AC 2008-1999: INDUSTRY EXPECTATIONS FROM NEW CONSTRUCTION ENGINEERS AND MANAGERS: CURRICULUM IMPROVEMENT

Gouranga Banik, Southern Polytechnic State University

Industry Expectations from New Construction Engineers and Managers: Curriculum Improvement

Gouranga C. Banik, Ph.D., P.E.
Associate Professor
School of Architecture, Civil Engineering Technology & Construction
Southern Polytechnic State University
Marietta, GA 30060

Abstract

In an era of unprecedented technological advancement and economic expansion, construction practice continues to evolve but construction education has not changed appreciably since the 1990s. This schism has prompted industry, government, and other key constituents to question the relevancy and efficacy of current programs. The Accreditation Board for Engineering and Technology (ABET) Engineering Criteria 2000 and the American Council for Construction Education (ACCE) emphasizes outcomes over process, and provides an opportunity for stakeholders to help universities define educational goals and objectives and design a curriculum to meet the desired outcomes . While the need for curriculum modification has been acknowledged, the "industry position" was amorphous and anecdotal and therefore difficult to address. Qualitative methodologies such as formal surveys and structured interviews can be used to capture and quantify industry expectations of the needed attributes (i.e., knowledge, skills, and experience) for entry level construction employees. Such instruments can provide key data useful in determining objectives and designing curricula to attain those objectives. This paper presents results of a formal survey of thirty five Atlanta based construction companies concerning the perceived importance of important attributes related to the ABET and ACCE Program Outcomes and Assessment categories. This study provides important information and feedback from the construction industry to initiate a continuing and evolving process for construction curriculum improvement.

Key Words: Construction, Curriculum Improvement, Assessment, Student

Introduction

From its beginnings, construction education in this country focused strongly on practice. The expansion of world economy mainly in India and China accelerated construction works significantly and gave opportunities for the greater advances. Post-expansion industries flourished, creating demand for contractors and engineers that exceeded the supply. Newly-minted engineering and technology Ph.D.'s joined the ranks of academia without much industry experience and perpetuated the research emphasis on campuses for the last ten years. While this research has contributed immeasurably to our technological advancement, the widening separation of faculty and curriculum from industry needs and expectations has resulted in a real threat to our competitiveness in the global marketplace.

The construction environment has changed dramatically. International competition, the concepts of world is flat and small is beautiful shift our economy from manufacturing to service enterprise and new technologies have restructured the industry and altered how contractors practice construction and engineering. William A. Wulf, the President of the National Academy of Engineering, defines engineering as "design under constraint." This statement is true for the construction profession since construction is construction under constraint like drawing and specification2. Increasingly, both contractors and engineers must supplement technical mastery with business and communication skills, and an understanding of the ethical and societal impact of technical solutions. Traditional construction engineering and management undergraduate programs, at over 130 credit hours for a BS degree, are not set up to handle an increased liberal education component or radically different modes of curriculum delivery such as team-based or affective domain modalities. The ABET Engineering Criteria 2000 attempts to address this issue in the accreditation process.1

In 1994 ABET held a workshop on accreditation criteria with financial support from the National Science Foundation. By then, the engineering accreditation criteria had grown to almost twenty pages from one in 1955. The workshop participants, representing industry, government, and academia, found the existing criteria too long, rigid, and prescriptive. Their report was distributed to the ABET Engineering Accreditation Commission (EAC), and the EAC and ABET Board subsequently approved Engineering Criteria 2000, with a two year experimental period and a three year transition culminating in full implementation in 2001. Engineering Criteria 2000 consists of eight criteria categories; this paper focuses on Criterion 3. Program Outcomes and Assessment.

The ABET Criteria 2000 approach to engineering accreditation affords universities opportunities to reengineer their curriculum to achieve specific objectives, goals, and outcomes. Criterion 3 addresses eleven attributes that engineering programs must demonstrate their graduates possess (Appendix A). Each institution may draw upon its unique capabilities to design educational experiences to achieve these outcomes, but is accountable for a process to measure results and validate that outcomes are achieved.

