

## An assessment of ABET programme outcomes (a) to (k)

Hosni I. Abu-Mulaweh

Indiana University-Purdue University Fort Wayne  
Fort Wayne, United States of America

**ABSTRACT:** In this article, the author presents a comprehensive assessment process for programme outcomes (a) to (k) of the Accreditation Board for Engineering and Technology (ABET), which is being implemented in the mechanical engineering programme at Indiana University-Purdue University Fort Wayne (IPFW) in Fort Wayne, USA. This assessment process is part of a plan that was developed by the author, with some feedback from the faculty, to assess the mechanical engineering educational objectives and programme outcomes using internal and external measures. This process involves data and feedback from several parties that include: course instructors (faculty), students and graduating seniors, local industries that sponsor capstone senior design projects, and the Fundamental of Engineering (FE) examination.

### INTRODUCTION

The major thrusts of the Department of Engineering at Indiana University-Purdue University Fort Wayne (IPFW), Fort Wayne, USA, are to ensure that its graduates understand the basic concepts of mathematics and sciences, have studied one engineering field in sufficient depth to appreciate its methodologies of analysis and design, and have acquired a solid basis for life-long learning. These goals are accomplished through the establishment of courses in the following:

- Science and mathematics;
- Required technical topics in the major area;
- Elective technical topics that combine breadth of subject matter with specific study in depth;
- General education.

It should also be noted that laboratory and designs experience are an essential part of the curricula.

The criteria of the Accreditation Board for Engineering and Technology (ABET) are based on the principles of total quality management and continuous improvement. The criteria require that each programme's mission be consistent with the institutional mission. The mission must be translated into specific programme educational objectives and programme outcomes that are expected as a result of the educational process. The programme outcomes should be measurable and must be assessed regularly. The results of outcomes assessment should be used as feedback in order to make programme improvements. Finally, a quality assurance and management process must be in place to achieve success. Mendelson and Noorani recommended that engineering programmes start early in their strategic planning and preparing for an ABET accreditation visit [1]. Several studies were published in the past that have dealt with assessment issues [2-7].

This paper presents a detailed assessment process of the programme outcomes utilising direct and indirect measures.

### MECHANICAL ENGINEERING PROGRAMME

#### Educational Objectives

These educational objectives are simply statements that describe the expected accomplishments of graduates during the first several years following their graduation from the engineering programme [9]. The faculty members of the Department of Engineering continuously work with alumni, local employers and the Department's Industry Advisory Board on the formulation of educational objectives.

The following educational objectives were established and approved by the faculty of the Department of Engineering in spring 2001. They were developed based on the 2001 alumni survey and on recommendations from the Department's Industry Advisory Board, and are consistent with the missions of the University, the School and the Department. They are as follows:

1. To prepare students for successful careers in industry, tailored to meet the needs of the Northeast Indiana region.
2. To develop student expertise in the synthesis process, with an emphasis on product design.
3. To provide the opportunity for students to work as a team on multidisciplinary projects.
4. To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to solve engineering problems and to pursue graduate studies.
5. To promote student awareness of the need for professional registration and life-long learning, to introduce students to written ethical codes and to offer them ethical guidance as they embark on their careers.

## MECHANICAL ENGINEERING PROGRAMME OUTCOMES

The mechanical engineering programme outcomes lead to the achievement of the programme educational objectives as illustrated in Table 1. The following programme outcomes of the mechanical engineering programme at the IPFW were established and approved by the faculty of the Department of Engineering in spring 2002:

1. Graduates will demonstrate basic knowledge in chemistry, mathematics, physics and engineering.
2. Graduates will demonstrate the ability to identify, formulate and solve mechanical engineering problems.
3. Graduates will demonstrate the ability to design and conduct experiments, interpret and analyse data, and report results.
4. Graduates will demonstrate the ability to design a mechanical system, component or process that meets desired specifications and requirements.
5. Graduates will demonstrate the ability to function on engineering and science laboratory teams, as well as on multidisciplinary design teams.
6. Graduates will use modern engineering software tools and equipment to analyse mechanical engineering problems.
7. Graduates will demonstrate an understanding of their professional and ethical responsibilities.
8. Graduates will be able to communicate effectively in both verbal and written forms.
9. Graduates will have the confidence for self-education and the ability for life-long learning. They will also have a broad education in order to understand the impact of engineering on society and demonstrate awareness of contemporary issues.

