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# Enhancing Student Learning through Using and Writing EPSA Scenarios

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# Enhancing Student Learning Through Using and Writing EPSA Scenarios


## ABSTRACT

Engineering programs often contain a senior level "Professional Issues" course to cover topics, such as ethics, which are related to the professional practice of engineering. These courses commonly utilize case studies focusing on ethics as the basis for student discussions. Measuring the student learning resulting from the case study process is often very subjective, and is difficult to generalize.

The Engineering Professional Skills Assessment (EPSA) was created as a direct method for eliciting and measuring professional skills, such as ethics, which are critical for all engineers. EPSA is a performance assessment consisting of: 1) a 1-2 page scenario about an interdisciplinary contemporary engineering problem intended to prompt discussion among a group of 5-6 students; 2) a 30 to 45- minute discussion period where students are asked to address a series of standardized questions about the scenario; and 3) an analytical rubric, which provides a consistent and standardized means to evaluate the students' discussion.

This paper describes how the faculty members responsible for a "Professional Issues" course at Norwich University have deployed EPSA scenarios. The course instructors have observed that the interdisciplinary EPSA scenarios generated more enthusiastic and higher level discussion than case studies focused solely on ethics. Based on their experience with the EPSA method, the faculty members involved with the "Professional Issues" course hypothesized that the process of writing and discussing EPSA scenarios would both enhance the students' interest in the scenario subject, and lead to a more mature understanding of the issues raised in the scenario. The EPSA development package includes an assessment tool for crafting timely, relevant, and engaging scenarios. This was utilized by the students to create their own scenarios.

Student-authored scenarios were added to the professional issues course in 2015. This paper inventories all the materials required to implement this scenario researching and writing assignment—a scenario assessment tool, discussion prompts, and the EPSA rubric. Feedback about the effectiveness of the scenario writing assignment was explored in an overall class assessment survey. Students reported a high level of interest, engagement, and value-added resulting from the assignment. Recommendations for refining the scenario writing assignment in future cycles of the professional issues course are also provided.

## Introduction

This paper presents findings from implementing the Engineering Professional Skills Assessment (EPSA)[1] method within the 'ethics' section of a senior level "Professional Issues" course. During the four years that the course instructors have been using the EPSA method, they have found that the interdisciplinary EPSA scenarios generate more enthusiastic and higher level discussion than case studies that focus solely on ethics. After using the EPSA scenarios, interest was expressed by the students in writing their own scenarios for future use in the class. Since the EPSA materials include a tool for developing as well as assessing EPSA scenarios, drafting student-authored scenarios was added to the course in 2015.

## Background

Engineering programs often contain a senior level "Professional Issues" course to cover topics, such as ethics, which are related to the professional practice of engineering. These courses commonly utilize case studies focusing on ethics as the basis for student discussions.[2] Assessing the student learning resulting from the case study process is often time consuming, subjective, difficult to generalize, and inconsistent between evaluators.[3, 4] Furthermore, documenting changes in student learning from freshman to senior year requires a clarification of the learning skills involved and utilization of general-purpose measurement tool that can be applied across a broad range of case studies.

Proficiency in engineering professional skills, such as ethics, as described in ABET criterion 3 - student outcomes[5], is critical for success in the multi-disciplinary, inter-cultural team interactions that characterize 21st century engineering careers. These professional skills may be effectively assessed using a performance assessment that consists of 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.[6]

## Engineering Professional Skill Assessment (EPSA)

The Engineering Professional Skills Assessment (EPSA)[7] was created as a direct method for simultaneously teaching and assessing professional skills, such as ethics. EPSA is a performance assessment consisting of:

1. a 1-2 page scenario about an interdisciplinary contemporary engineering problem intended to prompt discussion among a group of 5-6 students;
2. a 30 to 45- minute discussion period where students are asked to address a series of standardized questions about the scenario; and
3. an analytical rubric, which provides a consistent and standardized means to evaluate the students' discussion.

One of the main advantages of the EPSA method is that student learning and the assessment of the learning may take place simultaneously, providing the opportunity for immediate feedback after the discussion period.

Table 1 shows the alignment between the ABET professional skills and the EPSA Rubric. There are two versions of the EPSA Rubric: A one-page version and multi-page version. The multi-page EPSA Rubric has one page for each of the professional skills mentioned in ABET criterion 3, and is easiest to use while evaluating discussions. The one-page EPSA Rubric[1] covers all of the professional skills and is designed for training new EPSA users. The one page version of the EPSA Rubric is shown in Appendix A. The EPSA 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 with graduating seniors to validate learning outcomes associated with Criteria 3f, 3g, 3h, 3i, and 3j.

