AC 2010-1360: LEVERAGING THE INTERNET AND LIMITED ON-CAMPUS RESOURCES TO TEACH INFORMATION LITERACY SKILLS TO FUTURE ENGINEERING PRACTITIONERS

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Abstract

In the internet age, practitioners of engineering and technology may find themselves lacking information literacy skills so necessary in a modern global work environment. The needs may be manifested as researching technical and non-technical information, the basis for a price quote, equipment specifications, company profiles, standards compliance and a myriad of other types of information. Throw in issues of ethics and determining the validity and reliability of sources among the millions on the internet, information literacy becomes a critical instrument in the practitioners toolbox. Yet few classes address practitioner's needs for broad information research literacy skills.

This paper details strategies for a student research project that new faculty may use to enhance undergraduate technical research experiences in an information literacy context within any engineering or engineering technology discipline. It leverages the internet plus the resources of a well-endowed, or even a modestly-endowed, campus library and is readily adaptable to changing technology. As implemented at Purdue University, the project has been cited by multiple ABET re-accreditation teams for innovation and as an excellent example of continuously improved instruction. Over the years, it has grown to become one of the more noteworthy experiences cited in both student exit surveys and in postgraduate surveys.

Also discussed are specific information literacy skills identified by national organizations and their relationship to accreditation requirements especially relevant for engineering and technology students. Ultimately, whether student acquire the skills through a single project or through gradual skill acquisition in several classes, students need experiential avenues to learn these critical research skills.

Introduction

The primary case study cited is a curriculum-integrated information literacy assignment in *Production Design & Specifications,* a core course on product realization in the department of Mechanical Engineering Technology at Purdue University. The assignment spans roughly two weeks in the second semester problem-solving class. Dubbed the Treasure Hunt or simply the Hunt, the assignment consists of detailed questions from which each student must answer ten of twelve randomly assigned. questions. They must fully document a legitimate verifiable source for full credit, hence enhancing their research skills but also enhancing their confidence in finding technical information.

This paper additionally includes a literature review on aspects of the case study project, overview of information literacy standards, description of related engineering and technology accreditation requirements, and integration of information literacy into the curriculum. The case study and its evolution in a changing information world is related from the viewpoint of both instructional faculty and library faculty. Student learning experiences are also characterized.

Literature Review

Erdmann and Harding (1988) first described the Treasure Hunt in "Information Literacy: Needs – Skills – Assignments"[1] and discussed the definitions of library literacy and the concept of information literacy common at the time. It also covered a needs assessment and skills inventory, the project rationale, project history at that point in time, and results. Harding[2] (2003) elaborated the further evolution of the project, mechanics of administering the project and continuous improvement efforts to the assignment.

Sapp Nelson, Epps, and Fosmire made significant improvements for the The Hunt when they created an expert system and animated tutorial in 2007. An instructional improvement grant funded the creation of the expert system. This innovation was documented in two papers, first by Sapp, Van Epps, Fosmire and Harding (2007a)[3] and secondly Van Epps, Sapp Nelson, Fosmire, and Harding (2007b).[4] In the papers, the authors related the background of the The Hunt and the impact of the new system. The authors recommended that a student enter the complete question into the expert system to achieve the best results. While the first paper (2007a) describes the development and programming of the expert system and tutorial, the second paper (2007b) describes pre-test and post-test statistical analysis comparing students over two semesters. Students from the first semester did not use the expert system and animated tutorial while students from the second semester did. The authors measured self-reported changes in information literacy abilities and confidence factors with both groups when using various types of materials. For both semesters when comparing pre- and post-test data, students reported their research abilities and confidence levels increased significantly. However, the semester employing the expert system and tutorial, the number of reference desk queries decreased. The authors reported that "…it is likely that the expert system has worked as expected and been used by students instead of consulting with the library staff … a lack of change indicates a successful implementation" indicating a better utilization of reference staff. As this project involved 60-120 students at a time combined with the strain of lean budgets, efficient use of library personnel became an important issue. Hence the expert system continues to be in use today. As a side bar it should be noted that even though the students gained improvements in their abilities and confidence with or without the expert system, via the expert system they have a research tool available 24/7.

ACRL Standards and ABET Accrediting Criteria

The Association of College and Research Libraries (ACRL) is responsible for information literacy standards in academic libraries. ACRL work is now an integral part of setting standards to help students find information in a complicated information environment. The Accreditation Board for Engineering and Technology (ABET) is responsible for Criteria for Accrediting programs in Engineering and Engineering Technology. This paper identifies how applicable ABET and ACRL standards interweave.