Table 1: The relation between the engineering programme outcomes and the programme objectives.

		Programme Outcomes								
		1	2	3	4	5	6	7	8	9
Educational Objectives	1	X	X	X		X	X			
	2			X	X					
	3					X			X	
	4	X	X							
	5							X		X

## ABET AND ENGINEERING PROGRAMME OUTCOMES

According to the ABET, engineering programmes must demonstrate that their graduates have the following:

- a. An ability to apply knowledge of mathematics, science and engineering;
- b. An ability to design and conduct experiments, as well as to analyse and interpret data;
- c. An ability to design a system, component or process to meet desired needs;
- d. An ability to function on multidisciplinary teams;
- e. An ability to identify, formulate and solve engineering problems;
- f. An understanding of professional and ethical responsibilities;
- 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 [8].

The engineering programme outcomes at the IPFW encompass the ABET outcomes a-k, as illustrated in Table 2.

Table 2: The relation between ABET outcomes a-k to the IPFW's mechanical engineering educational outcomes.

ABET	a	b	c	d	e	f	g	h	i	j	k
Mechanical engineering	1	3	4	5	2	7	8	9	9	9	6

## MECHANICAL ENGINEERING COURSE OUTCOMES

Outcomes for all the required and technical elective mechanical engineering courses have been developed by the faculty members of the mechanical engineering programme. The Assessment Committee assigned a primary faculty and a related faculty, based on their area of expertise and experience, in order to establish the outcomes for each course.

The course outcomes were mapped to the ABET and mechanical engineering programmes outcomes. The mapping indicated that the courses outcomes would lead to the achievement of the ABET programme outcomes.

## THE ASSESSMENT PROCESS

The mechanical engineering programme outcomes at the IPFW are assessed using direct and indirect measures, as summarised in Table 3.

Table 3: Direct and indirect measures.

Direct Measures	Indirect Measures
<ol style="list-style-type: none"> <li>1. Interim assessment by faculty</li> <li>2. Capstone assessment: <ul style="list-style-type: none"> <li>• Industry sponsor</li> <li>• Faculty members</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li>1. Interim assessment by students: <ul style="list-style-type: none"> <li>• Course Outcomes</li> <li>• Laboratory Evaluation</li> <li>• Engineering Students' Fora</li> </ul> </li> <li>2. Exit interview</li> <li>3. Fundamental of Engineering (FE) examination</li> <li>4. Co-op education coordinator report</li> </ol>

As shown in Table 1, several measurement instruments or tools are used in this process. In all cases, the information collected is first reviewed by the assessment committee and then forwarded to the appropriate committee of the faculty member with a charge to make recommendations or to suggest corrective actions.

These recommendations are then presented to the faculty for discussion and a final action is fed back to offer possible changes in the curriculum content. This process is illustrated in Figure 1.

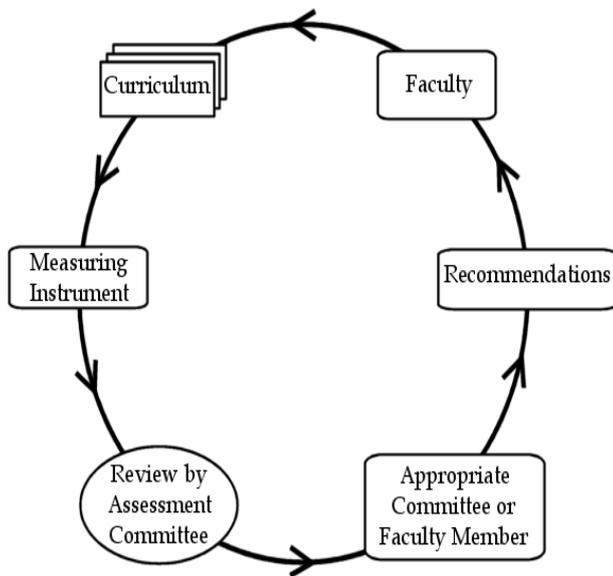


Figure 1: The assessment process cycle.

