AC 2010-1406: CITATION ANALYSIS OF ENGINEERING DESIGN REPORTS FOR INFORMATION LITERACY ASSESSMENT

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Citation Analysis of Engineering Design Reports for Information Literacy Assessment

Abstract

The application of information literacy standards and assessment in higher education are gaining importance in high-stakes decision making and accreditation. Therefore, those responsible for information literacy instruction must apply ongoing, multiple forms of assessment to effectively evaluate student proficiencies. This study explores the assessment of first-year engineering design students' information literacy skills in order to refine existing methods and library instructional strategies. A citation analysis is presented, representing references cited in first-year engineering design reports from Drexel University's Introduction to Engineering Design program during the 2008-2009 academic year. Citation style was evaluated and the quantity, resource type, and currency of each citation were recorded. From a sample of 234 citations, 38% of references were classified as websites, 28% of references were journal articles and 12% of references were books. Similarly to other studies, students showed a marked preference for obtaining background information through web searching over the use of reference books in either print or electronic format. The results of this study were compared to previous assessment efforts and aligned to the ALA/ACRL/STS Task Force on Information Literacy for Science and Technology's Information Literacy Standards for Science and Engineering/Technology[1]. The methods and findings of this study demonstrate an evidence-based approach, focusing on standards-based assessment of engineering information literacy, specifically in how to best serve students new to engineering research, design and communication. We conclude that a quantitative approach enabled by trained engineering librarians working in tandem with engineering design instructors is critical to enhancing the breadth and rigor by which engineering design students reference their work. We further assert that methods described herein be considered as an additional criterion for ABET accreditation.

Literature Review

A variety of information literacy assessment techniques have been developed to meet the growing demands of accountability in library instruction. Indirect assessment strategies such as interviews, focus groups and surveys have been used by some institutions to gain practical insights into student research behavior. Typically, since library instruction occurs in a "one-shot" class session, librarians often employ some form of direct assessment, mainly selected-response (multiple choice, fill-in-the-blank, or true/false) assessments focusing on library skills, the appropriate and ethical use of information, student perceptions regarding library resources and research self-efficacy. A review of the literature shows a wide range of case studies examining measured results and extrapolating the implications of such assessment. This type of summative, selected-response assessment can provide some indication of whether information literacy standards are being met. However to fully evaluate student proficiencies, information literacy assessment must also be able to assess a student's ability to apply information literacy skills. Herein we employ the bibliometric technique of citation analysis for evaluating information literacy among first-year undergraduate engineering students and assess the results.

In order to help meet the specialized needs of engineering students, a number of studies have focused upon assessing the effectiveness of library instruction for engineering students through a variety of techniques. Wilkes and Gurney[2] employed a structured questionnaire to examine first-year applied science undergraduate students' perceptions of information literacy. Students showed a marked preference for finding information from various web sources, specifically using Google as a discovery tool for background information. Few students in this study met assignment requirements in citing scholarly journals. Feldmann and Feldmann[3] used mixed methods of pre-test, post-test and interview techniques to investigate developing information literacy skills in first-year engineering technology students. It was found that ongoing collaboration with faculty and increased student contact improved the effectiveness of librarian-led information literacy instruction. Allegorically, the authors have also found that their own students, even when presented with the proper resources to search for and retrieve peer-reviewed articles, handbooks and conference proceedings will frequently resort to web references. Examples of this may be found in three works authored with undergraduates. Admittedly, as of this writing, the co-author's own work has fallen victim to the vagaries of online publishing, (e.g. Gadia et al., 2005a, Gadia et al., 2005b, Layton et al., 2007)[4-6]. Only the ASME conference proceeding may be found archivally. The two web-based publications are now defunct and unavailable through their original websites.

Bibliometric studies are used largely for collection development purposes; however researchers increasingly use citation analysis to evaluate information seeking behavior and to assess information literacy. Only a few studies were found in which citation analysis was used as a tool to assess information literacy and instruction for undergraduate engineering students. In a review of final-year reports, Edzan[7] found evidence of computer science students meeting performance standards regarding the use of a variety of information types and formats, though with an obvious dependence on web resources. Also of note, this citation analysis study showed a discrepancy between student proficiency in citing print and web resources with students less able to correctly apply citation standards to web and electronic resources. Yu et al[8] conducted a bibliographic analysis of project reports from first-year engineering and second- and final-year chemical engineering undergraduate students. The results from this study showed more citations overall and a larger inclusion of books and journal articles by upper level students, with a significant dependence on web resources from all student groups. Again, students showed difficulties in correctly citing a variety of information resources. Mohler[9] found in an analysis of first-year engineering research papers that students favor books and popular periodicals as they begin to explore the engineering literature. Web resources were the second most frequently cited type of resource after books. This decreased dependence on web resources seems to stem directly from an imposed limit of two web citations per paper.

