Methods for Efficient and Reliable Scoring of Discussion Transcripts

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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.
Abstract
The Engineering Professional Skills Assessment (EPSA) is a direct method for both teaching and assessing professional skills. In this method, groups of 4-6 students take part in a 45 minute discussion prompted by a one page scenario that frames an interdisciplinary, complex, societal problem related to engineering. Examples of scenarios include a discussion of the Fukushima Daiichi nuclear reactor incident and the use of offshore wind power. The student discussion is then scored by an instructor using the EPS rubric. The EPS rubric assesses student performance through indicators associated with an ability to function on multidisciplinary teams, understanding of professional and ethical responsibility, ability to communicate effectively, understanding of the impact of engineering solutions, recognition of and ability to engage in life-long learning, and knowledge of contemporary issues.

Collaborators from ABET, Norwich University, University of Idaho, and Washington State University are currently validating the EPS rubric by scoring 19 student discussions recorded and transcribed during the 2011-12 academic year. This effort has produced a number of best practices for annotating transcripts, summarizing data and justifying ratings on rubric score sheets, arriving at consensus scores between multiple raters, and assuring inter-rater reliability. In this paper, we examine a section from a scored transcript to illustrate the scoring methodology which includes rater practices and application of decision rules. Preliminary results are presented which include inter-rater statistics.

1. Engineering Professional Skills Assessment Overview
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. Engineering professional skills as defined by ABET include ability to function on multidisciplinary teams (3d), understanding of professional and ethical responsibility (3f), ability to communicate effectively (3g), understanding of the impact of engineering solutions in global, economic, environmental, and cultural/societal contexts (3h), recognition of and ability to engage in life-long learning (3i), and knowledge of contemporary issues (3j).

A variety of methods and instruments have been developed by engineering educators to teach and assess the ABET professional skills. Most of these instruments evaluate only one skill at a time and often evaluate skills indirectly [1-5]. Loughry, Ohland, and Moore [1] describe the basis of the CATME (Comprehensive Assessment of Team Member Effectiveness) system which is a highly effective tool focusing on team member performance. Students use the web-based CATME system to directly assess team member performance. Mourtos [2] focused on assessing lifelong learning using direct sources (student work) and indirect sources (course reflections and surveys). The author divided the assessment into both the recognition of the need and the ability to engage in lifelong learning. McMartin, McKenna, and Youssefi [3] developed a scenario tool and rubric to directly assess student performance in responding to an open-ended problem. Scenarios were presented as actual engineering problems where they were to respond as the project manager. The rubric is then used to assess the student’s problem solving abilities as well as considerations made for team, social, environmental, and technical factors associated with the scenario. Students work the problem alone as a homework assignment. Shuman, Besterfield-Sacre, and McGourty [5] developed a tool for assessing students’ abilities to
recognize and resolve ethical dilemmas. In their method, students respond to multiple engineering ethics related scenarios through an essay, which is then scored by an instructor. Multiple uses of the method with the same student can be used to measure growth over a period of time.

Investigators at ABET, Washington State University, University of Idaho, and Norwich University are developing and rigorously testing the Engineering Professional Skills Assessment (EPSA) method to directly assess ABET defined skill areas [6]. The EPSA method begins with a group of five to seven students discussing a complex, real-world scenario that includes current, multi-faceted, multidisciplinary engineering issues. To initiate the 45 minute long discussion, student participants first read an engaging two page scenario that presents some technical and non-technical details of the topic. To guide the discussion after reading the scenario, students are given a discussion prompt 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. An example scenario and discussion prompt is found in Appendix A.

Student performance with respect to the set of ABET professional skills is determined by scoring the discussion using the analytical Engineering Professional Skills (EPS) rubric. The EPS rubric is segmented into five dimensions defined by 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. The complete rubric is located in Appendix B.

Currently, the research team is scoring transcriptions of the discussions in order to test the reliability of the EPSA method and the EPS rubric. The research team will also perform additional scoring of the transcripts with existing, validated rubrics [7] that address a single dimension of the EPS rubric in order to validate the EPS rubric. This paper outlines our method for scoring transcribed student discussions using the EPS rubric. Also we propose a tool for gathering real-time data for scoring, in lieu of examining transcribed discussions, which will be too cumbersome for practical application.

