Infusing Information Literacy into Civil Engineering Curricula

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As information technology advances and the need for effective communication skills in engineering practice becomes even more important, it is essential that engineering educators encourage undergraduate students to develop and improve their communication skills in the context of the current and emerging information infrastructure. In the Civil Engineering Program at the United States Coast Guard Academy, specific performance indicators related to information literacy have been developed and linked to several of the Student Outcomes (i.e. ABET "a-k"). Faculty members have developed assignments and rubrics designed to assess student progress and improve student development in information literacy for each performance indicator. The authors suggest that information literacy should be progressively and consistently incorporated into undergraduate engineering curricula for students to develop and hone the required skills necessary for engineering practice and lifelong learning.

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Introduction

As information technology advances and the need for effective communication skills in engineering practice becomes even more important, it is essential that engineering educators encourage undergraduate students to develop and improve their communication skills in the context of the current and emerging information infrastructure. With the current trends in texting and instant communications, online access provides tremendous amounts of information that could be quickly downloaded and used. As a result, engineering educators must ensure that students learn the important steps of evaluating the credibility and appropriateness of sources while properly synthesizing, using and citing information from several sources. The National Forum on Information Literacy (IL) defines IL as "*The ability to know when there is a need for information, to be able to identify, locate, evaluate, and effectively and responsibly use and share that information for the problem at hand"* (1, 2). Therefore, key steps in practicing IL could be summarized as:

- Identify the need for information
- Identify and locate sources of information
- Evaluate the credibility of these sources
- Responsibly use and share the acquired information

Saleh (3) notes that information literacy is becoming increasingly important in the contemporary environment of rapid technological change and proliferating information. It is a critical thinking process that is iterative and linked to the acquisition and practice of discipline knowledge. Swanson (4) stresses that instructors and librarians should work together to create critical information literacy models that:

- "Views the information world as a dynamic place where authors create knowledge for many reasons.
- Seeks to understand students as information users.
- Emphasizes that information evaluation is a continual process during research.
- Recognizes that information evaluation is relative to the point of view of the reader.
- Provides opportunities for students to increase their understanding of finding, evaluating, and using information.
- Centers libraries within the curriculum as the experts on overcoming many of the obstacles to conducting successful research in the ever-changing information world."

In general, one of the main objectives of higher education is to prepare students to be life-long learners, critical thinkers and to take greater responsibility for their own learning. This cannot be accomplished without adequate/appropriate competency in information literacy. The Association of College and Research Libraries (ACRL) states that: "Information Literacy forms the basis for life-long learning. It is common to all disciplines, and to all levels of education. It enables learners to master content and extend their investigations to become more self-directed, and assume greater control over their own learning" (5). This is in harmony with ABET requirements on communications and life-long learning for accreditation of engineering programs.

In the Civil Engineering Program at the United States Coast Guard Academy (USCGA), specific performance indicators related to information literacy have been

developed and linked to several of the Student Outcomes (i.e. ABET "a-k"). Faculty members have developed assignments and rubrics designed to assess student progress and improve student development in information literacy for each performance indicator. By integrating information literacy development and assessment into the existing civil engineering assessment model, the faculty has successfully threaded this competency into the curriculum using a sustainable and effective framework. Part of the framework involves using a similar rubric throughout the curriculum that includes assessing student's ability to: (a) identify the type and extent of information needed**,** (b) search for and incorporate a variety of appropriate technical information sources, (c) use sources appropriately, legally, and ethically, (d) use technical writing skills, and (e) write a well-organized paper or report. This paper provides an overview of the approach used at the USCGA to embed and evaluate aspects of information literacy within the Civil Engineering curriculum without adding new courses. The progressive infusion of information literacy in the curriculum, the development of relevant performance indicators, and steps taken to collect and analyze assessment data are presented. The authors suggest that information literacy should be progressively and consistently incorporated into undergraduate engineering curricula for students to develop and hone the required skills necessary for engineering practice and lifelong learning.