The emphasis of ACCE (2004) criteria is to provide an education that will lead to a leadership role in construction and to prepare the student to become a responsible member of society. The curriculum should be responsive to social, economic, and technical developments and should reflect the application of evolving knowledge in construction and in the behavioral and quantitative sciences. The ACCE encourages accredited programs to regularly evaluate current curricula for and develop new curricula that reflect changing construction technologies and management trends.

ABET has identified a systematic approach to determine objectives and assess outcomes, which is represented here in figure 1. (It is shown as slide 18 in Reference 3.) The process of defining and prioritizing objectives and outcomes requires participation by key constituencies chosen by the university. State and federal agencies will influence outcome requirements. In addition to faculty, potential industry and government employers of the graduates are major stakeholders and can make a valuable contribution. Constituents must articulate needs with precision and specificity because ambiguous and anecdotal input will not bring results.

A formal survey instrument, developed by the Industry-University-Government Roundtable for Enhancing Engineering Education (IUGREEE) may help provide a valuable industry perspective on construction education and desired outcomes (Land et all, 2001). Certain portion of this formal IUGREEE study was used in this paper-making consistent with construction education. The results of the initial survey are the prime motivation behind this paper.

Approach

IUGREEE developed the formal survey instrument to provide a more specific, quantifiable industry response to ABET 2000 Criterion 3 - Program Outcomes and Assessments. The scope was deliberately changed towards construction education and limited to allow thorough survey completion in thirty to forty-five minutes. The survey instrument was submitted to all large construction companies in the Atlanta region based on the list of Engineering News Record (ENR) and Associated General Contractors (AGC).

Population

The survey produced 35 voluntary responses from construction engineers and construction managers representing twenty six construction companies in and around Atlanta; no sampling occurred. The population responding to individual questions varies and is noted in the response count column of the survey database. A privacy rule for this survey precluded the linkage of a response to a specific company.

All of the respondents are working for the construction companies-holding the senior management position either for the company and/or for the projects. Average working experience for the respondents in the construction industry is about 13 years. Questions regarding respondents' profile are shown in Figure 2.

