2006-851: DEVELOPING A SUPPLEMENTAL ASSESSMENT DOCUMENT FOR ABET CERTIFICATION: HOW CAPSTONE DESIGN CLASSES CAN HELP

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Developing a Supplemental Assessment Document for ABET Certification: How Capstone Design Classes Can Help

Abstract

Demonstrating successful fulfillment of Program Outcomes and Assessment Criteria 3a through 3k of ABET 2000 can be a daunting task. The criteria are widespread in their requirements and the “burden of proof” is placed on the shoulders of the subject program and institution. During the accreditation process in 2000, the Petroleum Engineering Department at the Colorado School of Mines prepared a supplement to the ABET Self-Study Report entitled “Petroleum Engineering Program Assessment Report Supplement to ABET Self-Study Report, Colorado School of Mines.” This supplemental document was focused entirely on demonstrating the execution of Criteria 3a through 3k. The document was extremely well received by the review committee. In fact, the review committee asked for copies of the supplement for distribution to other institutions and programs. A second iteration of this document is currently being prepared for an upcoming ABET review in 2006.

This paper describes the creation and content of this document and how the capstone design class plays an integral part in the fulfillment of the ABET requirements and the construction of the document. Triangulation methods, which use data from a variety of sources, are used to develop the arguments for fulfillment of the criteria. Sources of data include alumni surveys, student surveys, advisory board surveys, student interviews, recruiter interviews, program activities, peer evaluations, course records, videotaped presentations, and scoring rubrics. The hub of all these sources is the program’s capstone design course.

A review of the data sources and their collection is provided. Additionally, how the assessment supplement is constructed, which data sources are integrated, and how this supplement augments criteria fulfillment are reviewed. Finally, the paper provides a discussion of how the document enhances the program’s self-study.

Introduction

Anyone who has worked on their departmental ABET accreditation review or developed the self-study report knows the difficulty with demonstrating the successful satisfaction of the ABET Program Outcomes and Assessment Criterion 3¹ outcomes. Proving that a program satisfies these varied components to an outside evaluator in a succinct but coherent fashion takes a great deal of work throughout the six-year evaluation cycle and within the self-study document. In an effort to provide proof that the program meets the requirements of Criterion 3, the Petroleum Engineering (PE) Department at the Colorado School of Mines (CSM) developed a supplemental document in addition to the formal self-study that focused specifically on Criterion 3. This document entitled “Petroleum Engineering Program Assessment Report Supplement to ABET Self-Study Report,

Colorado School of Mines” does not replace the self-study report but rather provides a “road-map” to how the conclusions in the self-study report were reached and outlines the evidence relied upon. The supplemental document lends additional credibility to the achievements shown in the self-study and was highly regarded by the on-campus ABET reviewers during the 2000 visit.

Within the supplemental assessment document, the capstone design class was a critical component that aided in showing the interaction between the various data sources and the associated outcomes. This paper discusses the development of this document in detail and shows how the gathered data are analyzed and cross-referenced with the university objectives, the CSM Graduate Profile, and the departmental Criterion 2 objectives (Table 1) to demonstrate successful fulfillment of the outcomes associated with Criterion 3.

Justification for Development of Supplemental Document

The most recent ABET review for the Colorado School of Mines was during the 2000-2001 cycle. Since the new 2000 ABET Criteria had just recently been established, the Petroleum Engineering Department realized the critical need of demonstrating attainment of the Criteria 3a-3k outcomes. Therefore, it was decided to develop a second, supplemental document that would not replace the self-study in any way but would rather act as a complement to the self-study report. This supplemental document would help to organize the significant amount of data which had been collected throughout the previous six years and present it in a coherent manner. It would provide a “road-map” for the ABET reviewers by cross-referencing the program’s objectives with Criteria 3a-3k with the raw data sources and with the statistics and methods used to analyze the raw data. When presented to the ABET reviewers during the 2000-2001 cycle visit, both the Program and the entire school reviewers were very pleased with the document, and the PE Department is in the process of creating an updated document for their upcoming 2006-2007 review cycle.

Program Outcomes and Assessment ABET Criteria 3

Although most readers are likely familiar with the ABET Criterion 3 components, it would be prudent to provide a brief overview of them at this time for reference purposes.