ACRL, affiliated with the American Library Association, published *Information Literacy Standards for Science and Engineering/Technology* [5] in 2006. The document has since been revised.[6] It includes five standards with performance indicators and outcomes. These standards are:

The information literature student:

1. Determines the nature and extent of the information needed.
2. Acquires needed information effectively and efficiently.
3. Critically evaluates the procured information and its sources, and as a result, decides whether or not to modify the initial query and/or seek additional sources and whether to develop a new research process.
4. Understands the economic, ethical, legal, and social issues surrounding the use of information and its technologies and either as an individual or as a member of a group, uses information effectively, ethically, and legally to accomplish a specific purpose.
5. Understands that information literacy is an ongoing process and an important component of lifelong learning and recognizes the need to keep current regarding new developments in his or her field.

Finding answers for the questions from the Treasure Hunt demonstrates Standards 1 and 2. The standards and appropriate performance indicators are documented in Appendix A: ACRL Standards for the Treasure Hunt, excerpted from *Information Literacy Standards for Science and Technology/Engineering.*[7]

Curriculum Integration

The advantage of integration of information literacy early in the curriculum, as done in the case study, is that all students complete the project in an early core class. Otherwise, if information literacy instruction has not been course integrated, some students acquire skills that others do not. Based on accreditation criteria discussed below, the best opportunities for integration are core classes and design classes. This particular project, begun in 1982, continues without interruption. Librarians became a formal part of the introduction to the project in 1986.

ABET Curriculum and Outcomes

Two requirements of ABET *Criteria for Accrediting Engineering Technology Programs* (2009)[8] emphasize information literacy and standards education. These include Criterion 3: General Criterion of Program Outcomes and Criterion 5: Curriculum. Similar criteria are part of the *Criteria for Accrediting Engineering Programs* (2009).[9]

Broadly interpreted, there are many opportunities in any of the program outcomes to include information literacy activities. Based on ABET self-study documents, lifelong learning is used for information literacy in Engineering and Engineering Technology. The aforementioned project is but one example, and many professors and librarians have used a variety of these outcomes for information literacy skills and instruction in papers written and presented at ASEE in the last several years.

The authors agree that there are many opportunities to improve information literacy skills of students in this complicated information world. Accrediting criteria for both Engineering Technology and Engineering require improved literacy outcomes for graduates in these programs.

Engineering

Engineering's Criterion 3. Program Outcomes have similar themes as their program "must demonstrate that their students attain the following outcomes:"

a. An ability of apply knowledge of mathematics, science, and engineering.
b. An ability to design and conduct experiments, as well as to analyze and interpret data.
c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
d. An ability to function on multidisciplinary teams.
e. An ability to identify, formulate, and solve engineering problems.
f. An understanding of professional and ethical responsibility.
g. An ability to communicate effectively.
h. The broad education necessary to understand the impact of engineering solutions in a global economic, environmental, and societal context.
i. A recognition of the need for, and an ability to engage in life-long learning.
j. A knowledge of contemporary issues.
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Engineering Curriculum Criterion 5 emphasizes student experience with a "major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints." Standards are highlighted here but the authors assume that other types of materials may also be used in the 'major design experience.' In the Engineering Accrediting document, Criterion 4 is covered in continuous improvement.

Engineering Technology

In Criterion 3, the Engineering Technology criterion requires that each program must demonstrate that graduates have the following outcomes:

a. An appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines.
b. An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology.
c. An ability to conduct, analyze and interpret experiments, and apply experimental results to improve processes.
d. An ability to apply creativity in the design of systems, components, or processes appropriate to program educational objectives.
e. An ability to function effectively on teams.
f. An ability to identify, analyze and solve technical problems.
g. An ability to communicate effectively.
h. A recognition of the need for, and an ability to engage in, life-long learning.
i. An ability to understand professional, ethical and social responsibilities.
j. A respect for diversity and knowledge of contemporary professional, societal and global issues.
k. A commitment to quality, timeliness, and continuous improvement.

Engineering Technology Criteria for Curriculum and Program Outcomes are also used to document the Treasure Hunt assignment. It specifically highlights continuous improvement as an expected outcome.

Engineering Technology Criterion 5: Curriculum, begins with this opening sentence, a "program must provide an integrated educational experience that develops the ability of graduates to apply pertinent knowledge to solving problems in the engineering technology specialty." Curriculum criteria are divided into several subject areas including communications, mathematics, physical and natural science, social sciences and humanities, technical content, and cooperative education.