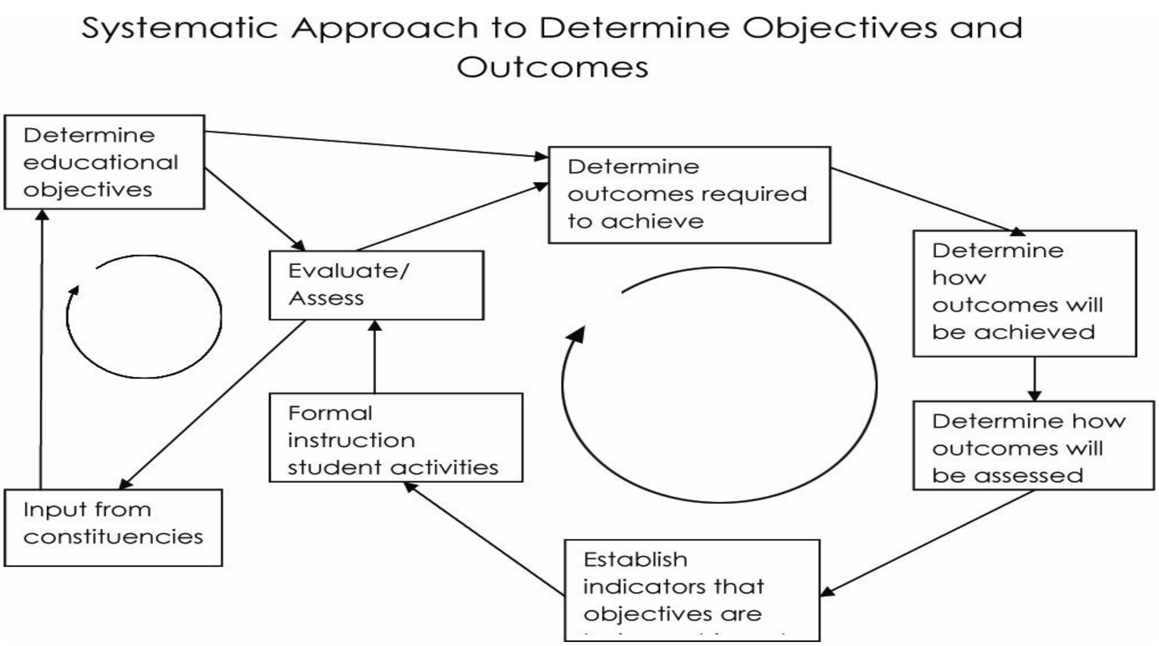

Figure 1: Systematic Approach to Determine Objectives and Outcomes

The Survey Instrument

The survey instrument selected from listed IUGREEE 172 skills, knowledge descriptors, and experiences that were mapped into the ABET 2000 Criterion 3 eleven outcome categories. The respondents were asked to rank each in importance for an entry-level construction engineer and manager on a scale of 1 (corresponding to very low) to 5 (corresponding to very high). Because the first ABET 2000 Criterion 3 outcome, "the ability to apply knowledge of mathematics, science, and engineering" addresses the fundamentals of construction education, the survey format differs from that of the remaining ten outcome categories. It was designed to provide input on curriculum scope rather than identify specific courses or course content. Respondents were asked to provide their expectations on the number of semesters of study related to selected topics and their relative importance in the curriculum.
For all other outcome categories, respondents were asked to assign importance for construction engineers and managers with three to five years of experience in addition to that for entry-level engineers. An example page from the survey is shown in figure 3.

Figure 2: Experience and Present Responsibilities of the Questionnaire Respondent

Management Experience	Yes O	NO O				
Program Management	Yes O	NO O				
Project Management	Yes O	NO O				
Estimating	Yes O	NO O				
Design	Yes O	NO O				
Scheduling	Yes O	NO O				
Specialty	Yes O	NO O				
Team Experience	Yes O	NO O				
Educational Background						
Civil Engineering	Yes O	NO O				
Construction Engineering	Yes O	NO O				
Construction Management	Yes O	NO O				
Mechanical Engineering	Yes O	NO O				
Electrical Engineering	Yes O	NO O				
Years of Experience	O < 5	O 5-10	O 10-15	O 15-20	O 20-25	O>25
Direct Involvement of Hiring New Employee				Yes O	NO O	
Direct Experience in Supervision of New Employee and Old Employee				Yes O	NO O	

Not surprisingly, all items were ranked more important for experienced rather than for entry-level contractors. This implies that continuing education, from some source, is expected beyond the entry-level. While all survey data are available for further analysis, this paper focuses on the results for entry-level contractors.

The last section of the survey characterizes the respondent's role and universe. Each respondent was asked to identify his or her relationship to management, team experience, job specialization, engineering discipline, and participation in the hiring and performance evaluation of new graduates. This section is shown in figure 2.

Figure 3: Ability to Identify, Formulate and Solve Construction Problems

Criteria	Experience Level	Level of Importance				
		1	2	3	4	5
Ability to Formulate a Range of Alternative Problem Solutions	New Graduates			X		
	3-5 Yrs. Experience			X		
Ability to Identify Problems	New Graduates		X			
	3-5 Yrs. Experience				X	
Ability to Choose Problem Solution	New Graduates			X		
	3-5 Yrs. Experience				X	
Ability to Resolve Conflicts in Problem Solution Decision-Making	New Graduates		X			
	3-5 Yrs. Experience			X		
Skill in Documenting Problem Formulation-to-Recommend Solution	New Graduates			X		
	3-5 Yrs. Experience					X
Skill in Conducting Library and Professional Field Research	New Graduates			X		
	3-5 Yrs. Experience			X		
Skill in Developing Creative Solutions	New Graduates		X			
	3-5 Yrs. Experience				X	
Ability to Solve Problems with a Multidiscipline Team	New Graduates			X		
	3-5 Yrs. Experience				X	
Experience in Requirements Development	New Graduates		X			
	3-5 Yrs. Experience				X	
Experience in Creating Alternative Solutions	New Graduates		X			
	3-5 Yrs. Experience			X		

Survey Results

The survey results are formatted to show for each survey item:
- Average importance ranking
- Standard Deviation
- Median and mode importance level
- Response count

An example of results from the database for all 35 respondents is shown in Table 1.