The Criterion 3 components are:¹

- (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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (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, economic, environmental, 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) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Supplemental Document Development

The main components included in the supplemental document are: 1) program assessment results with a section for each of the Criteria 3a-3k that includes the data sources, the methods used to analyze the data, and the results of the analysis; 2) various cross-referenced tables that list the program assessment objectives and outcomes and the available data evidence; 3) documentation of faculty meetings regarding ABET preparedness; and 4) assessment rubrics and questionnaires. The following sections provide a detailed breakdown of some of these components.

Program Assessment Results

ABET Criterion 3a: the ability to apply knowledge of mathematics, science, and engineering was measured on samples from three different PE courses using an assessment rubric (Table 2) designed specifically for assessing Criteria 3a, 3c, 3e, and 3k. For all the sections, the assessments were performed by a departmental assessment committee. The results of the Criterion 3a assessment are shown in Figure 1.

Additionally, answers from various exit interview questions were included. It should be noted that the exit interview questions were developed with the assistance of a specialist to minimize bias in the questions and were conducted by an engineering education professional. The specific questions used for 3a were:

From your perspective, were you prepared to handle the math and statistics required in PEGN 422 (senior-level engineering economics course)? If not, why not and what could be improved? Did you have all the prerequisites for taking the class? Did the problems in PEGN 422 help in your understanding of the application of probability and statistics in petroleum engineering?

Did you have any difficulties with the math encountered in any other PEGN courses? Which ones? What changes should be made to improve the situation?

Do you feel that you were prepared in the math and sciences for your petroleum engineering course work?

ABET Criterion 3b: the ability to design and conduct experiments, as well as to analyze and interpret data were measured using two different assessment rubrics (Tables 3 and 4), with the first rubric addressing “design and conduct” experiments and the second addressing the “analyze and interpret” portion. Several graphs similar to Figure 1 were created using the rubric results. The results for these criteria showed some room for improvement (see Figure 2), and this deficiency was addressed by the PE Program as explained in the self-study document with changes made to several courses during the past six years.

Additionally, two exit interview questions were written to address this criterion as follow:

Do you feel that you could design and conduct an experiment if required by your first job assignment after graduation? How would your laboratory experiences at CSM including CH 121 (intro to chemistry lab, freshman-level), PEGN 309 (reservoir rock properties, sophomore-level), MEL Labs (multidisciplinary lab, junior-level), and PEGN 413 (gas measurement, senior-level) help you complete this first job assignment?

Do you feel prepared to work open-ended design problems such as the Lone Cedar project and the Brazos problem you worked in PEGN 439 (senior capstone design)? Did the EPICS (freshman/sophomore design) program courses help develop your problem solving skills? Did PEGN 439 (senior capstone design) help? Why or why not?

ABET Criterion 3c and 3e: the ability to design a system, component, or process to meet desired needs and the ability to identify, formulate, and solve engineering problems were addressed together in the same report section and used results from the Problem Solving/Design Skills assessment rubric (Table 2) with results from three classes. The second exit interview question used for Criterion 3b above was also used to address these two criteria.

ABET Criterion 3d: the ability to function on multi-disciplinary teams is directly related to the PE Program's capstone design course. The capstone design course for the PE Department is multi-disciplinary and is taught along with CSM's Geophysical Engineering and Geology and Geological Engineering Departments.²⁻⁴ Data for this criterion were collected from four sources including rubric assessments for oral and written communication (Tables 5 and 6), interviews, peer evaluations, and end-of-course surveys. The peer evaluations demonstrated statistically significant increases in team skills over semester-long periods.⁵⁻⁷ The second interview question used in Criterion 3b was also used for this criterion, along with two additional questions as follows:

What are some of the benefits of working on a multidisciplinary team?

What are some of the challenges of working on a multidisciplinary team?

Since the 2000 accreditation cycle, alumni surveys have been designed and acquired for this Criterion 3d and will be included in the 2006-2007 assessment document in addition to these other data sources.

ABET Criterion 3f: demonstrating an understanding of professional and ethical responsibility is difficult but is important under the current ABET guidelines. All PE Department students are provided with a departmental Honor Code which is reviewed in all PE classes at the beginning of each semester. Additionally, one PE course specifically addresses professional and ethical issues through written and oral assignments. Two interview questions that address these issues are:

Have you been given a copy of the PE Department Honor Code? Did you read the Honor Code? Are you familiar with the SPE (Society of Petroleum Engineers) Code of Ethics?

