

Student portfolios for assessing ABET a-k outcomes

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An undergraduate professional development course, which is currently required within the Ohio State University's program for a Bachelor of Science in Food, Agricultural, and Biological Engineering, features several instructional activities for engaging students in their learning and assessing their attainment of ABET's eleven (a through k) general criteria 3 student outcomes. The goals of the course are to:

- Prepare students to enter the engineering profession by developing improved personal skills and confidence for interviewing and pursuing professional licensing
- Introduce professional development business topics
- Instill the need for life-long learning after graduation
- Explore the ethical expectations within the engineering profession
- Enable students to reflect upon and articulate what they have learned during their engineering education.

The student portfolio¹ is “a purposeful collection of materials capable of communicating student interests, abilities, progress, and accomplishments in a given area.” Christy and Lima presented a suite of portfolio methods to enhance and assess student learning in engineering programs². When constructing a portfolio in the context of a professional development course, the student becomes engaged in the process of selection and reflection on their undergraduate studies and develops creative descriptions of what they have learned³. Student portfolios encourage active learning strategies and can be used for program assessment and accreditation^{4,5} and to study how students view engineering and their role in their future profession⁶. Although portfolios are common in fields such as art, journalism, language arts, and architecture, their use in engineering has been a comparatively new phenomenon. Online e-Portfolios in engineering⁷ are also a more recent advance.

Portfolios can enhance industry ties in the classroom^{8,9}. These studies demonstrated that learning was improved by students engaging in the process of selection, self evaluation, and reflection that is inherent in the portfolio method. In exit surveys performed over several years, 76% to 88% of the students across two institutions and four undergraduate programs reported that the portfolio method had enhanced their learning. Students have received job offers based on their portfolios even where no job opening had previously existed. Interestingly, many of the recruiters who hire from the department now ask to see students' portfolios during their on-campus interviews¹⁰.

The official course description of the course described in this paper is “Professional development related to food, agricultural, and biological engineering; business communication skills for professional advancement; engineering ethics; health and safety; and the engineer’s responsibilities to society.” The objectives of this study are to present the methods and classroom activities for this course and to report on four years of outcomes assessment data.

Methodology

The course is taught annually and is structured to explore several instructor-determined topics during the first half of the semester, followed by those topics selected by class consensus for the second half of the course. The topics that are included in every offering of the course (i.e., the instructor-determined topics) are the following:

- Professional business communications: Resumes, cover letters, memos, letters, proposals, reports, emails, professional portfolios
- Professional licensing and ABET
- Planning for graduate school
- Job interviews, follow-up letters and calls, and evaluating job offers
- Engineering ethics
- Occupational health and safety for engineers

The second half of the course highlights professional skills and business practice topics relevant to the engineering profession and to that particular group of students enrolled in the course. The selection of those topics is made during the first and second class meetings. The class is presented with up to 30 topics, many of which are industry-identified professional competencies¹¹. Although fewer than a quarter of these topics can be covered in any given course offering, having a long list of candidates exposes the students to the breadth of potential topics available for study in class, and by extension, later in their professional careers. The students are also encouraged to add topics to this list. Potential topics are discussed in class, and any student questions are addressed. They are then encouraged to vote for their top four choices using an online survey tool. Table 1 presents, in alphabetical order, the topic list from which they chose in spring semester 2013, along with the number of times each topic has been chosen over the past nine offerings of the course:

Table 1. Professional skills and business practice topics from which students choose

| TOPIC | NUMBER OF TIMES SELECTED (over past 9 years: 2005-2013) |
|---|--|
| Action orientation (being proactive, taking initiative, maintaining energy and drive) | 1 |
| Command skills and leading others | 1 |
| Compassion / Understanding others (interpersonal skills) | |
| Conflict management | 1 |
| Conflict-of-interest (minimizing and managing COI) | |
| Decision-making | 2 |
| Difficult conversations (dealing with difficult people) | 8 |
| Engineering contracts, use of plans & specifications, cost estimates, and bid documents, | 6 |
| Intellectual property and patent protection | |
| Law and engineering (reducing professional litigation risks, engineering errors & omissions insurance, expert witnessing) | 7 |
| Listening | |
| Managing change and innovation | |
| Managing diversity | |
| Negotiation | 5 |
| Organizational skills | |
| Personality types | 1 |
| Perspective / thinking globally | |
| Planning | |
| Priority setting | |
| Process / systems management | |
| Results orientation (focusing on the bottom line) | |
| Self-knowledge / Self-development | |
| Sizing up people | 4 |
| Strategic agility | |
| Teamwork and team meeting dynamics | 2 |
| Time management | |
| Work / Life balance | 5 |

