A Direct Method for Teaching and Measuring Engineering Professional Skills: A Validity Study for the National Science Foundation's Research in Evaluation of Engineering and Science Education (REESE)

Dr. Ashley Ater Kranov, ABET, Inc.

Ashley Ater Kranov, Ph.D., is ABET's Managing Director of Professional Services. Her department is responsible for partnering with faculty and industry to conduct robust technical education research and providing educational opportunities on sustainable assessment processes for program continual improvement worldwide.

Dr. Rochelle Letrice Williams, ABET

Rochelle Williams joined the ABET headquarters staff as Educational Research and Assessment Manager in the Professional Services Department. In this role,Williams manages ABET's educational offerings on a global scale and leads technical education research projects. Prior to joining ABET,Williams held two positions at Baton Rouge Community College: Science Laboratory Manager and Adjunct Faculty in the Mathematics Department. In addition, Williams works closely with the National Science Foundation's Next Generation Composites Crest Center at Southern University. In this role, she supports the center's mission to increase the awareness of engineering education to underrepresented minority groups on both the secondary and post-secondary levels. Williams holds a Ph.D. in Science and Mathematics Education and a Master's of Engineering in Mechanical Engineering from Southern University and A&M College in Baton Rouge, La., and a Bachelor's of Science in Physics from Spelman College in Atlanta, Ga.

Dr. Patrick D. Pedrow P.E., Washington State University

Patrick D. Pedrow received the B.S. degree in electrical engineering from the University of Idaho, Moscow, in 1975, the Master of Engineering degree in electric power engineering from Rensselaer Polytechnic Institute, Troy, NY, in 1976, the M.S. degree in physics from Marquette University, Milwaukee, WI, in 1981, and the Ph.D. degree in electrical engineering from Cornell University, Ithaca, NY, in 1985. From 1976 to 1981, he was with McGraw-Edison Company, where he conducted research and development on electric power circuit breakers. He is currently an Associate Professor with Washington State University in the School of Electrical Engineering and Computer Science. His research interests are in plasma-assisted materials processing, including the deposition and evaluation of thin plasma-polymerized films fabricated at atmospheric pressure using weakly ionized plasma. Dr. Pedrow is a member of the American Physical Society, IEEE, ASEE, Tau Beta Pi and he is a Registered Professional Engineer in the State of Wisconsin.

Prof. Edwin R. Schmeckpeper, Norwich University

Edwin Schmeckpeper, P.E. Ph.D., is the chair of the Department of Civil and Environmental Engineering Department at Norwich University. Norwich University was the first private school in the United States to offer engineering courses. In addition, Senator Justin Morrill used Norwich University as the model for the Land-Grant colleges created by the 1862 Morrill Land-Grant Act. Prior to joining the faculty at Norwich University, Dr. Schmeckpeper taught at the University of Idaho, the Land-Grant College for the State of Idaho, and worked as an engineer in design offices and at construction sites.

Dr. Steven W. Beyerlein, University of Idaho, Moscow

Dr. Beyerlein is a professor of Mechanical Engineering at the University of Idaho where he has been employed since 1987. For the last ten years he has coordinated an inter-disciplinary capstone design program that involves faculty and graduate student mentors from mechanical engineering, electrical engineering, biological & agricultural engineering, and computer science. This two semester design experience with external clients from across the region is the locus of numerous professional skill assessments that have been part of larger national research efforts, such as the one described in this paper. Dr. Beyerlein also plays an active role in a variety of vehicle design and engine testing projects within the National Institute for Advanced Transportation Technology (NIATT) at the University of Idaho.

Prof. Jay McCormack, University of Idaho, Moscow

A Direct Method for Teaching and Measuring Engineering Professional Skills for Global Workplace Competency: Overview of Progress of a Current NSF-Sponsored Validity Study

TRACK: Student Development

Introduction

This paper describes an on-going research project in establishing the validity of a direct method for teaching and measuring undergraduate engineering students' professional skills. Proficiency in engineering professional skills (Table 1) is critical for success in the multidisciplinary, intercultural team interactions that characterize global 21st century engineering careers. Yet, faculty members around the world have struggled to define, teach and measure professional skills since their introduction as ABET criteria for engineering programs in 2000[1,2,3,4]. In fall 2006, the Washington State University (WSU) College of Engineering in the northwestern United States (US) developed an innovative, direct method to teach and measure the ABET professional skills simultaneously. This method has been used across the college since 2006, resulting in a dedicated community of 40+ engineering faculty using direct assessment to evaluate the efficacy of their own programs, and to plan and implement improvement at both course and program levels. *The Engineering Professional Skills Assessment* (EPSA) is the only *direct method for teaching and measuring these skills simultaneously in the literature*; the technical paper describing Year 1 implementation of the method won the 2008 ASEE Best Overall Conference Paper Award[5].