Have other experiences in the PE Program fostered a sense of personal accountability in the way you conduct your professional life? If so, how? If not, what could be improved?

ABET Criterion 3g: the ability to communicate effectively is addressed by assessing homework and project samples from five classes (sophomore to senior level) that are considered “writing intensive” courses. Two rubrics, one for oral communication and one for written reports, are used (Tables 5 and 6). Seven interview questions address this issue:

How would you rate your technical writing skills? Excellent, Adequate, Needs improvement

Do you believe that your technical writing skills improved while at CSM?

Did PEGN 311 (drilling junior-level), 413 (gas measurement senior-level) and 481 (senior seminar) help you become a better writer? Why or why not. What could be done to improve your writing skills?

How would you rate your oral presentation skills? Excellent, Adequate, Needs improvement

Do you believe that your oral presentation skills improved while at CSM?

What experiences have helped you improve? What could be done to improve your oral presentation skills?

Did the presentations in PE 481 help you develop your oral presentation skills? Why or why not? What could be done to improve your oral presentation skills?

ABET Criterion 3h: the need for abroad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context is met through CSM’s system and stem courses and many of the junior and senior PE courses. Minimal supporting evidence is necessary or provided in the supplemental document.

ABET Criterion 3i: a recognition of the need for, and an ability to engage in life-long learning is demonstrated based on six data sets including the preparation of “Individual Life-Long Learning Plans” by students, alumni surveys, research activities, student involvement in student professional groups such as the student SPE chapter, guest presentations from industry personnel, and exit interview questions. The results and documentation for these various activities are listed and inventoried in the supplemental assessment document. Exit interview questions include:

Did you participate in activities outside the classroom (e. g. the student chapter of SPE, AADE, Pi Epsilon Tau, student government, or Tau Beta Pi?). Which activities?

Do you plan on joining the Society of Petroleum Engineers or other professional societies after graduation?

Do you plan on becoming a registered professional engineer? Have you taken the fundamentals of engineering exam?

ABET Criterion 3j: a knowledge of contemporary issues is demonstrated based on six data sources including the preparation of “Individual Life-Long Learning Plans” by students, student placement records, exchange program records, field session course work, attendance at guest presentations, and one exit interview question. The results and documentation for these various activities are listed and inventoried in the supplemental assessment document. The exit interview question was:

What do you think is an important contemporary issue facing the oil and gas industry today? (an example might be the green-house effect?).

ABET Criterion 3k: the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice is addressed by assessing homework and project samples from four classes including the capstone design class (Table 2). One interview question addresses this issue:

Have your computer skills improved while at CSM? Have you used the computer program @Risk™ or Crystal Ball™? Have you used the computer program BOAST4D/WINB4D™?

Additional Assessment Document Components

In addition to individual breakdowns of the Criterion 3 components, the assessment document contains an Action Plan for Improvement based on the results of the data analysis. This action plan ties directly to the assessment portion of the self-study document. The report also contains several appendices listing the program objectives and outcomes, memos documenting departmental meetings on ABET and assessment, examples of the assessment rubrics, and the SPE professional competency matrices. Although the entire program and all available data sources are used, the capstone design course is one of the most critical components to linking the entire departmental assessment program. The following section demonstrates this linkage and the importance of the capstone design course.

Capstone Design Course Assessment Linkage Example

As with all ABET accredited programs, the CSM PE Department has established program objectives (Table 1). In the supplemental assessment document, three matrices, Tables 7, 8, and 9, are used to relate these program objectives to the ABET Criteria 3a-3k (Tables 7 and 8) and to

the evidence used to analyze the satisfactory achievement of the criteria, which is also available for the ABET reviewers' on-campus examination (Table 9). PEGN 439, Multidisciplinary Petroleum Design, is the senior capstone design class required by all undergraduate graduates of the Petroleum Engineering Department. Several geological engineering and geophysical engineering students also use the course to satisfy their capstone design components. Although all classes in the PE Program help to satisfy some ABET components, PEGN 439 is a significant contributor to most of the ABET requirements and shows the linkages among the necessary ABET components.