Table 1. Specific areas of the EPS scoring rubric.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Specific Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill 3f. Understanding of professional and ethical responsibility</td>
<td>Stakeholder Perspective, Problem Identification, Ethical Considerations</td>
</tr>
<tr>
<td>Skill 3g. Ability to communicate effectively</td>
<td>Group Interaction, Group Self-Regulation</td>
</tr>
<tr>
<td>Skill 3h. Understanding of the impact of engineering solutions in global, economic, environmental, and cultural/societal contexts</td>
<td>Impact/Context</td>
</tr>
<tr>
<td>Skill 3i. Recognition of the need for and ability to engage in life-long learning</td>
<td>Sources/References, Discern Fact/Opinion, Knowledge Status, Presumptions</td>
</tr>
</tbody>
</table>
2. Current Scoring Methodology

A current representation of the complete lifecycle of an implementation of the EPSA method is shown in Figure 1. The scoring methodology shown in Figure 1 and described below evolved from an earlier approach in which all five researchers scored each transcript. The initial approach allowed us to develop scoring rules and the more streamlined method described in this section.

In Figure 1, after the student discussion is complete, a recording of the discussion is transcribed and sanitized of all identifying information (e.g. student names, revealing locations, etc.). Two faculty raters are initially assigned to score the rubric and an arbitrator is assigned to mediate any potential disputes on scoring where the raters could not agree on a consensus score. To score the transcript, each rater first re-familiarizes themselves with the scoring rules of the rubric then annotates relevant passages in the transcript with flags corresponding to specific rubric areas (e.g. 3f: ethical considerations). If a passage informs multiple areas, cite all that are relevant in the annotation. The rater then gathers up all passages flagged for a specific rubric area and uses evidence to select the appropriate score from the rubric. The rater assigns a “gut” score in each specific area using the coarse scale provided by the rubric (e.g., 0, 1-2, 3-4, 5). The score is based on impressions from reading and annotating the transcript. The rater then assigns a complete score for the dimension by qualitatively weighing the coarse score for each specific area that is a subset. The complete score for a dimension is a single value from the rubric (e.g., 0, 1, 2, 3, 4, 5) and should be accompanied by comments by the rater.

After working through each scoring area on the rubric, the rater compares scores with the other rater that has independently arrived at a set of scores. The two raters merge their annotated transcripts (electronically if possible) and compare evidence that was used to generate scores. A consensus score is recorded for each rubric area including the rationale for deviations from original scoring. If a consensus score cannot be reached, the difference is recorded and passed on to an arbitrator. The final scoring is recorded for statistical processing along with any lessons learned about the scoring process.
Figure 1. The EPSA lifecycle including discussion, processing, and scoring.
3. Case Study

Three excerpts from a transcribed student discussion is used to demonstrate the individual and team scoring process as well as illustrates the type of work generated by the EPSA method. Figure 2 is a transcription of the opening statements in a student EPSA discussion about the Fukushima Daiichi nuclear reactor incident. The full Fukushima Daiichi scenario is in Appendix A. The complete student transcript was transcribed and annotated individually by two raters. The annotations were merged into a single document for comparison (Figure 2).

Table 2 contains the scores assigned by the raters for each specific area and the complete score for the dimension that was subsequently extracted. For **3f - Understanding of professional and ethical responsibility** the two raters (McCormack and Beyerlein) were in agreement on both the specific areas and the complete score for the dimension, so extensive discussion was not required. Note that the scores assigned by the raters were determined by examining the entire rubric, not just the excerpts in Figure 2, 3, and 4.

![Figure 2](image-url)

**Figure 2.** An excerpt of the student transcribed work including the annotations from individual raters.
Table 2. The scoring comparison of the two raters for ABET student outcome 3f.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>McCormack’s components</th>
<th>McCormack’s score</th>
<th>Beyerlein’s components</th>
<th>Beyerlein’s score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3f – Understanding of professional and ethical responsibility</td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>3-4</td>
<td></td>
<td>3-4</td>
<td></td>
</tr>
<tr>
<td>Problem ID</td>
<td>3-4</td>
<td></td>
<td>3-4</td>
<td></td>
</tr>
<tr>
<td>Ethical considerations</td>
<td>3-4</td>
<td></td>
<td>3-4</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3 shows another excerpt from the student EPSA discussion pertaining mostly to ABET student outcome 3h - understanding of professional and ethical responsibility. The rater annotations were merged into the document and scores were compared. The rater’s annotations were not perfectly aligned, but the raters were able to arrive at a consensus given the minor differences in the annotations (Table 3).

