Using the EPSA Rubric to Evaluate Student Work on Ethics Case Studies in a Professional Issues Course

Edwin R. Schmeckpeper, P.E., Ph.D., Mike Kelley, Ph.D., and Steve Beyerlein, Ph.D.

Abstract— Engineering programs commonly utilize ethics case studies as the basis for student discussions. Measuring the student learning resulting from the case study process is often very subjective and difficult to quantify.

The Engineering Professional Skill Assessment (EPSA) was created as a direct method for eliciting and measuring ABET professional skills such as ethics. EPSA is a performance assessment consisting of: 1) a 1-2 page scenario about a contemporary, interdisciplinary engineering problem 2) a discussion period where a small group of students are asked to address a series of leading questions about the scenario; and 3) an analytical rubric which is used to evaluate the students' discussion. The EPSA project is currently in the third year of a four year National Science Foundation sponsored validity study. As part of this study the team of researchers has applied EPSA to test groups of students at Washington State University, the University of Idaho, and Norwich University.

As a result of the work done on the validity study, faculty members from Norwich University who were not part of the project team were introduced to the EPSA method. These faculty members have independently started to utilize aspects of the EPSA method in their courses. This paper describes how the EPSA scenarios and EPSA rubric are being used in the "Ethics" section of a senior level "Professional Issues" course for engineering students. The EPSA Rubric provides a standardized means to evaluate the quality of student discussions and to help make the evaluation of students' work more consistent between the multiple sections of the course.

***Index Terms*— Professional Skills, EPSA, Ethics Case Studies**

I. Introduction

Engineering programs often contain a "Professional Issues" course to cover professional skills, 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.[1] Measuring the student learning resulting from the case study process is often very subjective, difficult to quantify, inconsistent between different evaluators, and costly to administer.[2,3]

A well-grounded method for skill assessment is 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[4]. Investigators at Washington State University, University of Idaho, and Norwich University have used the performance assessment paradigm to develop and rigorously test the Engineering Professional Skills Assessment (EPSA) as a vehicle for directly assessing ABET defined skill areas[5].

The EPSA begins with a group of five to six students discussing a complex, real-world scenario that includes current, multi-faceted, multidisciplinary engineering issues. To initiate the 30-45 minute long discussion, student participants first read a short scenario that presents some technical and non-technical details of the topic. Table 1 presents a summary of sample scenarios. After reading the scenario, the students are then asked to determine the most important problem/s and to discuss stakeholders, impacts, unknowns, and possible solutions. An example EPSA scenario is presented in Appendix A

Table 1.Summary of Sample Scenarios

Energy Critical Minerals	Hydraulic Fracturing
Power Grid Vulnerabilities	Fukushima Nuclear Power Plant Disaster
Offshore Wind Farms	Water Shortages
TVA coal ash spill	BP Oil Spill

To guide the discussion after reading the scenario, students are given discussion prompts in the form of a series of questions that direct the participants to identify problems, consider stakeholder perspectives, and outline a plan to learn more about the problems. The EPSA discussion prompts are shown in Table 2.

After the discussions have completed, The EPSA analytical rubric is used to evaluate the students' discussion. The EPSA rubric is segmented into five dimensions aligned with the ABET Engineering Criterion 3, Student Outcomes (3f, 3g, 3h, 3i, and 3j). The five dimensions of the rubric are then further divided into the specific areas for scoring shown in Table 1. A condensed version of the EPSA rubric is included in Appendix B. McCormack et al. explored best practices for administering and using the EPSA rubric[6].

Manuscript received February 16, 2014. This work was supported in part by the National Science Foundation, REESE.
E.R. Schmeckpeper, P.E., Ph.D., is chair of the Department of Civil and Environmental Engineering at Norwich University, Northfield, VT, 05663, USA, (corresponding author, 802-485-6295; fax: 802-485-2260; e-mail: EdwinS@ Norwich.edu).
Mike Kelley, is an Associate Professor in the Department of Civil and Environmental Engineering at Norwich University, Northfield, VT, 05663, USA (e-mail: mkelley@norwich.edu).
Steve Beyerlein is a Professor in the Department of Mechanical Engineering at the University of Idaho, Moscow, ID, 83843, USA (e-mail: sbeyer@uidaho.edu).