Overview of USCGA Civil Engineering Curriculum

The United States Coast Guard Academy, located in New London, Connecticut offers Bachelor of Science degrees in eight majors including Civil Engineering and all cadets must graduate in four years. Approximately 14 percent of the cadet corps graduates with a Civil Engineering degree. The Civil Engineering curriculum is broad and provides a solid background in the structures, environmental, geotechnical, and construction sub-fields of civil engineering. Graduates pursue a number of different career paths and many of them serve in the Coast Guard as practicing civil engineers, pursue professional licensure, and attend graduate programs in civil engineering. Emphasis is placed on balancing theory and practice of engineering so graduates are intellectually and professionally prepared to provide engineering services to the Coast Guard. Professional skills are particularly reinforced in the engineering courses through laboratory reports, technical papers, presentations, design projects, case studies, field trips, interaction with practitioners and Coast Guard Officers, community outreach activities, and professional membership. Students at USCGA take a wide variety of coursework outside of engineering to widen their horizon, encourage self-reflection and discovery, and develop professional skills. Civil Engineering students take at least 27 credit hours of non-technical core courses plus six additional credits of Health and Physical Education. Since leadership development is a continuous process, development opportunities are spread throughout the curriculum and extra-curriculum activities.

Information Literacy Across the Civil Engineering Curriculum

As a result of a program review and alumni feedback, the Civil Engineering faculty made efforts during the 2010 fall semester to specifically infuse components of IL into the current curriculum and emphasize its importance to life-long learning. One of the objectives was to infuse IL into the current curriculum without developing or adding new courses. To achieve this, a process of identifying IL related to ABET student outcomes, linking them to courses and developing assessment tools was established (6). The first step was to review all the courses that had a writing and/or research component throughout the four year curriculum. Civil Engineering students typically take 27 credits of non-technical courses such as *English Composition and Speech, Writing about Literature*, *U.S. History, American Government,* etc. Each of these courses has some IL component. Although these contribute to students' overall competency in IL, they do not adequately address technical writing relevant to Civil Engineering. Therefore, a decision was made to focus on courses directly controlled by the Civil Engineering Section that could be used to enhance technical writing skills. A schematic representation of the process is shown in Figure 1.

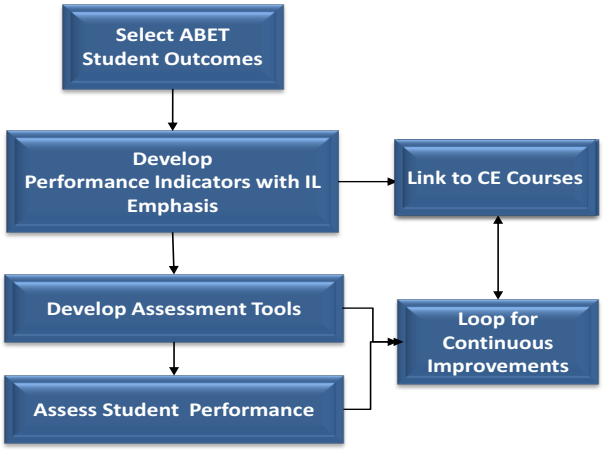

Fig. 1. Process of linking Information Literacy to ABET Student Outcomes

Initially, the ABET "a-k" student outcomes (7) were reviewed and three of them, "g", "i" and "j" were selected for their reference to some components of IL. Performance indicators were developed for each outcome. Performance indicators were then mapped or linked to courses within the current civil engineering curriculum, and assessment tools were developed and utilized to measure achievement of each performance indicator. An ongoing effort is being made to progressively infuse some components of IL throughout the Civil Engineering curriculum. The outcomes and related performance indicators developed for each of these ABET student outcomes and linked to upper level Civil Engineering courses are presented in Tables I to III. Student performance is then assessed in each course on the established performance indicators.

