Phase I - Volume I

Increasing Effective Student Use of the Scientific Journal Literature

National STEM Educational Digital Library Program

Sponsored by the National Science Foundation As part of the National Science Digital Library

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Executive Summary

(See also Section 6)

This NSF-National Science Digital Library (NSDL) project's main objective is to discover and test what system, interface, and learning enhancements will help improve electronic journal systems to encourage sustained use by undergraduate students. Phase 1, reported here, identified current use patterns of journals by undergraduate students, graduate students, and faculty and features that they value in online systems. Phase 2 of this project will be to conduct usability testing of selected features, using OSTI's ECD (and perhaps PrePRINT Network) as testbeds.

Focus groups and a review of related research studies were used in Phase 1. We found that scholarly journals are introduced at different times in the undergraduate science curriculum, depending mostly on individual faculty members' assignments and preferences, but most commonly the use and understanding of scholarly science journals is introduced for upper division science majors (in the junior or senior year.) The most effective way to introduce scholarly journals seems to be a cooperative venture between the science professor and librarian. Short introductions to resources that are offered early in a program by librarians or in general education lower division courses typically do not go into any depth and are not remembered later by many students.

Few lower division science majors know about subject specific databases or scholarly journals. Almost all college students today, however, use the Web, and many consider themselves experts. Preferences and suggestions for system enhancements identified in this report, include:

- Links to related articles and related information
- The ability to personalize or customize design features such as colors, type fonts, interface, etc.
- Some way of identifying the "quality" of an item (clearly marking something as peer reviewed, being from an important journal, etc.) and being able to restrict a search to just the highest quality items
- The ability to download, save, and use articles, with a bibliographic citation that can be cut and pasted into a report
- A consistent and clearly labeled structure that allows easy understanding, including a clear abstract and summary
- The ability to browse articles by journal titles and search for articles on a topic
- Restricting a search to just items for which the full-text is available
- Incorporating other types of literature on a topic, so undergraduates can better understand technical article content. For example, including dictionaries, handbooks, encyclopedia articles that will provide background information, linked definitions, etc.
- A combination of PDF for printing and a format that is better for searching, cutting and pasting, etc.

- Easy to understand “help” that assists with both search strategy and understanding of the type of literature
- The ability to tie journal articles with course content

1. Introduction

1.1. Objectives

The primary objective of this project is to gain an understanding of what features will make scholarly electronic journals useful to and used by undergraduate science students. This is to be accomplished in two phases:

1. Phase 1 (reported here) to establish through focus groups, a literature review, and a review of related research projects by the principal investigator, what is needed in electronic journal systems to encourage sustained use by undergraduates.
2. Phase 2 (to begin October 2002) working with the Department of Energy's Office of Scientific and Technical Information (OSTI), to test undergraduate and faculty reactions to selected technological and pedagogical enhancements.

To accomplish this objective, Phase 1 involved studying several questions, including:

1. How and when are scholarly journal articles introduced in the undergraduate science curriculum?
2. What do faculty expect their students to understand about scholarly journals?
3. How do undergraduate students learn to understand the structure, purpose, and content of scholarly journal articles?
4. How do undergraduate students search for information needed for their schoolwork?
5. What features of online systems and web search engines do undergraduates understand, use, and value?
6. What role do libraries and librarians play in helping undergraduates learn about scholarly journals?

Not all grade levels or subject disciplines will yield the same answers to these questions. Therefore, we also need to understand:

- At what college grade level (lower division, meaning freshman and sophomores or upper division, meaning juniors and seniors or graduate) are students expected to use and understand scholarly journal articles?
- At what grade level are they expected to search for scholarly journal articles and recognize on their own which are relevant to their task?
- How do these expectations differ in chemistry, physics, and engineering?
- How do these expectations differ for majors and minors in these disciplines?
- How does a student learning occur in the general education humanities or social sciences courses regarding seeking, retrieving, and using journals transfer to their science coursework?

Understanding these things will help us design more useful electronic journal systems, better instructional materials and coursework involving scholarly journals, and lead to more understanding and use of scholarly electronic journals in the National Science Digital Library (NSDL) by undergraduate students.

The OSTI-developed Energy Citations Database (ECD), which includes bibliographic information for over 2M citations and 70K full-text documents, and the PrePRINT Network, which facilitates access to 10K PrePRINT websites in 35 countries containing approximately 500K scientific and technical PrePRINTs (or eprints), will be used as testbeds for programming, testing, and verifying the usability of specific selected features.

A secondary purpose of this project is to suggest what should be included in an interactive learning module designed for lower division chemistry majors to increase the usability of a science journal article digital collection. This will also be a part of phase 2.

1.2. Background

Of the approximately 15,000 peer reviewed scholarly journals currently being published and listed in *Ulrich's*, nearly 12,000 of them are available in some sort of digital form. Studies show that many faculty and most students prefer electronic journals to print and the convenience of linked desktop access likely results in a greater amount of reading of journal articles. Research shows that the amount of reading per scientist per year is increasing, probably partly due to this increase in electronic availability (Tenopir & King, 2000.) Although we understand the reading habits of faculty and researchers in the sciences quite well, the reading patterns of students, particularly undergraduate students, remain somewhat of a mystery.

Working scientists in all types of settings recognize the value and importance of journal literature. A readership study done for the University of Tennessee, Hodges Library in 1993 and four studies done for companies from 1994-1998 show that readership of scientific scholarly journals by science professionals is considerable (i.e., 188 average readings per year per university scientist and 106 readings for scientists elsewhere). (Tenopir and King, 2000) (Reading is defined as going beyond the title and the abstract to the text of the article. Each time an article is read counts as a single reading.) Not only do these scientists read scholarly articles, they spend a substantial amount of time reading them – an average of 182 hours per university scientists and 88 hours per scientist elsewhere per year.

There is abundant evidence that scholarly journals are not only widely read by working scientists, but they are extremely useful and important to scientists' work, whether that work be teaching, research, administration, or other activities.

When preparing to do research in a new area such as preparing a grant proposal or writing a manuscript, readers use retrospective literature as well as current articles. They scan or browse through vast amounts of material, using articles to trigger new ideas. Evidence from surveys also shows that scientists who read more tend to receive more achievement awards and other special honors. (Tenopir and King, 2000) Although that does not necessarily suggest a cause and effect relationship between reading and achievement, it does suggest that this important resource should not be denied those who require it to succeed and that students should be made aware of the importance and value of high quality journal literature throughout their studies and careers.

Educators need to be able to take full advantage of tools that provide access to digital collections of high quality science literature. By encouraging students to access and use this literature, colleges and universities in the United States will take important steps in producing the world's finest scientists.

Journal literature has been shown repeatedly to be one of the most important communications channels for scientists of all types, whether they work in universities, industry, or government laboratories. (Tenopir and King, 2000) Convenient access to journal literature is important for scientists, as the typical university scientist reads approximately 188 journal articles per year from an average of 18 journal titles. (Tenopir and King, 2000)

Students do not come to college with an inborn knowledge of the importance of scholarly scientific literature, nor do many of them possess the skills and knowledge necessary to evaluate quality, read and understand scientific literature, or know when to use journal literature in their work. Recent studies have shown that undergraduate students today often use the sources that are most convenient to them, rather than carefully selecting the highest quality materials.

Librarians believe that for beginning students, one factor supersedes all others. Easily availability of full-texts of articles is the one overriding factor that undergraduate students take into account when selecting a digital resource for research – even if another source may provide indexing and abstracting data for higher quality literature. (Tenopir 1999)

As college students grow in experience and knowledge, part of the learning process is recognizing quality science reported in peer-reviewed journals. This learning process takes place in the classroom, through library instruction classes, or through feedback from professors in graded papers, but is rarely, if ever, incorporated into the digital library systems that provide access to this journal.

As journal literature is increasingly being digitized, creating a growing national digital library, current and future scientists need collaborative learning environments, which increase the usability of the NSDL. The digital library, in its fully operational form, will need interactive learning modules, which increase its impact, reach, efficiency, and value. Both users and collection providers can benefit from the introduction and development of learning modules. Existing digital library collections and services can be used as test-beds for the study and development of such interactive learning units; thus, a natural synergy emerges among existing collections and the development of services to support users and collection providers.

The Electronic Citations Database (ECD) and PrePRINT Network from OSTI, as existing collections, are ideal candidates for the focus on this study. They represent a tremendous long-term investment and ongoing commitment by the Department of Energy. To make digital collections more useful for educational users, both technological and pedagogical enhancements need to be made. The primary objectives of this NSDL Services Track project are: 1) design, develop and test interactive learning modules which increase the usability of a science journal article digital collection; and, 2) to gain an understanding of what features make a science journal article digital collection an important and interactive tool for sustained use by undergraduate students in the sciences. The specific objective is to use this knowledge to make NSDL collections a valuable educational tool by identifying, designing, testing, and implementing selected technological and pedagogical enhancements.

College students, in particular lower division undergraduates, often do not recognize the importance of high quality scientific journal literature. Faced with many choices, they may opt for accessing information that is most convenient, rather than carefully evaluating the content and quality of the many digital resources available to them. The Department of Energy's Office of Scientific and Technical Information (OSTI) is creating components of a national digital scientific and technical library, through web-based services such as their Electronic Citations Database (ECD) and PrePRINT Network.

While creation of such digital collections is central to the mission of the National Science, Mathematics, Engineering and Technology Education Digital Library (NSDL), educational users must also be able to effectively search and evaluate the content contained within the digital library. The OSTI projects are available to undergraduate users, yet the projects do not have components that will encourage undergraduate science use. Although collaborative learning environments and test-beds are provided to enhance educational access to all parts of a national digital network of learning environments for SMET education, usage is limited.

This project will develop features and interactive learning modules that will help undergraduate users recognize, access, and evaluate high qualify scientific and technical information. These products and services will be tested and reports generated so the findings will be more generally applicable to undergraduate users of other digital libraries of scientific information.

1.3. Project Methodology

1.3.1. Goals and Objectives

- The primary objectives were determined to be:
    - Gain an understanding of what features make a science journal article digital collection an important and interactive tool for sustained use by undergraduate students in the sciences
    - Begin to develop interactive learning modules which increase the usability of a science journal article digital collection

- The specific outcome was determined to be:
    - Use the Primary Objectives to make NSDL collections important tools for science education by identifying, designing, testing, and implementing selected technological and pedagogical enhancements to OSTI's digital collections
    - Validated programmed enhancements that will make digital collections more appealing and useful for academic users and identification of other desirable features and enhancements
- The major questions to address were determined to be:
    - How can undergraduate students be encouraged to recognize and use high quality science journal literature?
    - What features in a journal literature digital collection would be most useful to undergraduate science students and would encourage use?
    - What features would be most useful to graduate students and faculty in the sciences for their students that would also encourage student usage?

- More specific questions included:
    - How can the identified features be used in test collections to make them more useful to undergraduate science students, graduate and faculty scientists?
    - How can OSTI identify, test and implement features of the NSDL collection (and specifically OSTI journal literature digital collections) that will enhance the appeal and encourage sustained use by undergraduate science students?

1.3.2. Planning

- Phase I of the project was determined to concentrate on focus groups and the collection of preliminary information relative to the project objective(s).
    - The timeframe for Phase I was planned for the Spring and Summer 2001 semesters.
- Phase II of the project was determined to concentrate on the implementation and testing of features to promote the sustained use of digital libraries by undergraduate users.
    - The time frame for Phase II was planned for the Fall 2001, Spring 2002 and summer 2002 semesters.

- Staffing:
    - Principal Investor (entire project)
    - Two faculty associates (one semester each)
    - Consultant (as requested)
    - Two ¼ time graduate students (beginning January 2002)
    - One ½ time PhD student (beginning August 2002)
    - OSTI personnel to participate in meetings, focus groups and handle programming of test features
- Each research team member was assigned specific responsibilities, including:
    - Literature review
    - Logistics for focus group meetings
    - Participant contact, scheduling and follow-up
    - Agendas (Refer to Appendix 2.1.H. Sample Focus Group Agenda)
    - Questionnaires (Refer to Appendix 3)
    - Consent Forms (Refer to Appendix 2.1.G.)
    - Grants of Permission (as required by the University)

The research team for this project included at least 5 participants at all times (Principal Investigator, consultant, graduate students, and OSTI personnel). The team met weekly to review progress and the project time schedule, planning, and events. Informal meeting notes have been regularly maintained.

2. Focus Groups

2.1. Background

Focus groups were used to gain an understanding of and answers to the questions posed in Section 1.1. They allow for the collection of data from subject-matter experts and potential users, both of who have knowledge of or opinions about the topic of interest. Qualitative data collection and analysis provide insights into the opinions and motivations of university science faculty and students. Together with the quantitative data collected in related research (and summarized in section 4) we have information on not only what users do in regards to journal articles, but also on why they exhibit certain patterns and what they might do in the future.

Focus groups were organized for lower division undergraduate students, graduate students who are also graduate teaching assistants (GTAs), faculty, and for scientists at the Oak Ridge National Laboratory. Academic participants were selected from the chemistry, physics/astrophysics, and engineering departments at the University of Tennessee.

2.2. Focus Group Methodology

2.2.1. Objectives

A pilot focus group that included graduate students and science librarians helped us establish procedure and timing for the remaining focus groups. After the pilot, two rounds of actual focus groups were held in Phase 1 of this study. Round one focus groups (separate for faculty, graduate students and undergraduate students) concentrated on how participants use journal articles and other information sources in the classroom and for their work.

Round two focus groups concentrated on familiarity with and use of e-journals and other digital resources. Discussions of the systems the participants prefer and the features they find most helpful or desirable occupied much of the round two focus groups.

For the Oak Ridge National Laboratory scientists, a single focus group covered topics dealt with in both rounds of student and faculty focus groups.

2.2.2. Participants

University of Tennessee science librarians were asked to recommend faculty members in the fields of engineering, chemistry, and physics/astrophysics who were likely to have opinions about undergraduates' use of journal articles and would be willing to express those opinions. Faculty members who agreed to participate were then asked to nominate graduate students and lower division undergraduate students who they felt would be serious participants.

Sixteen total academic participants agreed to attend two rounds of meetings each during Phase 1 and also participate in an additional two or three usability tests during Phase 2. In addition, Oak Ridge National Laboratory scientists met in a separate focus group.

The majority of contact was conducted via email, telephone and in person. (Refer to Appendix III-1 Example of Preliminary Faculty Contact By Email. There are two examples: Email #1 went to faculty previously contacted; Email #2 went to faculty newly identified as possible participants; and, Email #3 was a follow-up email to faculty. Appendix III-2 Example of Student Email Contact. Email #4 went to undergraduate students, Email #5 to Graduate Teaching Assistants and graduate students.) Oak Ridge participants were coordinated by the Director of Libraries at ORNL, who also submitted separate human subject permission documentation

For the academic participants, all contact information including date of contact, name, college, title, email address, telephone, answer and comments which included indications of participation were maintained in table form, updated frequently and referred to often, throughout Phase I of this project. (Please refer to Appendix 2.1. Methodology)

Anonymity and security was guaranteed by restricting access to this information to the research team and keeping paper records secured in a locked SIS office. The ORNL librarian selected ORNL participants and the research team had no contact with them before or after the focus group meeting.

2.2.3. Documentation

Due to the nature of the focus groups and inclusion of human participants, permission had to be requested from the University of Tennessee SIS Human Subjects Committee. Form A was completed and approved. A consent form signed by all participants prior to each focus group meeting was required. (Please refer to Appendix 2.1.G.) In addition, the ORNL focus group was approved by ORNL's Human Subjects Committee.

An agenda for each helped the facilitator direct the discussion and keep time. The agenda helped the facilitator in guiding the discussion and ensuring comments were freely made and discussed among the group. (See Appendix 2.1.H. Sample Agenda).

The questions posed by the facilitator to the group reflected each group's level of expertise and knowledge of resources, but similar questions were asked of each group. Agendas for all of the first round of focus groups centered on use of journals in both print and electronic form and current practices and preferences. Second round focus groups centered on preferences and use of digital resources and the future.

In addition to the questions discussed in the groups, a questionnaire was used to gather additional information that may not have been covered during the focus group discussions. The questionnaire analysis can be found in Section 3. (See Appendix 3.3.1. Questionnaire: Scholarly Use Questionnaire and Appendix 3.3.2. Questionnaire: Electronic Journal Awareness).

2.2.4. Logistics

All academic focus groups were held in conference rooms at the University of Tennessee while the ORNL focus group was held at ORNL. Refreshments were served and the atmosphere was kept friendly and informal to encourage open discussion. A trained facilitator conducted focus group sessions, while research team members assisted.

2.2.5. Other

All focus groups were taped for transcription and analysis. Each participant was informed of the taping and anonymity assured. All the transcriptions are simply marked "Q." for Question and "A." for Answer; no names or identification of any type were recorded. Raw transcripts are included in Appendix 2.3.

Gift certificates were given to each participant (student and faculty) to motivate participation and strengthen the rate of return to future focus groups. ORNL participants were provided with lunch.