Background

At our institution, the majority of first-year engineering students entering in the fall term are required to complete Drexel University's Freshman Writing Program (ENGL 101-103). This is a three course, year-long writing intensive sequence focusing on building the skills necessary to successfully complete college-level coursework. As part of this sequence, students learn how to "*research a topic, specifically, how to access, evaluate, summarize, paraphrase, and effectively use information from the Internet and from books and journals in the library.*" During the first term Expository Writing and Reading Course (ENGL101), the same students are required to complete a six- to eight-page MLA-formatted research paper with substantial scholarly references. Comprehensive library instruction is provided to all students in a combination of online and face-to-face settings that focuses on providing the skills necessary to identify, access and select scholarly journal articles about a specific research topic using library resources.

Also during the first year, engineering students are required to complete Drexel University's Introduction to Engineering Design (ENGR 101-103) program. This is a three course, year-long engineering design sequence which aims "*to provide students with an understanding of the similarities, differences, and career options available in the various engineering disciplines, the importance of multidisciplinary teams to innovation, an appreciation for engineering measurements, errors, units, significant figures and reproducibility, and the ability to communicate relevant technical information concisely and incorporate experimental data clearly*." In the course sequence, all incoming engineering students representing the disciplines of Architectural Engineering, Biomedical Engineering, Sciences and Health Systems, Chemical & Biological Engineering, Civil Engineering, Computer Science, Electrical Engineering, Environmental Engineering, Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering are led through three ten-week terms of hands-on design, culminating in a final term where teams of four or five design, build and test an engineered structure, machine, system, or computer code. The course is structured with a one-hour lecture where techniques are presented and a two-hour lab where they are practiced. Module topics vary, but are typically designed to be relevant to emerging technologies. Current examples include nanotechnology and sustainable energy. Laboratory experiences are supplemented with weekly guest lectures, given by faculty with particular expertise in the topics being covered in the lab. For example, a professor researching nanotechnology-enabled drug delivery would give a lecture on her research just as the first-year engineering students are developing strategies for programming a robot to sense its environment and make decisions about which "cells" to kill and which to ignore. During the first two terms, there is more emphasis on proper laboratory notebook practices, data collection, and report writing, with little emphasis on independent research. During the third term of the course sequence, students are allowed to pursue engineering design projects that they themselves propose, or select from numerous projects sponsored by faculty members. Typically these projects are research-driven and thus require that students become familiar with fundamental concepts as well as the latest work being conducted in that particular field. Also during the third term, library instruction that focuses on providing a foundation for understanding the types and formats of engineering literature and how to identify, access and select appropriate engineering resources is provided for the 700-900 students per year in Drexel University's Introduction to Engineering Design program.

Goals

While the outcomes of this study are aimed to primarily impact practices at Drexel University, we hope that the methods and findings detailed will contribute to the growing literature addressing information literacy assessment for engineering students. As an example of evidence-based librarianship, this study attempts to meet the following goals:

- Support validity of citation analysis as a method to assess information literacy
- Align current assessment with established performance standards for information literacy to inform overall evaluation practices
- Identify students' strengths and weaknesses in the understanding of engineering literature and their ability to locate, retrieve and cite information correctly in order to instill more effective engineering library instruction
- Provide students with a foundational understanding of the ethics of information, including skills and practices to maintain their own intellectual property generated during the design process
- Revise and expand on present library instruction methodologies to address shortcomings identified in the assessment mapping to standards