The learning outcomes for the course are that upon successful completion of the course, each student will be able to:

1. Write and revise a professional quality resume and cover letter
2. Describe and begin taking those steps required for professional registration and/or application to graduate school or other professional schools (e.g., veterinary school, medical school, dentistry, optometry)
3. Analyze videotaped job interviews and identify good and bad practices
4. Identify and discuss selected professional development / business practice topics relevant to the engineering profession (e.g., reducing professional litigation risks, conflict management, engineering contracts, difficult conversations, work/ life balance, negotiation skills, decision making, managing meetings, team dynamics)
5. Describe the importance of continuing education and life-long learning to career advancement/ satisfaction and propose what forms this education may take in their future including self-study, graduate work, membership in professional societies, etc.
6. Recognize professional ethical dilemmas and analyze case studies from the engineering profession
7. Develop a professional quality career portfolio that showcases mastery of eleven specific industry-endorsed learning outcomes (ABET a-k):
 - a. an ability to apply knowledge of mathematics, science, and engineering
 - b. an ability to design and conduct experiments, as well as to analyze and interpret data
 - c. an ability to design a system, component, or process to meet desired needs
 - d. an ability to function multi-disciplinary teams
 - e. an ability to identify, formulate, and solve engineering problems
 - f. an understanding of professional and ethical responsibility
 - g. an ability to communicate effectively
 - h. the broad education necessary to understand the impact of engineering solutions in a global and societal context
 - i. a recognition of the need for, and an ability to engage in life-long learning
 - j. a knowledge of contemporary issues
 - k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Appendix A lists two of the individual weekly assignments used to build the portfolio. A rubric (Appendix B) was developed to aid the grading of individual submissions and is shared with the class via the course syllabus to help guide students as they complete their portfolio assignments.

Results and Discussion

Student performance on ABET outcomes as evidenced by grades on their portfolio assignments over four years are summarized in Figure 1. The average annual score did not fall below 80% on any outcome, reflecting the fact that these were materials

specifically selected by the student to show their mastery of the appropriate learning outcome, and that many of these materials had already received instructor feedback in the courses for which they were initially submitted.

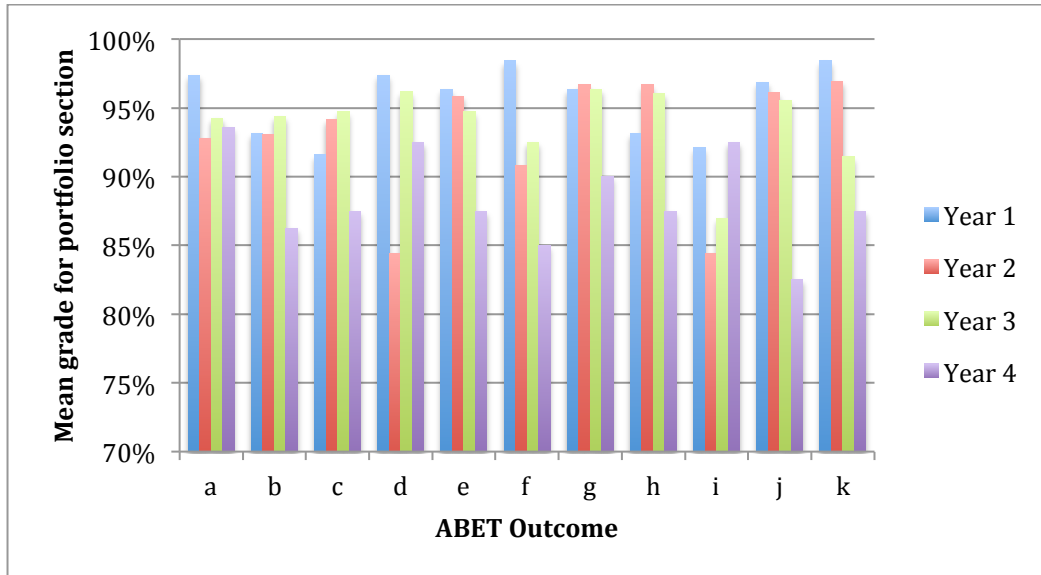


Figure 1. Assessment of student performance on portfolio assignments by ABET a-k outcome

ABET program evaluators have been very complementary about the portfolios, and how they provide the accreditation evaluator with a good overview of student outcomes attainment on an outcome-by-outcome basis. Employers have spoken with faculty about how impressed they have been by the creativity and professionalism exhibited by many of the portfolios. The instructor has observed that portfolios help shift the students' emphasis toward quality work, encouraging use of their evaluative and creative skills, and allowing them to take more control of their own learning.

