

## THE INFORMED ENGINEER

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**Abstract** – Future engineers need an education program that can provide them with the breadth of knowledge necessary to be knowledgeable and productive contributors to both the workplace and to society. In short, engineers need information. Unfortunately, most technical science courses don't require assignments that involve information research. It is even more unfortunate, that due the heavy technical nature of their curriculum, students are often only exposed to these information retrieval skills a few times in their college career. The Association of College & Research Libraries and the American Association for Higher Education endorsed Information Literacy Competency Standards for Higher Education to describe essential skills that a student should possess to effectively identify the need for and utilize information. These standards correlate with several of the ABET evaluation criteria. This paper will both examine these relationships and explore the need for engineering students to master information competencies.

*Index Terms* – Information Literacy, Evaluation Criteria, Curriculum Design

### INTRODUCTION

Engineering is unique in that it is one of the few disciplines where upon graduating with an undergraduate degree and completion of the FE exam, the student is awarded professional certification. Engineering does not require advanced studies in a graduate degree program before these students are recognized as professionals. For this reason, it is essential that engineering students receive an education that will provide them with the breadth of knowledge necessary to be knowledgeable and productive contributors to both the workplace and to society.

Engineers are unique users of information, which means that it is all the more important for engineering students to be exposed to skills that allow them to recognize, retrieve and apply information to fulfill their professional objectives. Unfortunately, most technical science courses don't require assignments that involve information research. It is even more unfortunate, that due the heavy technical nature of their curriculum, students are often only exposed to these information retrieval skills a few isolated times in their college career. Pinelli states, "The ability of engineers to identify, acquire, and utilize scientific and technical information is of paramount importance to the efficiency of technological innovation and the R&D process [1]."

It is disconcerting to read studies such as that from Weiner et al [2] reporting that engineering students don't

recognize the importance of using formal information resources as part of the engineering design process. It is studies such as this, in addition to the continual complaints from industry, that show that engineering graduates are lacking basic skills and proficiencies essential to being successful professional engineers. It is for reasons such as these that the Accreditation Board for Engineering and Technology (ABET) began working to revise the accreditation criteria, referred to as Engineering Criteria 2000 or EC2000 [3].

### ACCREDITATION OVERVIEW

While many of the engineering criteria remained true to the old accreditation process, the majority of revisions occurred in Criterion 2 (program objectives) and Criterion 3 (program outcomes and continuous program improvement) [3]. Focused on assessing learning outcomes rather than educational opportunities, engineering educators across the country have been working to develop program objectives, educational outcomes, teaching strategies and assessment methods to meet the revised accreditation criteria. While ABET recognizes that engineering programs need to have the flexibility to work within their individual institutional missions, the overarching goal of ABET remains the same – to provide the educational opportunities and skills necessary for students to become successful, productive contributors to the engineering profession.

Criterion 2 (program objectives) is focused on the formulation of program-level educational objectives (goals) and program outcomes (expectations). The development of these objectives and outcomes should form the basic framework for more specific curriculum development. Criterion 3 focuses on further development of specific assessment methods for a program's learning outcomes. Programs must develop ways to assess student success in each of eleven different outcomes. The outcomes for Criterion 3 are listed in Table I.

All eleven of the outcomes require some form of information skill or knowledge. For example, Outcome 3a, the ability to apply knowledge of mathematics, science and technology, requires that a student recognize what answer or outcome needs to be met, determine what formula(e) or technology needs to be applied, determine what variables, constants, or materials are needed and finally the technical knowledge to apply all of these to solve for the desired result. The underlying skills in this example directly correlate with information competencies. Of the eleven outcomes in Criterion 3 only a few emphasize or require

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technical capabilities. The teaching-learning process for the remaining skills have historically been delivered by non-

TABLE I

ABET CRITERION 3 LEARNING OUTCOMES

Programs must demonstrate that their graduates have:	
3a	An ability to apply knowledge of mathematics, science and technology
3b	An ability to design and conduct experiments, as well as analyze and interpret the data
3c	An ability to design a system, component, or process to meet desired needs
3d	An ability to function on interdisciplinary teams
3e	An ability to identify, formulate and solve engineering problems
3f	An understanding of professional and ethical responsibility
3g	An ability to communicate effectively
3h	The broad education necessary to understand the impact of engineering solutions in a global and societal context
3i	A recognition of the need for and an ability to engage in lifelong learning
3j	A knowledge of contemporary issues
3k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

technical courses taught externally to most engineering programs. Developing objectives and assessments for some outcomes such as communication, team-building and life-long learning may be unfamiliar territory for the majority of engineering faculty [4]. Outside support units on campuses, such as English departments, writing centers, and university or college libraries consistently work in these areas and have contributed much to the literature on learning outcomes and assessments. These units may prove to be important contributors in helping develop assessment methods or curriculum assignments to better demonstrate student capabilities and learnings to meet the ABET outcomes.