Table 1. ABET Professional Skills Addressed in the EPSA Rubric

| **EPSA Rubric Dimension** | **Specific Areas Considered** |
|---|---|
| 3f. Understanding of Professional and Ethical Responsibility | • Stakeholder Perspective<br>• Problem Identification<br>• Ethical Considerations |
| 3g. Ability to Communicate Effectively | • Group Interaction<br>• Group Self-Regulation |
| 3h. Understanding of the Impact of Engineering Solutions in Global, Economic, Environmental, and Cultural/Societal Contexts | • Impact/Context |
| 3i. Recognition of and Ability to Engage in Life-Long Learning | • Scrutinize Information<br>• Knowledge Status |
| 3j. Knowledge of Contemporary Issues | • Technical Issues<br>• Non-Technical Issues |

Funded by the National Science Foundation, investigators at Norwich University, University of Idaho, Rose-Hulman Institute of Technology, and Washington State University have been using this three-part performance assessment method to develop and rigorously test the Engineering Professional Skills Assessment (EPSA) as a discussion-based performance vehicle for directly assessing five learning outcomes simultaneously.[8]

The research team that developed EPSA has recently concluded a multi-year validity study funded by the National Science Foundation.[9] As part of this validation study, the team of researchers applied EPSA to test groups of students at three different universities. As a result of the work done on the validity study, the team members introduced other faculty members to EPSA, who then independently implemented the EPSA method in their courses.

**Implementation of the EPSA Method**

The faculty members responsible for the "Professional Issues" course at Norwich University have been using the EPSA scenarios for the past four years. The detailed facilitation plan for implementing the EPSA method in a course was presented in a previous ASEE paper.[1]

The students in each class were divided into teams. Some members of the team were assigned the role of discussant and others assigned the role of observer. The discussants were responsible for conducting the discussion. The observers were each assigned one or two dimensions of the EPSA rubric to use to assess the discussions. All assessment of the student discussions was conducted in real-time, during the discussions, with the assessors simply writing tally marks and notes directly on the relevant portion of the EPSA rubric.

In one class period, which served as a practice session, the students were introduced to the EPSA method, discussion prompts, and the use of the analytic EPSA rubric. In this practice sessions the discussion time was limited to approximately 10 minutes, so that the facilitator and instructor could provide comments and guidance on use of the EPSA method and the EPSA rubric.

In two subsequent class periods, the data was collected during the application of the EPSA method. The facilitator/moderator student distributed the EPSA scenarios and standardized EPSA discussion prompts and then read the prompts aloud to the students in the class. The students then reviewed their assigned roles and read the EPSA scenario. The discussants then conducted the discussion while the observers assessed the discussion. The student observers were also expected to read the scenario, listen carefully to the discussion, note evidence heard about their assigned EPSA rubric areas, and provide a rating of the discussion for each dimension of EPSA rubric that was their responsibility. After the discussion the observers presented their analysis of the discussion. The class time used for the EPSA scenario discussion was 75 minutes. This amount of time was found to be helpful in setting-up the groups, the facilitator's reading of introduction, students reading of the scenario, student discussion, post discussion analysis and finalizing assessments.

Two data collection sessions were conducted for each class, allowing every student to participate as both a discussant and an observer. Each observer was assigned primary responsibility for only a single dimension of the EPSA Rubric.

Based upon student comments compared to previous year's course evaluations, the instructors have found that the interdisciplinary EPSA scenarios generated more enthusiastic and higher level discussion than case studies that focused solely on ethics. An example of the interdisciplinary nature of the EPSA scenarios is demonstrated in the EPSA "Clean Energy" scenario, shown in Appendix B, which was selected because of recent campus acquisition of a bio-fuels energy plant. This scenario includes economic, political, regulatory, ethical, and environmental considerations, including such issues as effects of regulations on utility prices, reliability of renewable energy, global warming, and the international markets for energy.

In addition to using the EPSA scenarios, interest was expressed in having the students write their own scenarios for future use in the class. The faculty involved with the "Professional Issues"

course felt the process of writing EPSA scenarios would both enhance the students' interest in the scenario subject, and lead to a more mature understanding of the issues raised in the scenario. The EPSA toolkit includes a methodology and an assessment tool for crafting timely, relevant, and engaging scenarios. These resources are summarized in the next two sections of this paper and were utilized by the students in creating their own scenarios.[10]

## EPSA Scenario Development

Putchinski [11] articulated three criteria for effective discussion prompts:

(1) make the prompt relevant to your course content,
(2) make the prompt current by referencing something recently in the news, and
(3) add novelty to the prompt through unexpected information or an ethical dilemma.

These principles lie at the heart of EPSA scenario construction.[10]

As part of the preparation for conduction an EPSA discussion, students are given the instructions in Table 2. From the discussion instructions, questions 1, 2, and 3 relate to ABET 3f, question 4 relates to ABET 3h, and questions 5 and 6 relate to both ABET 3i and 3j. The EPSA discussion instructions are used to provide a framework for the creation of an EPSA scenario.