2.3. Analysis of Transcripts

Although the focus group facilitator had a list of specific questions to guide the discussions (Please refer to Appendix 2.1.H. Sample Focus Group Agenda), participants were encouraged to speak freely and take the discussion in any direction they wanted. Analysis of the transcripts from the focus groups therefore cannot easily be mapped exactly to the questions. It is more useful to analyze the transcripts by recurring themes.

Six major themes were identified in the analysis of all focus groups:

1. Variations by grade level
2. Variations by subject discipline
3. Access means for articles and search strategies
4. Variations in types of literature required for coursework and faculty recommendations of sources
5. Problems with understanding journals, accessing information, or other problems described with students in the information access process
6. Purposes for which they use information or journal articles

(See also Appendix 2.3 Original Focus Group Transcripts.)

2.3.1. Variations by grade level

2.3.1.1. Undergraduate students

Lower division undergraduate students have little knowledge or experience with print or electronic scholarly journals. The reasons include: their coursework is concentrated on textbooks and classroom lectures; their coursework is difficult and time-consuming; journal literature appears too difficult, they are not familiar with the library, they prefer to work from their homes, and, it is not required by their professors. There is limited journal usage at the senior level, but not in all classes.

Although the library does offer introductory classes to library resources and computer technology, undergraduate students who do not participate may not be exposed to the library capabilities. Whereas some chemistry and physics students have visited the library for assignments, the engineering students in our focus groups have not.

Undergraduates are not usually required to read journal articles. The students and faculty feel they are overworked with the regular course load and do not need to master scholarly journal literature until they are committed to a major and in upper division classes. Some believe, however, that it might be appropriate to expect all students to achieve a measure of familiarity and mastery with journal literature.

Although specific articles are generally not assigned by faculty to lower division students, seniors might receive an assignment to pursue a topic and research it through journal literature. Or, faculty might assign some journal articles for them to read and discuss later in class. From time-to-time, students may be assigned a project requiring locating bibliographic information about articles, which may force some familiarity.

The lower division students feel scholarly literature is too difficult for them which may be a result of academic immaturity and experience more than true exposure to the journal literature. Even a senior asked, "What is a thesis? What is a dissertation?" These areas are not included in an undergraduate curriculum.

Faculty believe the students consider articles to be a snapshot of the most recent discovery. There is not much preamble. Students don't understand where it is coming from or where it is going. Students like to know the history that led to this particular report of the discovery. Faculty believe students are unable to understand the theoretical content of scientific journals, and even if they did, they wouldn't understand the background and continuity. It is thus very difficult for students to understand and use journals effectively.

In undergraduate astronomy and astrophysics, the subject matter is very difficult. In an effort to maintain currency and interest, some topical classes do require searching journal literature.

Undergraduates may be assigned to look for a journal article on a specific topic and make a report, or they may be assigned a literature review for a project. As in an independent study, they would have to learn quickly about their subject matter. They may need to locate 15-20 articles to pull together a common theme for evaluation. Sometimes it isn't until their senior year that they may receive such a project, such as in physics. Physics faculty in our focus groups said the utilization of original literature by undergraduate physics majors in physics courses is minimal to negative.

One student remarked that use of journal literature might depend on the usefulness of class textbooks and materials. If there is a lot of information, the professor may just refer only to the textbook.

All students overlook the concept of peer-reviewed journals especially because they do not understand the publishing, refereed or peer-reviewed process. All levels of students believe this concept is for someone who is a serious researcher and for most undergraduates, it isn't that important. When a person wants to publish their thesis or important work, the quality of the journal becomes important.

Some faculty participants spoke from a cognitive approach about the use of journal literature being a creative, critical, evaluative and scientific skill that should be taught as part of the educational structure. Literature use is an intellectual skill that is part of the ability to reason logically, make critical selection, and applies equally to research as it does to browsing through the library.

In summary, the undergraduates in our focus groups do not need or want exposure to scholarly scientific journal literature. They feel overworked with the science and general education curriculum and lack an academic maturity to effectively absorb and use the information. However, once these students make a commitment to a major, usually in their junior year, they should be introduced to the journal literature of that discipline, which would be useable for thesis, research, and graduate school. As a student matures, they become more serious about their studies and might pay more attention to journal articles.

There is a consensus by faculty and students that a class should be offered on proper research and journal literature in perhaps as early as the sophmore year to offer familiarity and instruction for later use. It was suggested such a class might be a 1-hour seminar course.

2.3.1.2. Graduate Students

There is some disagreement over when students should first learn about journal literature, but most agree it does not, and should not, wait until the student is in a major, probably a junior or senior, or is working on a thesis option.

Graduate students responded that their first introduction to scholarly literature was in their junior undergraduate year. These students had identified their major academic area of interest early on and concentrated in just one area. For example, one participant began using journal literature as a junior; as a senior they took a chemical literature class which taught them how to find literature; and now as a graduate, this student is taking a literature course where they research and read two or three articles per class meeting.

Another participant spoke of doing scholarly journal research when he was a college senior and elected the thesis option to graduate. He spent six months working on background research and using electronic search engines to locate journal literature.

A first year graduate student gave an example of an assignment she received as an undergraduate using journal literature. The class had to find an article of interest, but not in their subject area, to read and try to understand (but not everything). They also had to write a 1-1 ½ page analysis of the article to help them practice their English as well as see how much they understood. The professor corrected it and had them rewrite it.

Another student said they read journals for an independent study, and because they are interested in subjects not normally found in standard texts, they learned to do research on their own line of topics.

One graduate student didn't think undergraduates would know the difference in the writing or information between a journal and regular magazine. For example, if you show them Analytical Chemistry and Time magazines and cut out an article in both (Time might be about ozone depletion, and Analytical Chemistry on lasers and absorption of CO2 and UV), they might be able to tell the difference between the technical writing versus nontechnical writing but from the information content, they probably wouldn't be able to tell a difference.

Graduate students believe they need to know about journal literature and peer-reviewed articles.

2.3.1.3. Faculty

Faculty believe an introduction to scholarly literature would be appropriate and is necessary for freshmen, however, it must be done carefully. For example, in chemistry, undergraduates should be able to use the Handbook of Chemistry and Physics, which is a standard reference. Although most introductions are done at the junior and senior level for committed majors and in preparation for graduate school, many graduate students are not familiar with journal literature.

Motivation is an important consideration with undergraduates; therefore, perhaps introduction to journal literature should be done on an individualized basis, perhaps on a more specific topic pertinent to the student's interests as opposed to a class topic.

Faculty also believe students need to be required to use journal literature as an introduction to research skills; otherwise, students will not do it. Although students should have a grasp of journal literature when beginning graduate school, the most beneficial point at which students should be assigned journal literature for reading should be at the time the student commits to a major. Also, at that point, it may be required. A graduate student participant spoke of spending weeks to understand some journal articles and had to disassemble the paper to analyze it. As an undergraduate, this person did read some scholarly literature, but only had a broad understanding.

There may be a difference at the University of Tennessee because there are no separate courses for majors. Other universities offer separate courses such as Organic Chemistry for chemistry majors, Majors Organics, Organic Chemistry for Pre-Med students, and Organic Chemistry for engineers. UT offers only a single Organic Chemistry class. The lack of specific course offerings at that level may move review of journal literature into a more general area and decrease its perceived value.

The chemistry faculty believe familiarity should begin earlier. Engineering faculty believe so much time is spent on classroom discussion and textbooks, there is no need for an exposure to journal literature at the lower levels; however, upper division students could benefit greatly from knowledge of sophisticated searching techniques.

2.3.2 Variations by subject discipline

There are great differences between the fields of chemistry, engineering and physics and the use of journal literature due to the nature of the disciplines: chemistry requires information on compounds, reactions, mathematical processes, etc.; engineering requires information from patents, diagrams and blueprints; physics requires information on mathematical processes.

2.3.2.1. Chemistry

Chemists appear to place more importance on journal literature and introduce it more systematically. There is a UT undergraduate class that focuses specifically on the literature of chemistry. This is not surprising, as journal literature is important in chemistry and to chemists. It seems to be less important in engineering classes and the participants in our focus groups reported that chemists use literature more than Engineers.

Searching the literature is difficult due to the proliferation and confusion of acronyms and synonyms, especially in chemistry. The majority of undergraduate chemistry work is math, doing equations and studying reactions. It is important to be able to locate chemical information quickly and accurately.

One faculty participant expressed the opinion that even chemistry classes don't teach literature use at the undergraduate level. He believes that literature is not even taught until the very end of senior year in chemistry because there are not that many real chemistry majors, most students are just taking chemistry classes.

Lower division chemistry classes can have hundreds of students and it is a full-time job to teach one class. For example, an undergraduate chemistry class might have 350 students and be taught twice a day including coordinating the labs (30-40 lab sessions for one lecture section) and recitations.

Chemistry has a long illustrious tradition, which has been well documented; some universities have a unique course in Chemical Literature. It is one of the few disciplines that has sponsored such a course, plus chemistry has a corpus of textbooks dating way back and even has literature specialists within the discipline. One participant said twenty years ago there were specialists in chemical literature in chemistry departments all over the country, not just in the library. Unfortunately, this emphasis faded about 15 years ago, precipitated by too much emphasis on specialization. Currently, there is one-third of a course in the UT curriculum where the focus is squarely upon chemical literature. This is taught in conjunction with the library.

There is usually a core group of five or six journals that everyone should know when students become specialized into a chemistry sub discipline, such as chemistry, analytical chemistry, inorganic or organic chemistry. If a student at any level is going to specialize in some field, they need to have some idea of what other people have done in the field through the journal literature. For example, in chemical engineering, core journals include: *Chemical Engineering Communication, International Journal of Controls, Process Design and Simulation, Computers in Chemical Engineering,* and the *American Institute of Chemical Engineering Journal.*

In searching journals, undergraduate and graduate chemistry students prefer to use CAS SciFinder and Chemical Abstracts because they can be approached from a scientific chemical perspective. A student can put in the structure or CAS number and it will retrieve relevant articles on that subject. In addition, they are familiar with different ways to search, such as by author and various keywords. Students do realize there are keyword limitations in general search engines such as Google. They believe SciFinder will persevere because it covers other fields in addition to chemistry such as Physiological Chemistry and Geological Applications; it is broad and encompasses many journals; they did not believe anyone else would come up with the resources to challenge it.

Chemistry faculty use specific sites they discover or are provided by the library for classes; however, they direct students to use general search engines when looking for topics. Some courses are team-taught with a librarian. In these courses, the students are required to find out what sort of gateway to chemistry topics is provided by general search engines.

In chemistry, undergraduates demonstrate use of journal articles when professors distribute lists of journals and assign students to "go find an article"; some of these articles will be in the online reserve.

Faculty focus group members believe eprints and eprint archives are not used in chemistry and engineering due to concern about poor quality and duplication.

2.3.2.2. Physics

Physics faculty believe that original literature isn't introduced until a student's senior year when they are assigned a special topic or project. The use of original literature by undergraduate physics majors in physics courses is minimal. Physics has two kinds of students: general education and thesis; journal literature is not an undergraduate requirement.

Astronomy students receive assignments that encourage Internet research since the subject matter is constantly changing. Students are assigned a current topic in astronomy with a week to write a paper. They are expected to use search engines and do Internet research. One undergraduate mentioned an astronomy assignment where the students were given a topic to research in journals. The students had to use their own judgment of the journal documents from that point forward.

Undergraduates demonstrate use of journal articles through written assignments and discussions in astronomy. Some specific online sources are required. For example, astronomy students were referred to the Nine Planets website by professors. Physics undergraduates and graduates use Google and other general search engines; however, for more scientific research, they use SciFinder for better focus, reliability, completeness, better citations and a higher level of professionalism. The students compared Google to newspapers and scientific engines to "professional" literature.

Physics professors direct their graduate students to eprint archives such as arXiv.org or its subset atrophy and believe they are able to judge quality.

2.3.2.3. Engineering

Students believe the point when students are assigned journal literature varies widely in engineering; however, faculty believe it depends on the class. For example, one professor might assign a research article to analyze and give a report, while in a Civil Engineering - History type class, a professor might require a general search to find information such as when one professor recalled helping students locate information on the failure of bridges. The first accounts come from newspaper articles of bridge collapses; later in time, there are computer models that show how the bridge will sway.

In searching, electrical engineers prefer IEEE Explorer. Comments included that although a course such as Civil Engineering is not really a technical course, students do learn how to write a technical paper. Also, engineering students should at least know how to find electronic journals because they will need them to be practicing engineers. Many students do not plan to go to graduate school but they need to know how to find information at the very least so they can do a better job when they graduate.

In reference to development of current awareness, engineering faculty discussed keeping up with professional societies and the trade journals, which differ depending on the area of engineering. Faculty also believe students need to understand the cycle of scientific literature researching, writing, and possibly obtaining a patent.

2.3.2.4. Other

Faculty commented that there is not much writing in undergraduate science classes; therefore, there will not be much journal reading. Also, undergraduates have so much in their curriculum to cover, where would they include perusing journal literature?

Faculty also discussed that even graduate students don't have a clear idea of how to approach the proper reading of an article, which is failure on the part of faculty throughout the educational process. Learning to read is not something you do up to the fourth grade and then you know how to do it. It is important to help students understand there is a hierarchy in learning with things such as reviews and introductory materials.

When searching is required, faculty believe they check undergraduates computer expertise and give them guidance on specific databases and search engines to use to narrow down the search processes.

Students mentioned they learned about journals and searching for articles in their general education courses (anthropology or English, for example) rather than in science courses.

2.3.3. Access means for articles and search strategies

In many cases, professors will hand out article copies for students to read. The students go by what is given to them; they do not actually locate the literature themselves. In other cases, students are asked to search and find relevant literature.

Over the past few years, the main difference in journal literature access is the Internet. Only a few graduate students referred to doing manual research in the library. They could have done it online, but were assigned to read journals and find specific articles, and preferred to do it manually.

2.3.3.1. Frequency of usage

All faculty believe students use more electronic resources now than in the past because of accessibility. Electronic resources are plentiful today and students do not have to go to the library to get them, but can access them from home or dormitories. Full-text databases are the most frequently used sources.

All the graduate students estimate they use Internet search engines or full-text sources anywhere from every day to five times a week from home or school. Graduate students also estimated they used abstract and indexing database systems such as SciFinder and Web of Science, ranging from daily to once a month or so. All are accessed through the library homepage and the ejournal link.

2.3.3.2. Depth of searching

Some chemistry courses do require indepth literature searching and even require access to old German documents.

The physics students do use to a few subscription journals but just scan the titles to find a topic of interest. One or two students estimated they might use two or three articles per month. They do not use the periodical room at the library.

Whereas some faculty read most of perhaps 20 or 30 journals in any given year, others say they scan the contents and read the articles that are pertinent to their work. A few do read a favorite professional journal, but again only the most important articles. One faculty reads current issues of *Chemical Abstracts* to find interesting abstracts because *Chemical Abstracts* cover foreign journals, obscure journals and regular journals.

2.3.3.3. Successful access

The graduate students show obvious experience accessing journal literature. They seem to compare notes, look at what other people have done, and model their searches after those. Although some of these students knew the journals were there, they did not have a need to use them in undergraduate school.

One graduate student uses SciFinder and Science Direct because they are quick, efficient and hold information on their major subject. They also have learned to review the references inside articles for clarifications.

Students have also found a higher level of success using databases and search engines they learned about in seminars and classes at the university. Advisors to the students recommended they attend because they were new additions at UT. In one case, a research advisor told them about SciFinder and Science Direct.

2.3.3.4. Problems with access

Professors believe the problems students encounter when they search for relevant journal articles center on searching knowledge and techniques. Students often have difficulty with acronyms; they are unable to identify correct databases and search in incorrect databases such as expecting to return full-text articles when they are searching in an abstracting and indexing database. There are numerous databases to choose from which lends to their confusion, they will use the path of least resistance and if they find a database with few articles on their topic, they will stop there.

Time is another major obstacle to locating relevant journal literature and was identified by faculty for student success at all levels in all fields. Students work on projects at the last minute; they want instant gratification; they want what they can print out immediately; InterLibrary Loan takes too long; and they do not search enough sources or spend enough time evaluating the sources and literature. Students will start on the Web using Google or AltaVista; if they can't find something fairly quickly, they will ask at the library Reference Desk and be directed to a database.

Faculty believe students are unable to perceive reliable information on the web. Students appear to think that inputting various keywords in a search engine will return reliable, credible information. One faculty member commented that there is no spontaneity or serendipitous discovery on the web such as that resulting from browsing the stacks.

Another problem is students' erroneous belief that they have located scholarly articles when they have not. They use ordinary search engines and find sites that are not necessarily technical journal articles. For example, NASA and some universities provide non-refereed articles intended for a general audience.

There is a lack of knowledge about the Internet, web and general searching philosophies in students from smaller, less sophisticated backgrounds.

A student may do a search and locate an article in a title not held at UT. The student will print the abstracts and try to find them either through the library or input the name and try to find the particular journal webpage.