Table I. Performance Indicators for ABET outcome 3g

Performance Indicator	**ABET 3g: Ability to communicate effectively**	
	Courses	**Assessment**
3g-1: Use appropriate presentation tools and techniques to orally communicate information, concepts and technical ideas effectively.	Soil Mechanics Civil Eng. Design	Technical paper presentation Project presentation
3g-2: Prepare written documentation in standard engineering format to communicate information, concepts and technical ideas effectively.	Soil Mechanics Civil Eng. Design	Written technical paper Project Report
3g-3: Research information from a variety of sources, utilize information to make engineering decisions/judgement and produce a technically sound report.	Enviro. Eng. I Civil Eng. Design	Technical report Project report
3g-4: Respond to questions from diverse audiences with justified and well formulated answers.	Soil Mechanics Civil Eng. Design	Technical paper presentation Capstone project presentation

Table II. Performance Indicators for ABET outcome 3i

Performance Indicator	**ABET 3i: Recognition for the need for life-long learning**	
	Courses	**Assessment**
3i-1: Take the Fundamentals of Engineering Exam.	Civil Eng. Design	Report on FE exam
3i-2: Utilize/use a variety of tools such as professional journals, books, codes & standards, etc. as sources of industry information.	Soil Mechanics Enviro. Eng. I	Technical paper Climate change paper

Table III. Performance Indicators for ABET outcome 3j

Performance Indicator	**ABET 3j: Knowledge of contemporary issues**	
	Courses	**Assessment**
3j-1: Identify several contemporary issues in civil engineering.	Enviro. Eng. I Construction Project Management	Journal Contemporary issue presentation
3j-2: Investigate, gather, and analyze information related to contemporary issues.	Enviro. Eng. I Construction Project Management	Climate change paper Technical Journal review

Campus Resources-Partnership with the Library

Librarians have the primary responsibilities of facilitating access to information resources and providing instructions on how to use those resources. As such, access to the appropriate library resources plays an important role in helping students develop and enhance their information literacy skills. One challenge in building information literacy in engineering students is to acquaint them with available library resources and how to intelligently utilize them (8). Therefore, librarians should be active partners with faculty in the effort to promote IL and help students develop the required IL skills.

The mission of the Coast Guard Academy Library is to support the Academy's educational and training missions by providing quality library services, resources, and facilities to the students, faculty and staff. Freshman students are required to attend a library skills session where they are introduced to the library research process and shown how to find books and reference materials and use general, multi-subject databases. The information in this session is built upon and expanded during the freshman year English and History classes when students are provided instruction on search strategies, more specialized databases, and primary sources in order to complete a specific assignment. Further library support past the first year is provided at the request of faculty and can include in-class sessions of discipline specific resources and resource guides tailored to a single course. Librarians play a very active role in not only providing access to information, but also working with faculty to promote IL.

Journal and database subscriptions are continually reviewed and updated to provide access to a greater number of resources. The library has continued to expand its electronic book and journal holdings. Students have access to almost 325,000 electronic books and more than 115,000 journals. Electronic access is provided to all ASCE journals, current conference proceedings, electronic books, and published standards. Important science and technology subscriptions to full-text electronic journals are available through ScienceDirect, Wiley Online Library, and Taylor and Francis. In addition, students have access to Knovel, ASM Handbooks Online, AccessEngineering, National Technical Reports Library, and Springer electronic books from 2005 to present. Indexing and abstracting services are provided with subscriptions to Compendex and Marine Technology Abstracts. Faculty members are encouraged to participate in collection review to ensure the most useful resources are being acquired. Each academic department is allotted a portion of the

annual budget and has a designated liaison to the library. As a result it continues to meet the needs of the program and the faculty. The partnership between the library and faculty at USCGA is strong as the librarians play a very active role in not only providing access to information, but are also engaged promoting IL.

The Hewitt Writing and Reading Center at the Academy was established two decades ago to improve students writing and communications skills. The Writing Center is staffed by faculty members from the various academic disciplines, professional editors, writers and educators. The Writing Center provides support: (A) to faculty as they prepare reports or articles for academic and professional journals and (B) to students as they prepare laboratory reports, technical papers, writing assignments, presentations in several courses. The partnership between the Library, Writing Center, and faculty at USCGA is an effective collaboration for developing the student outcomes to communicate effectively and engage in life-long learning.