Table 2. EPSA 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.*
3. *Who are the major stakeholders and what are their perspectives?*
4. *What are the potential impacts of ways to address the problems 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 this problem?*

*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.*

In order to develop a compelling scenario as well as one that balances information related to all six aspects in the discussion instructions, the EPSA leadership team identified the seven criteria described in Table 3.

| Table 3. EPSA Scenario Criteria | |
|---|---|
| **Criteria** | **Description** |
| **Interdisciplinary Scope** | The scenario involves more than one discipline within and beyond engineering. The issue/problem in the scenario should be able to be tackled by an interdisciplinary group at any level in the program. |
| **Relevant problem** | The scenario has some kind of unresolved problem, tension, a disagreement, or competing perspectives on how to address the problem. The problem is not emotionally disruptive and will be relevant for five to ten years. |
| **Non-technical complexity** | The complex and multifaceted scenario has multiple stakeholders including public, private, global, groups, and individual constituents. The diversity of stakeholders is representative of a problem with ethical, societal/cultural, economic, environmental, and global concerns. Any solution requires all critical stakeholders to be on board with the solution(s). |
| **Technical complexity** | The scenario includes some technical data for students to "hang on to" as they tackle the problem. The problem has a core component of technicality, benefiting from engineers on the solution team. |
| **Elicits engagement** | Scenario draws in the reader and engages the student group in deep discussions because the problem is complex and multifaceted without an obvious, quick fix solution. |
| **References** | The scenario has multiple references (3-4) from varied sources such as refereed journal articles, solid news sources, and publications from professional societies. The selection of references is objective and |
| **Packaging for classroom use** | The scenario can be read and understood by all engineering undergraduates in 5-7 minutes as a common starting point for a 30- 40 minute group discussion. There should be no pictures or tables. Lists are acceptable. The written text must be no more than 1.5 pages, 12-point |

## EPSA Scenario Writing Methodology

The EPSA scenario creation process is divided into three phases: scoping, development, and assessment (Table 4).

During the scoping phase, brainstorming takes place to identify possible topics that would both satisfy the EPSA scenario criteria (Table 3) and be appropriate for the intended audience. During the development phase, the scenario authors gather references from a variety of refereed and non-refereed sources, including media outlets. The authors then write an annotated bibliography, which includes ideas for the scenario storyline, quoted passages from the references, and the authors' summary statements of the references. The annotated bibliography is then used by the authors to build an outline of the scenario content using the major dimensions of EPSA rubric (Appendix A) as a guide. In the final phase of scenario creation, the scenario is assessed on a trial basis and then refined.

| Table 4. EPSA Scenario Creation Process |
|---|
| **1. Scenario Scoping**<br>**1.1.** Recognize need for new scenario<br>1.2. Review successful existing scenarios<br>1.3. Brainstorm possible new scenario topics<br>1.4. Select most promising topic |
| **2. Scenario Development**<br>**2.1.** Locate key reference documents<br>2.2. Create annotated bibliography<br>2.3. Outline scenario using EPSA rubric<br>2.4. Visualize student discussion<br>2.5. Generate scoring check sheet<br>2.6. Draft scenario |
| **3. Scenario Assessment and Testing**<br>**3.1.** Assess scenario<br>3.2. Revise outline, scenario, and scoring check sheet<br>3.3. Pilot with students<br>3.4. Adjust final draft for optimal impact |

**Student Development of EPSA Scenarios**

This was the fourth year that the professional issues class had been using the EPSA method, but the first time that the students attempted to develop an EPSA Scenario (as either an expanded outline or an actual scenario). About ¾ of the way into the semester, the professional issues class spent two weeks utilizing materials from the EPSA method.

During these two weeks, work using the EPSA materials was conducted over four 75 minute long class meetings. The first class served as an introduction to the EPSA method and materials. In the second class the students participated in a practice EPSA exercise using the Japanese nuclear disaster scenario.[8] During the 3rd and 4th classes the students applied the EPSA method, participated in group discussions, assessed the discussions using the EPSA rubric, and reviewed the results. The topics for the two EPSA exercises were unknown to the students until they received them just prior to the start of the exercises. The students used the EPSA Scenario on the BP Gulf of Mexico Oil Spill Disaster for the 3rd class period and EPSA Scenario on Power Grid Vulnerabilities for the 4th class period.[10]

Throughout the time period that the class was involved with the existing EPSA scenarios, the instructor reminded the students about the upcoming opportunity to develop ideas for future scenarios. At the conclusion of the 4th class period, the instructor formally gave an assignment to assemble materials and craft a new EPSA scenario. Table 5 outlines this assignment.