2.3.3.5. Preferences

Overall, students and faculty use general search engines, most likely Google, for most exercise; however, if the search is technical, the following are used:

- For all disciplines: SciFinder, Vivissimo, Web of Science
- For physics and chemistry: SciFinder, Web of Science, Copernicus, Nine Planets, Inspec

The style of search engines is changing along with the style of databases. Faculty and students spoke most frequently of using Google, but also specialized scientific search engines such as Vivissimo that aggregates scientific literature. Favorite scientific databases include SciFinder and Web of Science for physics and chemistry. Fortunately, most of the major periodicals now have online versions, so the credibility of ejournals is enhanced. There will always be journals of dubious quality.

Most undergraduates had completed a searching tutorial either in a class or independently in the library. All students agree on the ease of searching library catalogues today but prefer using the web from home.

Undergraduates mentioned the usefulness of Copernicus in that it highlights the keywords searched in the articles it pulls up. They like the feature in Google that puts bars underneath search words so a user can click on a link. Google will also archive a website so if something was up temporarily and is no longer available, a user can still read it. Vivissimo uses sub-categories of the search criteria, such as scientific or philosophical information. It will help narrow your search easily.

Students also mentioned the usefulness of the Google option "Are you sure you didn't mean to type this …" which will give you related information and enable you to correct a typographical error.

Graduate students like using the library catalogue to search on categories to locate a wide-range of information. Graduate students work on open searches most frequently and look by subject and author, and sometimes for particular groups from particular universities. They also believe SciFinder and Vivissimo are the best search systems because they are specific and don't turn up as much irrelevant information; they are more specific and narrow the number of responses.

SciFinder can be searched from a chemical perspective. Relevant articles can be retrieved from the structure or a CAS number and it can be searched by author. Students felt that in Google and other Internet search engines, you are limited to what you can put into words.

One older graduate student who considers himself "old fashioned" prefers the periodicals room to the online access. He believes it is more convenient, reliable, and faster. He feels Internet searching is meaningless with a high degree of useless, miscellaneous and extraneous material retrieved that can be time-consuming to review before discarding.

Graduate students consider abstracting and indexing or citation databases to be most helpful. For example, in SciFinder and Web of Science, a student may not be able to get the actual journal article, but can see all the references to it and articles that have referenced it.

The students also prefer .pdf print formats. Most computers have Adobe; the images are clearer and include more figures, charts and graphs. The downsides are that .pdf scrolling is difficult and if the document is long (20 pages or more), it can be time consuming to print with possible glitches in the printing.

The students feel Vivissimo retrieves relevant information and includes documents not found in other search engines without miscellaneous junk. Although the Folders option on Vivissimo was mentioned, the students had noticed but have not used it.

Faculty also feel students tend to use only articles they can get electronically and full-text. They do not hunt down print journals in the libraries anymore, but avoid it. For example, Inspec was mentioned as very useful for abstracts but would be more useful if it were full-text.

Students tend to use the library catalogue list to locate articles. It will tell them whether the library has a journal title or not; they then look for the electronic journals, do a special order, etc.

Physics students said they do not use Astrophysics Data Service (ADS) but believe they will in the future.

Faculty believe the general search engines are not straightforward and are becoming painful (Google, Yahoo, Lycos) with too many retrievals, retrievals put together under inappropriate headings, and pop-up ads.

Other faculty feel that sometimes there is a real specific, obscure fact that is not easily found in the literature or reference books but can be found on Google. Sometimes there will be commercial sites that have data that you can't easily find anywhere else short of a lot of hours in the library, which makes it prohibitive. There are many times specific scientific facts can be found and you have to look at it and judge the source after that and guess if you believe it or not. There are some weird little things that only Google can find.

Faculty believes that when a student discovers a journal article they want in SciFinder, the first thing to do is go to the UT catalogue and see if UT has it. If UT doesn't, they consult InterLibrary Loan, which can be done on the net and an application for it can be made. The last resort is to contact the journal publisher.

Another faculty member bookmarks the list of electronic holdings in the UT library and prints it out if necessary. Anything that can't be obtained that way goes in a stack of printed abstracts. Later they will go through the marked ones and get them through InterLibrary Loan or delivered by Library Express.

2.3.3.6. Strategies

One method undergraduate students use to judge the credibility of websites and web publishers is by the domain name, such as ".edu", ".gov", and ".org". They will also look at the site design. For example, if it is pink with flowers, they will not look at it seriously; if it is black and white with a lot of text, it is probably interesting.

Undergraduates are also aware that to search effectively for a certain topic, they need to have some type of information about that topic to make it easier to interpret the journal. Some journals have valuable information and make it a little bit easier for everybody to understand. For example, Scientific American is relatively easy for anyone to pick up and grasp a general knowledge about the subject. More technical ones such as Science publish very technical articles that are not nearly as pretty with photographs, but much more informative. Some journals give an overview of what is going on and some give the actual specifics of what they did and how they did it.

Undergraduates scan images, pictures, and charts in articles for illustration of concepts. The pictures usually include a simplified caption as an indicator of the content. They will use the caption as a clue to the relevance of the article.

Graduate students also scan articles first for value before printing; some will save a copy to CD for reference.

An alternative strategy the students are familiar with is InterLibrary Loan whereby photocopied article(s) can be received within a few days. The articles can be requested in two or three different formats, but not originals.

Another alternative is the periodicals room in the library which some graduate students do check frequently for current documents, but usually not specific articles. They thumb through three or four different journals to check new articles. The periodicals go back to around 1995-1996 and are bound in the stacks. Students feel they may find more current documents than what is found in the databases.

The Chemistry Department has its own collection of print journals that is fairly complete. They are not bound and go back farther than 1995 depending on the title. The Chemistry Department also circulates its subscription publications such as *Analytical Chemistry* to the faculty and students.

2.3.3.7. Suggestions for improvements

Graduate students believe 80-90% of the time relevant articles can be retrieved online unless it's a fairly new journal and the database hasn't been updated. However, you can request the system send a note when a particular author publishes on a particular keyword.

Graduate students suggested searches should be easily refined and they would like to see more multiple search engines such as Dogpile.

All students suggest the electronic systems should precede 1995 and everything should be available online. Some publications such as ACS are already working on it and the AAS have taken their journals back to the beginning in 1849.

Graduate and undergraduate students seem to believe they can identify an article as peer reviewed through familiarity with the publications, style in which it is written, etc., although an indicator on the article that it has been reviewed would be especially helpful for beginners. The students also perceive quality literature as being contained in databases, not particularly on the Internet.

All students believe the literature is not as adversarial as real-life. They noted that arguments and counter-arguments in different fields are important and they do not find it in the journal literature. It was noted that some articles anticipate criticism and alert readers upfront.

Comments were also made that even if material is controversial, it will be published and possibly collect comments under a "Letter to the Editor" or some sort of feedback mechanism. A downside is the time lag between publication of an article and publication of feedback, positive or negative. If the time lag is great, readers may have lost the specific article in question. They also believe editing could be better and more attempts made to have authors write more clearly and concisely.

2.3.3.8. Other

Although they are familiar with them, the graduate and undergraduate students in our focus groups do not use preprints or preprint databases. One student reviews them to increase his breadth of knowledge; however, if he finds any useful information in preprints, it is by accident.

Faculty repeatedly mentioned their concern that students need instant gratification and students want to obtain material as quickly as they can.

2.3.4. Variations in types of literature required for coursework and faculty recommendations of sources

This category mixes recommendations by faculty of specific sources plus different types of literature (patents vs. journals, etc.) that are used in classes. Some of the insights may be discipline specific or may also overlap with differences in grade level.

2.3.4.1. Undergraduate students

The literature required of undergraduates is generally limited to textbooks, what the professors photocopy and give them or make available on the professor's or class website for them to access, or are accessible through online reserves. The amount of literature is restricted due to the time constants of general coursework. Physics undergraduates also believe they do have enough knowledge to understand journal literature.

Undergraduates are occasionally assigned special projects that require research, locating information, references and writing a short paper. For example: one astronomy lecturer has a "recitation session" where they expect students to do independent research; in another course the lecturing professor meets and lectures the students 3 times a week, they have to do a lab session where the students are expected to do independent research on a given topic and write a short paper on what they found.

Undergraduates were asked about required readings in chemistry, physics and engineering. Their responses include textbooks, lab journals, chemistry magazines, fiction, and interpretations in chemistry class. In Engineering, they also receive specific handouts, such as details for design types.

Upper division undergraduates may be required to look up different journal articles, but they are usually for general information. For example, if they read a certain article it might help them better understand what they are doing. One engineering participant said the only magazines outside of journals that are required reading was in an E&M class. They were working on a problem that turned out to be something published in a journal in 1996 so they had to read the journal article to understand the problem.

Undergraduate use of databases is mostly of SciFinder and Web of Science. When faculty require Internet searching, they often provide the website. One student named stanford.edu as a good site. It will give research results; they are compiling a great encyclopedia; it has lots of information plus good quality academic links to more information about subjects.

2.3.4.1.A. Preferences

Undergraduate participants mentioned many specific favorite websites or search engines.

- Google was mentioned frequently as a favorite search engine although one undergraduate thought it was less appropriately influenced.
- One student used Dogpile for a paper and the professor made a note not to use it.

- Ultimate was named as a favorite because it has lots of windows and usually will give somewhere on the first page what you want.
- Another student prefers CubeFinder which lets you look up lots of information on all sorts of things like properties with links to useful health information.
- A physics student mentioned Copernicus; it compiles Google results with those of other leading search engines. It is not specific to a topic but all topics. It will also save results so you do not have to redo repetitive searches. This student was referred to Copernicus by a professor in Ecology and Evolutional Biology.
- In astronomy, udflow.com was recommended for a project on Einstein's papers, however, the student couldn't find anything.
- *Scientific American* (print) was favored because it has a "big picture perspective" unlike a journal article.

Undergraduates recognize that peer reviewed articles aren't always good; they are not always sure it is accurate. On the web, even if you find a fact in a hundred different places, if it is not from a journal, you can't be sure it is not a hundred people copying something they have seen somewhere else.

Undergraduates like to scan tables of contents in journals and magazines for their topics. They believe magazines are less technical but may have some good articles. For example, Scientific American has really "cool" articles and pictures, but are not recent. Another student wouldn't use *Scientific American* for research but subscribes because they like to read it. Some undergraduates also like to sit and leaf through print journals.

2.3.4.2. Graduate students

GTAs find they use journal articles, patents, and textbooks, rather than newspaper or magazine articles.

GTAs said they do look up things up in the library quite a bit. They are impressed that the library has journals over 100 years old. They were not so impressed when, as undergraduates, they were not allowed to use the university's InterLibrary loan service.

Some GTAs assign students to use web search engines and some do not.

2.3.4.3.A. Preferences

GTAs and undergraduates are directed to search engines by their professors.
Some GTAs and undergraduates had an open seminar class by SciFinder (1-1 ½ hrs.). It was a demonstration of capabilities, future prospects, what they are trying to do as a company, and what will be available in the future.

GTAs and undergraduates rely on publishers and aggregators such as Elsevier, IEEE journals on applications and physical science, *Physics Review* and ACS. The main journal for Physics is *Physics Review*. One GTA commented that the general research engines we have mentioned here such as Lycos, Google, etc., are very good for general topics, particularly outside their field, but they aren't as useful as they could be for details within the field.

- Google: One student had a technical report returned with notes to use Google for one thing. Professors in all 3 fields also recommend Google and SciFinder; for example, for a project on mass flow meter, the professor suggested using Google.
- SciFinder: One GTA was exposed to SciFinder as an undergraduate and still uses it.
- Ejournals: " … are great, call it up and print it out",
- Nature
- Science
- Inspec: It has a million abstracts that can be connected to an article.

Graduates use frequency of journal names found during searching as a way to recognize quality. Another GTA responded that they don't think anything they read is gospel just because it's in a journal. They take it all at face value and use their own judgment.

2.3.4.4. Peer Review

Graduates realize there is junk in journals. They mentioned a couple that are pretty bad, even though they have peer review. They feel if you give an article to some people that like you, your article will be accepted. If the editor selects the reviewer, then that article has a less likely chance of making it through, especially when they are anonymous and the reviewer can just tear it to pieces. Many times you will get better quality journals that way.

One GTA mentioned they have concerns about validity of web information. Once journal articles have been through the reviewing process, people that actually know a lot about the field have looked it over and it seems to be pretty sound. Some things on the web can be full of errors.

2.3.4.5. Preprints

Students are aware of preprints and although several graduates said they had used them, one remarked they haven't had any luck finding or opening any preprints. Through the discussion, the GTAs now know that preprints can be a combination of things that people may or may not be going to publish, things that may or may not be published, but have been written and are available for their use.

2.3.4.6. Faculty

2.3.4.6.A. Preferences

Although not required, faculty believe all students should be aware of society publications such as the American Chemical Society. The students might know the names of the societies but not the names of particular journals. Students also need to know the difference between news magazines such as *Newsweek* and journals. They do not understand "refereed".

Journal articles are seldom assigned. Even if students are looking for standards and patents, it does not mean they necessarily need journal articles. Sometimes they are encouraged to read journal articles if the professor thinks it's important for whatever reason.

Although asked for input regarding specific websites, indexes, and databases that faculty expected students to use, little particular information was given. One faculty member mentioned referring a physics particle data group site and some others for data, not journal articles. In physics, the faculty tend to use Medline, Scirus, Astrophysics Data System, and SciFinder. They found it hard to gauge use and do not know if they access them from home or the lab, but they are not in the library. Faculty felt everyone knew about Web of Science.

The library does bibliographic instruction classes to discuss specific resources such as Web of Science. The class content is usually dictated by a specific topic. For example, one class was about Science Direct online journals. The information contained in these classes is constrained by time; there is not much to be done in 50 min. or 30 min.

In response to a question about how faculty compile photocopies for classes, faculty state they use the library Reserves for old articles. One professor uses his own website and scans his notes to his webpage, which is password protected.

Faculty believe students use more electronic resources than in the past because of accessibility. There are more resources available and students don't have to come to the library. Before this wealth of information became available, students used the index. Full-text databases are the highest used compared to other general databases.

Faculty discussed the cycle of scientific literature; researching, writing, publishing and possibly obtaining a patent. It is important to show this to students. An engineering faculty member thought that for undergraduates, professors might explain it to them but they will discern this cycle more in journal article literature. In Chemistry Literature classes there may be 20 reserved books, and they would cover the cycle there.

Faculty questioned why we are focusing on journals; there are many other useful sources of information. Information given to students depends on their background and future plans, whether or not they plan to go to graduate school and what they plan to do after college.

Faculty believe students only look at journals after specific instruction for a specific assignment. Even if a paper is assigned, students will look at books first; journals must be specified.

Faculty also emphasized the preparative, highly specific character of journal articles. When they make an assignment in an undergraduate course it is necessary to give them a route into the paper by allowing them first to start with a simple encyclopedia. Then move from the encyclopedia to a more technical treatise, then perhaps from the treatise to a monograph, then review articles, and then into the article. This is a process that is not restricted to undergraduates. This is a process often done to ease a student into the background of the material and bring some clarification to the journal article so it becomes meaningful to students.

A faculty example: For a study on extra-solar planets, there is a webpage from the University of San Francisco, but the students need to get to the point where they begin to question themselves about how things are actually done. In many cases, it is at that point they are sent to the original literature. As to things being out of context, one can pick up the Astrophysical Journal and pick out an article and start reading. The Web is a great introducer and stimulus for wanting to go to original literature or preprints. Students might then be sent to the Los Alamos Preprint server (arXiv.org).

Faculty also mentioned Elsevier's search engine, Scirus, that focuses on original literature. It is more selective and the ultimate in search engines; the context part is probably the most important.

Physics, chemistry and other disciplines have "intermediate journals" or even newsletters that provide a semi-popular discussion of the research forefront in the various fields. The writing in them is brief, succinct, and meant to be relatively simple. Faculty do not have misgivings in referring students to this literature. For example, *Chemistry and Industry* was mentioned as a good intermediate journal as a gateway they will refer students to in order to give them a view, quicken their interest, and move them toward the research frontier.

In regards to when is it too soon and when is it too late to attempt to give students a view of the cutting edge of sciences, faculty discussed an essential aspect of undergraduate chemistry and physics literature, which is finding data. If they conduct a lab experiment and want students to compare measures with accepted values in literature, students have no idea how to proceed.

Faculty also think many students do not understand there is a library reference department. They believe that students do not know they can get help with a handbook, literature, tables of data, standard spectra collections, etc. For example, in chemistry, if they need the melting point of a compound, they don't know where to find it. Although much information is becoming available electronically, students need to know the basics.

Physics faculty believe handholding is necessary. Undergraduates will have a summer project where they spend 2 ½ months on a team of six students where only two people do the work. A student needs to be taught how to use the literature effectively. Time must be spent getting them started. After that, they can use the Astrophysics Data System (ADS), the search engine of choice of all professional astronomers, with full-text online.

Physics faculty also discussed that in terms of the core literature, particularly for what students need, ADS is far better than arXiv.org. Faculty believe that if a student is given a random article from their subspecialty journal, even then there is a good chance that if they read it once, there is only a certain portion they will understand upfront. They don't think students are going to be prepared to digest the whole thing no matter what it is, so they are usually asked to choose an article not as interesting and find two or three concepts imbedded in the article. Faculty do not necessarily expect students to understand the whole article but want them to find some things they do know, possibly something as simple as Ph adjustment or a simple spectroscopic tool. The idea is to find something in there they can use.