Methodology

During the spring term of 2009, all first-year Drexel engineering students were required to prepare for their library instruction session by completing a series of online tutorials. These tutorials were embedded into the lecture section through a central website. The tutorials introduced the various formats of engineering literature that students were expected to use throughout their research including scholarly journal articles, encyclopedias, handbooks, patents, standards, technical reports, company websites, books, and conference proceedings. Tutorials also describe how to access these resources using the W.W. Hagerty Library website. Engineering research instruction was provided to each of the nearly thirty laboratory sections that focused on library resources not covered in the students' prior Freshman Writing Program library instruction. This instruction was carried out in close collaboration with the lead instructor and co-author (BL) as well as the faculty laboratory instructors and graduate student teaching fellows. Engineering librarians demonstrated keyword search techniques and results filtering methods for all students. Databases searched included Engineering Village (Compendex & INSPEC), e-book collections Knovel, ENGnetBASE, and the US Patent Office website. There was a significant focus on the sources of foundational information such as specialized handbooks and encyclopedias that give an introductory overview of engineering concepts. Students were also afforded the opportunity to actively begin the search process for their research focus and interact with an engineering librarian for guidance. Immediately following the one-hour instructional sessions at the library, students were required to demonstrate their recently acquired research skills to the faculty laboratory instructor and graduate student teaching fellow. Students were also required to complete a selected-response assessment within one week of the library instruction. This assessment factored into the students' quiz grade for the class. Results were analyzed from 505 student responses.

First-year engineering student design teams are required to demonstrate their understanding of engineering design with a final design report. Table 1 outlines the design report and provides examples of project topics.

Table 1: Outline for Introduction to Engineering Design Report with Project Examples

Introduction to Engineering Design: Outline	Examples of Projects Examined
I. Abstract II. Introduction a. Problem Statement b. Design Objectives c. Background III. Decision Matrix a. Proposed Solution b. Alternative Solutions c. SWOT Analysis IV. System Analysis a. Engineering Theory b. Notation c. System Characteristics V. Testing a. System Comparison b. Data VI. Final Design a. Design Description b. Prototype VII. Project Management a. Gantt Chart b. Budget VIII. Conclusions a. Design Limitations b. Recommendations IX. Bibliography X. Appendices	• Propulsion of a Climber of a Carbon Nanotube Based Space Elevator • Optimization of a Traditional Transmission for an Electric Vehicle • Automotive X Prize Motor and Battery • Electric Vehicle Drive Train Control • Compost Bin: A Practical Approach to Composting • Scaled-Down Model of a Mechanically Stabilized Earth Retaining Wall • Bridge Corrosion Prevention • Making a More Energy Efficient Handschumacher Dining Hall • Digital Audio File Format • Engineers Without Borders: Footbridge Design • Walking Cane Redesign • Pencil Sharpening Robot • Self-cleaning Mass Transit Chair • Mobile Trash Collection/Sorting Vehicle • Stationary Guard Robot • Drinking Water Treatment: Filtration

Student design teams are required to cite a minimum of 10 resources, with a limit of two web citations per paper. These papers are submitted to faculty laboratory instructors for grading. The authors solicited faculty laboratory instructors for copies of the design reports. A self-selected sample of 29 design report bibliographies were collected and analyzed, representing 135 first-year engineering students.

Each bibliography was analyzed using a pre-design coding scheme for:

- the total number, type and currency of information sources used
- the completeness of the citation

Citations were coded based on a combination of classifications used by such researchers as Edzan[7], Yu et al[8], Knight-Davis and Sung[10], Davis and Cohen[11-13], Hovde[14] and Ursin et al[15]. The criteria used to define each resource type were based on descriptions from Subramanyam[16], Auger[17] and MacLeod and Corlett[18] and can be found in Table 2.

Table 2: Citation Categorization Scheme

Category	Classification	Criteria
Book	Encyclopedia	Contains general articles written by subject matter experts, usually with bibliography; ex., *International Encyclopedia of Composites*
	Handbook	Contains collected primary data from diverse sources that are categorized and presented for ready reference; ex., *Energy Efficiency Manual*
	Textbook	Presents subject matter in a manner that builds reader understanding; ex., *Chemistry: The Molecular Science*
	Other	Other monographs or reference books
Journal	Scholarly	Contains the reporting and discussion of research work contributing to the body of engineering knowledge; ex., *Electrical Power & Energy Systems*
	Trade	Contains technical information relevant to industry needs; ex., *Water & Wastewater News*
	Magazine (Science)	Contains scientific reporting aimed at a general audience; ex., *Popular Mechanics*
	Magazine (Other)	Contains nonscientific reporting aimed at a general audience; ex., *Business Week*
	Newspaper	Presents current reporting aimed at a general or specific audience; ex., *The New York Times*
Technical Paper	Patent	Authorized by US or international patent agency
	Corporate	Authored by corporate entity, electronic format distinguished from website by publishable format or separate download; includes product technical specifications or research and development findings
	Federal Report	Authored by federal government agency, electronic item distinguished from website by publishable format or separate download
	Local Government Report	Authored by state or regional government agency, electronic item distinguished from website by publishable format or separate download
	Other	
Conference Proceeding		Literature resulting from presentation at a conference; ex., *55th International Astronautical Congress*

Website	.com	
	.edu	
	.gov	
	.net	
	.org	
	Other	
Student Publication	Master's Thesis	
	Doctoral Thesis	
	Other	
Other		Format outside of typically cited resources; ex., *not formally published design competition materials, instructor-created materials (unpublished)*
Indiscernible		Not enough information provided in citation to identify resource type

There was no attempt to ascertain how students accessed the information; therefore a print journal article was coded in the same way that one obtained from an electronic database would be classified. No effort was made to check for persistence of website citations.