For example, results from respondents with construction engineering backgrounds can be sorted from the database and analyzed separately. Similarly, data may be sorted by team or management experience for more targeted input from specific subsets of the population.

Table 1: Ability to Identify, Formulate and Solve Construction Problems

Criteria	Experience Level	Level of Importance				
		Av	Med	Mode	St. Dev	Count
Ability to Formulate a Range of Alternative Problem Solutions	New Graduates	3	3	3	1.06	35
	3-5 Yrs. Experience	3.06	3	3	.99	33
Ability to Identify Problems	New Graduates	3.26	3	3	1.02	33
	3-5 Yrs. Experience	3.61	3	4	.96	33
Ability to Choose Problem Solution	New Graduates	2.79	3	3	.98	34
	3-5 Yrs. Experience	2.94	3	3	.93	33
Ability to Resolve Conflicts in Problem Solution Decision-Making	New Graduates	3.03	3	3	1.02	34
	3-5 Yrs. Experience	3.41	4	4	.96	33
Skill in Documenting Problem Formulation-to-Recommend Solution	New Graduates	3.06	3	3	1.13	33
	3-5 Yrs. Experience	3.26	3	3	1.06	33
Skill in Conducting Library and Professional Field Research	New Graduates	3.21	3	3	.99	33
	3-5 Yrs. Experience	3.30	3	4	.9	33
Skill in Developing Creative Solutions	New Graduates	2.79	3	4	1.07	32
	3-5 Yrs. Experience	3.21	4	4	1.09	32
Ability to Solve Problems with a Multidiscipline Team	New Graduates	2.94	4	3	.94	32
	3-5 Yrs. Experience	3.30	3	3	.98	31
Experience in Requirements Development	New Graduates	2.79	3	4	1.06	31
	3-5 Yrs. Experience	3.42	3	4	1.09	31
Experience in Creating Alternative Solutions	New Graduates	2.79	3	3	.85	33
	3-5 Yrs. Experience	3.09	3	3	.86	34

Survey Uses

Perhaps the most important use of this survey database is to provide curriculum designers a considered industry assessment of critical outcomes to achieve in a construction undergraduate curriculum. It provides a locus for curriculum reform by quantifying and prioritizing the expectations of key stakeholders without prescribing specific course content. For example, an overall ranking for items under Criterion 3, "ability to identify, formulate and solve construction problems" yields the list shown in Table 1.

Three of the thirteen items were not included because the items were ranked either 1 or 2 (low in importance) by the largest number of respondents. A preliminary analysis of these results would lead one to conclude that the most important outcomes are:

• Ability to identify problems

• Skill in conducting library and professional field research
• Skill in documenting problems and formulation to recommend solutions

This finding reflects the requirement of a team-based upper division of either simulation and/or capstone class where team member will work to identify problems, develop feasible alternatives and recommend solutions after a thorough research about a project or a company.

Analysis of these data can be useful in designing a curriculum to achieve specific outcome objectives. Each curriculum designer, however, should determine the level of skill to achieve any objectives and the unique capabilities of the institution and its faculty. Also, some items that are ranked lower may be important to other constituencies and may need to be considered for inclusion in the curriculum.

Appendix B contains a rank order listing of the 172 items under the eleven ABET outcomes categories which is summarized in Table 2. Reviewing the top items for each of the eleven outcomes from Table 2 reveals more subtle yet very valuable uses for the database. From the Table 2, the results indicated that 3 to 5 yrs experienced contractors will have better understanding and performance in all eleven criteria. It is interesting to note that five of the eleven Criterion 3 outcomes describe competencies not specifically addressed in traditional construction education. This has major pedagogical implications, not only for course content but also for course delivery. Are communication skills, ethics, and professionalism more effectively presented in specific courses or integrated into the curriculum through changes in content and methodology? How is the commitment to life-long learning instilled? Are there "best practices" to foster true collaboration in multi-disciplinary teams?