Specific Example

The Program Objective 3, Applied Problem Solving Skills, shown in Table 1 will be used as an example to demonstrate these linkages for PEGN 439. First, the program objective is broken into sub-categories (Table 1):

- 3.1 Designing and conducting experiments
- 3.2 Analyzing and interpreting data
- 3.3 Problem solving skills in engineering practice
- 3.4 Working real world problems

Next, these sub-categories, Program Objectives 3.1-3.4, and the requirements necessary to demonstrate the fulfillment of these objectives are listed and are linked to the associated ABET Criteria 3a-3k as shown in Table 7. For instance, Objectives 3.3 Problem solving skills in engineering practice and 3.4 Working real world problems are demonstrated by a "Passing grade on written reports and oral presentations prepared by multidisciplinary teams (PEGN 439), casing design problems (PEGN 361), artificial lift problems (PEGN 411), and well testing assignments (PEGN 414), demonstrating the integration of data and information from multiple sources, use of information to make an interpretation of the system, and develop recommendations based on interpretation." This demonstration is determined both by the class records and by the assessment team's rubric analysis (Table 2). The associated ABET Criterion three categories are also listed in Table 7. For Objectives 3.3 and 3.4, these criteria are 3a, 3c, 3d, 3e, and 3k (PEGN 439 is also a substantial contributor to 3g, but this link is addressed in Objective 5, Table 1).

Once Table 7 is used to link the program objectives to the appropriate ABET criteria, Table 8 is used to outline each program objective as it relates to performance criteria, implementation, evaluation methods, logistics, and feedback. Table 8 contains an explanation for each of these headings. For instance, the "feedback" heading describes "Who needs to know the results? How can we improve our program and assessment process?" For Program Objectives 3.3 and 3.4, the "feedback" is described as "Results are provided to the Departments of Geology and Geologic Engineering, Geophysics, Petroleum Engineering, and the EPICS Program Director to help learning and instruction in these programs and to assess how well ABET requirements are being met."

Finally, in Table 9, the evidence available for review of the satisfactory fulfillment of each departmental objective is cross-referenced complete with the physical location of the evidence.

As seen in Table 9, the evidence from PEGN 439 for ABET Criteria 3a is located in Boxes 5 and 10 and consists of written class reports and videotaped presentations. The available evidence from PEGN 439 for Criteria 3c, 3d, 3e, and 3k is also listed.

Conclusions

In an effort to demonstrate attainment of the Criterion 3 assessment criteria outlined in the departmental self-study, the CSM Petroleum Engineering Department has developed a supplemental assessment document that provides a “road map” for the assessment preparation and demonstration. This supplemental document is not intended to replace the self-study in any way but rather provides the ABET reviewers with a very detailed outline of how the department meets the various assessment criteria associated with the specific program objectives. The department’s capstone design class is a critical component that aids in showing the interaction between the program objectives, the various data sources, and the associated outcomes. The supplemental document was well received by the ABET reviewers during the last ABET review in 2000, which has encouraged the PE Department to continue with this practice in future review cycles.

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Table 1
Petroleum Engineering Program Assessment Objectives

1. **Broad Education, based on (3a,c,g,h,i,j,k)**
 - 1.1. CSM systems and design courses (3a,c,h,k)
 - 1.2. Effective communication (3g)
 - 1.3. Skills necessary for diverse and international professional career (3j), CSM**
 - 1.4. Recognition of need and ability to engage in lifelong learning (3i,j)
2. **Solid foundation in engineering principles and practices, based on (3a,h)**
 - 2.1. Society of Petroleum Engineers' ABET Program Criteria (3a)
 - 2.2. Strong petroleum engineering faculty with diverse backgrounds (CSM**, PE***)
 - 2.3. Technical seminars, field trips, and field sessions (3h) (CSM**, PE***)
3. **Applied problem solving skills, as demonstrated by (3a,b1,b2,c,d,e,k)**
 - 3.1. Designing and conducting experiments (3b1)
 - 3.2. Analyzing and interpreting data (3b2)
 - 3.3. Problem solving skills in engineering practice (3a,c,e,k)
 - 3.4. Working real world problems (3d,k)
4. **An understanding of ethical, social, environmental, and professional responsibilities as demonstrated by (3f,i,j)**
 - 4.1. Following established department and Colorado School of Mines honor codes (3f)
 - 4.2. Integrating ethical and environmental issues into real world problems (3f,i,j)
 - 4.3. Awareness of health and safety issues (3f,j)
5. **Multidisciplinary team skills, as demonstrated by (3d)**
 - 5.1. Integrating information and data from multiple sources (3d)
 - 5.2. Critical team skills (3d)

