<tr>
<td></td>
<td>U of Colorado, Norlin Library</td>
<td></td>
<td></td>
<td>63,104#</td>
<td></td>
</tr>
</tbody>
</table>

* from “NSDL Fact Sheet”
** average from monthly “Unique Visitors” count on AWStats “Statistics of NSDL.org”
^ from correspondence with Holly Devaul
^^ from email correspondence with Rajul Pandya
# from email correspondence with Brice Austin
*** from email correspondence with Joe Cahn
***~ from DPL Facts and Figures
*~ from email correspondence with Susan Hartman
**~ from Boulder Public Library 2002 Annual Report
***~ from Boulder Public Library 2002 Library Budget Summary

At first glance, it appears that the traditional libraries have far greater patronage and more numerous resources than the digital libraries for about the same (or perhaps less) cost to the society. Several factors qualify this statement, though. First, the resources within the digital libraries are specifically limited to one subject area, such as earth science. The holding information for the traditional libraries includes all holdings, from children’s literature to ancient philosophy. In the future, it would be beneficial to
compare the earth science resources of a traditional library to the resources of DLESE. This difference in the range of the holdings also effects any comparison that may be made between number of patrons per month and funding alike.

A second factor that is not addressed in this data set is the change in patronage, funding, and holdings over time. This too would be useful to know when making comparisons between traditional and digital libraries. Digital libraries are a relatively new phenomenon, and regulations and restrictions on what may be included in these libraries according to copyright and intellectual property laws are still being forged. The fact that holdings for digital libraries and patron usage are significantly lower than traditional libraries is therefore not surprising. Additionally, the trends in patron usage would also constitute a significant factor in the debate. If both types of libraries are not equally gaining or losing users, might there be signs of one growing in popularity and one declining? Are digital libraries augmenting the traditional library experience, or are they stealing away patrons from the book stacks?

Taking these uncertainties into consideration, then, what can reasonably be concluded from these figures? While digital libraries do seem to be just as expensive as traditional libraries while lacking the resource and patronage base, there is a significant point to be made in their favor. There are over 124,000 public libraries in the United States, including public, school, university, hospital, law, business, and governmental libraries (ALA, 2003). Each one of these must be funded, and the collections from location to location would most likely vary significantly in quality and quantity. A digital library, however, has the potential to augment all of these traditional libraries in such a way that people from all areas have the same access to quality materials with only
one funding cost to society. But how are digital libraries actually being perceived and used right now? We continue our investigation.

*An Anecdotal Investigation*

In order to find out how the DLESE library was being used, we devised an informal survey. The purpose of this survey was to see if DLESE was being used and who was using it for what purposes. Due to time constraints we were unable to distribute the survey to a large populace. We did, however, survey our colleagues in GCCS (undergraduate students), students at Colorado School of Mines, and a group of local K-12 teachers. This survey does not represent the final conclusion on DLESE about its effectiveness. It more or less served as anecdotal information. DLESE is pursuing its own evaluation at this time. Once the results from their surveys are made public, we will incorporate them into our study.

Six undergraduate/graduate students, one professional, and 11 K-12 teachers were surveyed.

Our results were as follows:

**Who has used NSDL:**
- 0% undergrads/grads
- 18% teachers
- 0% professionals

**Who has used DLESE:**
- 0% undergrads/grads
- 45% teachers
- 0% professionals

On a scale of 1-10, the participants were asked to rate the usefulness of a digital library (Scale 1- not helpful, 10- extremely helpful)

**Undergrad/grad:**
- Two rated it a 7
- Three rated it an 8
- One rated it a 3
K-12 teachers:
Two rated it a 10
Two rated it a 9
Two rated it an 8
One rated it a 7
One rated it a 2
Three did not rate it
Professional
One rated it a 4

On a scale of 1-10, the participants were asked to rate the usefulness of a traditional hardcopy library
(Scale 1- not helpful, 10-extremely helpful)
Undergrad/Grad:
Two rated it a 10
Three rated it an 8
One rated it a 7
K-12 teachers:
Three rated it a 10
One rated it a 9
One rated it an 8
One rated it a 6
Two rated it a 4
Three did not rate it
Professional:
One rated it a 9