Table 1.ABET Criterion 3 Professional Skills Student Learning Outcomes

3d	Ability to Function on Multidisciplinary Teams
3f	Understanding of Professional and Ethical Responsibility
3g	Ability to Communicate Effectively
3h	Understanding of the Impact of Engineering Solutions in Global, Economic, Environmental, and Cultural/Societal Contexts
3i	Recognition of and Ability to Engage in Life-Long Learning
3j	Knowledge of Contemporary Issues

The EPSA method is a discussion-based performance task designed to elicit students' knowledge and application of engineering professional skills. In a 45-minute session, small groups of students are presented with a complex, real-world scenario that includes multi-faceted, multidisciplinary engineering issues. They are then asked to determine the most important problem/s and to discuss stakeholders, impacts, unknowns, and possible solutions. The EPS Rubric, an analytic rubric, was developed to measure the extent to which student performance in response to a given scenario achieved the six learning outcomes associated with the ABET professional skills. This method is flexible, easy to implement, and can be used at the course level for teaching and measuring engineering professional skills and the program level at the end of a curricular sequence for evaluating a program's efficacy.

In 2010, the National Science Foundation's Research in Evaluation of Engineering and Science Education (REESE) funded a robust validity study to rigorously establish the reliability and validity of the EPSA method and the EPS Rubric through a significant collaboration among three disciplinarily-distinct engineering programs at two large public land-grant universities in the US pacific northwest, The University of Idaho and Washington State University, and one private university in the US northeast, Norwich University. This project directly contributes to fundamental research in engineering education on a problem of international importance and interest; it is due to be completed summer 2014.

Review of the literature

Professional Skills in Engineering Education

Proficiency in engineering professional skills is critical for success in the multidisciplinary, intercultural team interactions that characterize 21st century engineering careers. Fifteen years ago, in its report *In Restructuring Engineering Education: A Focus on Change*, the National Science Foundation[6] recommended that engineering courses include early and continued exposure to environmental, political and social issues and their international and historical contexts, as well as legal and ethical implications of engineering solutions. This report was one of many that preceded the development of the professional skills and the requirements that engineering programs both teach and assess them beginning this century. To ensure continued quality of entry-level engineers in the rapidly changing environment of the world economy and needs, engineering education must help students integrate professional and technical skills for more robust problem solving[7,8,3,9,10]. Therefore, there is a critical need to develop in students a deep understanding of the importance of the professional skills. Colleges and universities must align their curricula and teaching with the 21century workplace demands.

However, engineering programs across the nation have struggled to define, teach and measure professional skills since their introduction by ABET evaluation criteria for engineering programs in 2000[1,2,3,11]. Although a variety of methods and instruments have been developed by engineering educators around the nation to teach and assess the ABET professional skills, most of the instruments evaluate one skill at a time[12,13,14,15,16,17,11,18,19]. They are often cumbersome to implement. And more frequently than not, they evaluate given skills indirectly through focus groups, interviews or surveys eliciting student opinions[4].

The Engineering Professional Skills Assessment

The EPSA has three components: (1) a performance task including a scenario and prompts; (2) student discussion as a response to the task and; (3) an accompanying analytical rubric called the EPS Rubric as a criterion-referenced instrument to measure the quality of the students' performance in demonstrating engineering professional skills. First, in a 45-minute session, groups of five to seven students are presented with a complex, real-world scenario that includes current, multi-faceted, multidisciplinary engineering issues. Second, students are asked to determine the most important problem/s and to discuss stakeholders, impacts, unknowns, and possible solutions. Finally, trained faculty raters use the analytical EPS Rubric to measure the extent to which student performance demonstrate the six learning outcomes associated with the ABET professional skills in response to a given task. What has just been described is the "standard" version of the EPSA; the method and rubric are flexible, allowing for multiple implementation variations ranging from on-line group discussions to individual multi-week projects. Appendix A shows a sample performance task. Appendix B shows the EPS Rubric.