To determine the completeness of the citations, each entry was analyzed for required descriptors based on type of information resource. Since instructors provided different guidelines for preferred citation style, citations were not evaluated for adherence to any particular style, but on whether or not the citation included all relevant metadata needed for that type of citation. Admittedly, a more thorough analysis of the citations would explore the appropriate use of resources; however time limitations prevented a more exhaustive qualitative citation analysis.

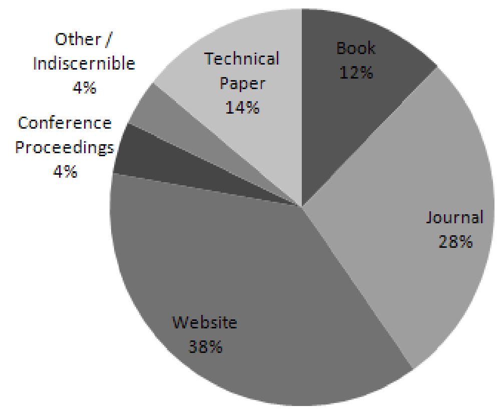
The ALA/ACRL/STS Task Force on Information Literacy for Science and Technology's Information Literacy Standards for Science and Engineering/Technology[1] served as the basis on which the assessments were mapped. Individual information literacy competencies evaluated were aligned to corresponding performance indicators.

Results

From the 29 student bibliographies, a total of 234 citations were analyzed. The average number of citations per design report was 8.1 items with one design report containing no citations. The maximum number of citations found was a 31-item bibliography. Since the minimum number of citations per paper was 10, student groups were to have points deducted from final design report grades as required by the final design report grading rubric. Table 3 shows the distribution of types of sources found in the student bibliographies. Website citations account for 37.6% of the total citations analyzed; a maximum of 12 website citations were found in one report. There was an average of 3.03 websites per bibliography. Again, student groups who did not follow the final report guidelines would receive point deductions in grading. This dependence on web resources supports the findings of other similar studies. Students showed a marked preference for obtaining background information through web searching over the use of reference books in either print or electronic format.