Participants were asked if they had ever used interactive online tools
Undergrads/Grads:
4 have not
2 have
K-12 teachers:
3 have not
5 have
3 did not answer
Professional:
1 has not

Participants were asked if they would rather have school funds go to enhancing their school’s hardcopy library or to developing a digital library.
Undergrads/Grads:
2 answered hardcopy
2 answered digital
2 answered both
K-12 teachers
4 answered hardcopy
Certain conclusions or assumptions about digital libraries cannot be accurately drawn from this survey. However, it does give us some idea of the outlook of a small population of people from various academic backgrounds feel about libraries. In order to have more certifiable results we should have developed the survey sooner, to insure adequate time to reach a larger number of people. I believe that it would have been useful to have separate surveys for university students and teachers, to make more direct correlations to the use of digital libraries in their work. There are a total of 3,000 teachers in the Boulder Valley School District (BVSD) where we surveyed 11 teachers. When they were asked how many teachers in BVSD have used DLESE they answered about 1%. This is noteworthy due to the fact that DLESE headquarters are located in Boulder. DLESE is planning on collaborating with groups of teachers who wish to contribute to the digital library. However, DLESE has the potential to be its own informant on educational research, and it would be invaluable to them and to their users to find out where their audience areas of needs are and can be met.

Methods of Evaluation

Various evaluation teams within and outside of DLESE are currently performing more in depth investigations into DLESE’s use. Evaluation is a central theme for DLESE, and their Evaluation Plan, as set forth in March of 2001, delineates three specific focus areas. First, “formative evaluation” refers to DLESE’s concern for the development of a quality system and collection of resources. Secondly, DLESE’s
“impact evaluation” aims to improve science education through their resources and opportunities for learning and communication. The third major area of evaluation is “evolution and engagement,” and it addresses DLESE’s capacity for effective long-term evaluation (DLESE Evaluation Plan, 2001).

One of the teams addressing DLESE evaluation is the newly formed Evaluation Core Services. Their project looks at how the digital library functions within classroom settings. Other groups address issues such as the usability of the interface, the values of teachers, and the concerns of faculty and department chairs. Many of the studies are done through focus groups and workshops. Some of these studies result in publishable studies on education and digital libraries, such as Sumner, Khoo, Recker, and Marlino’s “Understanding Educator Perceptions of ‘Quality’ in Digital Libraries.” The Annual Meeting also provides a forum for evaluation purposes and community feedback (from correspondence with Susan Buhr).

Another of the many evaluation groups at DLESE focuses on library use statistics. Determining the number of actual patrons is not as straightforward of a process for digital libraries as it is for traditional libraries. Simply counting the number of visits to the website does not represent the number of people using the page as a resource. Some of these ‘hits’ could be automated programs searching the web or people linking onto the website by accident. Those entering a hard copy library, however, would not have made the physical trip, most likely, if they were not interested in using the library. DLESE is in the process of devising ways to account for these spurious ‘hits.’ Currently, they use software that identifies unique IP addresses that connect to the DLESE server to request pages and then weeds out those IP addresses within the DLESE system (employees, etc.),
those who leave right away, and those that appear to be search engine crawlers. For the
official tally, they focus on the unique IP addresses that request materials with less than
30-minute intervals between requests (from email correspondence with Rajul Pandya).
DLESE then uses the data from this analysis to determine which of their tools and
services are most popular as well as the impact of being indexed in various search
engines (Wright, 2003).

New initiatives in evaluation constantly are appearing in DLESE. Far too many
are in progress to adequately address within the limits of this work. On the whole, the
evaluation of effectiveness, the refinement of goals, and the enhancement of systems are
all issues of great importance to DLESE – issues that are debated and collaborated on by
the entire DLESE community. Other digital libraries, the new and the more extensive
alike, also share this concern. NSDL, for example, also has extensive evaluation projects
and reports. The heart of their studies bear great resemblance to those mentioned above,
such as how people use the library and how effective the library is for meeting people’s
needs (Giersch, Jones, and Sumner, 2002).

