ABET Engineering Accreditation Criteria 2000

Mission Statements

School of Chemical Engineering

Oklahoma State University

Revised October 6, 2000

Preface

This document guides the continual improvement of the BS Chemical Engineering program at Oklahoma State University, serves as both a vision statement and a prescription of methods to evaluate our program. We will continually update it, and use it to guide our efforts to make the School of Chemical Engineering at Oklahoma State University a model, leading, nationally recognized program of quality and relevance.

University Mission

The Oklahoma State University is a modern comprehensive land-grant university that serves the state, national and international communities by providing students with exceptional academic experiences, by conducting scholarly research and other creative activities that advance fundamental knowledge, and by disseminating knowledge to the people of Oklahoma and throughout the world.

College Mission

The mission of the College of Engineering, Architecture and Technology is to advance the quality of human life through strategically selected programs of instruction, research, and public service, incorporating strong social, economic and environmental dimensions, and emphasizing advanced level programs in engineering that are internationally recognized for excellence.

School Mission:

The mission of the School of Chemical Engineering at Oklahoma State University is to development human resources, professional knowledge, and the infrastructure through which chemical engineering can contribute to human welfare. We expect to maintain national recognition for our contributions.

ABET Engineering Accreditation Criteria 2000
Definition of Constituents
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
October 6, 2000

OSU is commissioned and supported by the State to enhance welfare for citizens, both corporate and individual. Students and their families have aspirations and hopes, and view OSU as the path to those goals. Employers view OSU as a source of employees who can become partners, and ensure the success of their enterprises. CHENG faculty and all OSU employees expect their work at OSU to fulfill their personal aspirations. These (State, students and families, other employers, and OSU employees) are our constituents. They have a substantial personal investment in OSU, and they are substantially impacted by the outcome of OSU actions. Performance measures, which are simultaneously a statement of values, must reflect the expected impact on the constituents' desires.

Our Primary Constituents are:

1) STUDENTS IN THEIR PRESENT. We desire to have a program in which students enjoy their growth in understanding both life and technology. They will celebrate success in meeting the curriculum challenges that prepare them for engineering careers. Representatives of this constituent group would be students and recent graduates.

2) STUDENTS IN THEIR FUTURE. Nominally, CHENG alumni have a 30-plus-year career followed by retirement. We desire that they be happy and successful in all phases of their life, and posses the attributes to be so. Representatives of this constituent group would be our alumni.

3) EMPLOYERS. Employers expect our graduates to become business partners who can use their skills to improve quality, flexibility, safety, economics, etc. of their processes and operations. Demographics indicate that about 80% of our BS students enter industry, and that about 20% go to either professional or graduate school. Accordingly, representatives of the employers would be both industrial managers and graduate faculty. Representatives of the industrial manager group will be the CHENG Industrial Advisory Committee. Representatives of the graduate faculty group will be the School faculty.

4) CITIZENS. Many people benefit from the profit, resource conservation, and improvement in processes and products that are created by our graduates. Citizens include all people who share the student’s joy and pride in their development, accomplishments, and stature both before and after graduation. This includes the corporate State of Oklahoma, which will benefit from a first-class educational institution in National reputation, quality of life, and economic development. It also includes the families who invest in the students’ education. It includes the communities in which our graduates live. We need to remain open to input from diverse stakeholders.

5) SCHOOL FACULTY. School faculty members are the “trustees” of educational quality. Further, they have a first-hand and immediate awareness of the efficacy of the curriculum in meeting Program Outcomes. Accordingly, School faculty members will be a primary constituent group for evaluating and defining the School program.

ABET Engineering Accreditation Criteria 2000
A View of Good Engineering
And Implications for Engineering Education
Defining ABET Objectives and Outcomes
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
July 20, 2001

We cannot specify what engineering education should be until we have described what engineering is.

Engineering is an activity that delivers something that "works".
Good engineering:

1. is comprehensive.
2. is grounded in the technical fundamentals.
3. uses state-of-the-art technology.
4. balances uncertainty and risk with the cost of resources.
5. balances sufficiency with perfection.
6. seeks simplicity (K.I.S.S).
7. seeks a reasonably near optimum of results tempered by a reasonably near minimum cost of resources.
8. develops sustainable solutions.
9. places benefit to others (present and future) as a primary concern.
10. produces creative solutions.
11. uses systematic, organized, cause-and-effect, analysis.
12. is careful, correct, self-critical, and defensible.
13. is a collaborative, team activity.
14. leads to implementation.
15. is accepted by all stakeholders/customers.
16. is effectively communicated.