Research goal and questions

The primary goal of this research project is to establish the validity and reliability of the Engineering Professional Skills Performance Assessment in measuring students' professional skills. Participants in a performance assessment "demonstrate their knowledge and skills by engaging in a process [and] or constructing a product"[20].The project's theoretical proposition is that the EPSA effectively elicits and accurately describes the content and constructs that comprise engineering professional skills.

Performance assessment typically has three components: (1) a task that elicits the performance; (2) the performance itself (which is the event or artifact to be assessed); and (3) a criterion-referenced instrument, such as a rubric, to measure the quality of the performance. In our study, the Engineering Professional Skills Performance Assessment also has three components: (1) the CD method (e.g., scenario and prompts) as the performance task; (2) the student team discussion as a response to the performance task; and (3) the EPS Rubric as the criterion-referenced instrument to measure the quality of the student team performance of engineering professional skills.

This research project is driven by the following three research questions:

1) To what extent does the CD method as a performance task equally elicit students' consideration of engineering professional skills when implemented in different course types and at different points in a program's curriculum?

2) Do EPS Rubric scores reliably provide information about students' engineering professional skills proficiency levels?

3) What is the correlation coefficient between the EPS Rubric's scores and scores from other established instruments that measure the same or similar skills?

Research process

The project's leadership team has used *Assessing Performance: Designing, Scoring and Validating Performance Tasks*[14] to guide the validation process framework undertaken. Prior to embarking on the focused validity study, it was crucial to complete a set of performance assessment design, construction and implementation processes and procedures. Therefore, year 1 of this project was devoted to a systematic review of the existing set of 20 performance tasks (e.g., scenarios and prompts), the latest version of the EPS Rubric, materials, processes and procedures in order to determine specifics in categories, as recommended by Johnson et al[20] (see Table 2). An Engineering Professional Skills Assessment Manual was developed during the first two years of the project and is in its final revisions. An iteration of the validation process was completed in Year 1.

Table 2. Major Project Validation Procedures

Procedure	Specifics
1. Test Specification	Determine the examinee characteristics Determine the outcomes/skills to be assessed Determine the desired proficiency level Determine the number and type of stimulus materials (e.g., consent forms, scenario, prompts) Determine the equipment needed (e.g., audio recorders)
2. Task Features	Create a framework to guide parallel task development Revise existing performance tasks using framework guidelines Determine the time allotment for each task Determine the number of prompts for each task Develop additional parallel tasks
3. Administration Materials	Develop standard implementation procedure Training sessions for investigators on how to facilitate implementation of the CD method to ensure equal implementation across sites and settings Provide sufficient support
4. Scoring and Reporting	Implement procedures to maintain consistent and accurate scoring Implement training sessions with project scoring groups Define procedures for resolving score differences Ensure scoring is suitably reliable to support the intended interpretation of the scores
5. Psychometric Properties	Determine psychometric properties of the performance tasks (e.g., difficulty, differential functioning levels) Determine psychometric properties of the EPS Rubric (e.g., interrater reliability, score reliability, types of validity evidence)
6. Documentation	Document the entire performance assessment validity process including changes made and rationales, data analyses, results and interpretations, conclusions, recommendations.

Methods

A descriptive case-study methodology is being used as the framework for the design and analysis of this collective case study. We define case study as: an empirical inquiry into an event or set of related events within its real life context using multiple sources of evidence[21,22]. Case studies are useful for in-depth study of a particular problem, situation, or area of interest[23]. A collective case study, which we propose, is to study a number of cases to inquire into potential variations of seemingly similar phenomenon[22]. Using a descriptive collective case-study methodology will allow the investigators to understand and examine the contexts in which parallel performance tasks are implemented in three distinct sites and four distinct course-type settings (Table 3).

<u>*Design*</u>

In order to maximize what can be learned and to provide an adequate number of cases for a collective case study, we used purposeful sampling at three levels: 1) institution/program, 2) level of course in the curriculum and 3) instructor/course-type. When conducting purposeful multi-site sampling, it’s important to select sites that are expected to yield similar results for replication logic purposes (i.e., our theoretical proposition states that we predict similar results across cases).