In chemistry, faculty also team and have students use the skills of using handbooks, secondary reference material and the Internet with projects. One class begins simply with the Library of Congress system, how one works in the library with particular emphasis on chemistry, and carries them through using search engines such as SciFinder. One chemistry faculty member described SciFinder as "magnificent".

Faculty commented that senior students say they wish they had had a resources course earlier. Faculty wish that the course or something similar – it can be a 1-hr. course in one semester – should be available to students when they select a major or shortly thereafter.

Physics faculty believe one thing missing in journal articles is that they are insufficient. People write a textbook and by the time it's published, it is out of date. Many things we find aren't in the journals or textbooks and they end up often in conference proceedings. Conference proceedings are difficult to find and disappear. For example, one paper published from China a year ago was unobtainable from the website; it was finally retrieved from arXiv.org. Also, some conference speakers do not write-up their presentations.

Some conferences and workshops are now on slides and the web, although sometimes scanned images are difficult to decipher. We have gotten, in some senses, beyond the journals themselves.

Peer-reviewed journals were mentioned in that people can submit articles to arXiv.org before they submit it to the journal. Theorists might submit their work to the preprint server, however, and never get it published or peer-reviewed. Faculty believe that although they spell this out carefully to students, it never occurs to students to check the validity of an article and they need to check. One student asked, "Wouldn't this make the author mad?" after seeing a faculty's commentary. He said, "You know, this is exactly how scientific truth and everything gets refined. We look at each other, peer review. We are not against this person but against what has been put right here which is scientifically irresponsible. We explain that we all have a responsibility to point out blatant mistakes, not typos, etc." One student was flabbergasted that there are mistakes, especially from institutions such as Carnegie Mellon, for example. Faculty also mentioned that critical reading of articles is the way the "literature filter" works.

Faculty discussed the Web as the "dot.com you take with a grain of salt". When it comes out of a university, it is usually attached to someone and you can find out the quality. There are ways of determining who is responsible for a website, and if it makes sense.

Faculty believe that digital technology and search engines are wonderful. There is enormous power in doing specific things, getting them quickly, and getting stuff from all over the globe. One faculty member said faculty tend to be idiosyncratic and like the library and serendipitous discoveries made by scanning shelves, picking up journals and actually finding an article that was interesting that you weren't looking for.

Faculty believe that databases will probably not combine with web systems and students will be searching full-text databases only and using things like SciFinder less. They also think databases will all move to full-text sources.

Faculty would like to search through .pdf pages and pull out the text.

Faculty have to be the instigator for students to do certain things, otherwise, students will not do them.

2.3.5. Problems with understanding journals, accessing information, or other problems described with students in the information access process

2.3.5.1. Undergraduate students

Undergraduates do not understand keyword searching. In physics, for example, an assignment was to search for information on Einstein's work but they just found junk, another search honed in on scientific papers.

In a discussion on instruction on finding the topic, an undergraduate mentioned that in one of their chemistry classes they were required to find information someplace else to help understand what was going on. There was lots of information that was not explicitly covered but students were expected to know. The professor actually directed the class to, "Go find this particular book in the Library".

Undergraduates commented that there is a problem if a student doesn't know to use scientific specific search engines. There is a lot of quackery and there are a million and one people who think they have found the thing to replace general relativity. They believe that there is so much bogus information on the web because you don't have to go through a publisher to put anything on the web.

Another problem concerns the scholarly language of journals, which is difficult for undergraduates to interpret. It is also difficult for them to understand the use of unexplained acronyms in some journals. One undergraduate was reading an article about gamma-ray boosters. The theory concerned when an interstellar medium falls onto a neutron star, causing it to heat up. The article talked about ISM-this and ISM-that, but never explained the meaning of "ISM". The student was halfway through the article before realizing that "ISM" means "interstellar medium".

Undergraduates also mentioned that searching online can be painful if there is a slow dial-up connection. If that is compounded by using a generalized search engine, it can be time consuming and frustrating.

A question was asked if undergraduates have had a class in how to use library resources, possibly in an English class. Answers included no, not even in high school; engineering hasn't required any at this point plus the student has no clue how to use the resources; there is no one to walk a student through the resources, they have to just go in and figure it out, such as keywords and combining keywords. It can be tough. Another student said it really relates to the teacher; some of the teachers try to help you get familiar with the library, knowing that you are going to use it. An additional comment was that in an English class they were given a short library tour to learn how to do research, which helped as far as learning where the journals and textbooks were, but you still have to do it on your own a little bit until it makes sense.

Some of the undergraduates had a physical tour because the machines were on the blink and some did the web tutorial (about a year ago). The ones who did the web tutorial do not remember anything about it. Another student said they did the web tutorial but when they had to look up something on their own, it didn't make sense. A positive comment was that the main library website is much easier to navigate than the library catalogue.

Undergraduates suggested that the search engines need to be simplified because of their mindset of, "If I can't find it 30 seconds, it's not worth finding."

2.3.5.2. Graduate students

Several graduate students said they enjoy using the library. One student doesn't care for handbooks and the like; they think if you ask the right person, you can find the answer in 10 seconds. Without a clue as to where to find it, answers can take hours. Another graduate enjoys looking things up in the library, especially the journals over 100 years old. As an undergraduate, this student went to the downtown library where the librarians were very courteous and helpful and helped them find obscure items. They had not tried it as a graduate student.

Electronic access is also easier because most of the major periodicals and mainline scientific journals now have online versions. Students recognize some online journals are of dubious quality but there are dubious print ones also.

Usage of web directories by both groups of students, possibly through Yahoo or Google, is hindered by a lack of knowledge about appropriate keywords and categories to examine. They feel it is difficult to figure out what someone else is thinking.

Because of keyword and category difficulties, students can look up articles in the periodical room in a relatively short time, whereas it can be more difficult to try and find articles on the Internet. Students suppose this is contrary to the idea of what the Internet is for, but not contrary to researchers. Some students were raised on the Library of Congress system and have a fairly high degree of familiarity with the library, so it can be easier to find articles there than by using search engines. Students can be hindered by all the meaningless, miscellaneous, and extraneous information on the Internet. One great advantage to the library is the absence of frequent pop-up advertising.

Another GTA noted that it is frustrating when the abstracts are written with scripts and superscripts that are hard to read. Another comment observed that conference proceedings can be difficult to find online.

Another GTA believed that poorly written articles are a serious problem. They have encountered times when the professors, experts in the field, do not understand what an article is talking about because it's vague or poorly written. The student thinks it's very important for an article to be edited before communicated. Last semester they were working on a final project and the professor gave them an article that no one in the group, including the professor, could understand. These students think the quality of writing is very important in scientific literature.

2.3.5.3. Peer Review

All students say they believe the peer review process is important (although not all undergraduates, particularly in engineering, seemed to understand what it is). Searching on the Internet will uncover many people who cannot be convinced they are wrong -- they are right for 30 years about some crazy theory in left field that doesn't have a chance of being correct. Yahoo was mentioned as having this failing, although the pages look nice, the content can be dubious.

All students mentioned that *Scientific American* is a basic layman's journal but the Letters to the Editor are published a month or two after the article. If you've lost your journal, you can't find the specific articles and you have problems.

2.3.5.4. Preprints

In physics, graduate students were not familiar with eprint services. When asked about usage of preprints, one graduate student said they happened to find a preprint article but didn't know how they found it and didn't think they could find it again.

One mentioned that in Science Direct there are articles in press and you can look at them in the ACS journals. These are articles in galley proofs or articles that don't have a page number yet. One student reviews them to increase his breadth of knowledge. If they find a useful article now and then, it's by chance.

2.3.5.5. Search engines

In search engines, GTAs also mentioned problems where authors are listed by last name and one or two initials. Sometimes there is some ambiguity about whether they are the same author. Maybe a first name would help. Another student mentioned the engines cull them together and put on their own headings. Pop-up ads come up now.

Another GTA said they used Lycos but thought search engines are all getting to be the same. They felt an individual could get two or three things through one search engine but they point somewhere else. You get two or three choices in a line, then a few more other things. They are not straightforward anymore like they used to be.

In response to a question about general web search engines aspects that are difficult, the GTAs and undergraduates first mentioned pop-up ads as aggravating; then sites that are out of date, gone or really not relevant. They don't like to waste time chasing dead ends. Students suggested it would be useful if sites and pages were dated when they are posted; it isn't clear if it was 1982 or 1994 because most dates are not obvious. It would also be useful to know when the site was last accessed, updated or put in the database.

2.3.5.6. Faculty

Faculty discussed that when they ask a student to search for something, the student may put in one word and out comes a hundred items. It tends to be discouraging. Pages have so much information that students don't know what to do. Students don't know how to use them or they use them in different ways. Perhaps a pop-up Help function would be beneficial -- something to help them and tell them how to search, but tell them in a useful manner such as suggesting a certain method. A pop-up help option could also help develop critical thinking. (Push it toward their eyes so they can see it.) One faculty does check the "Help" option to see what is there.

Faculty also believe students have problems with literature because a lot of it is just over their heads. They don't have the background to absorb what is published in a journal.

Faculty commented that students need to at least be able to get to a journal title, with an assignment such as find volume so-and-so, page so-and-so. Then the system could give them the link of that journal title so they are able to navigate the site and retrieve the article. That may be where we are headed.

Faculty believe students have lost enough of their physical perspective because everything is the same. They don't know the difference between the catalogue and the databases because it's all on the computer -- all on the Web -- and they don't know the difference because they have not seen it physically. Another faculty member responded that surfing the web and making them go through all that stuff is not necessarily critical thinking, it is just information gathering.

The library is looking at databases like Gale who have a static URL (Infomark). When it is difficult to get to the article level, getting to the title level is helpful. The library is getting some gentle pressure to try to help instructors to create webpages for these types of links. Faculty thought it would be interesting when students get to the title element that they are still going to have to search and get into the volume, issue, and page number. The library is implementing SFX, which will go directly to the title level.

Even faculty realize there is no telling where a search will end up. A searcher will be in a database, link, and suddenly be in a catalog, or suddenly in annual reviews. They may have started in the Web of Science, but do not know where they are now. (Meanwhile, they are tying up ten simultaneous users on Web of Science, for example.)

Faculty also noted that another big issue with the advent of the Internet is that students think when they search and type a word or phrase into the search engine and retrieve information, the information is true and complete.

A problem when freshmen are asked to write a paper and explore options such as reading a book is that they cannot because they don't understand the library. For example, an honors students said, "Where can I find the book?" The amount of ignorance, particularly of students coming from small, unsophisticated backgrounds, is high.

One of the dangers today is that students are not going to like assignments that require going to the library. One colleague has been here about three years as a faculty member and apparently hasn't set foot in the library yet.

2.3.5.7. Other

Faculty also discussed that one of the things ignored in science education is professional or intellectual skill development. Chemistry and physics students have to see certain chemical or physical reactions. Students are expected to develop skills such as literature searching, ability to read, bibliographic skills, etc. magically, or they are sent to the reference library to be taught. Faculty believe it is possible within the context of an education to actually build these skills into the curriculum, so that by the time they finish a 4-year degree they can actually have entry-level skills for an industrial or graduate program.

Faculty commented that in Humanities, for example, you have to have required English courses. Perhaps it might be important to have an information literacy course like that for the scientists when they come in. Faculty further commented that when you marginalize information literacy, students do not realize it is something important. It should be built into every course and reinforced in every course. Reading skills are built into every course along with writing, computational and speaking skills. Information literacy should be combined with those efforts.

Faculty believe a major effort needs to be made to identify the deficiency students have in doing these things. The fact is that no systematic development of information literacy is in place. They get a scrap here, a scrap there. Faculty try tiny bits in some courses, but it is heterogeneous with no homogeneous, dedicated effort to make information literacy a part of the discipline. Being optimistic, if the professionals in various fields are made aware, it is going to have some effect. One faculty member feels it would be a wonderful thing for a student to come into a junior course when he is beginning the advanced part of study, knowing how to get into the literature without the instructor having to make this terrible effort to introduce them personally.

Library faculty gave an example of teaching an Introduction to the Library class the third class meeting of a semester. Eight weeks later the class received an assignment and didn't remember anything from the Introduction class. The library faculty did not have the power to give them a test, but pointed out that if you are going to talk about tools and process, there also needs to be constant reinforcement. With many library assignments, the librarian ends up doing the assignments, and the student doesn't really learn the skills.

Faculty discussed technical papers and student understanding. All agreed that technical papers are designed for people to publish, not for graduate students to learn because they are too difficult.

Online physics and chemistry literature is not trusted due to perceived low quality. There was a discussion about whether there is a way to add a qualification as to the reliability of a journal, however, it doesn't seem possible.

Faculty observed that it is an important part of a graduate student's education to get them to the point where they can judge quality. Whether by having them write a review article, having them write the first chapter of what they hope will be their dissertation, giving them introductory material to review or criticize, or showing them what has preceded the cutting edge, etc., this is an important skill.

Faculty did not think the entire corpus of literature would ever be put online in full-text, but specialized databases will become larger and go to full-text. They also believe publishers will merge.

Faculty also noted that one of the dangers of the student tendency to only use easy full-text database searching, is that these sources only access those materials that are available in full-text. There is information which is not available in full-text computer databases and never will be. It would be economically prohibitive to digitize everything and some information is not that important.

Chemistry faculty suspect the bottom line is that a student must know how to get the full-text literature regardless of where it is. A student must know how to get into the stacks and use old library procedures. Maybe sometime in the future, things are going to be more broadly available as full-text on the Internet, but then you are going to have the likelihood of going to more and more obscure journals, which is probably not going to pay to put full-text on the Internet. For example, if a student needs something from the obscure journals that Elsevier terminated 15 years ago or a journal that only had a life of five or six years, they need to know how to use the stacks.

Faculty also mentioned that in terms of library participation, many times the library's purchase of electronic journals is through a consortium or something like that but the faculty and students do not know that -- they think it's free on the web.

There was a discussion about two basic searches: one is browsing to keep up with literature and the other is the indepth search. Browsing is more what web search engines deal with and the indepth search is what traditional online databases deal with.

Faculty were asked about the issue of indepth searching. In terms of the browsing kind of searching, did they think that the term "Periodical Room" will continue to be important within the library environment or did they think they would ultimately go, within the next few years, to strictly browsing online?

Responses were that this is another version of the full-text discussion. As long as the full-text is not available on the net, yes, the Periodical Room is going to be important, even though the students are going to develop a reluctance to go there. Another faculty member said the periodicals room would go because the journals you browse are not the obscure ones that are hard to find, it is the mainstream journals that are probably already available electronically. Faculty and students bookmark three or four journal titles and they also use email alerts.

Faculty also believe information overload might come from these search processes: part of critical thinking is to know how to restrict and filter information.

Other comments included that there is an eclectic set of interests and strange things on the Internet. For example, one person found three different places to go to get *Shakespeare Quarterly Online* depending on the dates.

2.3.5.8. Suggestions for improvements

Faculty had several ideas for improving general web search engines. First, make sure students understand no search engine is complete and if they are looking for a generalized topic, don't stop with just one. One faculty member has a rule to always ask students to use at least three search engines when looking for any topic.

Search engines should have automatic stemming. One faculty member recalled when UT first implemented the Current Contents database, students would put in *polymer* but they would miss everything like *polys, polymeric*. Add an automatic stemming feature, so if a person does not think they retrieved enough, there would be an option to stem some of the words to possibly increase search response. The thesaurus might have that capability.

Another suggestion is having students look at the way a search engine operates, how it uses parentheses, quotation marks, how entries are made, which is as difficult as getting them to read the introductions to their textbooks. They are likely to miss a great deal if they don't understand how to enter a variety of things, such as how you put in the Boolean operators, how you *and* and *or*, how you ensure an exact phrase is entered correctly, and many other options of that sort.

A discussion of whether or not students understand what the strengths and weaknesses are of these systems elicited the comment: "No, probably due to the disadvantage of search engines in that it is easy to get something. The kinds of strategies one had to use before computerized data in searching things, the logical and mental strategies – don't have to be used anymore. It's kind of like before the pocket calculator and problem solving strategies. When you were a student, there were certain things you had to do because the arithmetic was hard. To survive you had to do things like reduce things to their simplest form and do conventional analysis. You had to do powers of ten because the actual calculation was either a laborious pencil and paper thing or a slide rule calculation. It was preset. The same is true of library searches. You had to know what you were doing to get anything so you got better. Now you can type *something* in and get *something*. Perhaps what you want or perhaps something of questionable validity. But its there and if you're not critical, then you get garbage."

2.3.6. Purposes for which they use information or journal articles

2.3.6.1. Graduate students

Chemistry graduate students said that during the first half of a course, the instructor assigned searches to them and the last half they were doing them on their own. The searches were discussed in class and focused on using journals, mainly spectroscopy and analytical chemistry.

Graduate students think professors want them to start not from someone else's website, but from journals or actual text from a website from a large company. Faculty prefer students get information from journals.