The role of Engineering Education

Engineering education must prepare students for careful, thorough, and creative application of technology, within a team environment, and with the benefit to others (present and future) as a primary concern. We receive non-engineers and must inculcate them with both the technology and the culture of engineering. Since key aspects of an engineer's work include state-of-the-art skills in science and technology, understanding of the enterprises and societal systems which engineering impacts, team leadership and effectiveness within the interpersonal arena in which the work is performed, and self-awareness for personal growth; we include these aspects within the curriculum.

However, upon graduation, we can not expect students to have attained either the depth and breadth of technical skill or the level of human and enterprise understanding of an experienced professional. Therefore, we must limit the expectation of career maturity to that which is reasonably expected from a student. In addition, we will focus engineering education on the science, technology, and technical skills because these form the critical fundamentals of a technical career, and because their concrete nature makes them more universally applicable than the qualitative, situation-sensitive human understanding.

ABET Engineering Accreditation Criteria 2000
An Elaboration on Good Engineering
Defining ABET Objectives and Outcomes
Bachelor of Science Degree in Chemical Engineering
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July 20, 2001

Engineering is an **activity** that **delivers something that "works"**. Chemical Engineers develop and apply the languages of math to describe physical and chemical phenomena, so that they can understand, design, operate, optimize, and troubleshoot chemical processes and devices. Chemical processes safely and economically transform matter and energy into useful products. Engineers deal with technology; but solutions must work within the context of human institutions, enterprises, and aspirations. Further, the process of engineering, how we do our job, must work within interpersonal and personal reality. Engineering creates solutions. Certainly for education, guiding of the student learning of the fundamentals is critical; but in addition, students must be guided in the activity that creates something that works.

Good engineering is **comprehensive**. It accounts for all of the legal, social, environmental, and human aspects of a project as well as the technical aspects. It is effective within human situations. It is sensitive to all stakeholders. Education needs to require students to integrate such diverse issues into their assigned projects.

Good engineering is **grounded in the fundamentals** and uses the **state-of-the-art technology**. Accordingly, it is essential that students are able to understand and apply the principles. In addition, while they must be able to use typical CAD and data processing tools, it is also essential that they are able to evaluate the correctness and limits of computer output.

However, information is incomplete and somewhat uncertain, and requirements of the future are uncertain. So, engineering must appropriate theory and make judicious approximations to the degree of detail necessary for the application. Good engineering must **balance uncertainty and risk with the cost of resources**. It must **balance sufficiency with perfection**. Good engineering seeks to achieve a **reasonably near optimum of results tempered by a reasonably near minimum resource cost** for society. It integrates constraints, both present and future. These are usually subjective, situation specific, judgments; and education needs to prepare students to be able to make appropriate decisions. Students need to be taught how to appropriately include economic analysis, risk analysis, uncertainty analysis into recommendations.

Good engineering uses **state-of-the-art** techniques, but education today cannot present everything that engineers will need to know for a 40-year career in the future. Good engineering requires continuing professional education. Accordingly, engineering education must prepare graduates to be able to value, direct, analyze, and evaluate their own continuing education.

Good engineering is not infected by personal ideology, personal gain, or individual psychological need. It places **benefit to others (present and future) as a**

primary concern. A commitment to excellence, a rejection of mediocrity is required. Engineers must be accountable and responsible for their action, non-defensible about personal mistakes and deficiencies, and open to other-directed growth. Engineering education should foster this ethos as students' progress in their personal development.

Good engineering produces **creative** solutions. Intuitive leaps are important. Engineering education will prepare students for creativity in both individual and team environments.

Simultaneously, good engineering is thorough, **careful, correct, and defensible** in its accountability to human welfare. Care is an engineering attribute, and engineering education will maintain high standards in the environment that it provides for the students as well in its expectations of the student's work.

Good engineering is a **collaborative, team activity**, where team synergism and creativity maximize benefit and performance. The team environment must be nurtured by personal behaviors. Engineering integrates people of multiple education levels, ages, and cultures. Individuals must both lead and follow. Engineering education will prepare students for effectiveness within team environments.

Good engineering **leads to implementation**. It delivers something that works, not simply workable. This requires that it is **accepted by all stakeholders,** which requires that the result meets all of the criteria for goodness and has been **effectively communicated**. Engineering education will prepare students to establish both technical and contextual credibility in effective oral and written communications.