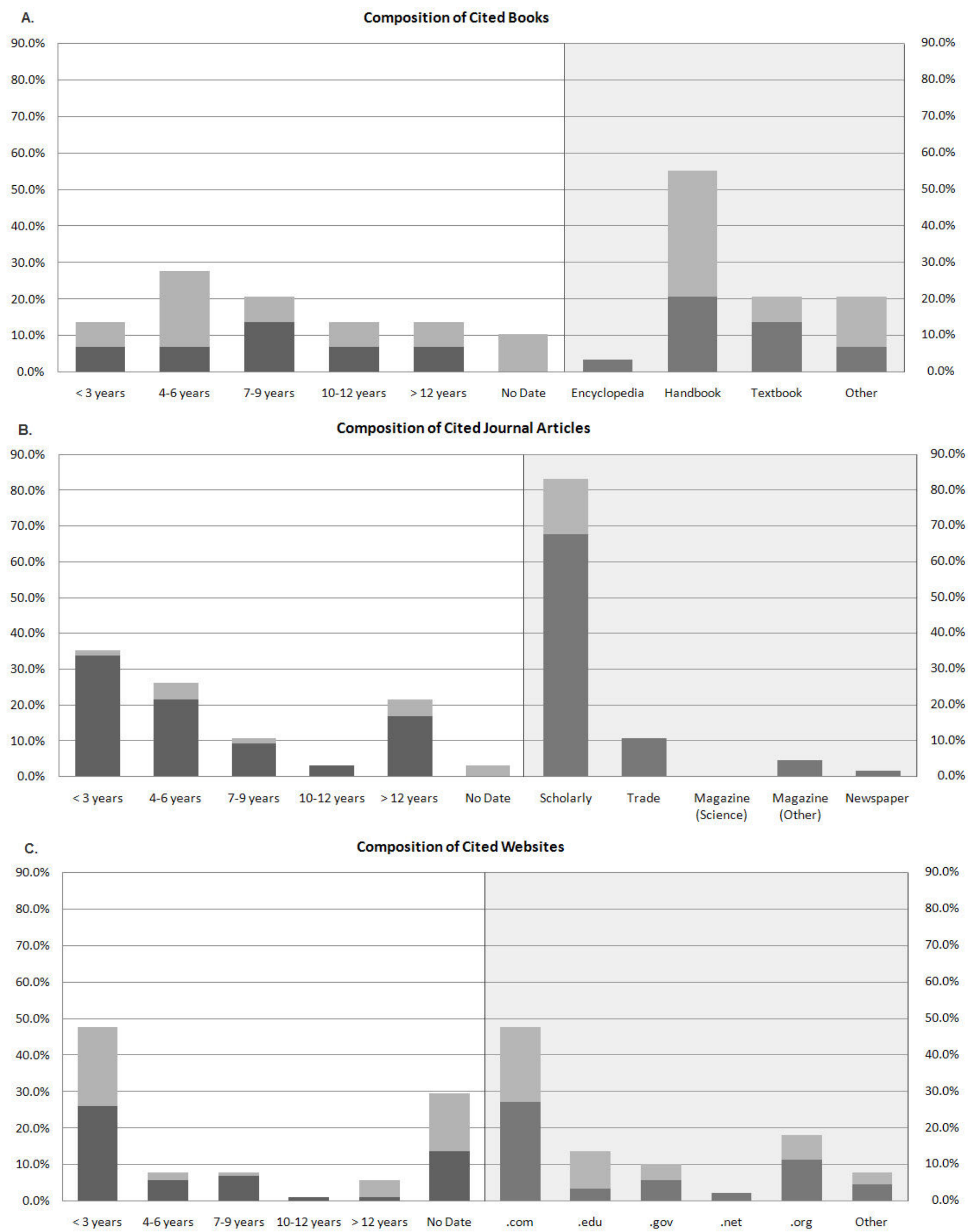
Table 3: Distribution of First-year Engineering Student Design Report Citations (n=234)

Format	Min.	Max.	Mean	Freq.	%
Book	0	6	1.00	29	12.4
Journal Article	0	7	2.24	65	27.8
Conference Proceedings	0	3	0.34	10	4.3
Website	0	12	3.03	88	37.6
Technical Paper	0	7	1.14	33	14.1
Other / Indiscernible	0	2	0.31	9	3.8



Unlike similar studies, books were cited less often than journal or other periodical articles. It is believed that this may be due to the stress placed upon the use of scholarly journal articles in the previous library instruction for the Freshman Writing Program as well as by comments made the course director, (BL), during lecture. Overall, students used more journal articles and websites than any other resource type. It was surprising to find a relatively small number of engineering reference books were cited in the design report bibliographies since these are some of the most valuable resources for finding physical constants and material data essential to engineering design. Electronic resource usage statistics show relatively high use of Knovel and ENGnetBASE collections in April-May 2009 when students worked on the design projects. This may indicate that while students did use these tools and book resources, they were not cited in the report bibliographies.