### INFORMATION COMPETENCIES

In January 2000, the Board of the Association of College and Research Libraries (ACRL) and the American Association for Higher Education (AAHE) adopted the Information Literacy Competency Standards for Higher Education [5]. The standards were developed to ensure the development of information smart, lifelong learners who can flourish in a rapidly changing, information rich environment. In today's society where people are overloaded with a variety of easily accessible information sources. It is essential that students and professionals alike are capable of making intelligent decisions about information. The Information Literacy Competency Standards are listed in Table II.

The Information Literacy Competency Standards for Higher Education [5] states, "Information Literacy forms the basis for lifelong learning. It is common to all disciplines, to all learning environments, and to all levels of education. It enables learners to master content and extend their investigations, become more self-directed, and assume greater control over their own learning."

It is important to note that the term "information literacy" is often confused with terms such as "technology literacy" or "computer skills". In actuality, information

literacy aims to develop knowledge and critical thinking skills around information. The focus of information literacy instruction is not on the mechanics of using any one specific library, but rather on the global structure and organization of information. While it is necessary to teach these skills in the context of one's institution and available resources, the competencies developed should be transferable to any library, information center, or future workplace. The goal is not to teach students "how to use the Library", but how to think critically about the need for, the acquisition of, retrieval of and use of information. It also focuses on introducing students to key information resources in a discipline so students are aware of the common information sources in their field.

The Information Literacy Competency Standards for Higher Education are broken into Standards (broad goals), Performance Indicators, and Outcomes, which describe essential skills that a student should possess to effectively identify, retrieve and utilize information. The format is similar to that envisioned for the ABET EC2000. ABET uses the term "objective", while ACRL uses the term "standard". Care should be taken not to get confused on the terminology, but rather to look at the similarities in the desired results.

TABLE II

ACRL INFORMATION LITERACY COMPETENCY STANDARDS FOR HIGHER EDUCATION

<b>Standard 1</b>	The information literate student determines the nature and extent of information needed.
<b>Standard 2</b>	The information literate student accesses needed information effectively and efficiently.
<b>Standard 3</b>	The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system.
<b>Standard 4</b>	The information literate student, individually or as a member of a group, uses information effectively to accomplish a specific purpose.
<b>Standard 5</b>	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.

### COMPETENCY INTEGRATION

In looking at the desired outcomes for the ABET EC2000 criteria and the Information Literacy Competency Standards for Higher Education, there is a direct correspondence between the two sets of desired outcomes. At first, one may see two very disparate sets of goals. But upon further evaluation, it becomes more obvious that the underlying skill sets are very much the same.

The Information Literacy Competency Standards for Higher Education could be viewed as one set of assessment tools that can be used in demonstrating the learning outcomes required by ABET for Criterion 3. The

competencies outline performance indicators and outcomes, that when applied with technical coursework, match the desired ABET outcomes. Table III demonstrates broad overlaps in the ACRL Competencies and ABET Criterion 3 Outcomes.

**TABLE III**  
BROAD OVERLAPS IN LEARNING OUTCOMES

		ACRL Information Literacy Competency Standards				
		Std 1	Std 2	Std 3	Std 4	Std 5
ABET Learning Outcomes	3a	X				
	3b			X	X	
	3c	X				
	3d				X	
	3e	X				
	3f					X
	3g				X	
	3h			X		X
	3i	X	X	X	X	X
	3j	X	X	X		
	3k	X	X	X	X	X

Understanding that each academic program will have its own unique needs and focus, the author will attempt to demonstrate broad overlaps for each of the Information Literacy Competency Standards and its applications to one or several ABET Learning Outcomes. More precise relationships could be established based on educational objectives and engineering discipline.

**Standard 1**

Standard 1 (determining the nature and extent of information needed) most broadly overlaps with the ABET Learning Outcomes. The ability to articulate and determine the need for information, to identify potential sources, to assess the costs and benefits of acquisition, to evaluate the information and to reevaluate the information requires the same skill base as assessing and recognizing the application of technical knowledge and skills to solve a problem (Outcomes 3a, 3e and 3k). While the end product varies, the thought processes and learnings are the same. Standard 1 also assists with Outcome 3c where students must demonstrate that they can identify and understand the desired needs for a system, component or process. Outcomes 3i and 3j focus on lifelong-learning skills and the ability for a student to recognize when they need information about contemporary issues. The ability for a student to be able to independently identify a source and locate information on current issues is an essential skill for a professional engineer.

**Standard 2**

Standard 2 (accessing needed information effectively and efficiently) involves selecting appropriate methods and systems for retrieving information, including designing search strategies, and extracting the appropriate information.

These are obvious life-long learning skills (Outcomes 3i and 3k). How can an engineering student be expected to be knowledgeable about contemporary issues and problems (Outcome 3j) in their fields if we don't teach the student how to retrieve research and reports on those issues from the professional literature?