Figure 3. An excerpt of the student transcribed work including the annotations from individual raters related to ABET outcome 3h.
Table 3. The scoring comparison of the two raters for ABET student outcome 3h.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>McCormack’s components</th>
<th>McCormack’s score</th>
<th>Beyerlein’s components</th>
<th>Beyerlein’s score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3h – Understanding of the impact of engineering solutions in global, economic, environmental, and cultural/societal contexts</td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 4 shows another excerpt from the student EPSA discussion pertaining mostly to ABET student outcome 3j - *knowledge of contemporary issues*. The rater annotations were merged into the document and scores were compared. There were some discrepancies in the annotated transcripts and subsequently, a difference in scores. The differences between the raters were in the form of passages annotated differently and passages that were not marked by both raters.

A primary source of the difference was the categorizations rules used to determine 3j versus 3h. In sharing their scores and comparing annotated transcripts, the raters determined a more guiding scoring rule -

> **3j passages are not impacts themselves, but valuable pieces of background information that are not derived from the scenario, which could be technical or non-technical. Two examples from the Fukushima scenario include a mention of half-life and the use of nuclear energy to reduce greenhouse gas emissions.**

Based on this clarification, rater McCormack adjusted his score (Table 4). The change in scoring was noted on the final rubric by the raters.

Figure 4. An excerpt of the student transcribed work including the annotations from individual raters related to ABET outcome 3j.
Table 4. The scoring comparison of the two raters for ABET student outcome 3j.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>McCormack’s components</th>
<th>McCormack’s score</th>
<th>Beyerlein’s components</th>
<th>Beyerlein’s score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3j – Knowledge of contemporary issues</td>
<td>Changed from 2 to 3</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Non-technical issues</td>
<td>3-4</td>
<td></td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td>Technical issues</td>
<td>Changed from 1-2 to 3-4</td>
<td></td>
<td></td>
<td>3-4</td>
</tr>
</tbody>
</table>

4. Data Collected
Collaborators from ABET, Norwich University, University of Idaho, and Washington State University are currently determining the reliability and validity of the EPS rubric by scoring 19 student discussions recorded and transcribed during the 2011-12 academic year. The first 14 transcripts were each scored by the five investigators on the grant. The individual scores were shared and a consensus was reached where possible. This scoring effort took approximately 270 minutes per transcript (2x45 minutes of scoring by individual raters + 45 minutes of sharing scores and forming consensus). Table 5 shows the scoring results for the first 14 transcripts. Consensus was reached when all scores fall into the major rubric categories – 0, 1-2, 3-4, and 5. When consensus was not reached, the majority score is shown and the score is marked with an asterisk. From the scoring of the initial set of transcripts, the team generated scoring decision rules and scoring tips to aid in the application of the rubric to future transcripts. The general decision rules are found on the first page of the rubric, which is located in Appendix B. Scoring rules per ABET skill are located on the corresponding ABET skill page in the rubric. These scoring aids allowed the research team to have only two research participants score each of the subsequent transcripts. By reducing the number of participants, scoring time was reduced to approximately 2 hours per transcript (2x45 minutes of scoring by individual raters + 30 minutes of sharing scores and forming consensus). The subsequent scores are shown in Table 6 where raters produced a singular consensus score. This effort has produced a number of best practices for annotating transcripts, summarizing data and justifying ratings on rubric score sheets, arriving at consensus scores between multiple raters, and assuring inter-rater reliability.

Table 5. Scoring results from 5 raters examining the first 14 transcripts.

<table>
<thead>
<tr>
<th>Transcript #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
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<tbody>
<tr>
<td>3f</td>
<td>1-2</td>
<td>1-2</td>
<td>3-4</td>
<td>1-2</td>
<td>3-4</td>
<td>1-2*</td>
<td>1-2</td>
<td>1-2*</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>3g</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>3-4</td>
<td>3-4*</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>3h</td>
<td>1-2</td>
<td>1-2</td>
<td>3-4</td>
<td>1-2</td>
<td>3-4</td>
<td>1-2*</td>
<td>1-2</td>
<td>1-2*</td>
<td>1-2</td>
<td>3-4</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>3i</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2*</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>3j</td>
<td>3</td>
<td>1-2</td>
<td>3-4</td>
<td>3-4*</td>
<td>3-4</td>
<td>3-4*</td>
<td>3-4</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Scoring results from 2 raters examining the subsequent 5 transcripts.