From Figure1.A, one can note that the majority of books cited can be further classified as handbooks. It is expected that students would rely on handbooks for engineering guidelines, practices and data. For the most part, students have difficulty citing books correctly. We believe that this stems from the high percentage of e-books accessible to students and difficulty among students to cite electronic materials correctly. We were surprised at the low percentage of encyclopedias that were cited since these tend to be much more approachable while providing a sufficient level of detail for a first-year engineering design course. For this reason, we believe that students should use specialized encyclopedias more to obtain background information. Based upon these findings, it is recommended that library instruction for first-year engineering students contain more focus on the use of specialized encyclopedias and to emphasize that these works are often written by experts in the field and can contain extensive bibliographies.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Composition of Cited Books
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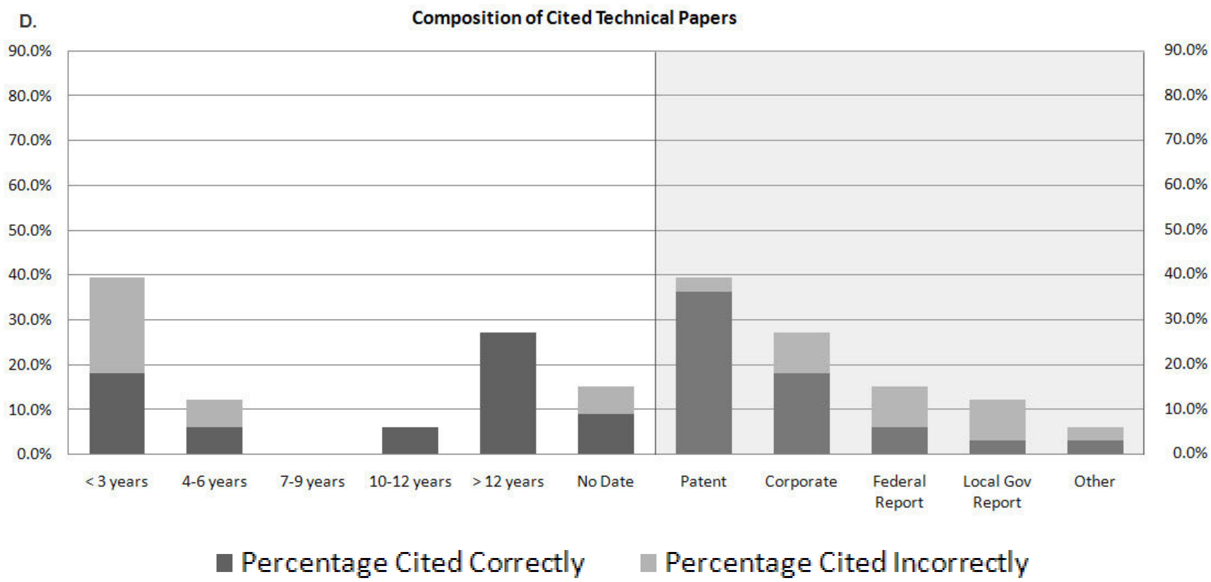


Figure 1: Composition of First-year Engineering Student Design Report Citations (n=234) Distribution of Resources showing Currency and Detailed Reference Types

From Figure 1.B-D, one can note that students' cite higher percentages of recently published resources for journal articles, technical papers, and websites. Since currency of resources is more relevant with these types of resources, we can conclude that students are appropriately evaluating resources for currency. A stronger argument for this conclusion could be made if the authors were able to further evaluate the quality of citations with regard to currency.

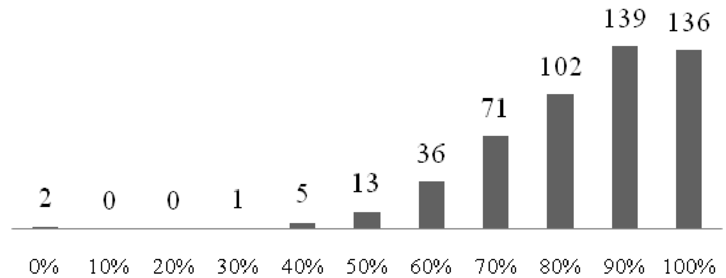
While students seem able to correctly cite journal articles, there is doubt among the authors that students are able to correctly interpret and use information provided in journal articles. From an informal assessment of citations, the authors noticed prevalence among students to list journal articles in the bibliography of the design report which were not actually referenced in the text. While the inappropriate use of information should result in a grade reduction, the authors are aware that all graders show bias towards their individual grading styles. This informal assessment of citations also led the authors to notice a high frequency of incorrectly referenced commentary on primary resources. For example, one such reference consisted of a correctly formatted website citation for a blog entry that quoted specific findings in a federal report on electric vehicles. In order to address this type of research behavior, it is recommended that library instruction for first-year engineering students include examples of these common missteps and how to appropriately locate and cite engineering resources.

The authors are satisfied with the currency and variety of websites and technical papers cited. It is important to note that students demonstrate more difficulty citing websites than any other reference type, which mirrors Edzan's findings[7].

In order to validate the results of the citation analysis, it is useful to compare these findings with the previous selected-response assessment results. From the 505 students that completed the selected-response assessment after the library instruction sessions, roughly 27% of students answered all questions correctly with an additional 27% of students answering one of ten questions incorrectly. The distribution of student performance can be seen in Table 4.