2.3.6.2. Faculty

Faculty noted that unless they are teaching a core course, 15 years ago they stopped giving examinations in non-core technical courses. Students are graded on "weight and sweat". Typically, they are given a project that is due mid-term. Students must have faculty approval for the project to make sure it is relevant to the class, then they write a paper and give a talk. At the term level they can either expand on what they did or start something new. Then they do a major paper, talk for a longer duration, or that sort of thing.

Another faculty member noted that this term he is trying something new and bizarre. This faculty member is doing cosmology, which he doesn't really like or understand, so he is having a symposium in a few weeks on general relativity. The class chose a topic and wants the entire department invited. Although the professor thinks it is disingenuous to invite everyone to something when they do not know what they are talking about, the class is excited.

Another professor has developed a series of projects. The students simply take these projects plus a bit of introductory lecture. They take the projects into the library, use the computer, and they answer all kinds of things. Faculty believe something of this type would work in all classes if students were offered an hour credit for doing it, and if the department would require it.

Faculty also played the devil's advocate in discussions. There are so many things required of students now, devoting that much time to information projects may not be practical. Students should view the ability to search as part of the necessary tools to get a Bachelors Degree in Science Engineering, just like using a computer, whether or not it is a Microsoft or computational kind of platform. To devote a course to teach an element of how to do that may not be practical. Students should be able to pick this up with enough information given by faculty to learn it on their own. By requiring in certain courses that students shall provide certain information that is only available by going out to search, students will do it or, if they don't, they will get an F. What is more important than not getting an F? This should be treated as a tool. When they have to learn it, they will.

Not all faculty agree with this view, and instead commented that students will not learn it when they have to – some faculty members are not adept at searching, nor do they know how to get into literature of their own theses topic.

Another professor agrees and disagrees. He believes in integrating information searching into the curriculum rather than as separate courses. Faculty have come to conceive of teaching in a slightly different way over the years. This is where scientists and engineers again fail in that they tend to think of courses as being contents. An education consists of at least five parts, only one part of which is content. Another is process, the kind of intellectual skills. There are tools, and what "we are talking about here is both process and tool areas." Teaching students how to use tools is part of what we do. Somehow we haven't brought this literature stuff into being one of the tools as context. All courses have context. There is a vague notion of "way of being" which has to do with, "How does a chemist think differently from a physicist?" How in fact does the profession approach what it does?

Faculty also commented that when you think of a course, you say, I'm teaching Organic Chemistry or Inorganic Chemistry. You think of some content that the student is going to learn. We tend not to think about the processes, except peripherally.

One faculty member commented that, "We are all doomed with the utter volume of content we want to communicate and bring across to the students. This utopian idea of education, which they love, is wonderful, but when you push most of us to these four other aspects, our content overwhelms us and we say, Good heavens, we are five lectures behind! Are we going to assign nine chapters in the last week? We can't possibly get through this course without teaching this really deep thing, which happens to be my specialty."

Faculty say searching depends on the keywords. If a searcher misses a keyword, the results are gone. "It's a matter of luck. Look at a few and see what's in there. Maybe you can pick up some keywords other people use and try to use them. It might be more useful if they could provide things like whether the search is missing, whether those are similar words."

SciFinder is a favorite because it retrieves good information with minimal stress on keywords and does not take issue with misspellings. Faculty also noted that it is important to remember that SciFinder has the American Chemical Society and all its financial resources behind it. Google has to be somewhat self-sustaining.

Faculty discussed what happens when students get out into the national labs and industry - where are these people going to work? One guessed that the quality of searching is going to be much more important than the speed and the time restraints. The question then becomes one of, are they willing to be prepared to get into that environment? That's what the educational process is all about.

Faculty also discussed economics as an interesting question because one of the things about print journals or books is that once they came into the Library, they were part of the "Commonwealth". As things become more digital, they become more expensive and they become more proprietary. That's a broader philosophical and policy question about who owns information or who should own information. One faculty member felt: "It is scary that information becomes increasingly proprietary. The idea that the library is a Commonwealth of information for people when they walk in the doors is decreasing. Somebody is going to make money – Bill Gates or somebody."

2.3.7. Discussions by scientists at a national laboratory

Note: Due to the nature of this particular focus group, the format of this analysis differs from Sections 2.3.1.-2.3.6. Part of this difference in focus may have to do with the nature of the questions asked and direction of discussion in the focus groups. (See individual transcript analyses).

2.3.7.1. Introduction to journals

The scientists felt that student interaction with journals usually begins when they start work on their thesis, because that is the point when the student must use journal literature. Also, in most universities, the best place to study is always the library, which happens to be where the journals are located.

Some scientists were exposed to journal literature as undergraduates through a one-credit introductory class to library science. In their senior year, they had to give a research seminar.

One scientist remembered a professor who used 1950 physics articles considered useful to "stump" everyone. Journals were very daunting because the literature assumed the student was an Einstein to read and understand them. They used equations such as, "It follows from here that … and such and such."

Another scientist felt there was a paradigm shift. They did not have much exposure as an undergraduate, but as a graduate student focusing on a specific subject (as opposed to a broad, remedial base of information), they made a self-imposed "Journal Day" and spent one entire day in the library locating chemical and physical abstracts, writing down the numbers, and looking up articles of interest. It took approximately an hour for someone behind the desk to retrieve the articles and books only to find out they were not relevant. During the 1970's, for $.05 per page, they "Xeroxed" the pages over 4-5 hours. They feel that now even undergraduates can use Google effectively to find research articles and print them out within 30 seconds. Although the process is similar intellectually, it is so much easier that it's revolutionary. These scientists feel current graduates take to [journal literature] like fish to water.

A problem associated with the point of introduction of journal literature to students concerns the, "Student's lack of recognition of research articles dated prior to 1990; to them they never existed. They will not go back and review the great organic chemistry done in the 1950's and 1960's, which might be available only in print. They have never done that before; they have always sat at a computer. They wouldn't look up something in Chem Ed abstracts if you paid them. They've never done it before and nobody ever told them how. They just know they can sit down and type a few keywords and it is instantaneously done for them. If you have to go down the hall, that is work!"

Scientists feel in some cases journal requirements vary by discipline and sometimes there is no need to look at information older than 3-5 years back. There are, of course, exceptions such as the first article on artificial intelligence. In chemistry, some graduate classes are studying research from 1956 because that is the best way to do it.

2.3.7.2. Print journals

2.3.7.2.A. Advantages and disadvantages

Overall, these scientists say they prefer print journals as their favorite mode of reading. They rely on their company library and do not like reading journals electronically, citing feelings of being "chained to a computer". They prefer to sit down at night with a journal, review the Table of Contents, and locate material to read at their leisure.

Scientists believe it is very important to maintain print journals because of the depth of research available in them that is not available in electronic versions. In addition to the date range and omissions of important information, research progresses in cycles. Some current projects such as space reactors, MHTGR reactions, and gas cold reactors are based in historical data from 10-20 years ago. The availability of older journals is very important for printing considerations also. There is a retrospective consideration that is very important that can be accessed in print but not electronic.

The major disadvantage of print journals is access. Subscriptions are too expensive. If scientists do receive a print journal it is part of a membership to a professional society; they do not maintain personal subscriptions. For example, an organic chemist will receive the Journal of Organic Chemistry as part of his/her membership in the American Chemical Society; otherwise, they would have to rely on the library. This group stated they are not aware of anyone in their building who personally subscribes to print journals.

2.3.7.3. Electronic journals

2.3.7.3.A. Advantages and disadvantages

The scientists in this focus group believe one main advantage of electronic journals is that an article in an electronic journal will be highly cited which is advantageous for the author and for reference.

Also, an organization like the APS is funded to archive issues going back to Issue 1, Page 1. The scientists know the archives are linked to the actual article so they can be printed.

Another advantage of electronic articles is the high retrieval factor. If a hard copy is made of an article and put away, the chances of locating it can be minimal, but with electronic, it will still be in the system. They feel bound compilations of journals in libraries do not print well, but electronic does.

Scientists see a plus in electronic format is the ability to post PowerPoint presentations instead of using overheads. They feel presentations look good when a picture or article from another journal is used. The quality is much better than scanning or hard copy.

The scientists use electronic journals frequently but did not quantify with a time estimate.

A chemist discussed the ability to transform chemicals such as chlorine, bromine and iodine different ways using the resources. They used to spend 3-4 days searching through journals and information but now can input a structure and ask, "Give me something that contains this, or looks something like that" and will retrieve a thousand suggestions. They can scroll through those thousand structures in 15 minutes to determine what they need. It may cost more but it saves a week's worth of library work.

One major disadvantages discussed is the unavailability of "all" journal literature electronically although some is just becoming available online such as ChemAbstracts and Elsevier Journals. Older research may not be available electronically. The scientists like to browse and skim historical articles; their interests are wide-ranging and they see electronic searches as difficult, particularly when browsing.

The participants discussed the fallacy of the accessibility of electronic journals. The libraries are dropping not only the hard copies, but also electronic versions due to confusion over packaging and high cost. Some companies package many journals into a single product. The journal that evolved from hard copy to an electronic version may not be available because of the cost increase.

Some products are discounted in the electronic-only package and, in some cases; there is an added fee to have both the electronic and the print version. Sometimes a facility will buy the print version but not have the extra money to purchase the electronic version. Publishers are still changing their model on pricing. A company will periodically check with the researchers and verify which journals are used, preferred and whether specific divisions will share the cost.

Another pricing difference concerns page charges. The American Nuclear Society has page charges and even pursues people to pay their bill. Problems include, "My project is finished, I published the paper and my grant has ended. I don't have any money." If all of the journals had page charges, it would probably work; however, because page charges are inconsistent between vendors and people resist paying them.

The evolution of journals has mirrored the expansion of scientific interests into many disciplines. It has been noted that in universities, scientists tend to follow a particular line of research over a long period of time. Journals have evolved in tandem with research in numerous fields. For example, one scientist began as an organic chemist but his projects have now moved into polymer chemistry because that is where there is opportunity.

Another problem with electronic journals is omitted content. For example, if a scientist writes an article for Physical Review with extensive tables, the publisher will encourage them to include tables in the electronic version but not the print version. The print version may be less expensive but will be incomplete. In a society journal there may be articles that are 400 pages long. The publisher may tell the author he/she may have only 30 pages, so they submit 30 pages to the journal with 370 pages as "Supplementary Material" in the electronic version. The journal may make note of this but not explain it thoroughly, such as, "We don't have the money so we are not buying the electronic version." The scientists believed this short-changing was unacceptable. The American Chemical Society has done this for a while; directions to order supplemental material are available on the masthead.

2.3.7.3.B. Virtual journals

Since the trend of number of articles per journal is increasing, online searching in electronic journals now means scientists have access to a progressively larger number of journals. For example, in the 1970's, scientists read 10-13 journals, but currently it is over 20.

One great advantage of virtual journals is the combining of articles, for example, The Virtual Journal of Nanotechnology combines 15+ journals together. The participants strongly felt articles have been found that never would have been looked at before.

Further discussion included how an editor from a discipline community chooses articles from a number of journals and makes concise linkings of all of them. For example, the American Physics Society has several on nanotechnology and things of this nature. The links bring in articles within the journal families that have the right to cross.

2.3.7.3.C. Search engines

Scientists use Google for searching, but prefer discipline-specific databases such as Chem Abstracts for scientific information believing "you are only as good as the coverage of that search engine and how good it does. If you miss a key article you could waste a year in the lab on something that has already been done."

Although they feel Google retrieves too many worthless items, it can find obscure articles such as those from Nuclear Instruments and Methods that may not be indexed in other search engines.

The computer science scientists learn about nuclear jets and current events and projects by networking at conferences, workshops, and through the grapevine. They liken this approach to using Google feeling that most of the time they are lucky and locate what they need quickly. Google can retrieve the name of a project, research index, or citation and point them to the correct place in the library for electronic copies.

2.3.7.3.D. Preprint services

These scientists are very familiar with preprint services such as DOE PrePrint and the Los Alamos Labs systems and use them frequently because they want timely advantages to learn new ideas.

Some did not feel the peer review issue is important for them. The scientists feel the articles have been reviewed indepth prior to being published, they have confidence in their professional knowledge, and feel they can determine what is right and what is wrong. The preprint service reflects serious work, authorship and reputation.

One scientist is the Chair of the Fuel Division of the American Chemical Society where everyone produces preprints. Their publications are going electronic because it is very expensive to publish. The group discussed discontinuing preprints but the majority of opinion was that everyone appreciates them, especially people in the industry. They feel they can publish great data easily, and it's not refereed so they don't have to go through all the internal hoops and patent clearances. They feel preprints offer information they would not know about otherwise. This particular industry is going in new directions, fuel cells, for example, with many small companies now starting to publish information. Preprints are an excellent way to stay abreast of developments.

In contrast, people in academia do not like preprints because they feel an unrefereed publication gives them no credit and precludes them from publishing in journals.

The scientists also discussed the overall scientific communication process where university scientists author approximately 76% of science articles, but around 70% of the readers are in industry. Since a majority of scientists are in industry or outside of universities, it does seem preprints offer an opportunity to improve communication for those readers.

One scientist felt the internal review process was poor for preprint articles, much more so than someone who is sitting right next to you who gets a journal article. He is going to review it more carefully than internal reviewers.

Authorship is an important factor in preprint credibility. Some scientists believe you can determine whether or not it's good by the author name. When these scientists submit a preprint, they are very aware their scientific reputation and career are represented by their name.

2.3.7.3.E. Review journals

Review journals were highly praised as being very useful. These scientists believe the importance of review journals is increasing along with those scientists' tendencies to jump fields. In that event, they need a few good review articles, links and references to prime themselves so they can speak knowledgeably. Surveys have shown interest and usage has increased greatly.

2.3.7.4. Electronic journal features

2.3.7.4.A. Browsing

The scientists feel that because they are interested in so many areas, electronic sites or virtual journals that index articles by topic are very useful. They feel it is a kind of "browsing" when a range of different journals linked electronically.

Older research may not be available electronically and the scientists like to browse and skim older historical articles. Their interests are wide-ranging and see electronic searches as difficult, particularly when browsing.

One feeling is that article titles do not accurately reflect article content. However, skimming and browsing electronic journals can be very serendipitous. An example is a chemist who found a solution to a problem he had been working on for a long time and found a relevant article by skimming through an electronic journal.

The new virtual journals collect articles from a range of different journals and link them all electronically so browsing many journals in one place is simulated. However, some scientists still prefer print to browse.

2.3.7.4.B. Graphics

Scientists like pictures that reflect article content believing they can be good indicators of interest. However, pictures and images take up space, which can make them slow to download and take up screen space. Some feel scientific information should be simple, downloadable in black-and-white.

Also, today's graphic quality has greatly improved in color and pictorial quality. The pictures are smaller, more descriptive and look better. The downside is sometimes the pictures are so "artsy" they are difficult to print. Scientists want specific, black-and-white research articles that are easy to download.

The participants noted many electronic journals are in .pdf format, which can be difficult to read. They thought perhaps the format is supposed to make the page look like a print journal.

They also discussed the trend today of posting PowerPoint presentations, instead of overheads, which can be found on the Web. They feel electronic graphics are very beneficial in enhancing presentations visually and the quality is much higher than scanning or hard copy.

2.3.7.4.C. Other

A favorite tool of these scientists is Citations although the ISI citations databases are very expensive. For example, a single citation can cost $1.50 to print out. If they want to research a person's participation in a particular area, they should have cited a certain paper but by checking the paper, they can find out.

A few participants used alert services. One uses Current Contents with weekly searches emailed with abstracts in 2-3 different areas. They find it is useful in keeping up with projects from diverse areas without overlap.

In reference to multi-discipline work, the scientists appreciate electronic books and pamphlets from different fields. They also believe electronic glossaries and dictionaries for different fields are very useful for reference.

2.3.7.4.D. Predictions

These scientists believe that print and electronic journals will exist side-by-side in complementary fashion in the future with forthcoming differences. The library has taken on a new meaning and expanded capacity by holding both hard copy and electronic.

The topic of whether or not scholarly journals will be replaced by author websites and archives was raised. Participants felt that would never happen because of the lack of peer review. (It is interesting to note that this somewhat contradicts their earlier discussion of peer review.)

Scientists in a government laboratory need journals to concentrate on discipline or industry specialties, yet follow specific lines of research. One scientist said, "When I started out I was working as an organic chemist and almost all my projects have moved into polymer chemistry now. Why? There is opportunity there."

Another scientist discussed the evolution of journals. "When I started in atomic physics, atomic collision physics sounded quite big and Physical Review Society is dominated by things that did not exist long ago, so the journals themselves sort of evolved in reflection of the submissions obviously. Journals change over time as well. You can use the same journals even if you switch fields."

2.3.7.5. Conclusions

Economics are a major consideration of electronic journal literature. The faculty and scientist focus group participants believe personal journal subscriptions are too expensive for individuals to bear. Their journal access is either through professional society membership benefits or through their business place library. Additional economic issues include print costs, and changing database and electronic journal subscriptions.

One substantial difference between faculty and scientists were the frames of reference from which they spoke. Faculty comments and opinions were focused on access issues such as search engines, search keywords and print journals. Scientists referred more to the content of the journals, print or electronic, such as peer review, referred journals, and how journal content evolves along with the discipline(s).