<table>
<thead>
<tr>
<th>Transcript #</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>3f</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3g</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3h</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3i</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3j</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
5. Real-time Scoring Tool
Currently, the research team is experimentally testing the reliability and validity of the EPSA methodology and EPS rubric. Ultimately the team plans to develop an instrument that can be used (if desired) in a real-time manner by an instructor and does not necessarily require recording, transcribing, and post-analysis. The team is experimenting with check sheets that correspond to a given scenario. Figure 5 shows a proposed check sheet for the Fukushima Daiichi scenario related to the 3f dimension. To use this check sheet, the observing instructor simply checks off subjects that were addressed and highlights connections that were formed. The instructor can then use this to assign scores with the rubric for an immediate debriefing session with the students.

Figure 5. A proposed check sheet for the 3f dimension of the Fukushima Daiichi scenario.
6. Future Work
The team will continue to record student discussions during the 2012-2013 academic year adding approximately 30 more transcripts to the current set. Additionally, the team will continue scoring each transcript with the EPS rubric. Further exploration and development will be performed on the real-time scoring tool including investigating the use of technology to streamline the administrative or scoring aspects of the work. The team will also use other standard rubrics [7] to validate the results. Finally, the scores will be analyzed for validity and reliability and the results will be disseminated.

7. Acknowledgements
This work was funded by the U.S. National Science Foundation under DRL 1313896. Any opinions, findings, conclusions and recommendations expressed in this material are those of the authors and do not necessarily reflect those of the National Science Foundation.

8. References
Appendix A – Discussion Instructions and Fukushima Daiichi Scenario

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.

Fukushima Daiichi Nuclear Disaster
Japan imports over 80% of its energy resources. Following the 2002 Kyoto Protocol, the Ministry of Economic Trade and Industry made a multi-year commitment to reduce greenhouse gas emissions by expanding electrical generation by nuclear power. In this environment, nuclear power in Japan has grown steadily, reaching 30% of electricity production in 2011 with plans to boost this to 50% by 2030.

Most of Japan’s nuclear plants are located in moderately populated areas adjacent to the sea coast. General Electric, a major supplier of pressurized water reactor technology to many Japanese utilities, designed for fairly aggressive ground accelerations (~.2g). At Fukushima, massive seawalls were also installed to prevent inundation by tsunami waves as large as 6 meters. Both of these limits were exceeded by the March 11, 2011 Tohoku earthquake at the Fukushima Daiichi nuclear complex. 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. In the course of the accident it is estimated that as much as 30% of the fuel elements in two of the reactors experienced meltdown. 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.
The Tokyo Electric Power Company (TEPCO) that operates the Fukushima complex was not immediately aware of the extent of damage to its reactors and spent fuel facilities and originally characterized it as similar to Three Mile Island in the United States. During the month that followed the earthquake, the rating of this accident on the International Nuclear Event Scale was raised from 4 to 7 where it is now viewed as the second most serious nuclear accident, exceeded only by Chernobyl in Ukraine. Radioactive Iodine and Cesium were emitted to the surrounding residential and farming communities, causing authorities to evacuate citizens from a 20 km zone around the plant. Agricultural products and seafood from an even wider area remain restricted from the market. Massive quantities of radioactive water have been spilled into basements throughout the nuclear complex and there have been complications in filtering out radioactive constituents so that water can safely be released.

Over 3500 workers have participated to date 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; many others are approaching this limit; retired engineers and utility workers are being considered as an expanded clean-up workforce to ensure that adequate labor is available. TEPCO will need to decommission four of the reactors since they have been made irreparable because of direct contact between nuclear components and salt water. The fate of the other two reactors in the plant complex is uncertain. The value of TEPCO’s original investment in its Fukushima Plant is more than $35 billion.

Sources


Appendix B – EPS Rubric

The 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.
Engineering Professional Skills Assessment (EPSA) Rubric

Rater’s Name: ___________________ Date: _______ Student Work: ____________________

EPSA TEAM: This is an internal use rubric for the time being – one that we are using to guide our rigorous rubric and method validation process. The scoring protocol, general decision rules and scoring tips are thus targeted to this objective and us as the audience. Most likely we will refine this rubric for outside audiences towards the end of the summer. It’s possible (and admissible) that our scoring rules will inform descriptor refinement (not performance indicator major revisions) after summer 2012 scoring is complete.

Note: The engineering professional skills that comprise this rubric are taken directly from the ABET Engineering Criterion 3, Student Outcomes. Each dimension of the EPSA Rubric comprises one ABET student outcome, an EPSA definition of the outcome, and the outcome’s performance indicators. Thus, “ABET skill 3 f” can also be read as “ABET criterion 3 student outcome 3f” with three performance indicators: stakeholder perspective, problem identification, & ethical considerations.