However, for some students the process was uncomfortable and required additional instructor support. Therefore, it is important to carefully explain to students how and why portfolios enhance learning, to provide an appropriate level of structure in the course assignments, and to help students design and implement effective time management strategies by staggering deadlines for the materials across the entire academic term.

Further refinements have been made on individual assignments, the grading process, and evaluative rubric used in conjunction with the student portfolio over the author's nine offerings of the course. The student portfolio is recommended for use in professional development courses. Future research and enhancements could include the use of e-Portfolios, student peer evaluation of portfolios, and pre-/ post- tracking of student success in interviewing and job-hunting skills.

Conclusions

Student portfolios have been useful tools for assessing and communicating achievement of ABET student outcomes. The use of student portfolios, along with the introduction of topics on professional skills and business practices, has also been successful for engaging students in a required professional development course, helping to prepare them for the engineering profession, and encouraging them to reflect upon their undergraduate career. Assessment data shows that students are achieving ABET outcomes and that students value both the course and the main deliverable for the course: their student portfolio.

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Appendix A. Examples of weekly a-k assignments used to build the student portfolio

Application Assignment

ABET outcome (a): “Engineering programs must demonstrate that their students attain an ability to apply knowledge of mathematics, science, and engineering” (www.abet.org)

Select a completed assignment (homework, lab report, exam, technical report, etc.) that demonstrates your ability to apply math, science, and engineering principles. Try to choose one that is error-free, neatly presented, and something you would be confident showing to a potential employer. Please make a copy (preferably with any grades blanked out) to place in your final physical portfolio for this assignment.

Write a one-paragraph introduction to your chosen document, explaining briefly what the selected document is and its context, then explaining how it demonstrates that you have achieved this ABET outcome (a). Place the draft of your introductory paragraph in the online course dropbox.

After you receive a grade for the draft, make those improvements suggested in the instructor’s feedback, print out the revised version, and place it in your portfolio directly before the document it describes.

Experimental Design

ABET outcome (b): “Engineering programs must demonstrate that their students attain an ability to design and conduct experiments, as well as to analyze and interpret data;” (www.abet.org)

TWO OPTIONS (Pick one):

1. *Select one completed assignment (homework, lab report, exam, technical report, etc.) that demonstrates your ability to design and conduct experiments. I recommend your lab reports from any FABE class. Try to choose one that is error-free, neatly presented, and something you would be confident showing to a potential employer. Please make a copy (preferably with any grades blanked out) to place in your final physical portfolio for this assignment.*

Write a one-paragraph introduction to your chosen document, explaining briefly what the selected document is and its context, then explaining how it demonstrates that you have achieved this ABET outcome (b). Place the draft of your introductory paragraph in the course CARMEN dropbox.

2. *If you cannot locate something appropriate, please complete the following alternative assignment:*

Assume you have been asked to design and conduct a set of experiments in conjunction with your capstone or other project (class or work-related) to aid the engineering decision making process.

In paragraph form, please answer the following ten questions:

1. Describe your project. What kind of experiment would work best for your project?
 - a. Laboratory experiment (small-scale)
 - b. Pilot experiment (medium-scale)
 - c. Field study (full- or large-scale)

- d. Survey (human opinion or state-of-practice)
2. Preliminary familiarization experiments are often used to duplicate earlier results from other tests, to learn to operate new equipment, to test the wording of certain survey questions, or to help better define the larger design problem. What preliminary familiarization experiments might you use for your project?
3. Once you have finished the preliminary stage, you are ready to begin the actual experiment itself. What would be your experimental test unit (i.e., the thing being tested)?
4. What would be your response variable (i.e., data to be collected)?
5. What would be your experimental factors (i.e., primary variables controlled by experimenter)?
6. What treatments would you use (i.e., specific levels or values of the factors of interest)?
7. How many replicates of each test would you run?
8. Why did you select that number of replicates (why not more or fewer)?
9. What statistical techniques would you use to analyze the data you collect?
10. How might the statistical results from your proposed experiment be used to improve the overall design of your project?