The scientists prefer to browse select print journals in an "orderly" routine. The journals reflect their discipline and "industry". That orderly approach also applies to electronic journals they browse through virtual journals, citations, Table of Contents, and databases.

Scientists are conscious of the peer-review and referee processes and consider them valuable and necessary to establish author and research credibility. However, they assign more value to preprints than faculty members. A scientist said, "I think you can determine by whom it comes from whether or not it's good. When I put out a preprint, my name is on it and it's my scientific reputation and career, I am going to put out a good product, which I think is honest and truthful."

The scientists were introduced to journal literature in undergraduate school by attending a one-time class in the university library about journal literature and being assigned small papers to research and write out, for the most part when they had declared majors. This echoed faculty comments that they followed the same pattern in teaching their students.

Both the faculty and scientists groups agree that undergraduate students should receive an introduction to scholarly literature carefully early in their academic careers, most likely when a student declares a major. The introduction should be individualized, perhaps on a specific topic pertinent to the student's interests as opposed to a class topic, to increase the student motivation. Students should be required to use the journal literature for reinforcement and skills development, otherwise, they will not do it.

The scientists also discussed using a large variety of electronic journal resources, for example, " That is the electronic books and pamphlets, for example, in different fields are useful and also the glossaries and dictionaries for different fields are good to refer to if they are in the library in electronic form, that's very good." Faculty appeared to concentrate on discipline-specific journals and discipline-specific search engines for their resources.

3. Questionnaires

Each focus group concluded with a questionnaire to enable us to gather more specific information about each attendee's use of journal articles and preferences for information retrieval system features. The round one focus group questionnaire concentrated on reading patterns and use, while the round two questionnaire concentrated on specific aspects of digital systems and user preferences.

Care must be used in comparing the analysis here with others and generally because the focus group participants were not selected randomly, but were selected purposefully as participants who would likely contribute valuable insights to discussions. Also, the small number of participants means that they cannot be considered totally typical of university scientists and students.

The two distinct questionnaires are reproduced in Appendix 3. Analysis of the results from each follows.

3.1 Questionnaire 1 Analysis: Scholarly article use

Faculty, 11 respondents
Graduate Assistants, 4 respondents

The first questionnaire administered to faculty and graduate students asked them about their reading of scholarly journals in general and awareness of various electronic alternatives. This questionnaire is a subset of a questionnaire used in many surveys of reading patterns by Tenopir & King.

Table 3.1.1. – Average number of articles read in the past month (30 days), various sources

	Faculty	Graduate Assistants
Scholarly or Professional Journals	26.7	18.5
Non-Technical Trade Journals	27.5	3.75
Scholarly or Professional Books	6.6	5.75
External Reports/Formal Documents	8.2	1.25
Electronic Documents	12.7	10.5
Other	0.3	0.75
Total	82	40.5

The amount of reading from all sources varies widely between faculty and graduate assistants, but both groups report they rely on a variety of sources for information. On average, faculty report they read much more than the amount reported by graduate assistants

Table 3.1.2. –Source of last article read

	Faculty		Graduate Assistants	
	Percentage	Frequency	Percentage	Frequency
Journal, Print	36.4%	4	50.0%	2
Journal, Electronic	54.5%	6	50.0%	2
Author's Web Site				
Paper PrePRINT				
Digital E-print Archive				
Other	9.1%	1		

Graduate assistants were evenly divided on the source of the last article read – with half citing a print journal as the source and half citing an electronic journal as the source. Over half of faculty, however, cited an electronic journal as the source of the last article read; 36.4% cited a print journal and 9.1% cited some other source. When asked how many articles they read from the same source in the last year, faculty read an average of 23.2 articles and graduate assistants read an average of 25 articles.

All of the last articles read where relatively recent articles. For 3 of 4 of graduate assistants the last article read was published during the current year (2002), while the year of publication was 2001 for the other graduate assistants. Seven of the eleven faculty members last read an auricle published in 2002, for two the year if publication was 2001 and for one the year of publication was 2000. This is in contrast to previous studies that show approximately one-fourth to one-third of readings are of articles more than two years old.

Table 3.1.3. – How thoroughly last article was read

	Faculty		**Graduate Assistants**	
	Percentage	Frequency	Percentage	Frequency
With Great Care	54.5%	6	50.0%	2
With Attention to the Main Points	45.5%	5	25.0%	1
Just to Get the Idea			25.0%	1

All of faculty and three quarters of graduate assistants said they had not previously read the last article. However, about half of both faculty and graduate assistants (54.5% and 50%, respectively) said they had prior knowledge of the information in the article. When asked how thoroughly they had read the article, the same percentage of faculty and graduate assistants (54.5% and 50%) indicated they had read the article “with great care”; 45.5% of faculty and 25% of graduate assistants said they read the article “with attention to the main points”; another 25% of graduate assistants indicated that they read the article to “just get the idea”.

Table 3.1.4. – Time spent reading

	Faculty		Graduate Assistants	
	Percentage	Frequency	Percentage	Frequency
10 Minutes or Less	18.2%	2		
11 - 20 Minutes	18.2%	2		
21 - 30 Minutes	54.5%	6	25.0%	1
31 Minutes or More	9.1%	1	75.0%	3

While 90.9% of faculty spent 30 minutes or less reading this article, only one of the four graduate assistants spent that little amount of time reading. Instead, three of the graduate assistants spent 31 minutes or more reading this article, while only one of the faculty spent that much time reading. Faculty spent an average of 26 minutes reading, while graduate assistants spent 46 minutes reading on average.

Table 3.1.5. – Form of last article read

	Faculty		Graduate Assistants	
	Percentage	Frequency	Percentage	Frequency
Printed Journal or Book	9.1%	1		
Photocopy	27.3%	3	50.0%	2
Facsimile Copy	9.1%	1		
Online Computer Screen	9.1%	1		
Previously Downloaded, on Screen				
Downloaded and Printed, Paper Copy	45.5%	5	50.0%	2
Other				

When asked the form of the last article read, graduate assistants were evenly split – with half indicating a photocopy and half indicating a downloaded and printed paper copy. Faculty were more dissimilar in the form they used; however, the majority of graduate assistants and faculty read the last article in some “hardcopy” format.

Faculty were more varied in their responses when asked about their principle purpose for reading the article – the largest percentage of graduate assistants (36.4%) cited “primary research” as their principle purpose; another 18.2% cited “teaching” as their principle purpose; another 18.2% indicated some other reason. Graduate assistants weren't as varied in their responses to the same question – half of them citied “background research” as the principle purpose; the other half were equally divided between “primary research” and “other” reasons as their principle purpose.

The majority of both faculty and graduate assistants indicated that the article was “somewhat important” to achieving their principle purpose (63.6% and 75%, respectively). Only 27.3% of faculty and 25% of graduate assistants said the article was “absolutely essential” to achieving their principle purpose; while only one faculty respondent said the article was “not at all important” to achieving their principle purpose.

The faculty are productive in terms of publishing in refereed journals – while none of the graduate assistants have published any articles during the past two years, 36.4% of faculty have published between 1 and 5 articles in refereed journals in the past two years; another 27.3% of faculty have published between 6 and 10 articles in refereed journals during the past two years; overall they average 2.2 articles per year.

Faculty members are also more productive in publishing in non-refereed journals during the past two years – 72.7% of faculty have published between 1 and 5 articles in non-refereed journals over the past two years; 9.1% of faculty and 25% of graduate assistants have published more than 5 articles in non-refereed journals during the past two years. The average for faculty members is 2.25 articles per year, while the average for graduate assistants is 2.5 articles per year.

None of the graduate assistants and only three of the faculty have ever submitted an article to a PrePRINT service. Of the faculty that have submitted to a PrePRINT service, all of them have submitted 3 or fewer articles.

We asked respondents to indicate awareness and use of some specific DOE/OSTI products. Awareness of the Energy Citations Database is slightly better among faculty – with 36.4% indicating they are aware of the service, only 9.1% of faculty and none of the graduate assistants have actually used it during the previous 12 months, however. (See analysis of Questionnaire #2 for information on PrePRINT Network).

While over 90% of faculty receive subscriptions paid for by themselves, only half of graduate assistants receive subscriptions, which are paid for by themselves. Only one of the faculty respondents and none of the graduate assistants receive subscriptions paid for by a grant or other source for personal use; and none of the graduate assistants or faculty receive subscriptions paid for by a grant or other source for shared use.

3.2 Questionnaire 2 Analysis: Electronic journal awareness

Faculty, 8 respondents
Students, 6 respondents

Another questionnaire was administered to participants after the second focus group meeting, which concentrated specifically on electronic alternatives and preferences of features for electronic journals.

3.2.1. E-Print services

Awareness is the first step in use of electronic alternatives. In prior surveys of university and non-university scientists we have found that from 2000-2001 the rate of awareness of various e-print services varies considerably by work field. Over 85% of astronomers, for example, are aware of the Cornell/Los Alamos National Lab e-print service (arXiv.org) or its subset astro-ph for astrophysicists. The level of awareness by general faculty or by chemists and engineers at another government laboratory is much lower however, about one-third in both cases.

Among our focus group participants, one of the students and four of the faculty are aware of arXiv.org. The same faculty and students are aware of DOE PrePRINT network. Only one student knows about other e-print services and only three faculty do.

Being aware of the existence of a service may be the first step toward use, but it does not guarantee use. The majority of the focus group faculty and students have never used any e-print service and even those few who had use them infrequently. Table 3.2 shows the amount of use of various e-print services by the focus group faculty and students. One of our faculty respondents is a heavy user of e-prints.

This range of use matches the results from our 2000-2001 surveys of University of Tennessee faculty and Oak Ridge National Lab scientists, which showed a very low percent of total reading came from e-prints (under 4%) and a 2001 survey of astronomers that found 21.6 percent of all reading by astronomers is done in e-print format.

Table 3.2.1. - Eprints read from arXiv.org, DOE PrePRINT and other sources

	ArXiv.org		**DOE PrePRINT**		**Other**	
	Students	Faculty	Students	Faculty	Student	Faculty
Never used	5	4	5	7	3	6
1-2 eprints per month	1	2	1	1	2	1
3-6 eprints per month (about one a week)	0	1	0	0	1	1
7-10 eprints per month (about two a week)	0	1	0	0	0	0

If no answer was given it was assumed these individuals had not used an eprint service.

None of the students in the focus group have ever submitted an article to an e-print service and only two of the faculty have. These faculty submitted articles as preprints before submitting to a journal.

Some eprint services as well as libraries offer early awareness/ table of contents services. Only one student and four faculty participants used such a service, with the table of contents being the most popular.

Table 3.2.2. - Importance of new paper awareness

	Students	Faculty
Not at all important	0	0
Marginally important	0	2
Somewhat important	1	3
Very important	4	2
Absolutely important	1	1

Scale: 1= not at all
2= marginal
3= somewhat
4= very
5=absolutely
Student Mean = 4
Faculty Mean = 3.25

We also asked questions about how they keep up with new papers, articles and developments. Only two faculty indicated that awareness of new papers is marginally important. The majority of both faculty and students rank current awareness as somewhat important or better.

Table 3.2.3. - Keeping up with recent developments

	Students		Faculty	
	Yes	No	Yes	No
Eprint	1	5	1	7
E-Journal	2	4	3	5
Paper PrePRINT	1	5	1	7
Paper Journals	4	2	3	5
Other	0	6	4	4

As seen in table 3.2.3, the majority of students use paper journals to keep up with recent developments. Faculty rely on journals as well, but they split evenly between electronic and print journals.

Table 3.2.4. - Information more than 2 years old

	Students		Faculty	
	Yes	No	Yes	No
Eprint	1	5	0	8
E-Journal	3	3	4	4
Paper PrePRINT	0	6	0	8
Paper Journals	3	3	3	5
Other	0	6	2	6

For articles or information more than two years old, both faculty and students use journals, both electronic and print.

3.2.2. Value

We also asked participants to rate the value of the information they use from a variety of sources. (Since so few people use eprint services these results should be interpreted with caution.) Those that use eprint services find the information to be of limited use.

Table 3.2.5. – Value of DOE PrePRINT for both recent and older information

	Recent		Older	
	Students	Faculty	Students	Faculty
Not at all useful	0	0	0	0
Marginally useful	0	2	1	3
Somewhat useful	2	2	1	1
Very useful	0	0	0	0
Absolutely essential	0	0	0	0
Do Not Use	4	4	4	4

Scale: 1= not at all
2= marginal
3= somewhat
4= very
5=absolutely

Table 3.2.6. – Value of refereed journals for current awareness and definitive results

	Current Awareness		Definitive Results	
	Students	Faculty	Students	Faculty
Not at all useful	0	0	0	0
Marginally useful	0	0	0	0
Somewhat useful	0	1	0	0
Very useful	3	1	4	2
Absolutely essential	3	6	2	6

Scale: 1= not at all
2= marginal
3= somewhat
4= very
5=absolutely
Current Awareness Student Mean = 4.50 Faculty Mean = 4.63
Definitive Results Student Mean = 4.33 Faculty Mean = 4.75

Table 3.2.6 indicates that refereed journals are rated by both faculty and students as more valuable for current awareness and for definitive results.

Three-quarters of faculty rate refereed journals as "absolutely essential" for both current awareness and as definitive sources. All students rate journals as more than "somewhat useful" in both categories. This importance of refereed journals is consistent with many other studies.

3.2.3. Specific features

In order to design electronic journal systems that will be used by students and faculty, it is helpful to know what specific e-journal features they find useful. Participants where asked to rate journal features on a scale of one to five, with 1 being not at all useful and 5 being absolutely essential.

Table 3.2.7. – E-Journal features

	Not at all useful	Marginally useful	Somewhat useful	Very useful	Absolutely essential
Reference Links					
Students	0	0	0	3	3
Faculty	0	1	1	2	3
Future Citation Links					
Students	0	0	1	3	2
Faculty	0	1	2	3	1
Machine Readable Format					
Students	0	0	1	1	3
Faculty	0	1	0	3	2
Color Graphics & Photos					
Students	0	1	3	1	1
Faculty	0	1	0	3	2
Sound & Video					
Students	0	3	3	0	0
Faculty	0	3	1	3	0

Scale: 1= not at all
2= marginal
3= somewhat
4= very
5=absolutely

Reference Links	Student Mean = 4.50	Faculty Mean = 4.0
Future Citation Links	Student Mean = 4.16	Faculty Mean = 3.57
Machine Readable Format	Student Mean = 4.40	Faculty Mean = 4.00
Color Graphics and Photos	Student Mean = 3.33	Faculty Mean = 4.00
Sound and Video	Student Mean = 2.5	Faculty Mean = 3.00

Table 3.2.7. shows that all e-journal features were rated at least marginally useful by all participants, but there are clear preferences. Both students and faculty rated links to references as the best feature with mean scores of 4.5 and 4.0. Sound and video clips where rated as the least useful feature with mean scores of 2.5 and 3.0

4 . Literature Review

A growing body of research literature is shedding light on how scientists use journal articles and other information resources in their work. The bibliography at the end of this report identifies many of these important recent studies. Section 4 of this report describes those most relevant to the current study. Other studies focus on how university science faculty and librarians are working on educating students in the use of electronic journals and other information resources to tackle the issue of information literacy.

4.1. Information literacy programs

The correlation between the National Science Education Standards (NSES) and the Association of College and Research Libraries (ACRL) Information Competency Standards for Higher Education suggest a foundation for increased integration of information literacy into science education programs (Laherty, 2000). The two most prevalent approaches to information literacy within undergraduate science studies are:

- Science professors integrating research and writing assignments within their courses;
- Academic librarians creating programs to specifically address information literacy issues within undergraduate science classes.

Academic libraries and librarians are experimenting with various methods to address information literacy within the context of science education programs. The initiatives studied within this review include four large categories:

- Collaboration between science faculty and librarians (Huerta and McMillan, 2002)(Gray and Langley, 2002), (Fosmire and Macklin, 2002), (Laherty, 2000);
- Development of webliographies and/or specific web sites for a scientific topic (Wellborn and Kanar, 2000);
- Creation of specific tutorials for specific science classes (Laherty, 2000);
- Compilation of resource guides for instructors who teach research ethics (Vaughan, 2001).

Literature on the efforts of science instructors include various case studies about collaborative teaching between science professors of various departments (Henderson and Buising, 2000); creating assignments that walk students through the process of conducting research and publishing research articles (Huerta and McMillan, 2002); exercises and quizzes that require students to be familiar with databases offered through the National Center for Biotechnology Information (NCBI) web site and Pub Med, Entrez, and BLAST (Morvillo, Schmidt, and Carlson, 2000); and offering a symposia on primary research articles (Houde, 2000) as well as many cooperative learning initiatives.

Basic requirements for academic librarians dedicated to increasing information literacy among undergraduate science students should strive to be “technologically savvy, to know what databases the library has and the searching techniques appropriate to each, a high comfort level with the basics of desktop computer support, and a thorough understanding of networking and proxy servers” (Gray and Langley, 2002).