ABET Engineering Accreditation Criteria 2000
Educational Objectives
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
July 20, 2001

Consistent with ABET terminology, **"Educational Objectives" are the desirable attributes and accomplishments of OSU ChE BS graduates expressed during the first few years after graduation.**

Most students seek private sector employment immediately after graduation. However, others enter professional schools (medical, law, or business) and some engineering graduate school. Some enter the military. It is common for some to leave professional practice and pursue a full-time commitment to raising a family. These are diverse life paths.

Regardless of the life path, there is a commonality in the activities, achievements, point of view, and style that lead to happiness and success in these after-graduation challenges. These are markedly different from the primary success-telling attributes before graduation.

A student's main commitment is to his or her own personal growth. This changes upon graduation, where success is measured by contribution to corporate welfare. Attributes for success change with the environment. Consequently, personal, professional and technical growth (learning) must continue after graduation, however the director for the educational process and the judge of quality shifts from the professor to the new graduate.

After graduation, success is strongly dependent on personal commitment to the mission of the organization. Contributions are most likely to occur when the new employee enjoys his situation, is enthused with the opportunities, is committed to the mission, and is comfortable enough with self and personal life to be free to work for others. Each organization will have identified desired attributes of employees, and these will be unique to the organization.

From this viewpoint our program educational objectives desire that within the first few years after graduation, our graduates will have demonstrated the ability to:

1. Work in a manner that is characterized as "good engineering" from the previous section.
    a. Deliver things and procedures that work within the comprehensive situation.
    b. Creatively use fundamental principles, knowledge, skills, and state of the art tools in a careful, legitimate way.
    c. Appropriately balance sufficiency, uncertainty, and risk with perfection.
    d. Use care for human welfare as a primary value.
    e. Work effectively within both team and individual environments.

   f. Learn and apply job-specific technology.

2. Be professional partners with both employer and community, and create value.
   a. Have a desire to contribute and succeed.
   b. Learn the culture, mores, and values of the new environment and operate in a manner that is acceptable and credible to the system.
   c. Communicate effectively so that the system accepts the deliverables.
   d. Be self-developing and self-actualizing.
   e. Effectively use company resources.
   f. Develop relationships that are beneficial for long-term team effectiveness.
   g. Learn enterprise objectives so that contributions are guided by mission-critical issues.
   g. Be receptive to and a catalyst for change (personal, organizational, technical, etc.).
3. Enjoy life.
   a. Enjoy work.
   b. Engineer personal life.
   c. Grow.

ABET Engineering Accreditation Criteria 2000
Evaluation of Educational Objectives
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
July 20, 2001

Consistent with ABET terminology; **“Educational Objectives” are “Evaluated”.** The intent is to improve the effectiveness of the undergraduate program. The expectation is that there would be a 4- to 8-year cycle time for evaluation, change, and reevaluation. Since it is unlikely that we will have access to the individual personal evaluations of our former students, evaluation will necessarily be indirect measures. They will include:

1. Primary: Survey of alumni, two years after graduation, relating to how well their undergraduate experience prepared them for success in life. Use scheduled phone interviews for better depth and response success. Use a visit of perhaps 3 alumni invited to campus for an in depth open discussion. Focus on both Good Engineering and the Educational Objectives, by asking about the extent that alumni incorporate the items in their work and life, and how they perceive their preparation at OSU compared to that of recent alumni from other programs.
2. Secondary: Comments from employers (on-campus recruiters, Industrial Advisory Committee members, graduate research supervisors, and other associates) who have first-hand knowledge of our graduates’ performance.
3. Secondary: Comments from alumni as to the utility of their undergraduate education at OSU. Use informal feedback from gatherings and conversations. Use a volunteer survey posted on the CHENG web page. Tie into the OSU alumni survey with specific questions for CHENG alumni.

Metrics for evaluation might include:

1. Point-by-point response by alumni as to the degree of expression in their personal performance of the Good Engineering attributes.
2. Point-by-point response by alumni as to the degree of expression in their personal performance of meeting the Educational Objectives.
3. Response to the question, “Would you select OSU again? Why?”
4. Response to the question, “How would you describe the degree of sufficiency of the ChE education at OSU? Were you prepared to do your job?”
5. Response to the question, “How well did the ChE education at OSU prepare you for your career growth?”
6. Response to the question, “How well did the ChE education at OSU prepare you to do good engineering?”