The criteria for communications mentions the preparation of technical reports and the use of technical literature. These abilities are related to information literacy:

a. Plan, organize, prepare, and deliver effective technical reports in written, oral, and other formats appropriate to the discipline and goals of the program.
b. Utilize the appropriate technical literature and use it as a principal means of staying current in their chosen technology.

In the case study, most types and forms of technical literature are used in the case study course integration.

The Case Study: An Example of Information Literacy Instruction

The Treasure Hunt as a case study is a an example of fulfilling information literacy goals by leveraging the unique terminology, concepts, subsets and precepts of a discipline, in this case mechanical engineering technology. However, in the broader sense, the project could be replicated with equal success in virtually any discipline.

The Hunt has been administered since the early 1980s and has grown to include questions spanning the breadth of engineering and technology, from details in standards and vendor specifications to locating a particular type and/quality of exotic material and much more. It emphasizes the broad nature of technical literature research. To emphasize selectivity in sourcing answers both ethically and technically, the grading is divided equally between the answer and documentation of a legitimate, published source for the answer. For this project, URLs, with the exception of wikis, are considered published.

After receiving twelve random questions from the database of questions, each student is to answer ten and drop two. Since a random number generator resets with each question, duplicates are possible and may be used. Students optionally may work in groups, merging their sets of twelve questions to maximize the pool of questions which may be dropped. Thus two students working together are responsible for answering 20 questions of their combined 24. Although rare statistically, duplicates may be used. One-half credit is awarded for the answer to each question, while the remainder of the credit is earned only by submitting a photocopy of the specific page and cover page of the published source. The cover page is unnecessary when a URL is used as the source.

Technology evolves. As such, standards driving the technology, the specifications on the technology, and all documentation associated with the technology must evolve. So too, Hunt questions evolve. This evolutionary aspect of information literacy is the reason correct answers alone earn only one-half credit. Perhaps the question was answered from a newer, older, or different source entirely. If the answer or source differs from the database answer key, it may be accepted as correct if the source information supports the different answer. In other words, a student cannot just ask someone. This aspect is unique because it reinforces a life lesson that one must have sound data to support one's position. As an exercise in continuous improvement, differing correct answers and alternate legitimate sources are added to the database each semester.

As implemented, the project has been cited by multiple ABET re-accreditation teams for innovation and as an excellent example of continuously improved instruction. Over the years, it has grown to become one of the more noteworthy experiences cited in both student exit surveys and in graduate surveys. A few examples cited as continuous improvement efforts include:

1. Initially sixteen questions were used (and answered each semester), resulting in a new set of questions having to be written each semester. The improvement became one of soliciting and writing sufficient questions so that a different set would be available each semester.
2. The project was envisioned as one encouraging students to more thoroughly read *Machinery's Handbook,*[10] a 2500 page handbook used for the course. However after the initial trial exercise, many more opportunities for questions were noted, plus graduates began suggesting questions from their practitioner experiences outside of *Machinery's*. The improvement effort became one of increasing the breadth of questions to cover aspects of virtually all disciplines in science, engineering and beyond.
3. Even with rotating questions, files of correct answers began to be compiled among campus Greek organizations and various student organizations. Originality of the

research suffered when students could get many answers from a file rather than research. The improvement effort became one of adding a random number generator so that each person could be assigned a different set of questions.

4. As with any test-like questions, some are more complex and/or more difficult than others. In this case the improvement became one of allowing students the option to drop two of twelve questions.
5. The random number generator in the macro resets for every question, allowing duplicates within question sets and across question sets. The improvement effort became one of growing the database sufficiently that statistically duplicates would be minimized.

Per ABET 2000 outcome-based criteria, first used for the 2006 self-study, the outcome was set at 80% of the class achieving 75% or greater grade. While that outcome may seem somewhat arbitrary for a freshman class where many have never set foot in a campus library, the level was (and is) considered sufficient. As can be seen from Figure 1, average grades data indicate that the mean Treasure Hunt grade has remained fairly constant with a slightly positive slope.