Table 3. Multi-Site Sample (Participating Institutions, Programs, Course Level, & Course Type)

Institution	Engineering Program	Course Level	Course Type
A	Electrical & Computer	Senior	Capstone Design Sequence
B	Mechanical	Sophomore	Design
C	Mechanical, Bio Ag Electrical & Computer	Senior	Interdisciplinary Capstone Design Sequence
D	Civil	Sophomore Junior/Senior	Statics, Structural Analysis, Reinforced Concrete, Steel Design

A complete randomized design is being used to sample student into control and experiment groups within each course offering, where each course offering is a block of the analysis. The student team is the primary unit of analysis within a block. Both the control and experiment groups are presented with a scenario. Only the experiment group is provided discussion prompts.

Instruments

An important strength of the case study is that it involves using multiple sources and techniques in the data gathering process[22]. In order to gather multiple sources of evidence, a number of instruments with established validity are being used to measure student performances and those scores will be compared to the EPS Rubric scores in our efforts to establish the concurrent criterion validity of the EPS Rubric. This provides opportunities for the triangulation of data during the analysis stage to answer our research questions. Table 6 enumerates the additional measures/instruments.

Table 4. Instruments for Determining Criterion Validity of EPS Rubric

Measure/Instrument	Corresponding ABET Criterion 3 Skill	Nature of Measure	Source
Engineering Ethics Rubric	f	D, QN	Shuman et al[4], 2004
Engineering Faculty Survey of Student Engagement	d/g, f, h, i, j	ID, QN	Cady et al[13], 2009
AAC&U Problem Solving Rubric	f, h	D, QN	AACU[24], 2010
AAC&U Lifelong Learning Rubric	i	D, QN	AACU, 2010
ASCE Body of Knowledge Rubric	d/g, j	D, QN	ASCE[12], 2008

Note. AAC & U refers to Association of American College and Universities. ASCE refers to American Society of Civil Engineers. D refers to direct measure. ID refers to indirect measure. QN refers to quantitative data. EPS refers to engineering professional skills.

Participants

We estimate that there will be 70 experimental teams and 66 control teams for a total of 136 teams (796 students) over the course of the validation study. Students enrolled in each class are randomly assigned into experimental groups and control groups. The student team is the unit of analysis. Table 5 presents the detailed estimated sample randomization for a given fall semester.

Table 5. Student Team Level Sample in a Given Fall Semester

Institution & Course	std. #	exp.grp	ctl.grp	exp.team	ctl. team
UI-Mechanical	50	25	25	4 teams, ~6 std/team	4 teams, ~6 std/team
UI - Interdisciplinary	50	25	25	4 teams,~ 6 std/team	4 teams, ~6 std/team
NU - Statics	24	12	12	2 teams, 6 std/team	2 teams, 6 std/team
NU - Steel Design	15	10	5	2 teams, 5 std/team	1 team, 5 std/team
WSU - Capstone Design Section 1	35	18	17	3 teams, 6 std/team	3 teams, ~6 std/team
WSU - Capstone Design Section 2	35	18	17	3 teams, 6 std/team	3 teams, ~6 std/team
Total	209	108	101	18 teams	17 teams

Note. std. refers to student. exp.grp refers to experimental group. ctl.grp refers to control group. exp. team refers to experimental team. ctl.team refers to control team. In spring semester, the only anticipated change is the number of students enrolled in the UI – Mechanical course, from 50 to 30. Thus given there are 5 students per team, there will be 3 experimental teams and 3 control teams. The total number will change accordingly as well.

Establishing Reliability and Validity

Reliability is the extent to which a team's scores are "consistent across repetitions of the same assessment"[20]. In other words, would the team's score be the same if the team were to take the performance assessment at a later date, using a parallel form (i.e., a variation) of the performance task and if scored by different raters? Validity refers to the accuracy of the rater's inferences based on interpretation of the assessment scores[20,25]. In other words, will decisions based upon how well the team achieved a given set of outcomes be valid?

Establishing reliability is a prerequisite for establishing validity[25]. The project assessment team made up of the PI/and 4 co-PIs will evaluate the student performances using the EPS Rubric. A consensus estimate approach will be used to estimate inter-rater percentage agreement, also called consensus estimate[26]. It is based on the assumption that raters should be able to come to exact or near-exact (i.e., within one point, not straddling the cut score) agreement about how to apply a scoring rubric's levels to the observed performances. If two raters come to exact or near-exact agreement, then one can say that they share a common interpretation of a given construct in the rubric[26].