From the results, it is evident that industry would like to have more emphasize on communication skill (3.50), broad education in global and societal context (3.48) and importance of life learning (3.43). Technical and design understanding is important but not important as other soft skills. But for the experience contractors, ability to design a system, component or process (3.21) and analyze and interpret data (3.56) are important like other soft skills such as communication skill (4.02), ability to work in multidisciplinary team (3.68) and importance of life-long learning (3.52).

What is the role of information technology, both as a computing and communications tool and as a method of educational delivery? A demonstrated understanding that construction is affected by information technology was the most highly ranked outcome in the "knowledge of contemporary issues" criterion. Unquestionably, information technology impacts how contractors practice construction today, but it has robust implications for curriculum designers as well. As a pedagogical tool, information technology can facilitate cross-disciplinary collaboration, communication, and inquiry based, interactive learning that enhances the educational experience. How is it effectively integrated into the curriculum? Implicit in the list of top outcomes is a need to address uncertainty and its effect on construction process and management. Stochastic problem-solving skills are necessary in an environment characterized by constraints and a concern for the impact of engineering solutions in a global and societal context.

Survey Limitations

One very important caveat is that the limitation of survey data must be well understood. In analyzing responses on the "design" items compared to the ten other areas, all design items had consistently lower ratings, averaging a range of 1.4 to 3. for the eighteen design items. The ten other categories ranged from 1.4 to 2.3 for the lowest items and up to 3 to 4.2 for the highest. One possible reason may be that the total pool of respondents was weighted about equally between those with analytical responsibilities and those with design (synthesis) responsibilities. Thus the data may reflect a lack of understanding and appreciation for design-oriented skills by about half of the respondents. Although it is increasing becoming important in the design-build construction projects.

Table 2: Student Education Outcome

Criteria	Experience Level	Level of Importance				
		Av	Med	Mode	St. Dev.	Count
Ability to Apply Knowledge of Mathematics, Science, and Engineering	New Graduates	3.26	3	3	.99	35
	3-5 Yrs. Experience	3.27	3	3	.94	34
Ability to Design and Conduct Experiments, as well as to Analyze and Interpret Data	New Graduates	3.24	3	4	.96	33
	3-5 Yrs. Experience	3.56	3	4	.97	34
Ability to Design a System, Component, or Process to Meet Desired Needs	New Graduates	3.06	4	3	.95	34
	3-5 Yrs. Experience	3.21	3	3	.93	33
Ability to Function on Multi-Disciplinary Teams	New Graduates	3.26	3	4	.96	34
	3-5 Yrs. Experience	3.68	4	4	.91	34
Ability to Identify, Formulate, and Solve Construction Problems	New Graduates	3.13	3	3	1.06	33
	3-5 Yrs. Experience	3.30	3	3	1.02	33
Understanding of Professional and Ethical Responsibility	New Graduates	3.28	4	4	.9	33
	3-5 Yrs. Experience	3.45	4	4	.87	33
Ability to Communicate Effectively	New Graduates	3.50	3	4	1.08	32
	3-5 Yrs. Experience	4.02	4	4	1.12	34
Broad Education Necessary to Understand the Impact of Construction Solutions in a Global/Societal Context	New Graduates	3.48	4	3	.98	32
	3-5 Yrs. Experience		3	3	.89	32
Recognition of the Need For, and an Ability to Engage in Life-Long Learning	New Graduates	3.43	3	4	1.09	31
	3-5 Yrs. Experience	3.58	4	4	1.09	31
Knowledge of Contemporary Issues	New Graduates	3.03	3	3	.86	33
	3-5 Yrs. Experience	3.33	3.5	4	.87	34
Ability to Use the Techniques, Skills, and Modern Construction Tools Necessary for Construction Practice	New Graduates	3.00	3	3	.95	34
	3-5 Yrs. Experience	3.29	3	3	.96	32

Recommended Use

We recommend careful attention to the survey results in order to understand its strengths and weaknesses in conveying industry expectations of the eleven ABET Criteria 3 outcome categories. A construction management department should be interested in the difference in results between CM respondents and the overall set. What do large differences mean? What about small differences? Is there ambiguity in the results?
Are there other significant differences? When sorting on “design relevant” backgrounds, is it clear how to structure a curriculum to achieve the items?