7. Response to the question, “How well did the ChE education at OSU prepare you for performance listed under Educational Objectives?”
8. Response to the question, “Relative to new hires from other programs, what do you see as the advantages and disadvantages of the ChE education at OSU?”
9. Response to the question, “Which courses/experiences/people at OSU were most important to your success in life? Why?”
10. Response to the question, “Which courses/experiences/people at OSU were least important to your success in life? Why?”
11. Response to the question, “As you observe recent graduates from other BS ChE programs, what are the advantages and disadvantages of the OSU program?”
12. Response to the question, “Compare the scope and diversity of assignments relative to alumni from other programs.”
13. Response to the question, “What has been your annual rate of salary increase during employment?”
14. Response to the question, “What have been additional responsibility or promotion assigned during employment?”
15. Response to the question, “State the number of presentations or publications, internal or external, which reveal creativity, solutions, dissemination of technology, or initiating action.”
16. Response to the question, “State the number of training courses, seminars, conferences, workshops, short courses, formal education courses, self-study units as reported by alumni.”
17. Response to the question, “Which professional magazines, newsletters, or journals do you regularly read.”
18. Response to the question, “What is your membership and participation in professional societies, local section activities, civic organizations?”
19. Response to the question, “Rate your personal satisfaction with achievements and successes at work and home.”
20. Response to the question, “Rate your personal satisfaction with personal, professional, and technical growth.”
21. Response to the question, “What have been your personal attributes and educational experiences that facilitated success?”
22. Response to the question, “What have been your personal attributes and educational experiences that hindered success?”
23. The number of special requests from employers and graduate programs wanting more applicants from OSU.
24. The fraction of OSU graduates (relative to national data) wanting employment that get job offers upon graduation.

25. The fraction of OSU graduates (relative to national data) wanting to attend graduate school that get accepted upon graduation.
26. The fraction of OSU ChE students (relative to national data) who participate in extracurricular activities by attendance and by leadership roles.
27. The geographical distribution of alumni or number of within organization transfers that might imply strong company acceptance.

ABET Engineering Accreditation Criteria 2000
Program Outcomes
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
October 6, 2000

Consistent with ABET terminology, **"Program Outcomes" are the desirable attributes of OSU ChE BS graduates upon graduation**. It is what they are expected to know and able to do at the time of graduation. It is the set of skills that they developed while in school, to meet the "Educational Objectives".

The Chemical Engineering program at Oklahoma State University has a strong history of being applications, and practice oriented. This includes structured student experience in interpersonal and communication effectiveness, as well as training to generate practicable process designs and to perform technical analysis of complex processes. As a necessary complement, OSU also has a strong history of graduating students who are competent in the fundamental sciences of chemical engineering. These include the mathematical methods, behavior of matter, and the engineering sciences of natural processes.

Fundamentals are of paramount importance. Future technical growth of the graduate depends on his knowledge of the fundamentals. Credible techniques must be built upon a fundamental basis. However, engineering solutions are realized within a context of nonidealities, human enterprises, legal/regulatory and economic constraints, and uncertainty. Therefore, students must understand both the practice as well as the science of engineering.

In addition, engineering is a people-intensive vocation. Communication effectiveness, good interpersonal relationships, and both personal and professional credibility are required by the new engineer to be effective in working through others, to make his assignments become realized.

Considering this, our program outcomes desire that our graduates have:

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

ABET Engineering Accreditation Criteria 2000
CHENG Interpretation of the a-k Outcomes
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
July 27, 2001

a) **An ability to apply knowledge of mathematics, science, and engineering**. This criterion is interpreted in two categories. First, it specifies that processed students have the fundamental skills commonly useful to chemical engineering. These include understanding the concepts of physical and chemical phenomena, describing these phenomena using mathematics, and solving the mathematics so the phenomena can be accurately represented. Second, that processed students are able to connect theory to practice. Not every knowledge or application event has to be demonstrated. Demonstration in the commonly accepted fundamentals of chemical engineering implies that students have the ability to perform in others. *What knowledge? Should we explicitly list subjects or refer to the Assessable subject matrix? What level of ability? How to quantify expectations?*

b) **An ability to design and conduct experiments, as well as to analyze and interpret data**. Design is an activity that develops specifications for a tangible process, procedure, program, or recipe. Design is not the following of a recipe or set of instructions. Design is a creative, open-ended activity that continually operates in the cognitive modes of synthesis (concept), analysis (determine performance metrics for the concept), evaluation (decide if the work is complete or needs improvement), until it is determined to be finished. Design of experiments includes the choice of measurement devices, experimental order, operating conditions, basis for analysis, methods for validation, ability to connect theory to practice, etc. The objectives for design and for conducting are to maximize operational safety, minimize cost and effort, minimize hazard and risk, minimize environmental impact, maximize data precision and accuracy, maximize validity of scale-up or other use of data, and generate a complete and credible conclusion. Students will implement their experimental designs, and then "analyze the data" in consideration of the fundamentals of engineering. *What analysis methods? What objectives? How to quantify expectations?*