** = Colorado School of Mines Graduate Profile

*** = Petroleum Engineering Program objectives in addition to ABET

Table 2
Problem Solving/Design Skills Scoring Rubric

Problem Solving/Design Skills: Scoring Rubric for Petroleum Engineering Program

Objective	N/A	Needs improvement	Meets Expectations	Exceeds Expectations	Comments	ABET	
3.3/3.4 and 5.1: Students will be able to demonstrate problem solving skills in engineering practice and working real world problems in written work and oral presentations:							
Apply Math, Engineering, and Science ▪ Use of equations, concepts, and theories	—	— Does not effectively apply equations, concepts, or theories available to solve problem	— Adequately applies equations, concepts, or theories available to solve problem	— Effectively applies equations, concepts, or theories available to solve problem			3(a)
Identify Problem ▪ Identify problem and main objective, based on stated requirements	—	— Inadequately identifies problem and objective	— Adequately identifies problem and objective	— Very clear identification of problem and objective			
Identify Information ▪ Identify basic information needed to solve the problem	—	— Does not identify basic information needed to solve the problem	— Adequately identifies basic information needed to solve the problem	— Clearly identifies information needed to solve the problem			
Analyze Alternatives ▪ Analyze alternative interpretations or solutions	—	— Does not analyze alternative interpretations or solutions	— Adequately analyzes alternative interpretations or solutions	— Analyzes multiple alternative interpretations or solutions			
Integration of Data ▪ Integration of data from multiple sources	—	— Low level of integration of data and information from multiple sources	— Moderate level of integration of data and information from multiple sources	— High level of integration of data and information from multiple sources			3(c) & 3(e)
Interpretation ▪ Make interpretation of system based on information gathered ▪ Strong supporting arguments	— —	— Uses very little of the information gathered to make an interpretation of system — Lacks supporting arguments for interpretation	— Uses some of the information gathered to make an interpretation of system — Adequate supporting arguments for interpretation	— Effectively uses the information gathered to make an interpretation of system — Strong supporting arguments for interpretation			
Recommendations ▪ Recommendations/ conclusions based on interpretation of the system	—	— Little evidence that the recommendations/ conclusions are based on interpretation of the system	— Some evidence that the recommendations/ conclusions are based on interpretation of the system	— Strong evidence that the recommendations/ conclusions are based on interpretation of the system			
Ability to Use Techniques ▪ Use of techniques, skills, and tools in engineering practice	—	— Does not effectively use techniques, skills, or tools available to solve problem	— Adequately uses techniques, skills, and tools available to solve problem	— Effectively uses techniques, skills, and tools available to solve problem			3(k)

Table 3
Design and Conduct Experiments Scoring Rubric

Design and Conduct Experiments: Scoring Rubric for Petroleum Engineering Program

Objective		Needs improvement	Meets Expectations	Exceeds Expectations	Comments	ABET
3.1: Students will be able to design and conduct experiments of Petroleum Engineering processes or systems:						
Identify Objectives ▪ Identify main objectives	—	— Inadequately identifies main objectives to be achieved in designing/conducting the experiment	— Adequately identifies main objectives to be achieved in designing/conducting the experiment	— Very clearly identifies main objectives to be achieved in designing/conducting the experiment		3b1 3b1
Idea Generation ▪ Generate workable ideas for designing the experiment	—	— Ideas generated are not workable for the experimental design	— In general ideas generated are workable for the experimental design	— All ideas generated are workable for the experimental design		3b1
Design Development and Implementation ▪ Incorporates logical, workable ideas/steps into developing the best procedure ▪ Uses precision in carrying out experimental procedure ▪ Identifies sources of error/uncertainty	— — —	— Incorporates illogical or unworkable ideas/steps into the procedure — Uses little to no precision in carrying out experimental procedure — Does not adequately identify the sources of error and uncertainty in the data/method of analysis	— Adequately incorporates logical, workable ideas/steps into the procedure — Uses some precision in carrying out experimental procedure — Adequately identifies the sources of error and uncertainty in the data/method of analysis	— Effectively incorporates logical, workable ideas/steps into the procedure — Uses great precision in carrying out experimental procedure — Thoroughly identifies the sources of error and uncertainty in the data/method of analysis		
Design Evaluation ▪ Discusses limitations of experiment/design ▪ Choice of design would result in desired outcomes/ achieve objectives	— —	— Does not discuss limitations of the experiment/design (procedure, materials, sources of error/uncertainty) — Little evidence that the design would result in the desired outcomes/achieve the objectives of the experiment	— Some discussion of the limitations of the experiment/design (procedure, materials, sources of error/uncertainty) — Some evidence that the design would result in the desired outcomes/ achieve the objectives of the experiment	— Thorough discussion of the limitations of the experiment/design (procedure, materials, sources of error/uncertainty) — Strong evidence that the design would result in the desired outcomes/ achieve the objectives of the experiment		