There are three types of evidence that are in the process of being examined to support the validity of the EPS Rubric. They are content, construct, and criterion. The questions and concerns that the PI rating team are asked to consider during each official round of rating are listed in Table 6[25]. The Advisory Board has been asked to focus primarily on those questions addressing content, concurrent and predictive criterion validity. Establishing criterion validity requires that a given performance be assessed using two or more measurement instruments: a) the instrument to be validated and b) other instruments with established validity[27]. Concurrent criterion validity will be established by correlating the EPS Rubric scores with the four established instrument scores.

While we have not gathered evidence using measurement instruments for predictive criterion validity, we have benefitted and will continue to benefit from our Advisory Board's ample professional knowledge to obtain their perceptions on how well the performance assessment elicits and identifies criteria that would indicate successful performance in the 21st century global professional engineering environment. This is critical, given the nature of the instrument, as we posit that high scores on the EPS Rubric will suggest high performance in engineering professional skills in the global workplace.

Table 6. Questions to Examine Validity Evidence (adapted from Moskal & Leyden[25])

Content	Construct	Criterion
• Do the rubric's criteria address any extraneous content? • Do the rubric's criteria address all aspects of the intended content? • Is there any content addressed in the task that should be evaluated through rubric's criteria, but is not?	• Are all of the important facets of the intended construct evaluated through the rubric's criteria? • Are any of the rubric's criteria irrelevant to the construct of interest?	• How do the scoring rubric's criteria reflect competencies that suggest success on related or future performances? • What are the important components of related or future performances that may be evaluated using the rubric? • How do the rubric's criteria measure the important components of related or future performances? • Which facets of related or future performances are not reflected in the rubric's criteria?

Data Analysis

We will begin our data analysis in summer 2013. Our approach to data analysis will show that we relied on all relevant evidence, dealt adequately with all conflicting interpretations, fully addressed the study's research questions, and successfully used investigators' prior expert knowledge as well as the project's Advisory Board's expertise.

Conclusion

This century's technology-driven economy and change-driven society needs nimble engineers: creative problem solvers who can cross cultural, disciplinary and geopolitical boundaries with confidence. Engineering education in the United States is still short of preparing engineers to address the complex, globally scoped ill-structured problems the world faces.

A robust technical solution to a contemporary engineering problem must include rigorous consideration of human and environmental impacts and interactions. The 2010 BP oil disaster is a prime example of overtly ignoring potential impacts of technical solutions to a narrowly defined problem, prioritization not based on ethical considerations, not having conducted an adequate number of use-case scenarios prior to implementing drilling, and most tragically not being able to use modern engineering tools and skills to fix the subsequent problems in a timely manner. This event highlights how an engineering failure can cross geopolitical, economical, national, and disciplinary boundaries.

Engineering curricula and the corresponding required learning outcomes must be updated to include early and continued exposure to environmental, political and social issues and their international and historical contexts, legal and ethical implications of engineering solutions, as well as how to generate and harness collective innovation using current technology.

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Appendix A

Discussion Instructions

Imagine that you are a team of engineers working together for a company or organization on the problem/s raised in the scenario.

1. Identify the primary and secondary problems raised in the scenario.
2. Discuss what your team would need to take into consideration to begin to address the problem(s).
3. Who are the major stakeholders and what are their perspectives?
4. What are the potential impacts of ways to address the problem(s) raised in the scenario?
5. What would be the team's course of action to learn more about the primary and secondary problems?
6. What are some important unknowns that seem critical to address the problem(s)?

You do not need to suggest specific technical solutions -- just agree on what factors are most important and identify one or more viable ways to address the problem(s).

Natural Gas from Hydraulic Fracturing of Shale

As the world's energy demands increase, the cross-continental search to tap natural gas reserves is on the rise. Local and national governments, oil and gas companies, energy officials and environmental protection agencies are caught in a vigorous debate over the benefits and drawbacks of hydraulic fracturing, otherwise known as "fracking." Fracking frees natural gas that previously was unrecoverable because of technology limitations.

This is how fracking works: Millions of gallons of a high pressure mixture of water, sand and chemicals are injected through a well into rock to release shale gas deposits buried deep underground. These wells typically descend vertically for approximately 5-10,000 feet into the shale layer where it turns and runs horizontally for a substantial distance. Next, explosives blow holes through the well casing to facilitate injection of the high pressure liquid that fractures the shale in numerous places. The resulting shale fissures allow the previously enclosed natural gas to escape into the well and up to the surface, where it is gathered for processing. Chemicals in the fracking fluid assist in the fracturing process, while sand is used to hold the fissures open allowing the "shale gas" to travel around the sand particles.