The Larger CONTEXTS

Our contribution to DLESE focused on the largely underrepresented historical,
societal, and philosophical issues related to earth system science and engineering. This
was stimulated by a proposal to enhance DLESE (and NSDL) with a new special
collection called CONTEXTS.

Description of CONTEXTS

CONTEXTS proposes to provide a broadly framed, interdisciplinary, and
crosscutting collection that will provide access to vetted materials on a wide spectrum of
issues at the intersection of science and society (Frodeman et al., 2002). This content focus arises from the growing body of resources that indicates that the study of Science, Technology, and Society (STS) provides the means by which both scientists and non-scientists can collaborate to improve scientific literacy. This interdependent literacy is seen as imperative to good political and economic decisions making in local, national, and global contexts (Frodeman et al, 2002). The authors of CONTEXTS have recognized that the DLESE/NSDL library and the proposed digital library, if funded, would be separate yet intimately related digital libraries. The audience of CONTEXTS consist of the following groups: formal learners and teachers in secondary and higher educational settings, scientific professionals, decision makers at the local, regional, and national level, and citizens and community groups (Frodeman et al, 2000). This audience is similar to that of the already established partners DLESE and NSDL.

The Development and Role of STS

The genesis of Science, Technology, and Society (STS) studies is a result of the marriage between the enlightenment and romanticism philosophies of the Middle Ages and the Renaissance periods, where the combination of attempts to change society and the critical reaction to this endeavor shaped STS. It was not until the mid-1960s that the Science, Technology, and Society relationship officially took form in academia. During this time many other movements were taking place, including the civil rights movement, environmentalism, and the Vietnam War. This momentum of challenging the status quo brought scholars and activist critics to doubt the benefits of science and technology - to belief had taken a hold on the nation since World War II. The momentum of the activists claiming to be speaking for the public good set the stage for this critique of American
‘progress.’ Before this period, science and technology were translations for American prosperity and blessings. These critics suggested that negative impacts also exist with the adoption of such lifestyles and beliefs. In his book, Ideas, Machines, and Values, Cutcliffe refers to this as “something of a pendulum-like swing of attitudes regarding science and technology” (2000, p. 7).

Many of the key events that occurred within the STS movement paralleled the environmental movement. For example, after Rachel Carson’s book, Silent Spring, exposed the health threats of DDT use in 1962, Ralph Nader’s 1965 expose of the automobile industry, Unsafe at Any Speed, was published. Although the authors are members of different movements, they both donated insights into the broader issues of STS. The grass-roots constituents of STS paired with many of the environmental movement’s concerns and actions because their issues were imminently related.

Presently, numerous environmental groups have formed “green parties” in the U.S. and Europe, and STS-related issues are an important part of their platform. The media has played a major role in exposing these issues to the widespread public. Cloning, stem cell research, and DNA manipulation have all received copious media attention. This media interest has lead to several important discussions and resolutions by communities against particular technological issues.

In response to STS and changing public perception, the U.S. Congress passed several acts and established a variety of new agencies. Several of these agencies address science and technology issues, including the National Highway Transportation Safety Administration (1966), the Environmental Protection Agency (1970), and the Occupational Safety and Health Administration (1970). Acts, too, reflected this STS
concern, such as the passing of the Clean Air and Clean Water Acts (1970, 1972). Responses to the STS movement occurred internationally as well, especially in European countries.

Within the academic and research community, scientists and engineers have shown their interest in questioning technoscientific development as well. In late 1968 they established the Union for Concerned Scientists (UCS) out of concern for the course of the Vietnam War. The Ethics and Values in Science and Technology (EVIST) program (now known as the Societal Dimensions of Engineering, Science, and Technology Program- SDEST) within the NSF was created “to improve the knowledge of ethical and value dimensions of science, engineering, and technology,” (Cutcliffe, 2000, p. 5). Other science organizations like the American Association for the Advancement of Science (AAAS) have declared themselves partners in trying to better understand STS issues through the development of special programs and committees.

Several other professional organizations have also joined the effort to better understand the impacts of science and technology on society. One in particular that is important to note, due to its familiarity and prestige, is the National Academy of Science (NAS). NAS carries the journal entitled Issues in Science and Technology, which is devoted to expanding and raising the quality of that national debate on policy issues involving science, technology, and health (Cutcliffe, 2000).