Scoring Protocol:

a) Skim the scenario students used for the discussion.
b) Quickly read the discussion, marking passages where a given skill is exhibited. A given passage may exhibit more than one skill simultaneously.
c) During a second read, highlight passages that provide strong evidence (either positive or negative) related to the skills.
d) Read the skill definition. Assign scores for each of the performance indicators.
e) In the comment boxes, provide line numbers and a short phrase, such as: 3f = lines 109-112: trade off of wall height/plant safety vs costs; lines 828-836: risk analysis. Be sure to refer back to the skill definition.
f) Update your initial scores should the data provide evidence for a score change.
g) Ultimately assign one score for the skill. Use whole numbers; no increments.

General Decision Rules

1. Assess what is transcribed. Don’t “read between the lines” (e.g., don’t make assumptions about what the group should know given what is transcribed.).
2. When conflicted on assigning a score, reference adjacent score description boxes to determine whether a higher or lower score within the description box is more appropriate.
3. Assign the higher score associated with a box only when evidence for all performance criteria is present.
4. Weigh all performance indicators within a category equally in assigning the overall score.
5. Read the skill definition after scoring to check the score for accuracy.
6. When averaging scores for the performance indicators, round down. For example, 2.6 would be a 2 not a 3.

Scoring Tips

1. Supply line numbers and/or student numbers for reference in the comment box.
2. Strive to complete transcript review and scoring within a 45-60 minutes.
**ABET Skill 3f. Understanding of professional and ethical responsibility**

**Definition:** Students clearly frame the problem(s) raised in the scenario and begin the process of resolution. Students recognize relevant 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).

<table>
<thead>
<tr>
<th>Stakeholder Perspective</th>
<th>0 - Missing</th>
<th>1 - Emerging</th>
<th>2 - Developing</th>
<th>3 - Practicing</th>
<th>4 - Maturing</th>
<th>5 - Mastering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students do not identify stakeholders.</td>
<td>Students identify few stakeholders, vaguely stating their positions or misrepresenting their positions.</td>
<td>Students consider perspectives of major stakeholders and convey these with reasonable accuracy.</td>
<td>Students thoughtfully consider perspectives of all relevant stakeholders and articulate these with great clarity, accuracy, and empathy.</td>
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</tr>
<tr>
<td>Problem Identification</td>
<td>Students do not identify the problem(s) in the scenario.</td>
<td>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.</td>
<td>Students are generally successful in distinguishing primary and secondary problems. There is evidence that they have begun to formulate credible approaches to address the problems.</td>
<td>Students convincingly frame the problem and parse it into sub-problems. They suggest detailed and viable approaches to resolve the problems.</td>
<td></td>
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</tr>
<tr>
<td>Ethical Considerations</td>
<td>Students do not give any attention to ethical considerations.</td>
<td>Students give passing attention to related ethical considerations.</td>
<td>Students are sensitive to some relevant ethical considerations and discuss them in context of the problem(s).</td>
<td>Students clearly articulate relevant ethical considerations and address these in discussing approaches to resolve the problem(s).</td>
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</tbody>
</table>

**Comments**

**Scoring Rules**
1. Review the general decision rules and scoring tips on the first page.
2. Stakeholder Perspective: To score at the 3-4 level, explanations of stakeholder positions are required.
3. Problem Identification: To score at the 3-4 level, linkages between issues and problems must be made.
4. Problem Identification: To score at the 3-4 level, primary problems must be identified and justified.
5. Ethical Considerations: To score at the 3-4 level, linkages between ethical considerations and stakeholder interests must be made.
ABET Skill 3g. Ability to communicate effectively

**Definition:** Students work together to address the problems 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 can include several forms of communication, such as written and oral presentation. This definition focuses on group discussion skills.

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

**Comments:**

**Scoring Rules**

1. Review the general decision rules and scoring tips on the first page.
2. Consider frequency of utterances among teammates.
3. Consider level of individual engagement (as measured by length and depth of utterances).
4. Trace discussion threads backwards and forwards to understand conversation flow.
5. **Group Interaction**: To score at a 2 level, fewer than 75% of students participate in the discussion. To score at 3 level, at least 75% of students in the group should be giving input, attempting to build on and/or clarify other’s ideas.
6. **Group Self-Regulation**: To score at the 2 level, one or two students attempt to regulate group discussion without success or lasting impact. To score at a 3 level, at least 75% of the students should participate in attempting consensus.
7. Give greater weight for building on ideas of others.
8. Give greater weight for successful attempts to achieve consensus/closure related to the performance task.
ABET Skill 3h. Broad understanding of the impact of engineering solutions in global, economic, environmental, and cultural/societal contexts