Engineering Design

ABET outcome (c): “Engineering programs must demonstrate that their students attain an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;” (www.abet.org)

Select one completed assignment (team project report, homework, CAD drawings, technical report, etc.) that demonstrates your ability to design a system, component, or process. Your final capstone design report, when available, would be the preferred choice. Try to choose an example that is error-free, neatly presented, and something you would be confident showing to a potential employer. Please make a copy (preferably with any grades blanked out) to place in your final physical portfolio at the end of this course.

Write a one-paragraph introduction to your chosen document, explaining briefly what the selected document is and its context, then explaining how it demonstrates that you have achieved this ABET outcome (c). Place the draft of your introductory paragraph in the course CARMEN dropbox.

Multi-disciplinary teams

ABET outcome (d): “Engineering programs must demonstrate that their students attain an ability to function on multi-disciplinary teams;” (www.abet.org)

Recall an experience you have had as a member of a team; it might have been at school, on the job, or within your community. Write a brief (1 page or less) essay addressing the following questions:

- *Describe the situation briefly: what was the team supposed to accomplish?*
- *Who was the team leader and how did that leader emerge?*
- *What was your role in the group and what contributions did you make to the team?*
- *How did your group make decisions?*

- *What teamwork problems or conflicts did you observe?*
- *Did the team deal with those problems openly?*
- *What techniques did your team members use (or might they have used) to solve their teamwork problems?*
- *Describe your overall evaluation of the team both in terms of accomplishing its task and in terms of the satisfaction each member felt.*

Place the draft of your teamwork essay in the online course dropbox.

Engineering problem solving

ABET outcome (e): “Engineering programs must demonstrate that their students attain an ability to identify, formulate, and solve engineering problems;”
(www.abet.org)

Select one assignment (homework, lab report, exam, technical report, etc.) that demonstrates your ability identify, formulate, and solve engineering problems. Try to choose an example that is error-free, neatly presented, and something you would be confident showing to a potential employer. Please make a copy (preferably with any grades blanked out) to place in your final physical portfolio at the end of this course.

Write a one-paragraph introduction to your chosen document, explaining briefly what the selected document is and its context, then explaining how it demonstrates that you have achieved this ABET outcome (e). Place the draft of your introductory paragraph in the course CARMEN dropbox.

Engineering Ethics

ABET outcome (f): “Engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility;”
(www.abet.org)

Select one of the engineering ethics case studies at either of the following websites:

<http://www.niee.org/cases/>

<http://www.engineering.com/Library/ArticlesPage/tabid/85/articleType/CategoryView/categoryId/7/Ethics-Case-Studies.aspx>

It may be one we mentioned in class or any other one that interests you. Read the facts given for the case, and perform or describe each of the 6 steps for approaching moral dilemmas as you would apply them to this case:

1. Identify relevant moral factors and reasons (conflicting responsibilities, competing rights, incompatible ideals)
2. Identify all pertinent facts
3. Rank moral considerations in order of importance (if possible)
4. Consider alternative courses of action
5. Talk with colleagues (or friends), seeking their suggestions and alternative perspectives
6. Arrive at a carefully reasoned judgment by weighing all the relevant moral factors and reasons in light of the facts and justify your decision

Write a three-paragraph essay. The first paragraph should describe the case. The second paragraph should address the 6 steps described above. Conclude with a third paragraph discussing the points where you agreed and where you disagreed with the NSPE's suggested ruling on the case (or the actual ruling in a court of law). Place the draft of your essay in the course CARMEN dropbox. *Please note that you may submit a completed assignment from a previous course you have taken if it also meets the requirements of this assignment.*

Communicate Effectively

ABET outcome (g): “Engineering programs must demonstrate that their students gain the ability to communicate effectively;” (www.abet.org)

Write a short essay which addresses the following:

- Identify three types of documents that you expect you will be preparing regularly in your professional career
- Describe a written document you prepared for a college assignment that is similar to or the same as each of the document types you identified
- Explain the role of oral presentations in your future career
- Describe the ways that your appreciation of quality communication skills has changed during your engineering studies

Place the draft of your essay in the course CARMEN dropbox. In your final portfolio, include one completed assignment (lab report, technical report, essay, PowerPoint printout, etc.) that demonstrates your ability to communicate effectively. Please make a copy (preferably with any grades blanked out) to submit for this assignment.