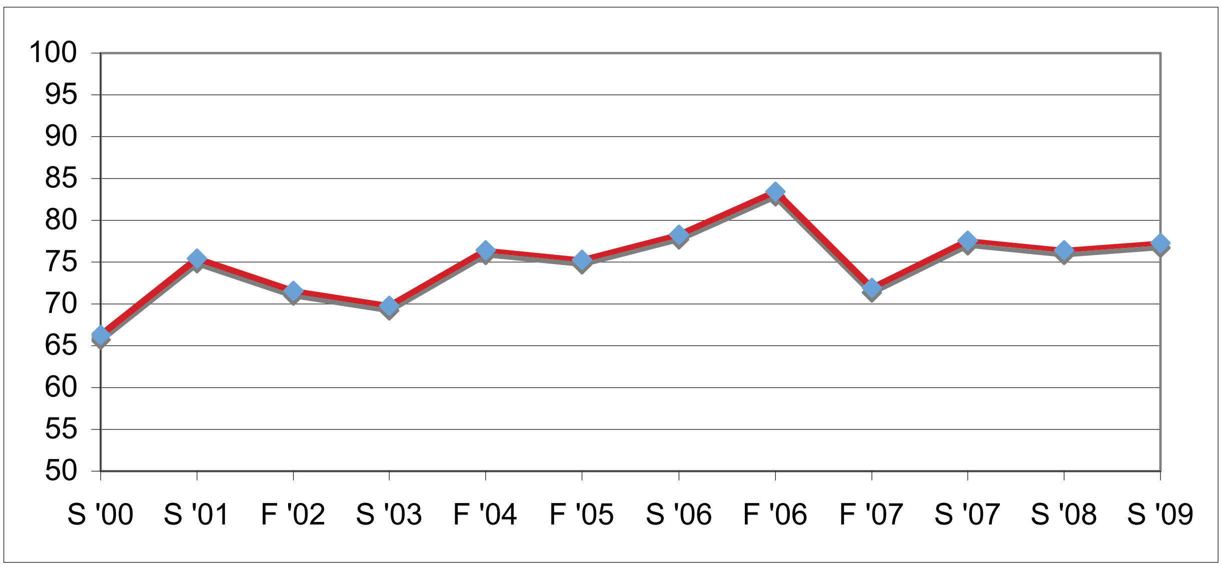

Figure 1. Average grades for the Treasure Hunt from Spring semester 2000 -- Spring semester 2009. S = Spring semester , F = Fall semester. Data was unavailable for earlier semesters and for some semesters during this timespan.

Evolution of the Project: Anecdotal Observations

Project Growth

As mentioned earlier, the project was initially designed to involve students more deeply in the *Machinery's Handbook*. It should be noted that the class under discussion in this case study project is a student's first opportunity to use this industrial handbook. It is subsequently used in other classes, so transference knowledge is useful. By design the initial sixteen questions were so minute and detailed that they required careful reading of selected portions and/or footnotes in

Machinery's in order to answer. Currently, many other sources, other faculty and even alumni contribute heavily to the questions database. However to remain true to the original intent of the project, roughly one-half come from *Machinery's Handbook.* This concept is maintained by culling old or obsolete questions as new are added.

Dropping two of twelve questions came about with the recognition that statistically some questions are more difficult than others. However, randomness suggests that some students are bestowed with the challenge of receiving a disproportionate number of difficult questions. With twelve questions in a set, the requirement to answer only ten gives students the opportunity to discard the two most difficult questions, and in groups it offers an even greater pool from which to drop. For every student on the difficulty edge of the distribution curve, another student exists on the easier edge of the curve. From an instructor view, the ten of twelve strategy tended to even any perceived issues of unfairness.

Sample questions (and type) include:

1. (Materials) What is the Rockwell hardness (M) of Lexan® 181 resin?
2. (Standards Spec) Given a plow bolt with an "R" on the top of its head, what does the letter signify?
3. (Standards Spec) When testing pouring spout performance on your home tip-to-pour coffee maker, how much coffee should be poured and at what rate should it be poured?
4. (Not what they seem – requiring study) Of the 50 United States, which states are the most northerly, southerly, easterly and westerly?
5. (Historical) What US National Historic Landmark can move from location to location?
6. (Safety/Standards) To complete emergency repairs, you must enter a plant area leaking hydrogen chloride fumes (< 50 PPM concentration). You have several standard color-coded filter cartridges from which to choose for your respirator. Which color do you use?
7. (Processes) What drill point angle (inclusive) should be used when drilling Acetal®?
8. (Price Quote, Plus) For a yet unidentified manufacturing process, you are asked to spec out gold (Au) microfoil (0.1µ X Ø10 mm). Identify a vendor (name, address, phone, FAX, URL, etc.), expected purity, current cost and precautions if any.
9. (Company History) In 1983, who was the CEO of Combustion Engineering?
10. (International Price Quote, Plus) For a yet unidentified manufacturing process in your plant in England, you are asked to spec 10 grams of 99.9% pure Caesium (Cs) in lump form. Identify a vendor in the U.K. (name, address, phone, FAX, URL, etc.), current cost in pounds sterling (£) and precautions if any.
11. (Legacy Question, now little more than a Google® query) What was the date of issue (mm/dd/yyyy) and to whom, was the first US patent issued for the safety pin?