Table 5: In-Class Instructions for EPSA Scenario Development

***"EPSA Scenario"***

*This is to be researched and developed solely as individual work. Come to class with the submission completed and ready to hand in.*

*Goal: Develop an expanded outline for a EPSA Scenario. Use the Japanese Nuclear disaster Scenario as a guide. (included on handout ).*

*Required elements: Include the title, three reasons why you chose this topic, five most important points that you would expand in the essay that the students would see, and three to five quality references.*

*We are looking for a thoughtful approach, a topic that is truly significant on a global level, or at minimum a national level, and something that is very difficult to solve. Think of future college students employing your case study in a course like ours. You should aim for a full one page to at max a two page, double spaced, in an expanded outline format.*

A total of 31 students participated in the project: 16 Civil Engineering majors, 8 Construction Management majors, and 7 Electrical and Computer Engineering majors. The students selected a wide range of topics for their scenarios. As shown in Table 6, the subjects of the scenarios covered 12 broad topics.

Table 6: Scenario Categories for Student Written EPSA Scenarios

| **Scenario Category** | **frequency** |
|---|---|
| Cognitive Development | 1 |
| Education & Design Issues | 1 |
| Humanitarianism | 2 |
| Implementation of New Tech. | 4 |
| Infrastructure Design Failure | 5 |
| International Co-operation | 5 |
| New Technology | 1 |
| Oceanic Pollution | 3 |
| Protection from Man-Made Disasters | 5 |
| Protection from Natural Disasters | 5 |
| Regional Power Grids | 1 |
| Risk Assessment | 5 |

Note: Several students' scenarios covered multiple categories

Table 7 presents the scenario topics for each of the 31 students in the course.

| Table 7: Student Written EPSA Scenario Topics | | |
|---|---|---|
| **Major** | **Scenario Topic** | **Broad Category** |
| CE | ADHD & Drug Therapies | Cognitive Development |
| CE | Banqiao Reservoir Dam Failure | Infrastructure Design Failure |
| CM | BP Oil spill – Gulf of Mexico | International co-operation |
| | | Protection from Man-Made disasters |
| CM | Corporate Average Fuel Economy Goals | Implementation of New Technology |
| ECE | Driverless Cars | New Technology |
| CE | Environmental Protection | International Co-operation |
| CE | Hydraulic Fracturing (Fracking) | Implementation of New Technology |
| CM | Global Climate Change (#1) | International Co-operation |
| | | Protection from Natural Disasters |
| CM | Global Climate Change (#2) | Risk Assessment |
| CM | Gulf of Mexico Dead Zones (#1) | Oceanic Pollution |
| CE | Gulf of Mexico Dead Zones (#2) | Oceanic Pollution |
| CE | Hurricane Katrina | Protection from Natural Disasters |
| CE | Hyatt Regency (Kansas city) Walkway Collapse | Infrastructure Design Failure |
| ECE | Interfacing Renewables w/ the Energy Grid | Regional Power Grids |
| ECE | Loss of the USS Thresher (Nuclear Submarine) | Protection from Man-Made Disasters |
| CE | Military Drones | Implementation of New Technology |
| CM | Minnesota Metrodome Structural Failure | Infrastructure Design Failure |
| CE | Mt. Polley Mine Tailings Containment Pond Failure | Protection from Man-Made Disasters |
| ECE | New Orleans Levee Failure (#1) | Protection From Natural Disasters |
| CE | New Orleans Levee Failure (#2) | Protection from Natural Disasters |
| CE | New Orleans Levee Failure (#3) | Protection from Natural Disasters |
| CE | Oceanic Trash Islands | Oceanic Pollution |
| | | Protection from Man-Made Disasters |
| ECE | Rogue Artificial Intelligence | Implementation of New Technology |
| CE | Space Shuttle Challenger (#1) | Risk Assessment |
| CM | Space Shuttle Challenger (#2) | Risk Assessment |
| ECE | Space Shuttle Columbia | Risk Assessment |
| CE | Saint Francis Dam | Education & Design Issues |
| | | Infrastructure Design Failure |
| CM | The Tacoma Narrows Bridge | Infrastructure Design Failure |
| CM | USS Arizona Memorial (Hawaii) | Protection from Man-Made Disasters |
| CE | Western Massachusetts Power Grid Failure | Risk Assessment |
| CE | World Hunger | Humanitarianism |
| | | International Co-operation |
| CE | World Poverty & Wealth Gap | Humanitarianism |
| | | International co-operation |

The topics that the student selected for their scenarios were quite varied. Only 4 topics were selected by multiple individuals. The New Orleans Levee was the only topic that was selected by more than two students.

**Assessment of EPSA Scenario Development Project**

Prior to the final exam, but after the students had written their expanded outline for a scenario, the students were asked in a course assessment to comment overall on the NSF scenario work as follows:

Table 8: Student Evaluation of EPSA Scenario Development Project

EPSA Project/Team Discussions

This was a valuable experience in the course and should be retained

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Remarks: _____

This was one of 10 content areas the students were asked to comment upon in the course critique. Note: This assessment question was on the overall EPSA team discussions, not just the EPSA Scenario development experience.