Natural gas is a clean burning fuel used to heat half of the homes in the US and is used to produce 1/5 of the electric energy consumed in the US. In the US, the Marcellus shale region (primarily in Pennsylvania, New York, West Virginia, and Ohio) contains enough natural gas to supply the entire US for about 7 years. In 2012 there were around 1.2 million fracking wells. 35,000 new fracking wells are estimated to be added each year. Due to domestic shale gas from fracking, the US has practically eliminated the importation of natural gas from other countries.

The US is not the only country with shale gas reserves. In ranked order, the five countries holding the largest quantities of shale gas are China, US, Argentina, Mexico and South Africa. China, the US and South Africa have shale gas quantities estimated at 1,275; 827 and 486 trillion cubic feet, respectively, with the US's amount sufficient to provide US natural gas needs for up to 100 years.

Countries such as South Africa, who imports 60% of its gas and oil, are especially interested in becoming more self-reliant in meeting its citizens' energy needs. Environmentalists in South Africa are fighting fracking in a pristine arid region that is home to the threatened black rhinoceros and the planned location of a $1.87 billion radio telescope that requires a very large buffer zone between it and the nearest industrial activity. South Africa currently has a moratorium on drilling exploratory fracking wells.

European nations have drawn widely varying conclusions regarding fracking. Poland views fracking as the path to energy diversity and energy security while Bulgaria and France currently ban fracking. With technology-intensive horizontal drilling and fracking techniques the probability of getting a dry well is very low and in fact the success rate for wells drilled in 2011 was 99%. More daunting is the fact that once the decision is made to develop a new shale gas region the time to production can be as long as ten years.

Concerns about water diversion, water contamination and air pollution introduce controversy into analysis of the energy and economic benefits of fracking. Water concerns stem from 1) the large volume of water needed; 2) the toxicity of chemicals used in the fracturing process; 3) the close proximity of the fracking wells to drinking water sources; and 4) challenges associated with reclaiming the flowback wastewater brine that typically contains chemical species such as sodium ions, chloride ions, barium, strontium, magnesium, calcium, iron, manganese, sulphate, silica, total dissolved solids, arsenic, selenium and radionuclides.

The depth of the shale that entrains the natural gas is well below the depth of the water table. Drilling companies claim that this difference in depth prevents the fracking chemicals from contaminating drinking water. However, examples of environmental damage exist: A) USGS and EPA data appear to show that fracking activities have caused some contamination of the Wind River aquifer near Pavillion, Wyoming and B) a shale gas well in northern Pennsylvania blew out during fracking and spilled thousands of gallons of fracking fluid onto surrounding land.

Another concern is methane from the wells polluting either the air or water. A study performed by researchers at Cornell University suggested that up to 7.9% of the methane from wells escapes to the atmosphere. By not reducing the leak rate of methane to the atmosphere, the environmental benefits of burning natural gas as opposed to coal would be eliminated.

Sources

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2. Stratis Camatsos, "Fracking reaches point-of-no-return for EU legislators," Online article hosted by New Europe Online, URL: http://www.neurope.eu/article/fracking-reaches-point-no-return-eu-legislators, May 11, 2012.

3. Ronald Balaba and Ronald Smart, "Total Arsenic and Selenium Analysis in Marcellus Shale, High-salinity Water and Hydrofracture Flowback Wastewater," Chemosphere, Vol. 89 (2012) pp. 1437–1442.

4. "Global shale gas boosts total recoverable natural gas resources by 40%," Online resource at the URL http://nextbigfuture.com/2011/04/global-shale-gas-boosts-total.html, April 6, 2011.

Appendix B – EPS Rubric

Student work is assigned a score of 0-5 using an analytical rubric that describes behaviors and actions for each of the ABET professional skills at three different levels of performance. A common scoring scale is used across all of the ABET professional skills: 0-absent, 1-emerging, 2-developing, 3–competent, 4–effective, and 5–mastering.

Effective use of any rubric requires rater training and calibration.

Skill 3f. Understanding of professional and ethical responsibility

Students clearly frame the problem(s) raised in the scenario and begin the process of resolution. Students recognize important stakeholders and their perspectives. Students identify related ethical considerations (e.g. health and safety, fair use of funds, risk, schedule, and doing "what is right" for all involved).