Questions such as these lead to the best use of existing data and will help us to improve the survey to provide more and better curriculum design relevant data. Similar help can come when the database is expanded to include more respondents and those beyond the commercial construction sectors. For example, the small sample size of respondents with construction engineering experience limits the statistical significance of those data used in isolation to derive requirements for construction engineering curricula

Summary and Conclusions

The ABET Engineering Criteria 2000 affords stakeholders the opportunity to help universities define goals and objectives and design a construction curriculum to meet desired outcomes. Industry input into this process has been anecdotal and sometimes contradictory.

The survey ranked in importance 172 knowledge elements, skills, and experiences that can be expected by engineering managers and engineers for BS entry-level engineers. From the survey, it is evident that construction curriculum designer should emphasize on soft skills such as communication and team building, decision making, understanding of social, ethical and global issues besides other technical and design skills

The 172 items, when ranked, give an indication of desirable curriculum objectives. University curriculum designers can sort the data to analyze by construction experience or job category. Careful attention must be given to understand the data and their limitations.

The survey provides an example of what can be obtained from industry in order to better understand their outcomes expectations for entry-level contractors. This survey goes beyond that to include expectations for contractors with 3 to 5 years of experience, and can be used to design continuing education, on-the-job training, or graduate level outcome objectives.

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Gouranga C. Banik, Ph.D., P.E.

Gouranga C. Banik is an Associate Professor of Construction Management Department at Southern Polytechnic State University in Marietta, Georgia. Dr. Banik completed his Ph.D. in Civil and Construction Engineering from Iowa State University. He has eleven years working experience in both private and public sector as an engineer and/or construction manager. He is a registered professional engineer. Dr. Banik has twenty nine refereed publications in the area of civil engineering and construction management. He presented some of his research in several well-known and peer reviewed conferences like ASEE, ASCE, ASC, WEFTEC and CIB, and published articles in those conference proceedings. He presented his research all over the world including the United States, Canada, Greece, Italy, Brazil and the Philippines.

APPENDIX A

Student Education Outcomes from ABET Criteria 2000

(a) Ability to Apply Knowledge of Mathematics, Science, and Engineering
(b) Ability to Design and Conduct Experiments, as well as to Analyze and Interpret Data
(c) Ability to Design a System, Component, or Process to Meet Desired Needs
(d) Ability to Function on Multi-Disciplinary Teams
(e) Ability to Identify, Formulate, and Solve Construction Problems
(f) Understanding of Professional and Ethical Responsibility
(g) Ability to Communicate Effectively
(h) Broad Education Necessary to Understand the Impact of Construction Solutions in a Global/Societal Context
(i) Recognition of the Need For, and an Ability to Engage in Life-Long Learning
(j) Knowledge of Contemporary Issues
(k) Ability to Use the Techniques, Skills, and Modern Construction Tools Necessary for Construction Practice

APPENDIXB

Rank Order of Survey Results

(a) Ability to Apply Knowledge of Mathematics, Science, and Engineering

- Engineering Courses with Applications (2.5 years)
- Ability to Structure, Solve, and Report on Solutions in the Engineering Specialty
- Ability to Apply Knowledge of General Physics (1.5 years)
- Single and Multivariable Calculus through Ordinary Differential Equations (1.5 years)
- Linear, Algebra, Vector Analysis, and Numerical Analysis (1+ years)
- Computer and Information Science - Software Development for an Engineering Specialty
- Ability to Structure, Solve, and Report on Solutions in Mathematics
- Ability to Structure, Solve, and Report on Solutions in the Physical Sciences
- Probability Theory and Statistics with Application to Engineering Problems

and the others

(b) Ability to Design and Conduct Experiment as well as to analyze and Interpret Data