The results of this assessment (28 responses of 31 students) showed the following:

The students were favorable to the question above with 11 students responding with a rating of 7 (highest), 9 students responding with a rating 6 (2nd highest), and 5 students responding with a rating of 5 (3rd highest) to the 1-7 scale question. The standard deviation of the sample of 1.41. Only 3 of the 28 students completing the assessment responded with a rating of 4 (neutral) or below.

The students who responded with remarks (7 written responses) wrote the following:

- Positive experience, needs more structure
- They sparked uneducated conversation
- Do more things like this
- Lots of repeats [ed note: comments during discussions]
- Good discussion by some, others made up facts
- Good practice for any meeting setting
- Maybe not so many, overkill

Four of the seven written replies were favorable.

The instructor listened to all three EPSA scenarios as they were being discussed – the practice session and the two data collecting sessions - and commented that the quality of the conversations each year has risen, with this year's groups doing very well, staying on track, focusing on the issues, and covering all the points of discussion that were expected.

In terms of the scenario development assignment (expanded outlines or complete scenarios), the 31 students, by and large, took the assignment very seriously. Comparing student written work

from earlier in the semester, it appears that the students benefitted from thinking through and developing their respective concepts. Two ways of thinking about this statement are: (1) to consider ABET assessment; and (2) to think of Bloom's taxonomy. While "lifelong learning" is not one of the ABET outcomes specifically assessed in this course, it is one of the most important skills we help develop in our students. The ability to conceive a worthy "ethical dilemma" demonstrates the ability to think independently and grasp the importance of an issue – both essential aspects "lifelong learning." The students, by and large, demonstrated the ability to *apply*, *analyze*, and *synthesize* (three of the four highest levels of cognitive learning [12] in the development of their scenarios.

**Next Steps in Student-Authored Scenario Development**

The development of an EPSA scenario is a valid exercise in lifelong learning and professional development. For the first attempt, it exceeded instructor expectations. Many students reflected on their selected scenario topic at a macro level and were able to articulate a concept worthy of further exploration. The course instructor plans to employ this exercise again in Fall 2016 with some minor modification. A six step, iterative development process is planned, with the ultimate goals of generating more polished, ready-to-use scenarios. These steps are:

1. initial concept development and first evaluation against Table 3 criteria;
2. updated concept development and rationale for choosing this scenario;
3. generation of an annotated bibliography;
4. draft scenario development and second evaluation against Table 3 criteria;
5. final scenario development and third evaluation against Table 3criteria; and
6. After Assessment Review (AAR)

This "enhanced requirement" would require more classroom time and out of classroom time, with necessary appropriate adjustments to other graded requirements. The EPSA Scenario work would now become a threaded exercise, not just a two week focus and final exam assessment. The cost would be: (1) reductions in other case study work – predominantly NSPE ethical case study discussions; and (2) reductions in leadership case study discussions. ABET outcomes in teamwork, professional and ethical responsibility, communications, and, "locally" leadership would also be enhanced with this more unified approach.

## Conclusions

Based upon course evaluations for the professional issues class, the interdisciplinary EPSA scenarios generated more enthusiastic and higher level discussion than case studies that focus solely on ethics. These scenarios include economic, political, regulatory, ethical, and environmental considerations, including such issues as public use vs. private rights related to land-use, effects of regulations on utility prices, reliability of renewable energy, global warming, and the international markets for energy. Since the scenarios are situated in contemporary contexts and show the interdisciplinary and complexity of real-world engineering problems, the EPSA affords students the opportunity to practice holistic engineering problem solving thinking with fellow students. In addition, the crafting of an EPSA scenario is a useful exercise in lifelong learning and professional development, and provides a valuable writing experience for the scenario developer.

The EPSA Rubric provides a standardized means for faculty to evaluate the quality of student discussions and to make evaluation of students' work more consistent between the multiple sections of the course. In addition, faculty gain insights into the strengths and weaknesses of students' abilities to pinpoint primary and secondary problems, identify stakeholders, work well in group discussion and consider the impact of potential solutions on different contexts, they then can determine where and when in the curriculum to improve teaching and learning of these outcomes. The flexibility of the EPSA method allows it to be readily adapted for use in courses at all levels in the curriculum. Repeated usage of the EPSA method in different course settings provides a convenient framework for studying ABET Professional skills a program level.

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## References


1. Schmeckpeper, E. R., & Ater Kranov, A., & Beyerlein, S. W., & Pedrow, P. D., & McCormack, J. P. (2015, June), *Using the EPSA Rubric and EPSA Score to Evaluate Student Learning at the Course and Program Level*, 2015 ASEE Annual Conference and Exposition, Seattle, WA.