Project Beginning

When the case study project started, the library's catalog was the Engineering Information System which contained tables of contents for books, resulting in students answering almost all questions from print sources. The library's move to more electronic formats improved student

access to materials. As a result of changes in databases, format, and needs, the library's instruction program also changed.
In 1982, the professor solely directed the project and delivered the project introduction. The library's involvement began when many students asked questions at the library's information desk. The assignment obligated library staff to go against their nature and training by requiring them to suggest possible sources but not find the answer for the student. Students used print books, periodicals, and standards with the first generation of questions since these were the sources of answers. They also sometimes phoned or faxed company sales people to get price quotes or product information that could not be discovered other ways.

The students used books in the reference collection, especially directories and handbooks, mostly in the engineering library. The library subscribed to print standards from the American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM). The students frequently used the massive 15-20 volume *Thomas Register* for product related questions and print directories from ANSI, ASTM and Information Handling Services (IHS) to identify standards. Students did not always find these standards directories easy to use.

In 1986, librarians began presenting a basic lecture on how to best utilize campus libraries and prepared a bibliography of sources. The lecture used overheads to describe library services and collections, define document types, introduce print sources, and discuss sample questions. At the time the Treasure Hunt began, campus librarians performed paid mediated database searching, but Treasure Hunt assignment guidelines and funding did not permit the use of these advanced services on this class project.

Searching and Learning

The perspective that students acquire while searching for information and answering Hunt questions has many of the same qualities now as at its inception. Then and now, the complicated nature of technical information remains new to freshmen. Though the Hunt began when print was the most common format, students still discover that information is available from a variety of sources including standards, vendor data, and properties.

The variety of source information has expanded and may have changed but careful reading of the question is necessary to understand the needed piece of information. Learning about the materials and working with classmates can be as important as finding the 'right answer.' Ultimately the assignment is the student's, not the librarians. Students must decide if the question has been answered and documented sufficiently to satisfy the assignment. Grades are determined by the answers found and authenticated, but the added benefits students receive include awareness of a variety of topics and sources as well as team work.

Students experienced success with dictionaries for defining terminology and directories, e.g. *Thomas Register* for finding product suppliers and owners of trade names. They had limited prior experience with standards, properties, handbooks, and encyclopedias. As expected, students found books with adequate indexes much easier to use than those with table of contents only. Students did encounter answers in books with only table of contents. Many students became experts on particular topics as a result of the process of answering their questions. The internet and Google became their first choice research tool, even when warned that much of the material does not exist there in sufficient detail if at all.

Improved Library Instruction and Innovations

Eventually, the Purdue University Libraries moved to a campus integrated library catalog and added significant online databases and materials during the span of 1992-2010. With broader material available, the introductory library lecture became more complex and moved to PowerPoint with online demonstrations.

The current library lecture now includes an alumnus testimonial and a framework for focusing the research. When considering their questions, students are encouraged to consider a four-step framework:

- What do you know?
- What do you need to know?
- Who would collect this information?
- Why would they collect the information?

With a more formal framework to analyze their questions, the authors agree that students have improved their focus on questions and answers. The lecture also highlights actual sample questions spanning those concerning standards, product catalogs, effective use of the internet and e-books databases. The Expert System has become a significant advantage in recent years. In it, students enter the complete question and receive a list of recommended sources. With this tool, students are able to identify possible sources and develop more independent information seeking skills. Especially noteworthy among students is that the system is available 24/7.

In the last few years, the library staff also created a *Purdue University Standards Database*[11] of print standards and converted the class bibliography into *MET102 Expert System Webliography*.[12] The Standards Database is particularly useful since it contains a considerable collection of ANSI standards and older British Standards as well as specially ordered standards.