Much literature focuses on collaboration with faculty and librarians to ensure that instruction reinforces the classroom experiences. Numerous librarians have reported successful collaborations with science faculty in achieving information literacy within various science disciplines (Laherty, 2000). Colgate University boasts six years of collaborative teaching of scientific writing to college undergraduates at both beginning and advanced levels (Huerta and McMillan, 2000). The course is designed to walk the students through the research process in order to model the interrelated nature of research and writing (Huerta and McMillan, 2000). Huerta and McMillan emphasize the importance of collaboration. They invite a professor from a science department to discuss how to incorporate statistics into scientific writing. They also have individual conferences with each student to discuss their progress. Their classes replicate the peer review process by having the students come to class with drafts of portions of their work that are peer reviewed during class.

At Purdue University, librarians Fosmire and Macklin teach science literacy where the learning takes place in the context of solving real-world problems. Purdue University Libraries conducted the LEADER Project “to promote information literacy skills for students in science and technology fields, in the context in which students will need them in the course of their work after graduation” (Fosmire and Macklin, 2002). LEADER is based on the premise that information skills will be better retained and better used if these skills are learned in the context of work-related problem scenarios. LEADER will consist of online modules and a shared digital workspace for students and faculty engaging in problem-based learning exercises (Fosmire and Macklin, 2002).

In their attempts to recruit science faculty to participate in the LEADER project, Purdue librarians invited the science faculty to a free lunch. During the lunch, the librarians explained information literacy issues and problem-based learning techniques. They explained to the science instructors that students gather and use information in a basic way and “they do not have the higher-level analysis skills needed to find, read, digest, and synthesize information, even though they have strong technology skills” (Fosmire and Macklin, 2002).

Purdue’s librarians informed the faculty “about the resistance of students to learning information skills, and the fact that problem-based learning can show where the students’ skills are lacking” (Fosmire and Macklin, 2002).

Providing websites that focus on specific science issues has enjoyed widespread support. Two librarians at the Science Library of University of California, Santa Cruz present website evaluation tools for other science librarians who create webliographies for specific scientific topics. These tools include guidelines developed from definitions of science literacy and science information literacy. Important criteria include:

- Building vocabulary on the topic;
- Building an understanding of the scientific processes involved;
- Building an understanding of the impact of the issue on society;
- Discussion of tools used in researching the topic;
- Building an understanding of how relevant resources are organized and accessed; and
- Building an understanding of the social context in which the scientific work is done (Welborn and Kanar, 2000).

In addition, from the results of their research of academic library web sites, Rich and Rabine recommend:

- An e-journal web site should be linked from more than one page within the library's web site;
- Search engines on a library's web site should be capable of finding individual e-journals titles listed there;
- Uniformly formatted, full annotations for individual e-journal titles; and
- The web pages should be manageable for the persons (Rich and Sabine, 1999).

Laherty publishes a web tutorial, “Physical Chemistry: An Introduction of Library Resources” at California State University at Hayward. The tutorial defines physical chemistry, describes information needs that may be needed for that discipline, and discusses CSUH library resources available to students (print, multimedia, books, bibliographies, indexes, articles, electronic catalogs and databases, Link+, and CSUH’s online catalog system, HAYSTAC) (Laherty, 2002).

Laherty also provides an overview of each type of reference tool and how one uses it, explains searching for articles through databases, accessing databases through the library or remotely, and searching the Science Citation Index. Search concepts such as Boolean operators and keyword searching are explained and demonstrated by searching the ASTA, Applied Science & Technology Abstracts, and IDEAL (a full-text journal database) (Laherty, 2000).

Guides can be helpful for a science professor who wants to incorporate research education into a course. Vaughan, an Information and Library Science graduate student at University of North Carolina at Chapel Hill, designed a guide that focuses on the integrity of the research process, from the reporting of data to plagiarism in which the resources have been chosen based on their applicability to the advanced undergraduate and beginning graduate student curriculum (Vaughan, 2001).

Integrating e-journals into a library's collection daunts the efforts of many science librarians. A survey developed by the Science and Technology Section's (ACRL) Subject & Bibliographic Access to Science Materials Committee surveyed public services librarians on their methods of providing access to e-journals. Survey respondents expressed unsatisfactory experiences with all of the methods surveyed. Methods included:

- Adding e-journal information to an existing bibliographic record;
- Adding an additional bibliographic record denoting electronic access;
- Providing an HTML list containing hyperlinks to e-journal titles;
- Providing a connection directly to an aggregators web site, instead of specific journals within that site; and
- A database-driven application that uses a search query to generate dynamic HTML lists (still in its earliest stage of development) (Riel, et al., 2002).

Meanwhile science faculty create their own information literacy movement. Professors Henderson and Buising created a peer-reviewed research assignment for large science classes that requires students "to do literature searches, read scientific papers, evaluate material and build connections between pieces of data and information to construct a larger, more coherent story" (Henderson and Buising, 2000).

Interest in teaching students how to read and digest primary literature seems widespread. Fortner describes a “jigsaw” approach whereby students become experts on a specific scientific journal or secondary (interpretive) print medium, then introduce it to peers (Fortner, 1999). This assignment acquaints students with various categories of literature in the field of environmental communication. Students learn to ask general questions about the publications including: “How much does the publication cost? How often is it published? What subject areas does it discuss? In what ways does the tone and vocabulary target the specific audience?” (Fortner, 1999).

A chemistry professor at St. Louis College of Pharmacy taught students to read the primary literature and was surprised by the success with which her students learned to read professional literature in microbiology. The class required no textbook, but textbooks were made available on reserve. Most of the lecture part of the course is structured around assigned articles from primary literature. Students complete an assignment that directs them to several well-indexed resources including scientific dictionaries. Students are expected to read through the article, underline words and phrases they do not understand and look up the definitions. Then, the students discuss the unfamiliar words or concepts and the definitions they find (Herman, 1999).

Hanks and Wright, professors of chemistry at Furman University, teach an undergraduate class in which students are expected to complete information searching assignments designed to stimulate the types of searches that a practicing chemist might be required to perform periodically. Students are exposed to a variety of printed and electronic information resources, ranging from chemical abstracts to primary literature to various compilations (Hanks and Wright, 2002).

Many faculty also support the concept of personalizing the goals of undergraduate research. Stage and Bowman recommend providing a time and structure to discuss the literature with the student. An example is given of a student who was unable to articulate her questions until the instructor generates some questions such as “What was the author’s hypothesis?” (Bowman and Stage, 2002).

Enough efforts have been initiated in scientific information literacy, that educators can share perspectives and identify potential pitfalls. Brem discusses implications of current science literacy movement in college teaching. Some primary literature includes only the scientists' conclusions without providing adequate details about the data and processes that support their claims. Brem warns that when students read articles that omit information, they tend to supply "unsubstantiated narrative explanations" when evidence is lacking. Assignments requiring critical reading of primary scientific literature should require students to discern between what is evident and not evident within the article. Brem supports teaching students to question covariational information by techniques. One such technique involves creating a matrix by crossing the presence or absence of the proposed cause with the presence or absence of the target effect. Brem concludes, "From a pedagogical standpoint, we would like students to approach the information gathering process in a way that maximizes their opportunities for getting what they need, and a covariational approach is preferable to a noncovariational one in that respect" (Brem, 2000).

Brem (2000) describes how treating information searches as exercises in critical thinking improves use of electronic resources. There are four main critical thinking skills: metacognition, hypothesis testing, argumentation, and using systemic analysis which can be treated as part of the search process. Learning to use heuristics when there is not enough information for systematic analysis is also important.

Brem asserts, “Once they locate information, people often overlook inconsistencies or conflicts. Inquiries are often weakened because disconnected knowledge allows conflicts to go undetected” (Brem, 2000). She suggests improving metacognition (defined as our ability to monitor what we know and how we know it) in several ways:

- Put the project aside for a brief time as it allows users to put into perspective what they have learned or not learned;
- Keep a running dialogue with oneself helps to identify inconsistencies and gaps in knowledge;
- Write down the pros and cons to ourselves; and
- Create a concept map that connects evidence to claims and provides a visual representation of a dense web of supporting evidence. (Brem, 2000).

Hypothesis testing involves testing a position on an issue, then testing and modifying this position based on evidence uncovered during research. Unfortunately, once a user forms an opinion, he or she tends to focus on sources that support the position and distort data to make the strongest case (Koehler, 1991). An antidote to this bias is to pursue alternative hypotheses. Additionally, Brem suggests developing an evaluativist stance, which involves recognizing that there are no right answers. There are better and worse answers, and they can be identified by weighing the evidence.

Argumentation requires that a user consider the reliability and structure of the source and to remember that even reputable sources are fallible. A user should ask if the results of the search are accurate and "the initial goal should be to collect as much relevant information as possible, as it is always possible to narrow the search later" (Brem, 2000). For searchers, Brem advises not limiting terms of a search nor the fields that are searched.

Systematic analysis involves identifying each claim and asking whether each piece of evidence supports it or refutes it. In this view "searching for information online is an exercise in critical thinking, and becoming an expert in critical inquiry takes practice" (Brem, 2000).

4.2 Research on use of journals and the web

Many would agree with Herring's assertion that "we are facing a radical change in the way people find and use information resources" (Herring, 2002), as journal literature is increasingly being digitized, creating a growing national digital library. Many researchers are beginning to conduct studies that will help us to understand how the electronic revolution is changing information selection and use patterns.

Journal literature has been shown repeatedly to be one of the most important communication channels for scientists of all types, whether they work in universities, industry, or government laboratories (Tenopir and King, 2000). A readership study done for the University of Tennessee, Hodges Library in 1993 and four studies done for companies from 1994-1998 show that readership of scientific scholarly journals by science professionals is considerable (i.e., 188 average readings per year per university scientist and 106 readings for scientists elsewhere.) (Tenopir and King, 2000). (Reading is defined as going beyond the title and the abstract to the text of the article. Each time an article is read counts as a single reading.) Thus, convenient access to journal literature is important for scientists, as the typical university scientist read in the 1990s approximately 188 journal articles per year from an average of 18 journal titles (Tenopir and King, 2000). That has now increased to readings from approximately 23 journals (Tenopir and King, 2002).

Readers value the ability to access relevant information in a timely manner and use it in the ways they need. Time spent reading scholarly articles is a useful cross-check on estimates of amount of reading, but more importantly, scientists' time is such a crucial resource that consideration of any alternative to current practices must take into account the effect on the time required to identify, locate, obtain, and read articles (King and Tenopir, 1999). Readers also consider the efforts and time to download, alter, or keep personal files of electronic journal articles, and do so at a low cost.

Readers, especially those who are not also experienced researchers and authors, need to have confidence that what they read is accurate and authoritative. This has been true for many years and remains so today. Three studies in the 1970s examined factors that affect readers' decision to subscribe to journals (Charles River Associates (1979); Institute of Physics (1976); McDonald (1979)). All of these studies – two in the United States and one worldwide – involved surveys of physicists. The Institute of Physics and McDonald both found that versions of attributes of information content, refereeing, and reputation of authors were the most important reasons to subscribe to a journal, while price, at that time, was rated relatively low (King and Tenopir, 1999).

There appear to be many factors that affect scientists' information seeking and reading patterns of communication channels. Perhaps the most important factor involves attributes of the information found in articles, such as precision, quality, conciseness, specificity, and readability. Many studies have found what is important to readers of journal articles including:

- Meadows (1998) (channel capabilities and attributes);
- Rath & Werner (1967); and Rosenberg (1967) (accessibility, ease of use);
- Line (1971) (availability);
- John Hopkins University Sogip Study Group (1971) (information content, relevance, writing);
- Lin & Garvey (1972) and Lin & Nelson (1970) (prestige of authors);
- Huth (1989) (barriers to the use of the literature);
- Katzen (1977) (factors that govern the effect of research articles on their readers);
- Reynolds (1979) (legibility);

- Buxton & Meadows (1978) (formatting of titles, abstracts, text).

Other factors include attributes of journal distribution means and media, ease of use or time required to use, and awareness of journals and the services used to identify, locate, and provide access to them (King and Tenopir, 1999).

Olsen (1994) found that the parts of an article that are used to determine pertinence or that are ultimately read vary with the subject discipline of the reader. Chemists and many social scientists do not read all of a print article but extract the information they need from the sections they deem useful, (e.g., chemists most often look first at the abstracts and figures (including captions). Olsen also found that scientists interact with the literature for “learning, creative thinking, and analytical thinking”; however, scholars expressed concern to Olsen that scrolling on a computer screen does not retain the same level of context, neither does it facilitate the browsing that is so important to them. Olsen concludes “good software design that facilitates searching, scanning, and browsing are crucial elements in electronic publications.”

Additional factors that are important advantages to readers of electronic publishing include:

- Opportunity to experiment with electronic media (Amiran et al., 1991);
- Timeliness of publication (Anderson, 1993; Stix, 1994);
- Location independence (Anderson, 1993);

- Instant updates and revisions (Rawlins, 1993);
- Better searchability (Olsen, 1994);
- Ability to create own personal electronic files of articles (Olsen, 1994);
- Space savings (Olsen, 1994); and
- Not reliant on library collection (Stix, 1994).

E-journals offer additional advantages and potential value to users. Liew et al. (2002) asked participants in a study regarding the future of e-journals to identify enhanced and value-added features provided by e-journals. They identified (in rank order):

- links to additional information/metadata/notification services/archive or history records to help in decision making and searching/navigation (42.3%);
- customizable system to suit different user needs based on user profiles (21.2%);
- more advanced features and functionality (19.2%);
- support for multimedia retrieval and interactive searching/navigation (19.2%);
- intelligent and easy-to-use user interfaces that allow more manipulation and interactions to enhance searching/navigation (17.3%);
- good indexing and archiving system (13.5%);
- more useful (e.g., more current and accurate contents), more user-friendly, easier to access and enjoyable systems (15.4); (Liew et al., 2002).

Tenopir, King and Boyce (2003) asked astronomers to rank the importance of various features in e-journals. Most of the approximately 500 respondents were experienced e-journal users, as the major astronomy journals from the American Astronomical Society have been available online since 1995. The astronomers ranked the following features from one to five, with one being not at all important and five being absolutely critical. The average score for each was:

- links to references - 3.9
- links to future citations - 3.7
- machine readable data tables - 4.1
- links to data centers - 3.9
- inclusion of movies and color - 3.1

Several recent studies examined factors involving use of electronic journals. The principal issues concern quality of electronic journals and reading them on the screen. Speier et al. (1999) asked respondents to rate the quality of peer-reviewed electronic journals versus paper. About 61% rated electronic journal quality in the three lowest ratings, 28% in the middle, and only 3% in the highest three ratings. Budd & Connaway (1997) also asked about the quality of electronic and print journals. Of the survey respondents, 1.9% said electronic journals were equal to the best print journals; 6.5% said they were equal to acceptable print journals; 4.2% said they were equal to lesser print journals; and 10.2% said they were inferior to most print journals. Berge & Collins (1996) found that 84% of survey respondents felt that the quality of electronic journals was the same or better than print journals and 14% said they cited electronic journal articles.

Butler (1995) asked contributors of electronic journals to rate their perceptions on the advantages and disadvantages of publications in electronic journals. The top five advantages reported were speed of publication (71% of respondents), reach the best audience (55%), enhance scholarly dialogue (48%), low cost to readers (35%), and remote geographic access (33%). The five top disadvantages reflect variations of some of those disadvantages observed by others including: perceived as not "real" publications (63%), less prestigious (54%), inadequate graphics (38%), inadequate indexing (38%), and archival instability (35%).

The SUPERJOURNAL Project (1999) took a similar approach, but found other kinds of advantages: the top five reasons being easy access (30% of respondents); convenience, desktop access (29%); searchable (25%); quick or direct access (19%); and good printouts, better than photocopy (15%). Disadvantages included slow access, downloading (42%); journal coverage, breadth or depth (27%); don't like to read on screen (27%); presentation, graphics (12%); and access problems, passwords (8%).

Printing capabilities are evidently essential because reading on a screen presents some problems to users. Richardson (1981) found that none of his survey respondents appeared to have read articles on the screen. Schauder (1994) indicated that 75% of respondents preferred to read printouts. Stewart (1996) interviewed 39 chemists who used Chemistry Online Retrieval Experiment (CORE) and found that the most important capability was creation of a print copy (80.0% very important, 14.3% important). Other features of importance were browsing graphics to determine the value of an article (72.7% very important, 15.2% important); and browsing that could support ongoing education and generate new ideas (65.8% very important, 21.1% important). She found that users would browse a page or two and then print. Of 154 viewing occasions, 75% looked at one page and then printed. Even though astronomers access about 80% of their readings from electronic sources, they still most often download and print out articles on paper before reading (57.6%). Less than a quarter (22.3%) of the total readings are read on a computer screen, (Tenopir, King, and Boyce, 2003).

Mercer (2000) proposes using automatically captured usage reports to measure patterns of use of electronic journals through a digital library. Not only are number of hits or downloads recorded for each journal title, but also more detailed information on such things as users' format preferences (HTML or PDF), what sections of a journal are read most frequently, and what searches or paths were taken by users to access an article.