All of these attempts, along with the many not mentioned, represent the contemporary interest to bring a more interdisciplinary understanding to science and technology - to educate scientists and engineers about the societal impact of their work.
Cutcliffe articulates this eloquently when he writes, “It was as though STS courses were for adding a cultural veneer to the ‘coarse’ surface of technical education,” (2000, p.8).

During the late 1980s and through the mid-1990s, the “contextualist” or “social constructivist” interpretation took a hold of STS. This stance advocated that science and technology are products of subjectivity and are dependent on causal factors. Bruno Latour, author of *Science in Action*, was one of the most influential scholars of this philosophy. This view held by some STS scholars has become a topic of active debate. Scientists and engineers who want to maintain their objectivity have published books to counter this interpretation, like Paul Gross and Norman Levitt's *Higher Superstition: The Academic Left and Its Quarrels with Science*. Gross and Levitt argue vehemently against the perceived anti-realist stance of some constructivist STS scholars (Cutcliffe, 2002).

This debate has led to the “pro-” and “anti-” science and technology labeling. In general, critics are pejoratively labeled “anti-” science and technology. Cutcliffe points out that this makes little sense because it would be akin to calling an art critic “anti-art” (2000, p.9). STS advocates seek to improve science education by showing the pertinence of the context in which it is taught.

STS authors like Cutcliffe promulgate that while science and technology do create numerous positive benefits, they can also result in negative impacts that may be unforeseeable. Both the negative and positive aspects of science and technology reflect the values, views, and visions of those who make decisions based on scientific and technological expertise. Contemporarily, the central mission of the STS field is to convey the socialization of science and technology- the broader and more comprehensive
understanding of its impacts on cultural, political, and economic values, and in turn their effects on the science and technological enterprise.

Science Education versus STS Education

The distinction between traditional science education and the STS perspective is important to clearly note. In his essay “Understanding Technological Culture through a Constructivist View of Science, Technology, and Society,” Wiebe Bijker describes the widely held standard image of science as “objective, value-free, and discovered by specialists” (2001, p. 21). In a similar way, he notes that the majority of people, from the general public to professionals, view technology as a “rather autonomous force in society” as well (2001, p. 21). This standard understanding of science and technology, Bijker argues, sets the stage for the two to become the comfortable and reliable answer to nearly all varieties of problems. (Include a statement about DL’s?)

In such a system, the predominant educational style that has evolved separates science theory from technological application. According to Robert Yager, science has become “more abstract and theoretical,” while technology has become “concrete and practical, separating theory and practice” (2001, p. 88). In addition, the increasing complexities of science and technology have forced professionals in both fields to become more and more specialized. Educators have transferred the value of specialization into the classroom setting, where theory or practical skills are often taught didactically and without real-world context. As Yager states, “during the last three decades faith in objective scientific knowledge has served as the unquestioned basis for most of the teaching in K-12 schools as well as in institutions of higher education” (2001, p. 92). (Another DL statement)
How well does this view translate over into the real world, though? While standard science education is 'comfortable' and traditional, the STS perspective asserts that it is also incomplete. Science and technology are no less separated from each other than they are from society, politics, and culture. Therefore, Bijker and other STS proponents believe that “all who live in this culture - citizens, scientists, engineers, STS-students - have an obligation to try to understand the technological culture” (2001, p. 21). This call to understand the interaction of science, technology, and society drives the theories behind STS education reform. The first and perhaps foremost goal of STS education is to put science and technology education into its larger context. Teachers ought not to feed students bits of scientific theory or chunks of technological practice alone. In order for students to see the usefulness of the knowledge they are learning, the interaction between science, technology, and the world that they exist in needs to be emphasized. Doing so allows the student to make connections to the real world (Yager, 2001).