978-1-4799-5233-5/14/$31.00 ©2014 IEEE

Table 2. EPSA Discussion Prompts
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.

Table 3. ABET Professional Skills addressed in the EPSA Rubric

Dimension	Specific Areas Considered
3f. Understanding of Professional and Ethical Responsibility	Stakeholder Perspective Problem Identification Ethical Considerations
3g. Ability to Communicate Effectively	Group Interaction 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 Knowledge Status
3j. Knowledge of Contemporary Issues	Non-Technical Issues Technical Issues

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.

II. Implementation in the Classroom

As a result of the work done on the validity study, faculty members from Norwich University who are part of the project team introduced other members of the Norwich University faculty to the EPSA. These faculty members independently started to utilize aspects of the EPSA in their courses. This portion of the paper describes how the EPSA scenarios and EPSA rubric are being used in the "Ethics" section of a senior level "Professional Issues" course for engineering students. The EPSA analytic rubric was used to provide Real-Time evaluations of the student discussions. The course instructors have found the interdisciplinary EPSA scenarios to generate more enthusiastic and higher level discussion than case studies that focus solely on ethics.

In the Fall 2013 semester aspects of the EPSA were incorporated into two sections of Norwich University's EG450-Professional Issues. The EPSA was utilized during two class periods each followed by an all-hands review. In the first class period, which served as a practice session, the students were introduced to the EPSA, discussion prompts, and the use of the EPSA's analytic rubric. During the second class period, the students were formally evaluated and the results recorded.

There were two sections of the class, one section with 14 students and one section of 31 students. The class time for each group 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, and post discussion analysis.

During the practice session all groups used the Fukushima Nuclear Power Plant disaster scenario, which is shown in Appendix A. Since this was a practice session, the discussion time was reduced, so that the facilitator and instructor could provide comments and guidance on use of the EPSA and the EPSA Rubric.

During the record session, the professor selected the "Offshore Wind Farm" scenario for all groups due to Norwich University's proximity to local land-based wind farms. This scenario, which is shown in Appendix A, includes 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.

In both sessions the students were divided into teams, with one part of each team conducting the discussion and the other part of the team assessing the discussion using the EPSA Rubric. In the NSF sponsored study, evaluators typically use a transcript of the student discussion when rating students' discussions. During the in-class implantation, all data was collected as the discussions took place, with the assessors writing tally marks and notes directly on the relevant portion of the EPSA Rubric.

The teams for both the practice scenario and the record scenario were organized as shown in Table 4.

Table 4. Organization of the discussion and assessment teams

Discussion Sub-Team	Assessment Sub-Team
3-4 individuals, participate in the discussions Facilitator/moderator, also serves as time-keeper Antagonist, brings up differing views	2-3 individuals, do not participate in discussions, took notes on the EPSA Rubric (Ideally 3 individuals each have two rubrics with one overlap)

The facilitator distributed the discussion prompts shown in Table 2 to the students on the Discussion Sub-Team, who then read the scenarios and then discussed the scenarios. The discussion prompts help the students focus on the problems in the scenarios. The Assessment Sub-Team evaluates the discussion as the discussion takes place, and has evaluations available to the discussion sub-team almost immediately after the discussion has ended.

Notes:

1. Roles are changed from practice day to record day to allow each student a different role.
2. Each team was in a separate classroom
3. The class with 14 students was divided into two teams and the class with 31 students was divided into four teams.
4. All data was collected during the discussions. There were no electronic recorders.
5. The facilitator / moderator student was responsible for keeping the team focused. There was no additional faculty employed in this exercise.
6. Faculty member observed each team several times during the discussion, but did not participate or moderate the discussion.