c) **An ability to design a system, component, or process to meet desired needs**. Design is an activity that develops specifications for a tangible process, procedure, program, or recipe that accomplishes a specific objective. This includes the design of computer instruction, sizing and choice of process units, design of oral and written presentations, and integrated processes. The design choices must be grounded in both the fundamental technical principles and acceptance and utility of the designed item. *Design of what items? Should we explicitly list subjects or refer to the Assessable subject matrix? What level of ability? How to quantify expectations?*

d) **An ability to function on multi-disciplinary teams**. "Multi-disciplinary" is interpreted as relating to individuals and groups with other experiences, values, cultures, age, priorities, and training. Individuals on "teams" must share theirs and accept others unique personal expertise and resources to enrich the awareness of teammates, and integrate diverse aspects (safety, environmental, legal, economic, etc.) into a project. *What level of ability? How to quantify expectations?*

e) **An ability to identify, formulate, and solve engineering problems**. This criterion relates to systematic diagnosis followed by solution. *What complexity of problem? What level of ability? How to quantify expectations?*

f) **An understanding of professional and ethical responsibility**. This criterion is interpreted as being consistent with the AIChE Code of Professional Ethics. *What are the appropriate interpretations of the code for students? What level of understanding? How to quantify expectations?*

g) **An ability to communicate effectively**. Communication involves oral, written text, equations, graphical data presentation, and drawings. Effective communication requires audience analysis, and a presentation that is easily understood. *What level of ability? How to quantify expectations?*

h) **The broad education necessary to understand the impact of engineering solutions in a global and societal context**. Students should understand that a "correct" engineering solution is dependent on the local culture, infrastructure, economy, resources, etc. which change with time and place, and accommodate these issues in their engineering activity. *What level of understanding? How to quantify expectations?*

i) **A recognition of the need for, and an ability to engage in life-long learning**. This includes technical, professional, and personal development. Since most of the life-long learning is self-directed, the "student" must also become the "professor" in guiding his/her growth, and testing his/her ability. We need to excite students with a passion for learning, and provide them successful experiences and examples of self-learning. *What level of ability? How to quantify expectations f both ability and recognition?*

j) **A knowledge of contemporary issues**. This criterion includes political, social, and technical issues. *What level of knowledge? How to quantify expectations?*

k) **An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice**. We interpret these tools to support both technical work (computer aided simulation, design, math analysis, etc.) and presentation tasks (word processor, graphics, etc.) and that use will be integrated throughout the curriculum. *What explicitly are the techniques, skills and tools? What level of ability? How to quantify expectations?*

ABET Engineering Accreditation Criteria 2000
Assessing Program Outcomes
Bachelor of Science Degree in Chemical Engineering
Oklahoma State University
July 25, 2001

Consistent with ABET terminology; **"Program Outcomes" are "Assessed"**. One reason for "Assessment" is to develop and improve the program. The other is to design the program so that it can be determined that each student achieves the "Program Outcomes" before graduation. For ABET the "Program Outcomes" become the degree requirements, and the ABET evaluator will require evidence that each student achieved "Program Outcomes" in the place of auditing compliance with the degree plan. Assessment tools are shown below by category.

Assessments via student input:

1. Student evaluations of course and instructor- form written by university
2. Student evaluations of course and instructor- form written by faculty
3. Student evaluations of course and instructor- form written by students (AIChE, etc.)
4. Student peer evaluations on team projects
5. Input from student members of EC 2000 committee

Assessments via faculty input:

1. Instructor evaluations of prerequisite material (e.g. compare prerequisite grades with prerequisite problem areas)
2. Instructor evaluations of student performance (e.g. an analysis of grades and grade distributions w.r.t. assignments and tests)
3. Faculty end-of-course evaluation
4. Continual evaluation of course matrix sheet to assess missing/redundant/etc. educational components.
5. EC 2000 committee summary of all assessment materials
6. Exit interviews of seniors conducted by faculty

Assessments via IAC/Alumni/etc. input:

1. Feedback by industrial personnel on industrially-sponsored projects
2. Exit interviews of seniors conducted by IAC during the annual IAC meeting
3. Alumni comments
4. Feedback from employers participating in intern programs
5. Survey of interviewers

Assessments via available data

1. Student achievement levels in National, Regional, and local competition
2. FE Exam pass rates including an analysis of subject scores
3. Employment and graduate school acceptance rates (our graduates and national average)