**Standard 3**

A person cannot be a life-long learner without the skills and knowledge about how to retrieve and assess and evaluate the quality of information (Standard 3). The World Wide Web brought an information boom to the world. It allows for the free and open exchange of information, but it also allows for the publication of much faulty information. It is even more important in this information age that our future engineers can critically assess the information they are gathering for quality, authority and appropriateness. Although primarily technical, learning outcome 3b (conducting experiments and interpreting the data) requires a student (to an extent) to use the same steps in thinking critically about the data being analyzed and interpreted. Above all else, the student must determine whether this new knowledge impacts his or her previous learnings and validates these learnings through communication and discourse with others in the field (Outcomes 3g, 3h, 3j). Life-long learning (Outcome 3i) and the ability to apply these life-long learning skills to the practice of engineering (3k) have already been covered in Standards 1 and 2.

**Standard 4**

Standard 4 (uses information, individually or as the member of a group, to accomplish a specific purpose) overlaps directly with Learning Outcomes 3g (ability to communicate effectively) and 3d (functions on teams). Being able to communicate either information needs or analyzed information to a group as well as managing to work within the constructs of that group to accomplish a goal is essential in today's workplace. Industry often complains that engineering graduates are not able to communicate effectively. By having students work through the planning, revising, and communication process of applying and retrieving information for a specific project, students develop foundational communication skills. This process provides an easy assessment method for demonstrating learning outcomes. This standard also reinforces several of the information competencies and skills already discussed in Standards 1, 2, and 3 (Outcomes 3b, 3i, and 3k).

**Standard 5**

Teaching students the economic, legal and social issues of information use is always a challenge. However, since engineers need information, it is essential that a basic understanding is developed around issues such as privacy, copyright, intellectual property. Many of these issues are related to the topics already being taught in engineering ethics courses about professional and ethical responsibilities

of engineers (Outcome 3f). But there is often not a specific mention of the broader applications of these concepts such as information use. Integrating information literacy may provide the opportunity to strengthen these discussions and coursework and provide a broader base on which to demonstrate learnings. This standard also overlaps with the knowledge and skills needed to demonstrate learnings for Outcomes 3h, 3i, and 3k (previously discussed).

### ACHIEVING INTEGRATION

Information Literacy skill sets are often assumed to be taught or obtained in some other course or educational opportunity. Unfortunately due to the heavy technical nature of engineering coursework, many students are only exposed to these skills a few times in their college careers. Faculty establish the context for learning and the inspiration for continuous exploration. Information literacy provides the skills that allow students to pursue and acquire information. EC2000 requires that students are presented multiple opportunities to develop these skills and demonstrate learning outcomes, which means that you, the faculty, must take on these curriculum changes.

Integrating information literacy into coursework and curricula requires partnership and collaboration between both faculty members and information professionals [5]. Creating course content to achieve specified outcomes requires effort in three areas: planning (identifying course content and defining measurable learning objectives for it), instruction (selecting and implementing the methods used to deliver content and facilitate student achievement), and assessment and evaluation (determining how well the objectives have been achieved) [4]. In a study evaluating the obstacles engineering faculty face in adding new assignments requiring writing in the technical classroom, [6] found 5 primary reasons:

- Too much work involved in assigning and evaluating writing.
- Problems in developing effective assignments that emphasize engineering concepts and good writing skills
- Disappointment in the writing that students submit
- Fear that so much class time will be spent on writing that there won't be time for technical content
- Difficulty in finding support for their efforts (i.e. release time)

However, writing is not the only way to integrate information literacy skills. Many course assignments can be easily adjusted to incorporate one or more skills. It is not the author's opinion that librarians must teach these skills. While librarians have pursued advanced studies and degrees to understand the complexity of information and its organization, partnered with faculty, they can work together to revise and create course assignments that enforce the applications of both technical and non-technical knowledge bases.

The Association of College & Research Libraries endorsed the Information Literacy Guidelines to describe essential skills that a student should possess to effectively identify the need for and utilize information. The guidelines correlate with many ABET evaluation criteria. The new ABET criteria indicate the need for including some of these non-traditional skills, but can this be accomplished without overloading both the faculty and the students? Traditionally faculty feel pressured to fit all the scientific principles and training necessary for students into the curriculum. The thought of adding yet one more component to an already overcrowded course is not well accepted.

Assignments that can help achieve the Criterion 3 outcomes include course activities that require independent literature searches. This also helps to promote individual responsibility and develop the ability to find and organize information in the absence of instructors and course notes and texts. Many articles have been written through the years about course curriculum changes that integrate information literacy. Pinelli [1] suggests a number of assignments including written project reports, oral presentations, research proposals, student-formulated problems, research proposals, abstracts, executive summaries, papers, written critiques of documents. Problem-based learning, taking realistic situations and problems and asking students to solve them may be a good way to impress on students a skill they will need continually as engineers [1] and for life-long learning.

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