Initial Observations on the process:

1. Roles - "extra duties" are important to assist the facilitator and give everyone a specific responsibility.
2. Initial feedback from some students indicated that 45 minutes is too long a discussion period. (The EPSA team has experimented with shorter time periods, and found that 30-35 minutes is often adequate.)
3. Students anecdotally stated that they desired more information in the off shore wind power scenario.
4. Students seemed more comfortable with the scenario information they received in the Japan Nuclear scenario and the time they had to discuss the issue. Since it was a practice session 30 minutes was allotted.
5. Several students wrote about the process and exercise in their course journals. Overall those who discussed it were very positive about the experience.

Instructor Questions [on reflection after the exercise and prior to reviewing the assessment forms and receiving the course feedback analysis]:

1. The instructor assigned teams and additional duties. Should the process call for a random selection process? In retrospect, yes.
2. Should the process allow the students to receive the scenarios and rubrics in advance to do some research on their own to better understand the dilemma and examine the rubrics in more detail? In retrospect, yes.
3. The provided materials discuss voice recordings and transcriptions; this then allows a professional team evaluation approach. It was confusing to the students to have the materials discuss recordings. In retrospect, the decision to not record the discussion seems appropriate. Recommend revising the materials to reflect a student written recorder duty but not a transcription.
4. How does one validate the observations of the assessment sub teams? In retrospect, a "you tube like" training scenario would allow the students to practice assessing their peers. Peer assessment is a valuable part of the exercise, and should be retained.

After the course concluded the Norwich faculty member assessed student written observations in the end of course assessment and analyzed the numerical scores on the assessment rubrics in aggregate.

III. Students' Evaluation of the EPSA Method

In the Norwich University's course evaluation system, thirty-six of forty-five students numerically rated the experience in their assessment of the course. The mean of their observations was 5.92 / 7.00. That is, by and large the students thought it was a valuable experience in the course and should be retained.

- Of the 36 students who provided a numerical rating only six provided a rating of 4 (neutral) or below when assessing the value of this experience.
- Of the 36 students who provided a numerical rating, only six ranked the experience in the lower half of the experiences in the course.

These observations demonstrate strength associated with this approach to ethics in professional issues courses.

Exercise Assessment Rubric Observations:
The mean numerical ratings are shown in Table 5.

Table 5: Assessment rubric observation summary

ABET Criteria	# of notes	Mean	Low	High
ABET Skill 3f – Understanding of professional and ethical responsibility	15	3.74	2.0	5.0
ABET Skill 3g – Ability to communicate effectively	18	3.77	2.0	5.0
ABET Skill 3h – Broad understanding of the impact of engineering solutions in … contexts	13	3.95	3.0	5.0
ABET Skill 3i – Recognition of the need for … life-long learning	12	3.62	2.0	5.0
ABET Skill 3j – Knowledge of contemporary issues	13	3.50	2.5	5.0

IV. Summary and Conclusions

The interdisciplinary EPSA scenarios generated more enthusiastic and higher level discussion than case studies that focus solely on ethics.[7] The EPSA Rubric provides a standardized means to evaluate the quality of student discussions and to make evaluation of students' work more consistent between the multiple sections of the course. The flexibility of the EPSA Method allows it to be readily adapted for use in courses. The course instructor plans on using the EPSA method in subsequent years as a means to assess the ABET Professional skills at the program level.

References

[1] Loendorf, W., "The Case Study Approach to Engineering Ethics", Proceedings of the 2009 American Society for Engineering Education Conference, 2009

[2] American Society of Civil Engineers. (2008). Civil Engineering Body of Knowledge for the 21st Century: Prepare the Civil Engineer for the Future (2nd ed.). Reston, VA: American Society of Civil Engineers.

[3] The ABET "Professional Skills" - Can They Be Taught? Can They Be Assessed? By Shuman, Larry J.; Besterfield-Sacre, Mary; McGourty, Jack Journal of Engineering Education , Vol. 94, No. 1, 2005

[4] Assessing Performance: Designing, Scoring, and Validating Performance Tasks, Robert Johnson, James Penny, and Belita Gordon, The Guilford Press, New York, NY, 2009.