- Demonstrated Ability in Data Analysis and Interpretation
- Team Experience as a Team Member
- Experience in Executing Designed Experiments (1.5 years)
- Demonstrated Ability in Performing Experiments
- Demonstrated Ability in Design of Experiments

- One Year of Team Experience
- Understanding Methodology for Design & Analysis of Experiments (Single-Variable Problem)
- Two Years of Team Experience
- Experience in Executing Experiments in Single Discipline Teams
- Experience in the Application of Design & Analysis of Experiments (Single-Variable Problem)
- Experience in Using and Interpreting Results of Designed Experiments (Single-Variable Problem)
- Experiments to Evaluate Products at Component Level
- Understanding Methodology for Design of Experiments (Multivariable Problem)
- Experience in Executing Experiments in Multidiscipline Teams
- Experience in Using and Interpreting Results of Designed Experiments (Multivariable Problem)
- Design and Execution of Experiments Considering Design-to-Manufacturing Predictability
- Three Years of Team Experience
- Design and Execution of Experiments Considering Fabrication and Assembly
- Knowledge of Concept and Application of Manufacturing Variability
- Knowledge of Concept of Quality and Cost of Quality
- Experiments to Evaluate Products at Subsystem (Black Box) Level
- Knowledge and Experience of Statistical Process Control

and the others

(c) Ability to Design a System, Component, or Process to Meet Desired Needs

- Demonstrated Ability to Design a Component
- Demonstrated Ability in an Upper-Division, Team-Based Design Project
- Understanding of the Concept of “Form Follows Function”
- Demonstrated Ability to Design a Subsystem (or Black Box)
- Demonstrated Ability to Design a Process
- Knowledge and Understanding of “the Concept of Robustness”
- Demonstrated Ability to Design a System
- Knowledge of Materials and Materials Science
- Experience in Designing Systems Considering Performance Requirements
- Experience in the Design of Structures Considering Manufacturing and Cost Requirements

and the others

(d) Ability to Function on Multi-Disciplinary Teams

- Function on a Team in Laboratory Science or Engineering courses
- Function on a Team in an Upper-Division, Team Based Design Project
- Function in a Team in Team-Based Reporting of Project Results
- Participation as Team Member
- Participate as Member of a Problem-Solving/Decision Making Team
- Participation as Industry Summer Employee
- Participation as Industry Co-op Student
- Participation on a Collaborative Industry/Student Design Team
- Participation in Reporting Team Results
- Participation in Developing Team Strategies, Plans, and Schedules
- Participate in Computer Simulation Teams
- Participate in Evaluating Team Products and Team Performance
- Participate in Development of Risk Management Plans
- Participation as Team Leader

and the others

(e) Ability to Identify, Formulate, and Solve Engineering Problems

- Ability to Formulate a Range of Alternative Problem Solutions
- Ability to Identify Problems

- Ability to Choose Problem Solution
- Ability to Formulate Problems
- Ability to Resolve Conflicts in Problem Solution Decision-Making
- Skill in Documenting Problem Formulation-to-Recommend Solution
- Skill in Conducting Library and Professional Field Research
- Skill in Developing Creative Solutions
- Ability to Solve Problems with a Multidiscipline Team
- Experience in Requirements Development
- Experience in Creating Alternative Solutions

and the others

(f) Understanding of Professional and Ethical Responsibility

- Demonstrated Understanding of the Importance of *Honesty* in Science and Engineering
- Demonstrated Understanding of the Importance of *Code of Ethics* in Engineering Specialty
- Personal Commitment to a Stated or Documented *Code of Ethics*
- Awareness of Ethical Issues of Employment Regarding Accuracy of Reporting and Maintaining Data
- Understanding of Individual's Responsibility Associated with an Agreement to Recognize Proprietary Rights,
- Trademarks, and Copyrights
- Awareness of Ethical Issues of Employment Regarding an Employer's *Code of Ethics*
- Awareness of Professional Responsibility Regarding Product Liability
- Awareness of Ethical Issues of Employment Regarding Employer's Work Rules
- Education in Business and Professional Ethics and Conduct
- Understanding *Code of Ethics* of Specialty Engineering Society
- Understanding and Experience in Formulating Individual and Team Roles and Responsibilities