Assessment of Student Performance

The different assessment tools used to assess students' performance on the performance indicators are presented in Tables I to III. Details of each assessment tool assignment are as follows:

- *Soil Mechanics technical paper*-Students prepare a written technical paper on a selected topic in geotechnical engineering according to established technical writing guideline from ASCE or the Frontiers in Education (FIE). They are also required to give a 20-minute formal presentation to fellow students and faculty. The papers and presentations are graded consistently using established rubrics. The technical writing and presentation aspects are part of a campus-wide "*Class of 1959*" IL competition. Students with the best written and best presentation are selected separately from each major. Then they compete campus-wide for the best overall paper and presentation. The graduating class of 1959 generously established an endowment for the purpose of encouraging excellence in the writing and speaking skills of the future officers enrolled at the Academy. Each academic year, the Academy holds the "*Class of 1959"* Contest, and the contest has helped reinforce communication skills within the curriculum by infusing writing and public speaking across all the academic disciplines.
- *Environmental Engineering I water quality report*-Students discuss results of water quality testing in relation to their predictions. Students draw appropriate and reasonable conclusions based on the results of the lab.
- *Environmental Engineering I student journal*-Students collect articles on a variety of contemporary environmental issues and write about the article and issue.
- *Environmental Engineering I climate change paper*- Students use a variety of reliable sources to prepare a research paper based on climate change. The objectives of the paper include: (a) To become familiar with the basic scientific principles behind climate change; (b) to become aware of the challenges that remain in predicting the effects of climate change and in developing solutions to the problem, and (c) to recognize and use established scientific sources to develop an informed position on a contemporary issue.
- *Construction Project Management technical journal review*-Contemporary issues specific to the engineering profession or construction industry are explored. Achievement is assessed through individual student research and written analysis of contemporary industry issues as published in technical journals.
- *Construction Project Management contemporary issue presentation*-Students work in teams of two to research, analyze, and present contemporary issues in engineering or the construction industry. This assignment is a follow-up of the individual effort technical journal review assignment specific to contemporary issues. Achievement is assessed through performance during team presentations.
- *Civil Engineering Design (CED) Project Presentation*-Capstone teams are required to present their team experience and project results to a diverse audience of peers, faculty, professional engineers, and clients. Students work in groups of 4-5 on their capstone projects; each student is expected to be the subject matter expert on a particular topic related to the project and complete a technical paper. There is some "open-endedness" to the assignment because the technical topics are determined based on the scope of each project. Team presentations are approximately 20-30 minutes long, and each team member is required to contribute to the presentation. Achievement is assessed through performance during oral presentations scored using a grading rubric.

Grading rubrics were developed to ensure that the important components of IL (such as scope of research, variety of sources, and use of sources) were consistently assessed and evaluated by different instructors. USCGA faculty opted to develop rubrics that would accomplish the goal of IL assessment and improvement. After reviewing initiatives at other institutions, overly complicated rubrics seemed difficult to use, less sustainable, and could discourage faculty members from embracing IL assessment and development (6). For assessment tools where a rubric is used, students

received the grading rubric together with the assignment to ensure that the expectations of the instructors were known. The rubric used for written technical papers is presented in Table IV.