Focusing on understanding science and technology's real world implications in STS education shifts the traditional classroom roles in ways unfamiliar to the traditional science classroom. The emphasis now rests on the learner rather than the teacher. No longer is the teacher's main role to pour his or her knowledge into the minds of students; rather, the teacher's role is to help guide the students' individual constructions of meaning. The important factor in education is not the words the teacher says but the way the students process the information they encounter and link it to their lives (Yager, 2001). DLESE has the potential to assist teachers in teaching earth systems science in earth system science.
These basic tenants of STS education are meant to serve several larger purposes. A greater understanding of the interrelatedness of science, technology and society allows people to be better technology users and producers and to be closer to their culture and world. The specific style of teaching - referred to as a constructivist perspective - promotes future learning, problem-solving abilities, and a “problem resolution” perspective. The “problem resolution” perspective, as put forward by Yager, refers to the ability to see problems as a complex whole and then to start a piece of ongoing work to move toward a resolution. Such a skill is highly transferable to life beyond the classroom, where getting one right answer to a limited question is not often a realistic expectation (Yager, 2001). DLESE could also play the role of assisting teachers in teaching these skills.

While more and more comprehensive STS programs and STS-style interdisciplinary studies are appearing, Yager predicts that there is still a long road ahead of the STS education reform (2001). He feels that the largest obstacle to STS lies in the new roles for educators. Many teachers are overly comfortable with the traditional methods of science education, and they subsequently perpetuate the life of this style as they pass it on to their students. Cozzens adds that the future of STS may also be jeopardized by the movement's own inability to remain interdisciplinary (2001). The nature of STS involves professionals in policy fields, in research, and in education alike. The work of these professionals, she argues, will “be improved if they interact, both with each other and with action specialists. If they do not, then their intellectual products stand in danger of being isolated, fragmented, and weak” (Cozzens, 2001, p. 55). STS
encourages this interdisciplinary communication, and DLESE could be a catalyst for discussion.

*STS: Enhancing Earth Science Education*

Who is the greatest genius? It depends on what kind of physicist you talking to, but most would answer Albert Einstein. Not only does Einstein have a lengthy list of theories like the Special Theory of Relativity and the Quantum Theory of Light, but Einstein was also a great humanist. From 1905 to 1925 Einstein changed humankind’s understanding of nature on every scale, from the atom to the cosmos (Levinson, 1996). But, Einstein also took the time to think about the context in which his thinking was done and theories created. His contemplation of the bigger picture is expressed in his quote: “A human being is a part of the whole, called by us ‘Universe,’ a part limited in time and space. He experiences himself, his thoughts and feelings as something separated from the rest, a kind of optical delusion of his consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us. Our task must be to free ourselves from this prison by widening our circle of compassion to embrace all living creatures and the whole of nature in its beauty. Nobody is able to achieve this completely, but the striving for such achievement is in itself a part of the liberation and a foundation for inner security” (Quoted in H. Eves *Mathematical Circles Adieu*, Boston 1977).

Science, Technology and Social studies are founded on this strive for “widening our circle of compassion.” The most prestigious scientists committed themselves not only to understanding the natural world, but also to acknowledging and understanding the broader implications of their search for truth to benefit the human condition. The
explanatory power of science has increased dramatically during the early twentieth
century. However, contemporary science, technology, and engineering are constricted to
the facts that give them their expertise. However, there are several ways in which STS
studies can widen this expertise to succeed in an interdisciplinary understanding of
science.

To begin, STS encompasses a broader and, in turn, more comprehensive teaching
and learning of science. How does it do this? STS sheds light on the humanity issues
that are so closely linked to scientific information and knowledge. Through studying the
ethics, philosophy, policy, theology, history, and sociology of science, students and
professionals are presented with advice and direction on how to use their knowledge, and
what implications this use entails. The societal contextualization of science insists that
our understanding of science is a socially mediated process. With the insistence, modern
science becomes more germane to contemporary issues, and contemporary issues address
the importance and nature of scientific knowledge.