Global and Societal Impacts

ABET outcome (h): “Engineering programs must demonstrate that their students gain a broad education necessary to understand the impact of engineering solutions in global and societal context;” (www.abet.org)

Write a short essay which addresses the following:

- Identify by title three non-engineering courses that you attended that included coverage of global or societal issues.
- For each course, describe one issue that engineering solutions would impact and explain that impact briefly.
- Describe the ways in which your Capstone Design project (or other applicable design project you have worked on at OSU or on the job) has global or societal impacts that you had to consider in your design.

Life-Long Learning

ABET outcome (i): “Engineering programs must demonstrate that their students attain a recognition of the need for, and the ability to engage in life-long learning.” (www.abet.org)

Write a short essay which addresses the following:

- Describe your **career goals**.
- Describe the **formal** continuing education learning experiences you will likely seek out after you graduate with your B.S. FABE from OSU.
- Describe the **informal** learning experiences will you seek out (e.g., reading technical journals and books, web-based training, participating in professional organizations such as ASABE, presenting papers at professional conferences, other)?
- Describe the **strategies** you will use to stay current technically and professionally in the future.

Contemporary Issues

ABET outcome (j): “Engineering programs must demonstrate that their students attain a knowledge of contemporary issues;” (www.abet.org)

Write a short essay which addresses the following:

- Identify two contemporary issues, and describe how your training in engineering has prepared you to contribute to these two issues. (For instance, global warming is a contemporary issue. You could then describe what you have learned that could be applied to reduce carbon emissions from industrial facilities.)
- Identify a third contemporary issue that is not related to engineering, and how your experience at OSU has prepared you to understand this issue.

Techniques, Skills, and Modern Engineering Tools

ABET outcome (k): “Engineering programs must demonstrate that their students gain the ability to use techniques, skills, and modern engineering tools necessary for engineering practice;” (www.abet.org)

Write a short essay which addresses the following:

- Identify three techniques, skills, or modern engineering tools you have used during your academic career or any internship. For each of the three, describe why this was an appropriate technique, skill, or tool for the task, and what you learned from its application.
- Describe how you anticipate using at least one of the three techniques, skills, or tools you identified during your future professional career.

Place the draft of your essay in the course CARMEN dropbox. In your final portfolio, include one completed assignment (lab report, technical report, essay, PowerPoint printout, etc.) that demonstrates your ability to use modern engineering techniques, skills, and tools. Please make a copy (preferably with any grades blanked out) to submit for this assignment.

Appendix B. Grading rubric for student portfolio materials

| | What would an excellent example look like? (SCORE = 3%) | What would an acceptable example look like? (SCORE = 2%) | What would an unacceptable example look like? (SCORE = 1%) |
|---|--|---|--|
| Audience awareness <i>[Course deliverables are intended to meet professional standards and to be viewed by potential employers. Course instructor provides feedback and evaluation but is not the ultimate audience.]</i> | Student persuasively articulates a clear purpose and recognizes the expectations that a potential employer might have for the materials within a professional context. | Student articulates a clear purpose and shows some recognition of the audience. | Purpose is unclear, and the student shows little recognition of audience or context. |
| Engagement with topic | Student not only follows the basic requirements for the assignment, but demonstrates a serious, thoughtful engagement with the topic, going above and beyond basic requirements. | Student follows the basic requirements for the assignment. | Student attempts but does not complete the basic requirements for the assignment. |
| Mastery supported by appropriate evidence | The selection of materials or completed assignment shows exemplary achievement of the corresponding ABET outcome. | The selection of materials or completed assignment shows acceptable proficiency in the ABET outcome. | Student fails to support claims with appropriate evidence or the evidence selected is unclear or not relevant. |
| Organization and logic | Student arranges material in a clear, persuasive way that an audience can easily follow and that strengthens the overall claims of mastery. | Student arranges material clearly so that an audience can follow reasonably well, but there are occasional gaps in thinking. | Material is poorly organized, and audiences may have a hard time following the student's ideas and logic. |
| Effective use of professional conventions | Student has carefully and thoughtfully proofread and followed appropriate stylistic conventions. Very few or no mistakes in spelling, grammar, word choice, and punctuation. | Work generally proofread, but some conventions have not been followed. More than a few mistakes in spelling, grammar, word choice, or punctuation, but these don't obscure the student's ideas. | Work has been poorly proofread, and stylistic conventions are not followed. Many distracting mistakes in spelling, grammar, word choice, and punctuation that obscure the student's ideas. |