Table 4
Analyze and Interpret Data Scoring Rubric

Analyze and Interpret Data: Scoring Rubric for Petroleum Engineering Program

Objective	N/A	Needs improvement	Meets Expectations	Exceeds Expectations	Comments	ABET
3.2: Students will be able to analyze and interpret data from Petroleum Engineering problems or experiments:						
Identify Objectives ▪ Identify experimental or main objectives	___	___ Inadequately identifies experimental or main objectives	___ Adequately identifies experimental or main objectives	___ Very clearly identifies experimental or main objectives		3b2
Data Analyzed ▪ Logical/accurate analysis	___	___ Problem analysis is lacking in logic and accuracy	___ Problem analysis is logical and accurate	___ Problem analysis is very logical and accurate		
▪ Uncertainty/error identified	___	___ Does not adequately identify the sources of error and uncertainty in data/ method of analysis	___ Adequately identifies the sources of error and uncertainty in the data/ method of analysis	___ Thoroughly identifies the sources of error and uncertainty in the data/ method of analysis		
▪ Alternative methods	___	___ Uses only one method to analyze data	___ Analyzes data using an alternative method	___ Thoroughly analyzes data using alternative methods		
Interpret Data ▪ Information gained from analysis	___	___ Inadequate interpretation of the data and information gained from analysis	___ Adequate interpretation of the data and information gained from analysis	___ Strong interpretation of the data and information gained from analysis		3b2
▪ Uncertainty in information	___	___ Inadequate explanation of how the uncertainties/errors affected the outcome or interpretation	___ Adequate explanation of how the uncertainties/errors affected the outcome or interpretation	___ Thorough, accurate explanation of how the uncertainties/errors affected the outcome or interpretation		

Table 5
Oral Presentations Scoring Rubric

Oral Presentations: Scoring Rubric for Petroleum Engineering Program

Objective	N/A	Needs improvement	Meets Expectations	Exceeds Expectations	Comments	ABET
1.2a: Students will be able to demonstrate effective communication skills in oral presentations						3(g)
Quality of Content ♦ Audience awareness (interacts with audience: e.g., stepping toward audience and speaking to them, not at them) ♦ Focus: goal, evidence, conclusion (gives audience a road map and follows it) ♦ Transitions (phrases smoothly link one part to next) ♦ Use of visual aids (to tell the story and enhance the quality of the presentation)	___ ___ ___ ___	___ Does not interact with audience ___ Does not give audience an adequate road map of goal, evidence and conclusion ___ Abruptly transitions from one phase to the next ___ Does not use visual aids effectively to tell the story; too much dependency on visual aids	___ Some interaction with audience ___ Gives audience an adequate road map of goal, evidence, and conclusion ___ Transitions are generally smooth ___ Overall, uses visual aids effectively to tell the story; visual aids add to presentation	___ Interacts with audience throughout presentation ___ Gives audience very clear road map of goal, evidence, and conclusion ___ Very smooth transitions ___ Uses visual aids very effectively to tell the story; visual aids enhance presentation		
Mechanics ♦ Body Position (e.g., facing audience or screen) ♦ Eye Contact (e.g., scanning entire audience) ♦ Body Movement (e.g., hand gestures, stepping back) ♦ Visual aids e.g., (clear, not too busy, readable size font) ♦ Delivery (e.g., fluency, pace, voice projection, um's, uh's)	___ ___ ___ ___ ___	Does not effectively use (e.g.'s): ___ Body position (faces screen) ___ Eye contact (not enough, looking down a lot) ___ Body movement (lack of gestures, glued to overhead) ___ Visual aids (too busy, blurry) ___ Delivery (too fast, too many um's, not projecting voice, lack of enthusiasm)	Adequately uses (e.g.'s): ___ Body position (faces audience most of the time) ___ Eye contact (some scanning of audience, looking at people) ___ Body movement (some hand gestures, steps back f/ OH) ___ Visual aids (can read clearly, usually not too much material) ___ Delivery (good pace, usually projects voice, some enthusiasm)	Very effectively uses (e.g.'s): ___ Body position (always facing audience) ___ Eye contact (excellent scanning, looking at people) ___ Body movement (good use of hand gestures, steps back) ___ Visual aids (clear, right amount on each slide) ___ Delivery (excellent pace, projects voice, great enthusiasm)		
Questions ♦ Asks audience for questions ♦ Answers questions effectively and smoothly	___ ___	___ Does not ask for questions ___ Does not answer questions adequately	___ Asks for questions ___ Answers questions adequately	___ Effectively opens ("I'd be happy to answer questions") ___ Answers questions effectively and smoothly		