Table 4. Distribution of Selected-Response Assessment Results (n=505)

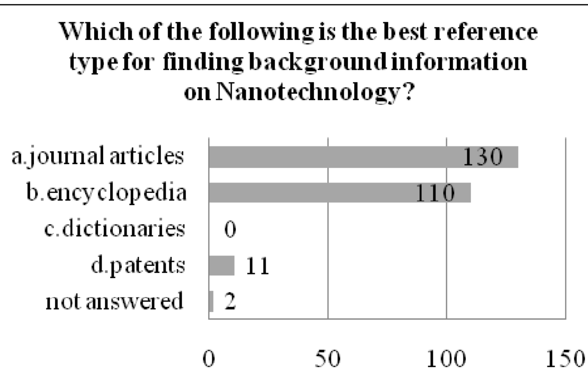
Min.	Max.	Mean	Std. Dev.
0	100	83.72	15.29

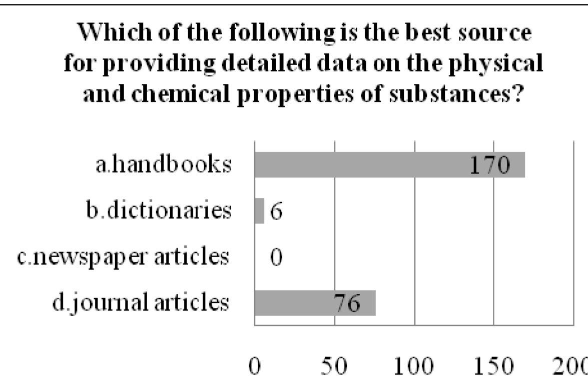


The majority of the individual question responses showed expected response distributions; students demonstrated proficiency in navigating library resources to find preselected items. However there was one notable exception when students were asked to select the most appropriate engineering resource for a specific inquiry. As seen in Table 5, a larger than expected percentage of students selected journal articles as the most appropriate reference type to locate information that would typically be found in engineering reference materials. This again seems to indicate the heavy focus on the use of scholarly journal articles in previous library instruction and later reinforcement by engineering faculty has created a journal article bias for first-year engineering students. The demonstrated misunderstanding of the role of scholarly journal articles in engineering research found using the selected-response assessment is mirrored by the heavy usage of scholarly journals and light use of encyclopedias in the engineering design reports as found through the citation analysis.

Table 5: Appropriate Use of Engineering Resources from Selected-Response Assessment

Selecting the Best Reference	Finding Technical Information
n = 253 43.48% correct response	n=252 67.46% correct response





Mapping to Standards

From the bibliographies evaluated, it appears that students demonstrated information literacy competence in the selected indicators of the ALA/ACRL/STS Information Literacy Standards for Science and Engineering/Technology's Standards 1 and 3 (Table 6). Competency in meeting these standards can be shown by the students' use of a variety of types of information resources, and the appropriate use of current resources. When students include a bibliography in a written work, they are indicating that they have used information resources to meet an identified information need. The citation analysis provides evidence of students' abilities to evaluate information resources with the inclusion of appropriately current references. There is a mixed demonstration of proficiency in Standard 4 which can be tied to the correct citation of resources. This echoes similar findings in which generally, few undergraduate engineering students are able to correctly cite information resources. When students correctly follow citation formats and demonstrate an understanding of information rules instead of plagiarizing, it can be interpreted that students are acting with an understanding of the ethics of information.

Table 6. Alignment of Citation Analysis to Performance Indicators

Bibliography Feature	Performance Indicator	Evaluation – Standard met?
Number of Citations	1.1 Defines and articulates the need for information.	Yes – only one of 29 design groups did not include a list of references
Types of Resources Cited	1.2 Identifies a variety of types and formats of potential sources for information.	Yes – students cited a wide variety of information resources
Currency of Resources Cited	3.2. Selects information by articulating and applying criteria for evaluating both the information and its sources.	Yes – students included appropriate formats of current resources
Completeness of Citations	4.1. Understands many of the ethical, legal and socio-economic issues surrounding information and information technology.	No – students did not provide complete citations for 39% of references
	4.2. Follows laws, regulations, institutional policies, and etiquette related to the access and use of information resources.	
	4.3. Acknowledges the use of information sources in communicating the product or performance.	Yes – only one of 29 design groups did not include a list of references

There were also mixed results from the selected-response assessment regarding information literacy competencies. This evaluation was tied to Standards 1 and 2. Students demonstrated varying levels of competency in understanding the various formats and types of engineering information resources. While most students were able to navigate a variety of information retrieval systems, we would have preferred for at least 85% of students show proficiency in each of the performance indicators listed in Table 7. It was difficult to ascertain if the results from the selected-response assessment accurately reflected the students' understanding or if a lack of motivation or attention may have contributed to lower than expected scores in this area.