[5] Ater-Kranov, A, Beyerlein, S., McCormack, J., Pedrow, P., Schmeckpeper, E.R., and Zhang, M. "A Direct Method for Teaching and Measuring Engineering Professional Skills: A Validity Study." Presented at the ASEE 2011 Annual Conference & Exposition, Vancouver, BC, Canada, June 2011

[6] McCormack, J., Ater Kranov, A., Beyerlein, S., Pedrow, P., Schmeckpeper, E., "Methods for Efficient and Reliable Scoring of Discussion Transcripts", Proceedings of the 2013 American Society for Engineering Education Conference, Atlanta, GA, June 23-26, 2013.

[7] Lewis, J. E., Ralston, P., Delatte, N., Wheatley, D., "Implementation and Assessment of Case Studies in a Freshman Engineering Program", AC2011-417, Proceedings of the 2011 American Society for Engineering Education Conference, 2011

Appendix A: EPSA Scenario Examples

1) The Fukushima Daiichi Disaster and the Future of Nuclear Power

Following the 2002 Kyoto Protocol, the Ministry of Economic Trade and Industry in Japan made a multi-year commitment to reduce greenhouse gas emissions by expanding electrical generation by nuclear power. In this environment, nuclear power in Japan grew steadily, reaching 30% of total Japanese electricity production in 2011 with further plans to boost production to 50% by 2030. On March 11, 2011, the most powerful earthquake on record to strike Japan devastated the region, particularly the Sendai area. The earthquake triggered a powerful tsunami with waves that exceeded 130 feet in height and traveled 6 miles inland. The earthquake was so powerful that the main island of Japan was shifted 8 feet to the east.

The Fukushima nuclear power plant featured six boiling water reactors, designed and constructed by General Electric. The reactors were designed to withstand approximately .2g ground accelerations and the plant had massive seawalls to prevent inundation by tsunami waves as large as 6 meters. Both of these limits were exceeded by the March 11, 2011 earthquake and tsunami. The earthquake damaged four of the six reactors at this location and the 14 meter tall tsunami that arrived 45 minutes later severed connection with the electrical grid, rendered auxiliary generators inoperative, damaged external cooling water pumps, and flooded basement areas in the turbine buildings. Only three of the reactors were operating at the time, and while these successfully executed immediate shutdown, some of the pipes leading in and out of the reactors were severed, causing steam to escape and water levels to drop.

Without cooling and ventilation to remove heat generated by natural decay of fission products created before shutdown, reactor temperatures could not be contained even after deployment of fire-fighting equipment to pump seawater directly into the reactors and spent fuel pools. Interaction between fuel elements and high temperature steam produced explosive quantities of hydrogen gas that accumulated in roof areas in three of reactor buildings. This led to a series of violent explosions that ultimately ripped through the roof and side of these reactor buildings in the week following the earthquake.

Over 3500 workers participated in plant decontamination. Two workers died from blood loss associated with the hydrogen explosions; two others have exceeded their annual dosage allowed for nuclear workers. A parliamentary panel concluded that TEPCO (plant operator), government, and regulators were negligent in establishing and maintaining safety protocol at Fukushima. The panel points out that the government, regulators, and TEPCO failed to prevent the accident and subsequently "betrayed the nation's right to be safe from nuclear accidents". They concluded that the natural disasters could not be anticipated or necessarily designed for.

This accident once again brought the safety of nuclear power into the forefront of public discussion similar to the Three Mile Island and Chernobyl accidents. Japan has taken all 54 of its reactors out of service, reversing 20 years of surplus and resulting in record $18 billion deficit. Oil and natural gas imports have increased and power shortages have been observed at factories. Germany plans to close all reactors by 2020 and will import natural gas and nuclear power created electricity in other countries to make up for the difference. While the reaction in the United States has not been as severe, the projected resurgence of the nuclear industry has not come to fruition. Many nuclear power plants in the United States are nearing the end of their original projected operational life, which is about 40 years. The county's 104 reactors are now on average 32 years old. Instead of building new reactors, reactors are being retrofitted and upgraded in addition to extending their licenses for 40 to 60 years. The cost of building a new reactor makes it risky and potentially cost prohibitive for any organization that is concerned with making a profit. The only 2 planned reactors (under construction) in the US (in Georgia) were designed to use a passive cooling system to avoid some of the problems at Fukushima.