Table 6
Writing Technical Reports Scoring Rubric

Writing Technical Reports: Scoring Rubric for Petroleum Engineering Program

Objective	N/A	Needs improvement	Meets Expectations	Exceeds Expectations	Comments	ABET
1.2b: Students will be able to demonstrate effective communication skills in writing technical reports						3(g)
Purpose <ul style="list-style-type: none"> Focus (clearly states the objective, has a central focus, idea) Significance (shows an awareness of main ideas) 	 	Objective not clearly stated, paper lacks central focus Lack of awareness of main ideas	Objective adequately stated paper has central focus Some awareness of main ideas	Objective very clearly stated, paper has strong central focus Strong awareness of main ideas		
Organization <ul style="list-style-type: none"> Structure (structure or pattern of whole report is clear) Coherence (whole report is clear, tells coherent story) Paragraphing (transitions f/one idea to next) Tables/Figures (link to text) 	 	Loses reader: No clear structure or pattern Whole report lacks clarity; story lacks coherence overall Lack of or too many paragraph transitions Tables/Figures do not link to text	Guides reader: Adequate structure or pattern Whole report is clear; story is coherent overall Adequate paragraph transitions Most Tables/Figures link to text	Engages reader: Clear structure or pattern Whole report is very clear; story is very coherent Excellent paragraph transitions All Tables/Figures link to text		
Evidence <ul style="list-style-type: none"> Accuracy (statements) Support (opinions are adequately supported) Documentation (sources are identified and referenced appropriately in the body) 	 	Inaccurate statements Lack of support for statements/opinions Sources are not identified and referenced appropriately in the body	Most statements are accurate Adequate support for statements/opinions Most sources are identified and referenced appropriately in the body	Statements are very accurate Strong support for statements/opinions All sources are identified and referenced appropriately in the body		
Mechanics <ul style="list-style-type: none"> Sentence structure (grammar, sentence structure, spelling, punctuation) Appearance (Report, Figures/Tables/ References) 	 	Many errors in grammar, spelling, and/or punctuation Poor appearance of Report, Figures/Tables/ References	Few errors in grammar, spelling, and/or punctuation Acceptable appearance of Report, Figures/Tables/ References	Excellent grammar, spelling, and punctuation Excellent appearance of Report, Figures/Tables/ References		

Table 7
Relationship between Petroleum Engineering Objectives
and ABET Outcomes and Assessment Items