2. Loendorf, W. (2009, June), *The Case Study Approach to Engineering Ethics*, 2009 American Society for Engineering Education Annual Conference and Exposition, Austin, TX.

3. Davis, M., & Feinerman, A. (2012, June). Assessing graduate student progress in engineering ethics. Science & Engineering Ethics, Vol 18, Issue 2, pp 351-367

4. Shuman, Larry J., Besterfield-Sacre, Mary and McGourty, Jack. (2005, January). *The ABET "Professional Skills" - Can They Be Taught? Can They Be Assessed?* Journal of Engineering Education, p.41-55, Vol. 94, No. 1.

5. ABET Engineering Accreditation Commission, *Criteria for Accrediting Engineering Programs.* (2015, October), ABET, Baltimore, MD.

6. Johnson, R., Penny, J., and Gordon, B. *Assessing Performance: Designing, Scoring, and Validating Performance Tasks.* New York, NY : The Guilford Press, 2009.

7. Hauser, C., & Olsen, R., & Girardeau, L., & Ater Kranov, A (2008, June), *A Direct Method For Teaching And Assessing Professional Skills In Engineering Programs*, 2008 ASEE Annual Conference and Exposition, Pittsburgh, Pennsylvania.

8. Ater-Kranov, A, Beyerlein, S., McCormack, J., Pedrow, P., Schmeckpeper, E.R., and Zhang, M. (2011, June), *A Direct Method for Teaching and Measuring Engineering Professional Skills: A Validity Study*, 2011 ASEE Annual Conference & Exposition, Vancouver, BC.

9. Zhang, M., Ater Kranov, A., Beyerlein, S., McCormack , J., Pedrow, P., Schmeckpeper (2015), *Investigating a Scenario-Based Performance Assessment of Engineering Professional Skills.* 2015 IEEE Integrated STEM Education Conference, E. Princeton, NJ.

10. McCormack, J. P., & Beyerlein, S. W., & Ater Kranov, A., & Pedrow, P. D., & Schmeckpeper, E. R. (2014, June), *Scenario and Scoring Sheet Development for Engineering Professional Skill Assessment*, 2014 ASEE Annual Conference and Exposition, Indianapolis, IN.

11. Kelvin Thompson, Aimee DeNoyelles, Baiyun Chen and Linda Futch. *Discussion Prompts. In K. Thompson and B. Chen (Eds.).* Teaching Online Pedagogical Repository, University of Central Florida. Orlando, FL : Center for Distributed Learning, 2013. http://topr.online.ucf.edu/index.php?title=Discussion_Prompts&oldid=2536, Retrieved January 30, 2016.

12. Bloom, B.S. *Taxonomy of Educational Objectives, Handbook 1: The Cognitive Domain.* New York, NY : David McKay Co. Inc., 1956.

# Appendix A. One-Page Version of EPSA Rubric

The Engineering Professional Skills (EPSA) Rubric (one-page version 04-26-2016)