An alternative approach to combating the risk associated with generating electricity via nuclear fission is to reduce consumption. A citizen led movement in Japan is trying to reduce electricity consumption by installing smaller, 20 or 30 amp, circuit-breaker boxes in their homes. The smaller breaker boxes are in contrast to the 100 and 200 amp boxes in most US homes. The restriction is not easy however, as many household items use substantial power (small AC unit – 10 amps, vacuum cleaner – 10 amps, microwave – 6 amps).

One author argues that the panic over many "hotspots" near the Fukushima disaster site was unwarranted. The International Commission on Radiological Protection recommends evacuation of a locality whenever the excess radiation dose exceeds .1 rem per year. However, citizens of Denver are exposed to three times that amount from the area's natural radiation emissions.

Scenario Sources:

- Fukushima Nuclear Accident Update Log. (2011). International Atomic Energy Association.
- In Japan, People Get Charged Up About Amping Down. (October 3, 2012). The Wall Street Journal.
- The Panic over Fukushima. (August 18, 2012). The Wall Street Journal.
- Old Reactors, New Tricks. (August, 2012). IEEE Spectrum. pp 31-35.
- Japan Panel Blames Disaster on Negligence. (July 6, 2012). The Wall Street Journal.

2) *Development of Offshore Wind Resources*

The US pioneered land-based wind farms in the 1980's and in 2008 had a total installed land-based capacity of about 18,300 MW. Yet, it wasn't until 2010 that the US Department of Interior gave its approval for the first US offshore wind farm called Cape Wind which will consist of 130 turbines with total output power 400 megawatts. Each turbine will extend 400 feet above the surface of the sea and the wind farm will cover 24 square miles of ocean about five miles off the Massachusetts coast near Hyannis Port and Nantucket Sound. In 2010, Google announced that they contracted for 37.5% of the startup equity for developing the Atlantic Wind Connection, a $5 billion project to build a 350-mile corridor of wind turbines located in shallow water 10 to 20 miles from the US Atlantic coast extending from New Jersey to Virginia. The AWC system take up to a decade to complete and government approvals are an important part of that process. The system could ultimately provide 6,000 MW of capacity.

Offshore wind patterns are known to contain larger wind energy content than land-based sites. One of the earliest offshore wind farms was constructed in 1991 by Denmark and it has a capacity of 5 MW which is arguably capable of supplying 5,000 households with electric power. This wind farm is named "Vindeby" and contains 11 turbines located about a mile from shore in water with a depth of 3.5 meters. Since the completion of Vindeby more than 25 other wind farms have been built near Europe with a total installed capacity exceeding 1,781 MW.

Sponsoring companies for these European wind farms include Denmark, Netherlands, Sweden, UK, Ireland and Belgium. Underwater power grids are required to move the electric power from the offshore generators to the land-based consumers. Distance of these offshore wind farms from land and the proximity to land-based grid connection points have substantial influence on construction and maintenance costs associated with these systems.

Negative impacts of offshore wind farms include maritime navigation safety, excessive bird mortality through collisions with the turbines, deleterious effects on mammals and fish, prospective reduction in property values, issues associated with travel of construction and maintenance crews to and from the offshore turbines, the corrosive environment associated with salt water and the influence of electromagnetic fields on the maritime environment.