PE Program Objectives	PE Program Outcomes and Assessment Items	ABET Program Outcomes and Assessment Items: Section 3 Requirements
3. Applied problem solving skills	3. Demonstration of applied problem solving skills	(3a,b1,b2,c,d,e,k)
3.1 Designing and conducting experiments	3.1 Passing grade on applied problems involving students designing and conducting laboratory experiments (PEGN 413, 308).	3b1: ability to design and conduct experiments
3.2 Analyzing and interpreting data	3.2 Passing grade on applied problems emphasizing analyzing and interpreting statistical data (PEGN 422), on applied problems on well-testing and analyzing and interpreting the data sets, (PEGN 414), on applied problems involving students conducting laboratory experiments and analyzing and interpreting the experimental data (PEGN 308).	3b2: ability to analyze and interpret data
3.3/3.4 Problem solving skills in engineering practice; Working real world problems	3.3/3.4 Passing grade on written reports and oral presentations prepared by multidisciplinary teams (PEGN 439), casing design problems (PEGN 361), artificial lift problems (PEGN 411), and well testing assignments (PEGN 414), demonstrating the integration of data and information from multiple sources, use of information to make an interpretation of the system, and develop recommendations based on interpretation.	3a: ability to apply knowledge of math, engineering, & science 3c: ability to design system, component or process to meet needs 3d: ability to function on multidisciplinary teams 3e: ability to identify, formulate, and solve engineering problems 3k: ability to use techniques, skills, and tools in engineering practice

Table 8
Petroleum Engineering Program Assessment Goals and Objectives Matrix

Petroleum Engineering Program Assessment Goals and Objectives Matrix					
Goal # 3: Applied Problem Solving Skills (3a,b1,b2,c,d,e,k)					
Program Objectives	Performance Criteria	Implementation	Evaluation Methods	Logistics	Feedback
<i>What are the program objectives? What should our students know and be able to do?</i>	<i>How will we know the objectives have been met? What level of performance meets each objective?</i>	<i>How will the objective be met? What program activities help students meet each objective?</i>	<i>What methods will we use to collect data? How will we interpret and evaluate the data?</i>	<i>When will we measure? How often? Who will collect and interpret the data and report the results?</i>	<i>Who needs to know the results? How can we improve our program and assessment process?</i>
3.3/3.4 Problem solving skills: engineering practice, working real world problems (3a,c,d,e,k).	Multidisciplinary teams demonstrate in written reports and oral presentations the integration of data and information from multiple sources and use the information to make an interpretation of the system and to make recommendations based on their interpretation. Passing grade in PEGN 439.	PEGN 439 (3a,c,d,e,k), working real data problems.	Collection of data by course. Data is evaluated using a department level rubric.	The data is collected by the multidisciplinary faculty team. Assessment is done on an annual basis by the assessment committee.	Results are provided to the Departments of Geology and Geologic Engineering, Geophysics, Petroleum Engineering, and the EPICS Program Director to help learning and instruction in these programs and to assess how well ABET requirements are being met.

Table 9
Petroleum Engineering Program: Evidence Available for Review

PE Program Objectives	ABET	Evidence Available for Review
3. Applied problem solving skills		
3.3/3.4 Problem solving skills in engineering practice; Working real world problems	3a	PEGN 439: Reports, videotaped presentations (Boxes 5, 10) PEGN 311: Assignments and exams (Course Notebooks) PEGN 411: Assignments and exams (Course Notebooks) PEGN 414: Assignments and exams (Course Notebooks)
	3c	PEGN 439: Project reports on open-ended design problems (Boxes 5, 10) PEGN 411: Artificial lift design problems (Box 11) PEGN 414: Well-testing design problems (Box 8)
	3d	PEGN 439: Reports by multidisciplinary teams (Boxes 5, 10)
	3e	PEGN 439: Project reports on open-ended design problems (Boxes 5, 10) PEGN 411: Assignments on artificial lift problems (Box 11) PEGN 414: Assignments on well-testing problems (Box 8)
	3k	PEGN 439: Reports reflecting use of economics programs Course Notebooks PEGN 311: Assignments involving use of drilling software programs Course Notebooks PEGN 411: Assignments involving use of artificial lift software programs Course Notebooks PEGN 414: Assignments involving use of well-testing software programs Course Notebooks

Figure 1: The results of rubric analysis (Table 2) for ABET Criteria 3a. The rating categories equate to 1.00 = Needs Improvement, 2.00 = Meets Expectations, 3.00 = Exceeds Expectations.

Figure 2: The results of rubric analysis (Table 3) for ABET Criteria 3b. The rating categories equate to 1.00 = Needs Improvement, 2.00 = Meets Expectations, 3.00 = Exceeds Expectations. The results shown in this figure were used to make changes to the Program.