With new STS-relevant resources integrated into DLESE, the library takes on a
more comprehensive and valuable utilization. Earth science is no doubt imperative to
understanding the environment that we live in, and STS helps us with this understanding.
STS provides a “prism” through which scientific and technological knowledge can be
viewed. Specifically with earth science, STS assists by presenting both sides of
conflicting issues. For example, a PBS site on evolution
(http://www.pbg.org/wgbh/evolution/) presents both the theological and scientific
arguments with equal prevalence. The site contains interactive tools, movies, reports, and
audio clips to assist in a comprehensive learning of evolution.
Several university and college programs have recently adopted STS courses into their curricula. A handful of schools have made STS a discipline, while others require that STS classes be taken as part of the student’s core education. While it seems as though making STS a discipline would guarantee a full education in the ingredients of science, technology, and society, some STS scholars claim that it detracts from the intentional interdisciplinarity of STS studies. STS scholars, like Robert Yager see the STS not as a “body of knowledge to be mastered by students,” but an effective approach to a greater “learning” outcome (2001, 83). STS provides a “prism” through which scientific and technological knowledge can be viewed. Yager also claims that, “STS provides a vision for change” (2001, 94). It enlivens traditional scientific teaching and learning, encouraging ‘active learning’ and interaction with other disciplines to obtain a greater knowledge. STS maintains an assessment of real learning that is more relevant to the demands modern education and society.

In order for the STS approach to be put in place, learning resources need to become more available. Digital libraries are one way of accomplishing this. By making STS-type resources in the form of references, reports, and classroom tools available on the web, STS students and scholars have access to a broad array of materials that assist in research and learning. A library like CONTEXTS that specializes in interdisciplinary resources compliments the existing DLESE library. DLESE provides the fundamental materials for learning science, while CONTEXTS resources reveal the social, ethical, philosophical, and historical surroundings of science and technology education.
Conclusion

Let’s assume that digital libraries work just the way that their proponents want them to, and within the next few years we are accessing information through a digitalized system that gives us all the credible resources we desire. No need to go to the library, or even leave your dorm room or office to find the sources you need. PDA’s will make information instantly accessible from anywhere. Time looking through books at the university or public library is replaced with time spent at the computer looking through electronic books. Technology serves to make our life more convenient; digital libraries may be the next step in this evolution. With all this time you’ve saved by not leaving your office or dorm room you can spend more time doing what you really want to do. Is relaxation in order? This is in fact what all the major technological innovations claim. The washer machine and the dishwasher have given mom more time to spend with the kids, and the automobile has given us the liberation to go where we want, when we want to. The same could be said for Genetically Modified foods and nanotechnology, as they are both modifications to our world that make it more affordable and expedient. The opportunities for improvement in work, capacity for knowledge, and brainpower are limitless. Technology gives us complete control over our lives. Or does it?

In an article written by Kevin Warwick, professor and writer, he describes his nine-day experience wearing an implanted silicon chip under the skin of is arm. Prof. Warwick, appropriately nicknamed ‘Professor Cyborg’ believes that the direction of technology is towards increasing human brainpower. With this prediction in mind, Warwick has pursued an intimate relationship with computers. His next experiment entails an even closer link by directly connecting the nerve fibers situated between his
elbow and shoulder to a computer. The nerves will transmit signals to the computer and
the computer in turn will transmit signals to the nerve fibers. Warwick states from his
last intimate connection experiment that, “you are not just a human linked with
technology; you are something different and your values and judgment will change,”

This appears to be much different from the ‘normal’ employment of a personal
PC. Then again, while typing your brain sends messages to your fingers, just as mine is
now as I write this. And even though I may not be directly aware of its transmissions, the
computer displays something back to me. These transmissions from the computer are
sensed through my eyes, ears, and even my nose (the smell of hot plastic). In this way I
am currently experiencing an intimate relationship to my computer. I still feel as though
I dominate the relationship. I can chose to get up, to look away, or even to shut the
computer down. However, the computer’s computational power surpasses my own. It
can process certain types of information infinitely more efficiently than my brain. Some
of the programs and their inner workings are too cryptic to understand. In this way, the
computer dictates how I use it and controls that area of the relationship. Warwick
predicts that in the near future “humans face the distinct possibility of being superseded
by highly intelligent machines,” (2001). I would argue that this has already happened
and we just haven’t taken notice. With the increasing use of digital libraries, we are
intensifying a relationship with our computers that is yet to be explained.