Prospective damage to bird species is highlighted by the land-based wind farm at Altamont Pass in California where the bird strike mortality rate was relatively low but one of the impacted species was the golden eagle. Mammals and fish are especially influenced by noise associated with construction (pile drivers) and blade noise during normal operations. Some ocean species are known to perceive electric and magnetic fields and use these perceptions for orientation and prey detection. Electromagnetic fields emanating from the offshore power grid might interfere with these processes.

Positive results from offshore wind farms must also be considered by government policy makers. These positive results include a reduction in greenhouse gases, fish aggregation resulting from pilings acting as a substrate for species that attract fish, reduced reliance on fossil fuels, reduced freshwater withdraws by fossil-fueled power plants and added jobs within the local economy as well as added jobs within the economies associated with wind turbine manufacture. Life cycle analysis of multi-megawatt wind turbines shows that the turbine "pays back to the ecosystem" about 31 times the environmental damage that results from its manufacture, start-up, operation and decommissioning.

Scenario Sources:

- Brian Snyder and Mark J. Kaiser, "Ecological and economic cost-benefit analysis of offshore wind energy," Renewable Energy, Vol. 34 (2009) pp. 1567–1578.
- Peter Galuszka, "Google's winds of change in Virginia," All Opinions Are Local: A Forum on Hot Topics in D.C., Maryland and Virginia; The Washington Post; October 13, 2010.
- Christopher R.Jones and J. Richard Eiser, "Understanding 'local' opposition to wind development in the UK: How big is a backyard?" Energy Policy, Vol. 38 (2010) pp. 3106–3117.

Appendix B. The Engineering Professional Skills (EPSA) Rubric (one-page version - March 2014)

ABET Skill 3f Understanding of professional and ethical responsibility

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
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.
Problem Identification	Students do not identify the problem(s) in the scenario.	Students begin to frame the problem, but have difficulty separating primary and secondary problems. If approaches to address the problem are advocated, they are quite general and may be 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 problems.		Students convincingly and accurately frame the problem and parse it into sub-problems, providing justification. They suggest detailed and viable approaches to resolve the problems.
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
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. The majority of students give thoughtful input and attempt to build on and/or clarify other's ideas with some success.		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 dominate (inadvertently or on purpose), or become argumentative. Students may attempt to regulate the discussion, but without success. There may be some tentative, but ineffective, attempts at reaching consensus.		Students regulate the discussion by identifying unproductive communication. Students attempt to reach consensus, but may find it challenging to implement strategies that equitably consider multiple perspectives. The majority of students work to achieve consensus in order to frame the problem and propose approaches.		Students use self-regulation strategies to ensure a productive discussion. Students clearly work together to reach a consensus in order to clearly frame the problem and develop appropriate, concrete ways to resolve the problem.

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, justify possible solutions with reasonable accuracy. Impacts considered may be associated with relevant secondary problems, and 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 begin to examine information presented in the scenario. Examples include, but are not limited to: questioning the validity of information sources, distinguishing fact from opinion		Students examine information presented in the scenario, and potentially the information sources. Examples include, but are not limited to: questioning the validity and potential biases of information sources, distinguishing fact from opinion, recognizing what is implied and what is explicit		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 issues raised in the scenario. Examples include, but are not limited to: recognizing information that is new to them, beginning to ask questions, injecting their own life experiences, possibly without questioning the validity in relationship to other sources		Students identify the limits of their knowledge of the issues raised in the scenario. Examples include, but are not limited to: connecting personal experiences or information read/heard elsewhere, recognizing that personal experiences may or may not benefit analysis of the issues, considering related historical events, identifying specific knowledge gaps and reliable sources to consult		Students identify the specific limits of their knowledge of the issues raised in the scenario and how those limitations affect their analysis. Examples include, but are not limited to: checking assumptions related to personal experiences or information read/heard elsewhere, considering related historical events, acknowledging that they learned from the scenario, each other and the discussion, identifying specific knowledge gaps and a variety of reliable sources to consult

ABET Skill 3j Knowledge of contemporary issues.

	0 - Missing	1 - Emerging	2 - Developing	3 - Practicing	4 - Maturing	5 - Mastering
Non-Technical	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 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).