Table 7. Alignment of Selected-Response Assessment to Performance Indicators

Performance Indicator	Evaluation – Standard met?
1.2. Identifies a variety of types and formats of potential sources for information.	Yes – 90% of students are able to identify scholarly resources.
1.3 Has a working knowledge of the literature of the field and how it is produced.	Mixed - 55% of students are able to select appropriate resource for given information need. 84% of students are able to use a specific engineering resource to obtain desired information.
2.1. Selects the most appropriate investigative methods or information retrieval systems for accessing the needed information.	Yes – 85% of students are able to select the most appropriate engineering resource retrieval system to obtain desired information.
2.2. Constructs and implements effectively designed search strategies.	Mixed – 78% of students are able to effectively search the local OPAC to obtain desired information. 88% of students are able to correctly use search fields to obtain desired information.
2.3. Retrieves information using a variety of methods.	Yes – Overall, 87% of students are able to use a variety of resources to locate desired information.

Outcomes

Ultimately this study was performed to give the authors evidence-based insight into first-year engineering students' research behavior. It is clear that local library instruction for first-year engineering students should be modified to include significant focus on the use of specialized encyclopedias for background information and how students can avoid common research missteps. In addition to informed instructional strategies, our findings support the following outcomes:

- The use of citation analysis as a means of information literacy assessment is an effective method of documenting how students use information resources. It can provide insight into students' understanding of the types and varieties of information resources.
- Current instruction methods allow for the assessment of some of the ALA/ACRL/STS Information Literacy Standards for Science and Engineering/Technology, notably standards regarding identifying, accessing and using appropriate information resources.
- Perhaps due to previous library instruction and engineering faculty reinforcement, students have a misunderstanding about the appropriate use of scholarly journal articles. Overall, results from this study support previous findings that students show an obvious preference for web resources.
- In order to better observe students' abilities to evaluate information resources and revise information seeking strategies, a mid-semester review of references will be included in future instruction. It is also expected that a mid-semester review will improve the quality and completeness of citations.

Conclusion

After mapping the ALA/ACRL/STS Information Literacy Standards for Science and Engineering/Technology to current assessment techniques, it was clear that the citation analysis component of the evaluation process was integral to understanding students' use of information resources. The tool designed to perform this evaluation was deemed acceptable for reuse in future assessment activities, although there was discussion of separating Patents from the Technical Papers category and making it a stand-alone category similar to Conference Proceedings. Also, it was noted that a category should be added for Engineering Standards if this tool is applied to upper-level undergraduate or graduate engineering student groups.

It is also clear from the mapping exercise, that the current assessment model does not address all components of the ALA/ACRL/STS Information Literacy Standards for Science and Engineering/Technology. In the areas that were assessed, some major gaps in understanding were identified regarding the appropriate use of scholarly journal articles and the accurate citing of materials. There will need to be a more collaborative approach among librarians, faculty advisors and laboratory instructors to aid in correcting these misunderstandings. There is also an obvious need to employ other forms of assessment that will address the remaining information literacy standards. One proposed method of addressing Standard 3, which relates to students' abilities to evaluate information resources and revise information retrieval strategies if necessary, is to establish a Mid-semester Reference Review practice. This review would require students to submit a working bibliography to the engineering librarians near the midpoint of the design project and follow-up with a group meeting. The engineering librarians would be able to evaluate the references provided, correct any incorrectly cited items, and work with the group members to evaluate the information resources used. An overview of the proposed multiple assessment strategy can be found in Table 8.

Table 8. Proposed Alignment of On-going, Multiple Assessment Strategy

Standard	Assessments
1. The information literate student determines the nature and extent of the information needed.	Informal Questioning Selected-Response Citation Analysis
2. The information literate student accesses needed information effectively and efficiently.	Informal Questioning Selected-Response Citation Analysis
3. The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system.	Citation Analysis Design Report Mid-semester Reference Review
4. The information literate student, individually or as a member of a group, uses information effectively to accomplish a specific purpose.	Citation Analysis Design Report
5. The information literate student understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally.	Informal Questioning Comparative Study

To better evaluate Standard 5, relating to students' on-going use of information, a comparison of different student communities' information literacy competencies would be valuable. It is proposed that a similar study be conducted focusing on final-year design students.

This study would not have been possible without the active collaboration of engineering faculty, laboratory instructors, and graduate fellows – in general, a small community that values the role of the library and information literacy in engineering education. The authors feel that including information literacy as a measurable outcome of the ABET Lifelong Learning Objective may improve participation of engineering educators in information literacy assessment activities.

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