When does the consumer decide when a certain technological innovation is worth
it? The truth is that we don’t. There is no democratic regulation on the formulation of
technology. For example, DDT was widely used in the 1950’s without knowing its
detrimental affects to humans and other animals. It was not until Rachel Carson published *Silent Spring* in 1962 that the wide-use of DDT began to be questioned. While DDT eradicated malaria from North America, it poisoned animals, polluted rivers and soil, caused cancers and mutilated fetuses. Was it worth it? Eliminating malaria was most important, but shouldn’t this question have been asked *before* DDT was sprayed on kids in the playground and in the streets of the cities? Perhaps a better alternative could have been utilized just as effectively, without the horrible side affects. Technological innovations are intended to avoid suffering, so why in such cases like DDT has it resulted in more? The problem with modern technologies is that we do not ask all the necessary questions before the tool or mechanism becomes integrated into our lives.

It’s not necessary for us to become cyborgs in order to stay in control of our relationship with computers or other technologies. This type of relationship may even be more dangerous than beneficial. What happens to Prof. Warwick when he hooks himself up and downloads his emotions onto his computer? Similarly, but not to that extreme, what happens when a student or teacher utilizes a digital library? Warwick sacrifices part of his human identity when he pursues this unnatural computer-like state. Is anything compromised when accessing digitalized information? It is necessary is that we ask what the use of a certain technology implies or conveys about our society and how it affects our quality of life. How do we want our children to relate to computers? The DLESE learning experience should be positive, with an emphasis on the computer as a supplemental tool.

Digital libraries and digital learning are not equally well esteemed by all critics. On one side of the debate, the experience of a virtual classroom might be able to “provide
the inquiring mind with an endless array of interactive visual extravaganzas designed to keep even the dullest students interested” (Wertheim, 1999, 28). Digital libraries would be the ultimate in educational advancements – anyone could learn about the topic of their choice from the experts of their choice at the moment of their choice. On the other hand, in his book *Neuromancer*, William Gibson creates a dystopian world in which his main character, Case, lives in the nightmarish high-tech world after being banished from the matrix. When we build vocabularies and pursue improvements in the digital realm we create a new kind of world. This culture of portals and programming may not look like the Neuromancer world of Gibson’s imagination, but it is significant in that it changes the nature of knowledge and the process of learning. Perhaps Warwick’s promethian-like pursuit of knowledge is laudable, but he may also be lifting the lid of Pandora’s box. By supplying every school with computers and encouraging the use of digital libraries it is possible that we are entering something more life altering than we realize.

Nevertheless, before digital libraries are put to use in classrooms and at work, we should consider the potential implications of their use. Digital library advocates would not only like to see digital libraries meet the needs of its patrons, but also for them to understand the context in which they are using this tool and what it should be used for. It is imperative to consider the root presumptions of technology before incorporating it into one’s life. Before embracing digital libraries like DLESE, we must first ask how the digitization of information fundamentally alters our world.

For this reason and from our experiences, we believe that DLESE should make itself into a digital information paradigm from which other educational web libraries can be modeled. The vision of a successful DLESE should include a study of the
implications as well as the benefits of using digital libraries. How does this affect children? Does it affect relationships with their peers or their teachers? How does it teach appropriate behavior in all situations? What kind of values does it convey to influential minds? What does it say about the expectations we have for our students and their capacity for knowledge? What kind of attitudes and skills are necessary in order to actually learn from this new and still developing tool? Furthermore, should we continue to invest resources and money into its development, or should focus be on improving the educational tools that are already being used? In general, how does DLESE plan on addressing these questions along with the fact that teachers and students alike are overwhelmed with information? Context for scientific knowledge may be more important than more information today.

To some extent STS studies can help us answer these questions, but STS has its own shortcomings. Interdisciplinary studies pressure students and teacher to specialize in all fields, creating expert generalists. However, we need experts, like those who teach, not only to be confident in their knowledge, but also to take the extra steps to understand the effects of their work. Perhaps this identifies a problematic presumption of contemporary society. Are we forced to find and teach only knowledge that is demonstrable? What about those things that cannot be demonstrated, like the value of wisdom, respect, and discipline? STS forces us to ask these fundamental questions that are too often overlooked. By incorporating STS into earth science and in turn, the DLESE library, we address key fundamental issues that have the potential to enhance education and society.
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