Database Gems

Some of the databases acquired by the Libraries since 1998 assist students greatly in researching questions since the databases are full-text searchable. These have included standards, product catalogs, and online handbooks. Many of these are funded by special library funds. Newer databases specifically impacting the case study project include:

- IHS Specifications and Standards (now IHS Standards Expert), *a commercial database to identify standards and full-text subscriptions to standards from several organizations.*
- ILI Standards Infobase, *a commercial database for identifying standards.*

- Catalog Xpress, *a commercial full-text product catalog database with several thousand industrial producers.*
- Knovel and EngNetBase, *e-book suppliers specializing in technical handbooks and encyclopedias.*
- Thomas Register, *a free web directory subscription service available for many years. It also has links to company web sites.*
- United States trademark search databases, *a set of government databases from U.S. Patent and Trademark Office identifying trademarks and service marks and their owners.*

There have been some disappointments among other acquired databases. One example is a source that includes only some of its content that is in print. Others are potentially useful for general library users, but are actually seldom used. These may be candidates for future cancellations.

Recent changes in subscriptions include:

- Move of ANSI print subscription to a librarians' selected plan with less funding available.
- ILI Standards Infobase has been discontinued because of budget constraints.
- Discontinued ITU-T Standards since most are available free.

Student Successes and Challenges

The advent of electronic full text with more comprehensive keyword searching in an appropriate source appears to have made the project easier. Google® and the internet in general sometimes make the project too easy. In turn, it may overload students with too many choices. Using Google Books® and Google Scholar® may narrow searches, but also presents the possibility of losing relevant information.

In this age, and with this generation of students, the internet has often been students' first choice as a search tool. However concentrating on the internet exclusively may leave library information, such as licensed databases, e-book subscriptions, and many print sources, unsearched. Without heeding the search strategies covered by library faculty, students may spend hours trying to answer a question in an inappropriate place. Strategies used in appropriate sources are major factors in successfully finding answers.

Authors Perspectives

Experience suggests that students ability to research and successfully answer the questions, improves when the person starts the assignment early, uses critical thinking skills to determine the key components of the question, determines what types of sources might contain potential answers, and persists by trying alternate sources when the first source does not yield an appropriate answer. A student who chooses keywords carefully and modifies the words when they prove unproductive, may be more successful than those students who do not follow this regimen.

The advent of the new expert system also helps students find leads to answers. Successful students also learn when to ask the library staff for assistance, especially when the student has spent a large amount of time on a question and failed to discover the answer.

Student Perceptions

Some students love the project while others hate it. Regardless, as freshmen the Treasure Hunt is probably their first experience with formal information research, so it can be intimidating. It has become part of satisfying ABET criteria and has been singled out by ABET program evaluators as unique and noteworthy. On graduate surveys, graduates, upon joining the workforce, generally praise the project as being one of the most useful of their college career. More than a few have parlayed jobs through the contacts developed with vendors when seeking Treasure Hunt information. Several companies specifically seek graduates who enjoyed this project.

Conclusion

The case study project has been an insightful learning experience since the early 1980s. This curriculum integrated assignment has offered opportunities for students and library staff members to acquire increased appreciation for the knowledge, skill, and persistence needed to solve the complexities of challenging questions facing future engineering practitioners. With little effort, a similar project can be instituted in almost any discipline as a simple method to teach information literacy. While it leverages internet access and local resources, the experience does require cooperation among professors, students, and library staff. Modern online systems have improved the process and aided access to information and understanding of technical questions. However the actual experience gained by finding appropriate sources in print or online and skillfully choosing appropriate keywords, ultimately helps students gain valuable skills useful while in school and into their professional careers. Experience with multiple ABET evaluation teams indicate that these information literacy skills are highly valued by evaluators and employers.

Appendix A

ACRL Standards for the Treasure Hunt

Information Literacy Standards for Science and Technology/Engineering

The ALA/ACRL/STS Task Force on Information Literacy for Science and Technology

Standard One: The information literate student determines the nature and extent of the information needed.

Performance Indicators

The information literate student:

1. Defines and articulates the need for information.
2. Identifies a variety of types and formats of potential sources for information.
3. Has a working knowledge of the literature of the field and how it is produced.

Standard Two: The information literate student acquires needed information effectively and efficiently.

Performance Indicators

The information literate student:

1. Selects the most appropriate investigative methods or information retrieval systems for accessing the needed information.
2. Constructs and implements effectively designed search strategies.
3. Retrieves information using a variety of methods.
4. Refines the search strategy if necessary.
5. Extracts, records, transfers, and manages the information and its sources.

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