Respondents in Liew et al. (2000) study believed that the functionality "of an e-journal was most important, in particular – access. Access to additional information such as links was important to users, as was, currency of contents". Users also value searching and navigation features, including the ability to temporarily save interesting objects for later use and the ability to extract and use ‘retrieved information’ as ‘query set’ for further queries. Liew et al. found that “generally, the presentation and organization aspects were of secondary importance”. Just a few respondents added other features, including “ability to copy or extract contents into personal collection, ease of indexing and referencing, ability to get a large amount of information within a short period of time and the ability to print full articles as positive reasons for choosing e-journal” (Liew et al., 2000).

Conversely, shortcomings of e-journals were identified by participants in Liew et al. (2000). They found that “Most of them [the participants] (83.1%) agreed that one of the shortcomings of e-journals was that ‘it was difficult to read from screens’. Other deficiencies cited included the inability to scan information within a single field of view (need for scrolling), inability to highlight and make notes, dependence on computer hardware and software, problems with security and authority of contents, costliness and problems with archival and out-of-date information. However, these disadvantages did not outweigh the positive aspects, hence the high percentage (73.5%) of preference for the electronic medium” (Liew et al., 2000).

Llewellyn et al. (2002) identify factors that influence the ability of individual e-only journals to survive and/or flourish. Many of these factors relate "to use – or the lack of use – of electronic journals by librarians, faculty and students" [Llewellyn et al. reference Quinn (1999) findings]. These include: availability; full-text searching; accessibility and stability; price; text mutability and authority; speed of publication; article length; media and hyperlinks; lack of standardization; citation; quality; permanence; critical mass and index/abstract coverage.

Although many academic reference librarians observe that appropriate content is an important factor in why students select a particular digital resource for research (Tenopir, 1999), most also mention the importance of ease of use, convenience, and prior success. Recent studies have shown that undergraduate students today often use the sources that are most convenient to them, rather than carefully selecting the highest quality materials. Students select a journal database that is relevant to their course assignments, but a positive experience using it brings them back to that source the next time.

Faculty and peer recommendations are also important in determining which digital resources students select, as is direct mention in an assignment. When their teacher mentions a specific resource in class or on a syllabus, students will seek out that source (Tenopir, 1999).

Students and others have experience using the Web, and many consider themselves expert web searchers. Their personal preferences regarding Web site design (e.g., layout, multi-media/graphic, color, font size, site categories, descriptive summaries) play a major role in their evaluation and use of the Web and may provide clues to features that would create sustained use of e-journal systems.

Cognitive limitations (e.g., information/outcome overload) influence Web-based decision making. Participants in Agosto’s (2002) study explained that they devoted much of their Web use time to culling out low-quality sites from the pool of sites under consideration. The uses of “function-based site categories” were suggested as solutions that would help reduce outcome overload (Agosto, 2002). Subjects were also supportive of **“**short but accurate descriptions to accompany lists of retrieved sites, appreciated output ranking, and mostly disliked extensive scrolling” (Large et al., 2002). Reporting that children did not scroll long screens as fully as they did short ones, Bilal (2000) concludes that the amount of screen and homepage scrolling may influence use and is associated with effective screen design.

Young Web users opt for graphic rather than textual information and base relevance on this determination. Within individual sites, the participants in Agosto’s study found that resources with large percentages of textual content, as opposed to graphic or multimedia content, were tedious and mentally taxing. One participant from the Agosto study commented: ‘I just wish they’d make things shorter and less to read’. Kafai and Bates’ (1997) study that ‘text-only sites were often left unexplored’ was used as supportive evidence (Agosto, 2002).

Studies confirm that young Web users are not patient – they often only scan the first retrieved screen, and they often move to another place when faced with long lists on the results page (Fidel et al., 1999). Similarly, Spink et al. (2001) found that "a large percent of users do not go beyond the first page", regardless of the age of the user.

In her study of children's cognitive, affective, and physical behaviors using the Yahooligans! search engine, Bilal (2000) found that a common behavior in young Web users is reliance on the "*Back*" browser button. Bilal concludes that this action was common among Web users because Fidel (1999) observed similar results in high school students, and "considered it [the *Back* button] as a safeguard when they were lost". Additionally, since searches are "rarely linear", students spent a considerable amount of their searching time going back to the safe and familiar sites often designating a "*landmark*" to return to and continue the search (Fidel et al., 1999). In order to decrease disorientation during traversal, for example, mediators may encourage children to keep a "conceptual map" of their traversal activities", which implies the importance of a history function.

Bilal makes many suggestions for improving web systems. She recommends that system designers should provide:

- Search instructions;
- Search examples;
- Browsing instructions;
- Browsing examples;

- A natural language interface;
- Retrieval relevance ranking;
- Simple screen displays;
- A context-sensitive help Wizard;
- A spell-checking technique;
- An effective feedback method; and
- An online tutorial coupled with effective user training (Bilal, 2000).

Ease of use and speed are found to be favored characteristics of the Web, but users are willing to make multiple modifications to searches. The progression of a search was guided by "*clues*" (Liew, 2000) that were seen on the screen, and as a result, users did not feel inclined to prepare ahead (Fidel et al, 1999). Information needs are highly negotiated by users in Web-based environments and often undergo "multiple iterations of finding and using information resources" (Borgman, 1996).

Liew et al. (2000) highly advocates the exploitation of "the electronic medium's basic properties – with 'interactivity' as the primary characteristic of new technologies"; in this manner "end-users are recognized as active participants in the communication process". "The best interface is the one that lets users do what they want to do, when they want to do it, and how they want to do it" (Large et al. 2002 reference Mandel's book on interface design).

Personal preferences play an important role in web site selection and evaluation. Agosto believes, "This concept indicates that designers should program choice into their products as much as possible to match varying user tastes and styles". For example, by allowing users to select their own color schemes, designers would "create sites that are more likely to appeal to larger audiences". Many of the participants in Agosto's study dismissed one web site solely because of its background color. Agosto feels "It is unfortunate that the educational potential of this resource is lost on a large number of possible users when such a simple modification could increase its appeal".

Allowing users to choose features such as web color schemes and interface design not only provide a high level of interactivity, but also "gives the user feelings of empowerment and confidence, feelings that might partially counteract the disappointment and frustration so common in youth Web use" (Agosto, 2002). User modified interfaces such as “My Yahoo” and “MyLibrary” systems also provide such convenience and user empowerment.

Color was a highly criticized feature of Web design among young participants in several studies. One participant in Agosto's study "even attempted to change the shade of green by adjusting the monitor buttons on the computer she was using". Young Web users prefer colorful and bold sites and consider white to be "boring" (Large et al., 2002; Agosto 2002). However, designers should take note that this "run(s) counter to widely recognized guidelines for the use of color in interfaces (see, e.g., Galitz, 1997; Mandel, 1997) as well as contradicting the results from experimental studies (at least with adults) on screen readability, where dark colors superimposed on a light background are recommended (Muter, 1996)" (Large et al., 2002).

Web site colors and design is not the only area where user preferences influence use or where they express preferences. Other useful design features include:

- Larger fonts (Agosto, 2002; Large et al., 2002);
- Access to an encyclopedia, synonym finder, and dictionaries, and easy to remember URLs (Fidel et al., 1999); and
- Highlighted keywords in retrieved results, icons that reflect categories, and subject categories (Large et al., 2002).

"Searchers also need the conceptual knowledge of how search terms can be combined if they are to construct search statements with multiple concepts" (Borgman, 1996). Users often incorrectly employed the Boolean logic/function. Some common mistakes included: not capitalizing the Boolean operator, as required by the Excite search engine (Spink et al., 2001); "and" and "or" used backwards (e.g., *and* is inclusive providing more results; *or* is exclusive, as in either/or, providing less results) (Borgman, 1996).

5. Strengths and Weaknesses of OSTI's Energy Citations Database and PrePRINT Network

The OSTI-developed Energy Citations Database (ECD) will be a testbed for which possible system enhancements for undergraduate science students will be tested. The lessons learned in Phase 1 of this study and summarized in Section 6, go far beyond a single system or single database, but for the purposes of Phase 2 testing, it is necessary to understand the specific testing environment posed by using ECD as a testbed. Another OSTI-developed resource, the PrePRINT Network, may also be used as a testbed. Strengths and weaknesses for both OSTI resources are described here.

5.1. Energy Citations Database: A Testbed Collection for the National Science, Mathematics, Engineering, and Technology Education Digital Library Project http://www.osti.gov/energycitations/

5.1.1. Strengths

- Publicly available
- Enables searching of 2M+ citations of the Department of Energy's (DOE) scientific and technical information from 1948 to the present.
- Includes 70K full-text documents.
- Encompasses information from disciplines of interest to DOE such as chemistry, physics, materials, environmental science, geology, engineering, mathematics, climatology, oceanography, computer science and related disciplines.

- Search features address or provide for adjacency, case insensitivity, date range searching, Boolean searching, and the use of wild cards.
- Basic and advanced searching available. Basic search allows searching of the Bibliographic Info, Title, Creator/Author, or Identifier Numbers. Advanced searching allows searching of the Bibliographic Information as well as the specific, following fields:

  Title

  Creator/Author

  Subject

  Identifier Numbers

  Publication Date

  System Entry Date

  Resource/Document Type (e.g., Journal Article, Conference Paper, Patent or Patent Application)

  Research Organization

  Sponsoring Organization

  Language of Full-text

  Country of publication
- Search results can be sorted by Relevance, Publication Date, System Entry Date, Resource/Document Type, Title, Research Organization, Sponsoring Organization, or Office of Scientific and Technical Information (OSTI) Identification Number.

5.1.2. Weaknesses

- Database and capabilities are still being matured since last year's release.
- No capability is available to:

  - search for only citations that include full-text.

  - search the available full-text (only the respective citations are searchable).

  - search selected subsets.

  - search the search results.

  - select 'next' or 'previous' to go from one bibliographic citation to another without returning to the search results page.

5.2 PrePRINT Network: A Testbed Collection for the National Science, Mathematics, Engineering, and Technology Education Digital Library Project http://www.osti.gov/PrePRINT

5.2.1. Strengths

- Publicly available
- Facilitates access to 10,000 PrePRINT Web sites in 35 countries containing approximately 500,000 scientific and technical PrePRINTs (or eprints).
- Disciplines include physics, materials, chemistry, biology, environmental sciences, and other scientific disciplines related to the Department of Energy's research interests, with single-query access to databases within each discipline.

- The resources are provided by a variety of sources including academic institutions, government research laboratories, scientific societies, private research organizations, and individual scientists and researchers.
- In most cases, access to the full-text information is open, accessible, and free of charge.
- Several access options are offered -- browsing or searching of one specific PrePRINT site, a selected set of sites, or all listed sites.
- The distributed searching capability enables patrons to search Deep Web content of multiple PrePRINT databases and servers via a single cross-site search interface.
- Originating sites are accessed each time a search is executed, so that search results are always current.
- Indexed searching allows patrons to query PrePRINT Web pages using researchers' names or keywords. This peer-to-peer tool promotes scientific networking by enabling patrons to locate information about the scientists' research history and collaborations.
- **PrePRINT Alerts** is a personalized, profile-based alert service that harvests information from the Deep Web, where the underlying content of selected Web sites and databases is searched rather than only surface pages of Web sites. Additionally:
    - Patrons control the volume and content of the data received by simply registering and creating one or more personalized search profiles.
    - Patrons receive weekly e-mail notifications as new information on their topic is added to the selected PrePRINT servers.

5.2.2. Weaknesses

- A current renovation of the network is under way to identify and provide access to more information-dense collections of energy-related scientific and technical information in an effort to return more relevant results. Daily improvements may be available.
- Sources are not held by nor maintained by OSTI, but rather by multiple originating sites.

6. Summary and Where Do We Go From Here?

6.1. Lessons from Focus Groups and Related Research Studies

Many common themes are beginning to emerge from the focus groups held for this study and analysis of other research studies. These are first summarized here and then are translated into possible system enhancements.

Focus groups and analysis of related research provide some answers to the questions posed in Section 1.1. For convenience, these questions are repeated here.

1. How and when are scholarly journal articles introduced in the undergraduate science curriculum?
2. What do faculty expect their students to understand about scholarly journals?
3. How do undergraduate students learn to understand the structure, purpose, and content of scholarly journal articles?

4. How do undergraduate students search for information needed for their schoolwork?
5. What features of online systems and web search engines do undergraduates understand, use, and value?
6. What role does the library and librarians play in helping undergraduates learn about scholarly journals?

Not all grade levels or subject disciplines will yield the same answers to these questions. Therefore, we also need to understand:

- At what college grade level (lower division, meaning freshman and sophomores or upper division, meaning juniors and seniors or graduate) are students expected to use and understand scholarly journal articles?
- At what grade level are they expected to search for scholarly journal articles and recognize on their own which are relevant to their task?
- How do these expectations differ in chemistry, physics, and engineering?
- How do these expectations differ for majors and minors in these disciplines?
- How does student learning in the general education humanities or social sciences courses regarding seeking, retrieving, and using journals transfer to their science coursework?

Scholarly journals are introduced at different times in the undergraduate science curriculum, depending on individual faculty members' assignments and preferences. Most commonly the use and understanding of scholarly science journals is introduced for upper division science majors (in the junior or senior year.) Short introductions to resources that are offered by the library or in general education lower division courses typically do not go into depth and are not remembered later by many students.

Even when (or if) scholarly journals are introduced to science majors, not all students understand the structure, purpose, or content of journals until they are working on a senior thesis or doing independent research as graduate students. Classroom approaches that introduce journal articles systematically and incrementally in a subject discipline or subdiscipline that is of personal interest to each student seem to be most effective. One approach that has worked is to first have the instructor give students a selected article, which they analyze for structure and meaning. Next students are introduced to core journal titles in their field and are asked to locate some articles they can understand.

Finally, students are taught search strategies, relevance and quality judging, and are asked to use the journal articles in their own work. Another approach is to have students first read background information, such as from an encyclopedia or handbook, that will help them better understand gradually the content of a selected research article. Understanding research content is best accomplished incrementally.

Faculty differ in what they expect students to understand about journals and how they expect students to gain that knowledge. Among the three fields we studied, chemistry has the longest tradition of scholarly journal use and the highest expectation for student use of journals. Engineering emphasizes journals the least of these three fields, with physics/astrophysics falling somewhere in between. Chemistry relies on peer-reviewed traditional journals more than engineering and physics, while physics makes more use of preprint and eprint archives. Chemistry is most likely to have an undergraduate course devoted to the study of the scholarly literature of the field.

An effective way to teach students about journal and information systems seems to be librarians working with science faculty to tie information literacy skills to the course content. Stand-alone short courses offered by the library are often poorly attended by undergraduates or the information is not retained by the students long enough. Students often do not readily transfer the information knowledge and skills they are taught in required lower division humanities courses to their science major.

Few lower division science majors know about subject specific databases or scholarly journals. Almost all college students today, however, use the Web, and many consider themselves experts. Good students, at least, feel they are able to judge the quality of Web sites (faculty members do not always agree with this self-assessment). Their Web preferences and search patterns may help designers of e-journals provide scholarly journal systems that will encourage sustained use by undergraduates. In addition, faculty have certain expectations and make certain suggestions that will assist students in using journal systems. Preferences and suggestions identified in this report, which can guide the choice of features to be tested, include:

- Links to related articles and related information
- The ability to personalize or customize design features such as colors, type fonts, interface, etc.
- A way of identifying the "quality" of an item (clearly marking something as peer reviewed, being from an important journal, etc.) and being able to restrict a search to only the highest quality items
- The ability to download, save, and use articles, with a bibliographic citation that can be cut and pasted into a report
- A consistent and clearly labeled article structure that facilitates easy understanding, including a clear abstract and summary
- The ability to both browse articles by journal titles and search for articles on a topic
- Restricting a search to just items for which the full-text is available

- Incorporating other types of literature on a topic, so that undergraduates can better understand technical article content. For example, including dictionaries, handbooks, and encyclopedia articles that will provide background information, linked definitions, etc.
- A combination of PDF for printing and a format that is better for searching, cutting and pasting, etc.
- Easy to understand "help" that assists with search strategy and that teaches students about the structure and purpose of journal articles.
- The ability to connect journal articles with course content

6.2 Where Do We Go From Here?

Most of these suggestions are not revolutionary or new. Many, such as linking and search restrictions, are features that are already available on some e-journal or bibliographic database systems. Others, such as the ability to tie journal articles with course content, are more specialized and difficult to accomplish in an open-access system.

Phase 2 of this project will be to conduct usability testing of selected features, using OSTI's ECD (and perhaps PrePRINT Network) as testbeds. The first step in "Where do we go from here?" then is for the research team and OSTI to work together to identify other potential features, prioritize all features by their importance to researchers and system designers, their importance to OSTI, and the practical likelihood that OSTI's programming staff can make them available for testing in the spring semester 2003.

Once we have agreed on features to be tested, the second step involves several simultaneous processes. OSTI should proceed with the required programming, while, at the same time, Faculty Associates Wang and Pollard in consultation with P.I. Tenopir will design the usability tests. Testing will take place between January and June 1, 2003, to be completed fall 2003. Also simultaneously, Tenopir will begin outlining an interactive learning module for chemistry students.

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