| | | | | | |
|---|---|---|---|---|---|
| **ABET Skill 3f Understanding of professional and ethical responsibility** | | | | | |
| | **0 - Missing** | **1 - Emerging** | **2 - Developing** | **3 - Practicing** | **4 - Maturing** | **5 - Mastering** |
| **Problem Identification** | Students do not identify the problem(s) in the scenario. | Students begin to frame the problem(s). Approaches advocated to address the problem(s) may be general and/or naive | | Students are generally successful in distinguishing primary and secondary problems with reasonable accuracy and with justification. There is evidence that they have begun to formulate credible approaches to address the problem(s). | | Students convincingly and accurately frame the problem(s) and parse sub-problems, providing justification. They suggest detailed and viable approaches to resolve the problem(s). |
| **Stakeholder Perspective** | Students do not identify stakeholders | Students identify few and/or most obvious stakeholders, perhaps stating their positions in a limited way and/or misrepresenting their positions. | | Students explain the perspectives of major stakeholders and convey these with reasonable accuracy. | | Students thoughtfully consider perspectives of diverse relevant stakeholders and articulate these with great clarity, accuracy, and empathy. |
| **Ethical Consideration** | Students do not give any attention to ethical considerations | Students give passing attention to related ethical considerations. They may focus only on obvious health and safety considerations and/or fair use of funds involving primary stakeholders. | | Students are sensitive to relevant ethical considerations and discuss them in context of the problem(s). Students make linkages between ethical considerations and stakeholder interests. Students may identify ethical dilemmas and discuss possible trade-offs. | | Students clearly articulate relevant ethical considerations and address these in discussing approaches to resolve the problem(s). Students make linkages between ethical considerations and stakeholder interests and incorporate them into their analysis and resolutions. Students may discuss ways to mediate dilemmas or suggest trade-offs. |
| **ABET Skill 3g Ability to communicate effectively** | | | | | |
| | **0 - Missing** | **1 - Emerging** | **2 - Developing** | **3 - Practicing** | **4 - Maturing** | **5 - Mastering** |
| **Communicate Effectively** | Students do not stay on task and/or encourage participation of others. | Students pose individual opinions. They may not link what they say to what others. Some students may dominate (inadvertently or on purpose), or become argumentative. Students may attempt to regulate the discussion, but without much success. There may be some tentative, but ineffective, attempts at reaching consensus. | | Students give thoughtful input and attempt to build on and/or clarify other's ideas with some success. Students attempt to reach consensus, but may find it challenging to implement strategies that equitably consider multiple perspectives. Students defer quickly to a dominant opinion, converging rather than attempting to reach consensus. | | Students clearly encourage participation from all group members, generate ideas together and actively help each other clarify ideas. Students actively work together to reach a consensus in order to clearly frame the problem and develop appropriate, concrete ways to address the problem(s). |
| **ABET Skill 3h Broad Understanding of the impact of engineering solutions in 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 potential solutions | Students give cursory consideration to how their proposed solutions impact contexts. Contexts considered may not be relevant. Students don't seem to understand the value or point of considering impacts of technical solutions or the contexts within which the solution is proposed. | | Students consider how their proposed solutions impact major relevant contexts, and possibly re-think their understanding of the problem(s) themselves, justify possible solutions with reasonable accuracy. Impacts considered may be associated with relevant secondary problems | | Students clearly examine and weigh how their proposed solutions impact major relevant contexts. Students justify possible solutions with reasonable accuracy. Impacts considered may be associated with relevant secondary problems. Students understand how different contexts can affect solution effectiveness. |
| **ABET Skill 3i Recognition of the need for and ability to engage in life-long learning.** | | | | | |
| | **0 - Missing** | **1 - Emerging** | **2 - Developing** | **3 - Practicing** | **4 - Maturing** | **5 - Mastering** |
| **Scrutinize Information** | Students do not refer to or scrutinize information presented in the scenario. | Students refer to the information presented in the scenario (e.g. "it says"). Students may distinguish fact from opinion. Students may question the validity of one or more sources. | | Students examine information presented in the scenario. Students may recognize that the sources may have potential biases. Students may recognize what is implied or implicit. | | Students examine not only information, but also information sources. Examples include, but are not limited to: discussing potential and probable biases of the information sources, distinguishing fact from opinion in order to determine levels of information validity, analyzing implied information. |
| **Identify Knowledge Status** | Students do not differentiate between what they do and do not know. | Students begin to identify the boundaries of their knowledge of the information presented. Students may inject their own life experiences, possibly without questioning the validity in relationship to other sources. | | Students identify the parameters of their knowledge of the information presented. Students may connect personal experiences or information read/heard elsewhere, while recognizing the limits of their contributions. Students may refer to related historical events. Students may identify specific knowledge gaps, and reliable sources to consult. | | Students identify the specific limits of their knowledge of the information presented and how those limitations affect their analysis. Students may check assumptions related to personal experiences or information read/heard elsewhere, including related historical events. Students specify a variety of reliable sources to be consulted. |
| **ABET Skill 3j Knowledge of contemporary issues.** | | | | | |
| | **0 - Missing** | **1 - Emerging** | **2 - Developing** | **3 - Practicing** | **4 - Maturing** | **5 - Mastering** |
| **Non-Technical Issues** | Students do not consider contemporary political or geo-political issues. | Students give limited consideration to contemporary political and/or geo- political issues. Non-technical issues may be treated in a condescending manner, or without understanding of why an engineer may need to consider non-technical issues. | | Students give meaningful contemporary events and/or political and/or geo-political issues. Students show some accurate understanding of how non-technical issues may affect framing the problem(s) and possible solutions. | | Students give extensive meaningful consideration to contemporary political and/or geo-political issues. Students fully understand the importance of how the non-technical issues considered impact framing the problem(s) and possible solutions. |
| **Technical Issues** | Students do not consider modern methods, technologies and/or tools. | Students give passing consideration to modern methods, technologies and/or tools. Students may not show awareness that certain methods, technologies and/or tools are not relevant in framing and/or solving the problem(s). | | Students give relevant consideration to modern methods, technologies and/or tools in framing and/or solving the problems(s). | | Students give extensive relevant consideration to modern methods, technologies and/or tools in framing and/or solving the problems(s).). |


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## Appendix B: EPSA Scenario: Clean Energy Sources

As of August 2015, the people on Earth have officially depleted a year's worth of resources. This means that for the next four months, whatever water, food, energy, and fuel is consumed is "borrowed," in a sense. Only a certain amount of resources can be produced each year and the rate in which they are being consumed only makes it more improbable that the Earth will rebound on its natural resources.