Table IV. Technical Report/paper Grading Rubric

Assessment Areas	Exceeds Expectations (90% to 100% of allotted points)	Meets Expectations (70% to 89% of allotted points)	Below Expectations (<70% of allotted points)
Ability to identify the type and extent of information needed. _____/10	Introduction clearly articulates the relevance of the topic to soil mechanics and/or foundation engineering. Scope and extent of the research in the entire paper provides excellent background to support the topic.	Introduction touches on the relevance to soil mechanics and/or foundations. The scope and extent of research in the entire paper provides some good background to support the topic, but is not comprehensive.	Little to no mention of tie between the topic and soil mechanics and/or foundations. The type and extent of research is inadequate to provide background for the topic.
Ability to search for and incorporate a variety of appropriate technical information sources. _____/20	At least 6 appropriate & credible technical information sources are used that represent a variety of sources. The sources are varied and comprehensive enough to fulfill the scope of the research without over reliance on one or two sources.	At least 4 appropriate & credible technical information sources are used that represent at least 2 types of information sources. The sources generally support the scope of the research and no one source is too heavily relied upon.	There are less than 4 technical information sources used and/or one or more sources are inappropriate for a technical research paper. One or sources heavily relied upon. Sources do not adequately cover the scope of research. One or more source not credible.
Ability to use sources appropriately, legally, and ethically. _____/10	Sources are properly paraphrased; all direct quotes are in quotation marks. References are cited properly within the text and are appropriately listed in the bibliography according to the ASCE referencing guidelines.	Sources are properly paraphrased and direct quotes are in quotation marks except for minor issues. References are in the bibliography using the ASCE or similar referencing guidelines.	Sources are not properly paraphrased and/or direct quotes are not properly attributed. Citations are missing from the text and/or are not properly listed in the bibliography according to the ASCE or similar referencing guidelines.
Technical content _____/40	All technical aspects are covered with sufficient details in the context of topic. All important conclusions are clearly stated. Student shows excellent understanding of the relevance of the topic to soil mechanics and foundation engineering.	Most of the important technical details are covered. Only minor details missing. Conclusions regarding major points are stated. Student shows good understanding of the relevance of the topic to soil mechanics and foundation engineering.	Several important technical details are missing or not addressed in sufficient details. Conclusions are missing important aspects of the topic. Student shows lack of understanding of the relevance of the topic to soil mechanics and foundation engineering.
Technical writing skills. _____/10	Writing is clear, concise, and easy to understand. Sentences are grammatically constructed. Passive voice is used. There are no typos or spelling errors. Tables and figures are numbered and properly incorporated into the text after being introduced.	Writing is fairly easy to understand with a few unclear or poorly constructed sentences. There are a few typos or spelling errors. Tables and figures are properly used and incorporated.	Writing is of poor quality. Concepts are poorly explained. Multiple grammatical errors and/or typos. Tables and figures are not numbered, properly incorporated into the text, and/or introduced.
Ability to format a well-organized paper. _____/10	The paper is well organized as per guidelines or format provided; introduction explains how the research supports the topic. Sub-headings flow logically. The conclusion ties together the main ideas.	The paper is fairly well organized with an introduction, main research section with sub-headings, and a conclusion. The conclusion ties together the main ideas. Formatting generally good as per guidelines provided.	The paper lacks good organization. The paper is missing an introduction or conclusion. Formatting does not follow guidelines provided.

Examples of students' performances on the various components of the written paper and oral presentation grading rubrics are shown in Figures 2 and 3. In both figures, "exceed," corresponds to a score of 90%-100%. "Meet," and "below" corresponds to scores of 70%-89% and less than 70%, respectively. Although the overall performances were generally good, areas such as "formatting," "source of information" where some students struggled could be identified. Performance in these areas were used to provide targeting instruction and revision of assignments (where appropriate) to enhance learning.