**Rater Score for Skill:**

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

- **Global:** Students relate the issue or proposed approaches to larger global issues (such as globalization, world politics, etc.).
- **Economic:** Students relate the issue or proposed approaches to trade and business concerns (such as project costs).
- **Environmental:** Students relate the issue or proposed approaches to local, national or global environmental issues (such as ozone depletion).
- **Cultural/Societal:** Students relate the issue or proposed approaches to the needs of local, national, or ethnic groups affected by the issue.

<table>
<thead>
<tr>
<th>Impact/Context</th>
<th>0 - Missing</th>
<th>1 - Emerging</th>
<th>2 - Developing</th>
<th>3 - Practicing</th>
<th>4 - Maturing</th>
<th>5 - Mastering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students do not consider the impacts of the solutions.</td>
<td>Students give cursory consideration to how the ways to address the problem impact in relevant contexts.</td>
<td>Students give evidence on how the ways to address the problem impact in relevant contexts.</td>
<td></td>
<td></td>
<td>Students clearly examine and weigh the impact of the ways to address the problem in all relevant contexts.</td>
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</tbody>
</table>

**Comments**

**Scoring Rules**

1. Review the general decision rules and scoring tips on the first page.
2. To score at the 2 level, students considerations are superficial and potentially related to only one or two relevant areas.
3. To score at the 3 level, student consider impacts in meaningful ways in all major relevant contexts.
4. Consider assigning a subscore to each context, similar as is done for individual performance indicators, but recognizing that some contexts are not necessarily as relevant as others to the scenario discussed.
5. Impacts should be related to solution approaches associated with relevant subproblems.
ABET Skill 3i. Recognition of the need for and ability to engage in life-long learning

**Definition:** 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.

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

**Scoring Rules**
1. Review the general decision rules and scoring tips on the first page.
2. Sources/references and discern fact/opinion relate to the scenario itself.
3. Discern Fact/Opinion: To score at a 2 level, students merely reference back to facts or opinions in the scenario, using indicators like: “it says”
4. Knowledge Status: Simply asking questions is not necessarily a questioning of knowledge; it could indicate building on or clarifying other’s ideas. Note type as well as number of questions raised as evidence of knowledge status.
5. Asking for validation/confirmation is a form of checking presumptions, using indicators like: “what do you think about xyz?”, “Have you heard xyz?”
6. To score at the 5 level in any performance indicator category, the group should be significantly engaged and potentially transformed as a result of the discussion.
**ABET Skill 3j. Knowledge of contemporary issues**

**Definition:** Students consider non-technical issues such as societal, economic, and political concerns in their discussion, identification of the problem(s), and possible ways to address the problem(s). Students also display awareness of relevant technical issues/methods/tools surrounding the problem(s).

<table>
<thead>
<tr>
<th>Non-Technical Issues</th>
<th>0 - Missing</th>
<th>1 - Emerging</th>
<th>2 - Developing</th>
<th>3 - Practicing</th>
<th>4 - Maturing</th>
<th>5 - Mastering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students do not consider any current societal, economic, and/or political issues</td>
<td>Students give only a superficial consideration to current societal, economic, and/or political issues. Non-technical issues may be treated in a condescending manner.</td>
<td>Students give some consideration to current societal, economic, and/or political issues.</td>
<td>Students give full consideration to current societal, economic, and/or political issues.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical Issues</th>
<th>0 - Missing</th>
<th>1 - Emerging</th>
<th>2 - Developing</th>
<th>3 - Practicing</th>
<th>4 - Maturing</th>
<th>5 - Mastering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students do not consider modern methods, technologies and/or tools.</td>
<td>Students give only passing consideration to modern methods, technologies and/or tools.</td>
<td>Students give some consideration to modern methods, technologies and/or tools.</td>
<td>Students give full consideration to modern methods, technologies and/or tools.</td>
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</tbody>
</table>

**Comments**

**Scoring Rules**

1. Review the general decision rules and scoring tips on the first page.
2. Keep track of the number and depth of different non-technical issues raised/discussed.
3. Keep track of the number and depth of different technical issues raised/discussed.
4. To score at a 4 level in either performance indicator category, students consider relevant current topics in ways that inform their identification of the problem(s) and possible ways to address the problem(s).
5. Give equal weight for investigation of secondary problems.