Addressing the issue of switching to clean energy consists of change in multiple fields: gas emissions and the use and efficiency of resources such as electricity. There are plenty of viable, short-term solutions such as the "Nest Thermostat" that moderates temperature depending on the time of day to help conserve energy while lowering the customer's electric bill. Although truly beneficial, the problem lies within marketing them to the public at a manageable price because otherwise these short-term solutions won't have enough of an impact to address the reality of the depleting natural resources. The issue of clean energy for any country requires more than just a few small, individual efforts as we are past the point where small-scale changes will outweigh the impending negative impacts.

"The [American Society of Civil Engineers] calculated that an additional investment of $107 billion was needed by 2020 to keep the electrical infrastructure whole." The appliances and utilities used by most are not exactly known for their efficiency, and without an increased budget, the country will soon overload the power grid. Electrical infrastructure failures throughout the US have been ongoing for the past couple of years as the power grid ages and our country demands more and more power. The power grid failures have been compared to the way a water system works. Each time an electrical "pipe" bursts and shuts down due to the aged infrastructure, the pressure only increases on the remaining electrical "pipes" until another one bursts; which would result in a complete system shut down.

Gas emissions in relation to climate change and global warming directly correlate with the amount of energy used by society. Drastic variations in weather patterns affects how much energy people will use in response to change as well as how much energy power plants are allowed to produce because of new regulations designed to combat the issue of continual climate change. President Obama has stated that "climate change is not a problem for another generation, not anymore" and has made it clear that the problem will no longer be ignored. Laws introduced under his administration intend to drop the output of emissions by about thirty percent by 2030. This is viable yet optimistic goal and one that can only be attainable with the support and understanding of the people who have the power to introduce these regulations and from society itself. Obama is pushing for "environmental regulations devised to sharply cut planet-warming greenhouse gas emissions from the nation's power plants and ultimately transform America's electricity industry." Acting off of the basis provided a few years back by the Environmental Protection Agency, the President intends to combat factories and other industry powerhouses with more strict regulations and even close the doors on some of them for good, all the while building more wind turbines and installing solar panels to garner energy in a more efficient way to add to the overall efficiency of our electrical infrastructure.

Despite all the good that would come from the movement, the environmental regulations will almost definitely be met with opposition. Companies such as Koch Industries, whom have funneled $79 million dollars into climate-denial front groups and political pockets are also relying on these toxic plants to power their customers and firmly oppose such regulations. States at large are also expected to file suit on the basis that their major profit is a result of the cheap coal and other local sources that the regulations are aiming to outlaw. Their arguments revolve around projected increases in energy and electricity prices for the people within the state and the losses of jobs for those who work in the affected areas. While some may see these regulations as punishments for such corporate companies, whereas in reality they are more geared toward redirecting the ways in which energy is created by encouraging companies develop cleaner practices.

Society's mindset takes on a more positive state, however. One source says that "Americans 'overwhelmingly' prefer solar and wind energy to coal, oil, and nuclear energy, according to a Harvard political scientist who has conducted a comprehensive survey of attitudes toward energy and climate for the last 12 years." The first step toward any change is recognition of the issues and a desire to improve, to motivate society towards bettering our necessary resources.

**Bibliography**

**Humans Have Used Up A Year's Worth Of The Earth's Resources In 8 Months**
Lydia O'Connor, The Huffington Post, August, 2015
http://www.huffingtonpost.com/entry/ecological-debt-day-2015_55cbc544e4b0cacb8d32ed58

**The Lowly Lightbulb Outshines Solar and Wind on U.S. Power Grids**
Naureen Malik, Bloomberg Business , August, 2015
http://www.bloomberg.com/news/articles/2015-08-13/the-lowly-lightbulb-outshines-solar-and-wind-on-u-s-power-grids

**Obama to Unveil Tougher Environmental Plan With His Legacy in Mind**
Gardiner Harris, The New York Times, August 2015
http://www.nytimes.com/2015/08/02/us/obama-to-unveil-tougher-climate-plan-with-his-legacy-in-mind.html?_r=0

**Americans Want America To Run On Solar and Wind**
Jeff McMahon, Forbes, January 2015
http://www.forbes.com/sites/jeffmcmahon/2015/01/01/americans-want-america-to-run-on-solar-and-wind/

**Aging power grid on overload as U.S. demands more electricity**
Ashley Halsey III, The Washington Post, Aug. 1, 2012
https://www.washingtonpost.com/local/trafficandcommuting/aging-power-grid-on-overload-as-us-demands-more-electricity/2012/08/01/gJQAB5LDQX_story.html

**Koch Industries: Secretly Funding the Climate Denial Machine**
Greenpeace, 2015
http://www.greenpeace.org/usa/global-warming/climate-deniers/koch-industries/