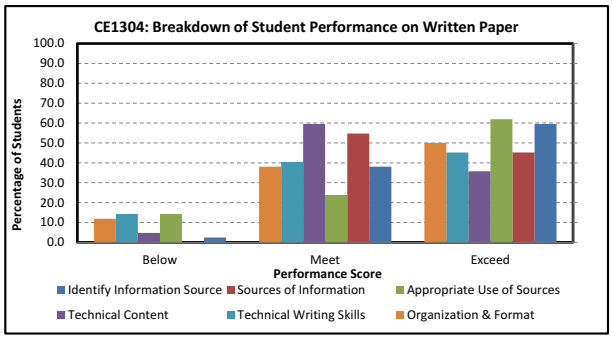

Fig. 2. Student performance on technical paper in Soil Mechanics course

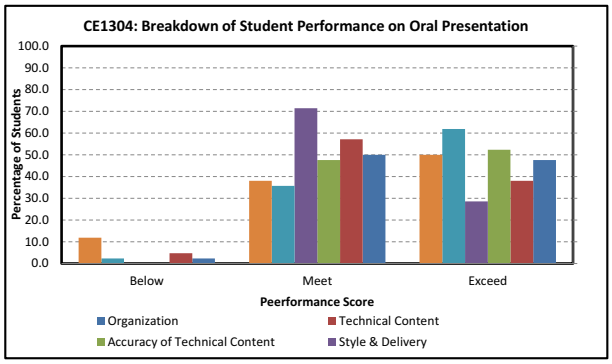

Fig. 3. Student performance on oral presentation in Soil Mechanics course

In Environmental Engineering I, similar data are gathered annually to assess information literacy skills using a comprehensive water quality report, a contemporary issues paper on climate change, and informal writings on contemporary environmental issues collected in a journal. Some challenges noted have been acclimating students to reference and citation methods typically used by Civil Engineers in place of the Modern Language Association (MLA) style used in early core courses in the Humanities Department. Another challenge has been helping students critically evaluate the difference between reliable scientific sources and sources that convey opinions rather than facts.

By their senior year, students would have had several opportunities to hone their general communication and information literacy skills. The culminating test of these skills takes place in the CED capstone design course. Performance on the CED oral presentation for the graduating class of 2014 is shown in Figure 4. At least 80% of the students either met or exceeded expectations in each component of the CED grading rubric. It is important to note that faculty members typically have higher expectations for seniors and, in some cases, the actual achievment of performance indicators may appear to be the same or higher in the junior level classes. This phenomen is discussed and taken into consideration during biennial program review meetings and also at end of course review meetings.

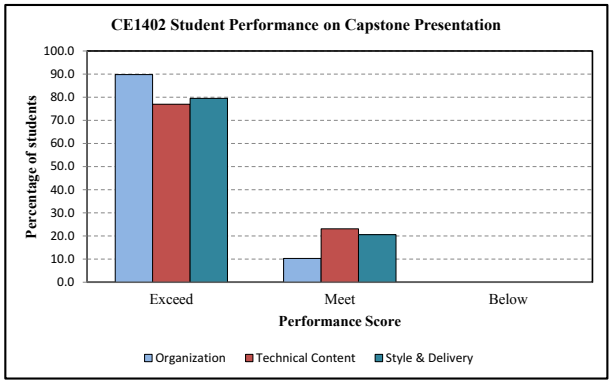

Fig. 4. Student performance on CED capstone presentation

Conclusions

In the Civil Engineering Program at the United States Coast Guard Academy, specific performance indicators related to information literacy were developed and linked to several ABET student outcomes. The goal is to promote information literacy within the current civil engineering curriculum by developing assignments, assessing student achievement of performance indicators linked to student outcomes, and making improvements as needed based on an evaluation of assessment data. The assessment tools were kept as simple as possible and woven into existing assessment practices in order to keep the burden on faculty members to a minimum. Components of information literacy were progressively infused throughout the curriculum to enable students to develop and foster the appropriate skills. Student performance was assesses using a common rubric in several courses. It was observed that students mostly struggled in selecting appropriate sources of information and in formatting their work to meet the varying requirements of the different assignments. It was noted that more coordination is required with the Humanities Department to ensure that students understand and are made aware of formatting and citation styles other than that of the Modern Language Association. Most recently, there has been an institutional effort to develop information literacy as a thread throughout the Academy. A committee is now working with representatives from every major to establish an academy-wide implementation strategy with the objective to track the progressive development from freshman to senior year. As this work progresses, it is important that faculty take the lead in promoting information literacy in close collaboration with the library staff so that life-long learning skills are valued and supported in the context of academic disciplines. As the Coast Guard Academy develops a more unified approach to weave essential skills, such as information literacy, throughout the four year cadet experience, the information literacy approach described here will serve as an example for other educators.

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