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
Stakeholder Perspective	Students do not identify stakeholders.	Students identify few stakeholders, vaguely stating their positions or misrepresenting their positions.		Students consider perspectives of major stakeholders and convey these with reasonable accuracy.		Students thoughtfully consider perspectives of all stakeholders and articulate these with great clarity, accuracy, and empathy
Problem Identification	Students do not identify the problems in the scenario.	Students begin to frame the problem but have difficulty separating primary and secondary problems. If solutions are advocated, they are quite general and may be naive.		Students are generally successful in distinguishing primary and secondary problems. There is evidence that they have begun to formulate credible solutions.		Students convincingly frame the problem and parse it into sub-problems. They suggest detailed and viable approaches to resolve the problem.
Ethical Considerations	Students do not give any attention to ethical considerations.	Students give passing attention to related ethical considerations.		Students are sensitive to some relevant ethical considerations.		Students clearly articulate relevant ethical considerations and address these in discussing approaches to resolve the problem.
Comments:						

Skill 3g. Ability to communicate effectively

Students work together to address the issues raised in the scenario by acknowledging and building on each other's ideas to come to consensus. Students invite and encourage participation of all discussion participants. Note: The ABET communication outcome includes several forms of communication, such as written and oral presentation. This definition focuses on group discussion skills.

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
Group Interaction	Students do not interact as a group.	Students pose individual opinions, without considering other student's ideas.		Students try to balance everyone's input and build on/clarify each other's ideas.		Students clearly encourage participation from all group members, generate ideas together and actively help each other clarify ideas.
Group Self-Regulation	There is no evidence of group self-regulation.	Some students may monopolize or become argumentative. There might be some tentative, but ineffective, attempts at reaching consensus.		Students attempt to reach consensus, but have some difficulty in developing approaches that equitably consider multiple perspectives.		Students clearly work together to reach a consensus in order to clearly frame the problem and develop appropriate, concrete approaches to resolve the problem.

Comments:

Assigned Score for Skill

Skill 3h. Understanding of the impact of engineering solutions in global, economic, environmental, and cultural/societal contexts

Students consider how their ways to address the problem impact relevant global, economic, environmental, and cultural/societal contexts.

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
Impact/ Context	Students do not consider the impacts of the solutions.	Students give little or no consideration to how the ways to address the problem impact in relevant contexts.		Students give some consideration to how the ways to address the problem impact in relevant contexts.		Students clearly examine and weigh the impact of the ways to address the problem in all relevant contexts.

Comments:

Assigned Score for Skill________

Skill 3i. Recognition of the need for and ability to engage in life-long learning

Students consider what needs to be learned (what they know and don't know). Students verbalize a credible plan to retrieve and organize needed data. Students take action to respond to personal beliefs that might hinder attainment of a satisfactory solution.

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
Sources/ References	Students do not question sources or references.	Students begin to question sources/references cited in the scenario.		Students question sources/references cited in the scenario.		Students evaluate sources/references cited in the scenario.
Discern fact/opinion	Students do not distinguish between fact and opinion.	Students have difficulty distinguishing between fact and opinion.		Students demonstrate some ability to distinguish between fact and opinion.		Students are successful in distinguishing fact from opinion.
Knowledge Status	Students do not differentiate between what they do and do not know.	Students begin identify what they know as well as what they do not know, but have difficulty differentiating between the two.		Students identify what they know as well as what they don't know.		Students identify what they still need to know and describe methods for obtaining that information.
Presumptions	Students do not recognize presumptions that may hinder their problem solving.	Students begin to recognize their presumptions, but have difficulty recognizing how these presumptions may hinder their problem solving.		Students recognize presumptions that may hinder their problem solving.		Students take action to address presumptions that may hinder their problem solving.

Comments:

Assigned Score for Skill________

Skill 3j. Knowledge of contemporary issues

Students consider current societal, economic and political issues their discussion, identification of the problem and possible ways to address the problem. Students also consider modern technologies and tools in their discussion, identification of the problem and possible ways to address the problem.

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
Non-Technical Issues	Students do not consider any current societal economic, and/or political issues	Students give only a superficial consideration to current societal, economic, and/or political issues. Non-technical issues may be treated in a condescending manner.		Students give some consideration to current societal, economic, and/or political issues		Students give full consideration to current societal, economic, and/or political issues
Technical Issues	Students do not consider modern methods, technologies and/or tools	Students give only passing consideration to modern methods, technologies and/or tools.		Students give some consideration to modern methods, technologies and/or tools		Students give full consideration to modern methods, technologies and/or tools

Comments:

Assigned Score for Skill________