and the others

(g) Ability to Communicate Effectively

- Interpersonal Skills (verbal, non-verbal, and written) which Maintain High Professional Quality, Convey
- Appropriate Respect for Individuals, Groups, Teams, and Develop a Productive Working Environment
- Ability to Give a *Solo* Presentation
- Ability to Write a Concise Business Letter
- Skill in Technical Report Writing (which organizes and presents all pertinent information relative to a technical topic, with conclusions and recommendations)
- Skill in Concise Expository Writing
- Ability to Write a Team-Based, Case-Study Report
- Verbal Presentation Skills
- Skill in Concise Expository Writing of Letters
- Skill in Sketching and Illustrating to Communicate Technical Information or Concepts
- Ability to Write a Concise Ten-Page Essay
- Skill in Concise Expository Writing of a Ten-Page Essay
- Viewgraph Presentation Skills
- Ability to give a Team-Based Multimedia Presentation
- Ability to Publish a Technical Paper
- Multimedia Presentation Skills

and the others

(h) Broad Education Necessary to Understand the Impact of Engineering Solutions in a Global/Societal Context

- Understanding that Engineering Solutions are Affected by and should be Responsible to Limited Resource Availability

- Understanding that Engineering Solutions Impact the Environment (e.g. CFCs, Heavy Metals, Energy Consumption, etc.)
- Understanding that Engineering Solutions alter the Structure of Society (e.g. Air Transportation)
- Knowledge of the History of Developments in the Technical Field
- Awareness of Business and Technical Cycles
- Understanding of the Potential Impact of S&T on the Economy, Environment, Industry, and Educational Needs
- Knowledge of the History of S&T
- Knowledge of Transition from a Task-based Factory Culture to an Integrated Product &
- Process Development Culture

and the others

(i) Recognition of the Need for and an Ability to Engage in Life-Long Learning

- Understanding that Skill Training is an Employee's Responsibility and a Part of Life Long Learning
- Plans and Commitments to Skill Improvement in Learning Associated with the Work Environment
- Understanding that Life-Long Education is a Professional Responsibility of Every Engineer
- Demonstrated Ability to go Beyond the Professors' Course Expectations
- Demonstrated Interest in Pursuing Advanced Degrees
- Plans to Acquire Experience on Multi-Product, Multi-Discipline Product Design and development Teams
- Plans to Participate in Life-Long Development Reading Plan
- Plans and Commitment to Attain Advanced Educational Degrees
- Plans to Secure Choice Assignments on Multidiscipline Product Teams

and the others

(j) Knowledge of Contemporary Issues

- Demonstrated Understanding that Engineering is Affected by Information Technology Issues
- Understanding of the Information Superhighway
- Demonstrated Understanding that Engineering is Affected by Environmental Issues
- Demonstrated Understanding that Engineering is Affected by Economic and Business Issues
- Understanding of Design Principles to Produce Products which are Environmentally Safe
- Demonstrated Understanding that Engineering is Affected by Socio-Political Issues
- Understanding of Global Environmental Issues
- Understanding of National, Regional, and Local Environmental Issues
- Understanding of Diversity Issues and their Impact on Industry

and the others

(k) Ability to Use the Techniques, Skills, and Modern Engineering Tools Necessary for Engineering Practice

- Computer Literacy in Analysis Tools used in Engineering Specialty
- Computer Literacy in Design Tools used in Engineering Specialty
- Computer Literacy in Simulation and Modeling Tools used in Engineering Specialty
- Skills in use of Office, Telecommunications, and Information Technology Systems and Tools
- Skills in Use of Modern Analysis Tools
- Skills in Use of CAD/CAM Tools
- Computer Literacy in Data Analysis and Statistical Methods
- Skills in Systematic Evaluation of Product Design and Development Team Efforts
- Skills in Applying Statistical Methods to Measure Quality and Customer Satisfaction
- Knowledge of Probability Theory to Evaluate Quality, Design, Development, and Manufacturing Processes

and the others.