## DIRECT MEASURES

### Interim Assessment by Faculty

A standard *Assessment Form* (see the Appendix) developed by the Assessment Committee is used in the assessment of the programme outcomes by the faculty. Several rubrics have been developed for each ABET programme outcome to help the faculty in the assessment of the outcomes. At the end of a given semester, each faculty must complete and submit a separate assessment form for the assigned programme outcomes for all of his/her courses offered in that semester.

#### Frequency:

- Each engineering programme outcomes are to be assessed by the faculty in all corresponding courses over a four-semester period starting spring 2004;
- Starting spring 2006, in each semester, the Assessment Committee will assign a representative set of programme outcomes to be assessed in certain courses.

#### Action:

- The assessment forms are reviewed by the Assessment Committee. The results are shared with the rest of faculty;
- Any outcome in any given course that was not achieved is reassessed in the following semester of the offered course;
- If the outcome was not achieved, the faculty outlines a plan (ie solution) that helps in achieving the outcome. This plan is forwarded to the faculty member who will be teaching the course next time around.

### Capstone Senior Design Assessment

#### Industry Sponsor

Capstone senior design projects are team projects with the majority of these projects being sponsored by local industry. The achievement of the course outcomes of the capstone senior design is to be assessed by the project supervisors of the corresponding industry sponsors. In addition, the percentage of the senior design projects that are sponsored by industry is also a measure of the programme's outcomes.

#### Frequency:

- The Capstone Senior Design Coordinator sends the assessment form to all project supervisors of the corresponding companies by mid-April of each spring semester. The completed assessment forms are returned back to the coordinator before the senior design presentation.

#### Action:

- The Assessment Committee reviews the feedback;
- Any concerns or negative feedback are referred to the Senior Design Committee and/or Curriculum Committee to act upon and provide recommendations.

#### Faculty Members

The faculty members of the Department of Engineering also assess the achievement of the course outcomes of the capstone senior design. A sample copy of the assessment form that is completed by the supervisors can be found in the Appendix.

#### Frequency:

- Faculty members complete the Capstone Senior Design form after the senior design presentations.

#### Action:

- The Assessment Committee reviews the feedback;
- Any concerns or negative feedback are referred to the Senior Design Committee and/or Curriculum Committee to act upon and provide recommendations.

## INDIRECT MEASURES

### Interim Assessment by Students

#### Course Outcomes

For each course, the achievement (or not) of the course outcomes are assessed by all students enrolled in the course.

#### Frequency:

- Student evaluation of the course outcomes is carried out by all students enrolled in a class at the end of the semester (in the week before the final examinations week);
- This assessment is carried out by students enrolled in all mechanical engineering programme courses over a two-semester period starting fall 2004;
- The assessment for technical elective courses that are not offered in fall 2004 and spring 2005 will be carried out the next time that they are offered;
- Starting fall 2005, this type of interim assessment will be carried out only in selected courses each semester.

#### Action:

- The Assessment Committee reviews the feedback;
- Any negative feedback is forwarded to the course instructor;
- The instructor, in turn, addresses the concern;
- Any course outcomes that were not achieved are reassessed in the following semester in which the course is offered.

## Laboratory Evaluation

Laboratories are an integral part of the mechanical engineering programme at the IPFW. The mechanical engineering curriculum consists of five laboratories: ME 281 - Electronics and System Engineering through Robotics Laboratory, ME 282 - Measurements and Instrumentation Laboratory, ME 304 - Mechanics and Materials Laboratory, ME 319 - Fluid Mechanics Laboratory, and ME 322 - Heat Transfer Laboratory.

In order to ensure that the laboratories are well equipped and up to standard to fulfil their mission in achieving the related programme outcomes, the Assessment Committee has developed a laboratory evaluation form to help with this assessment. All students who are enrolled in a laboratory course carry out the laboratory evaluations.

### Frequency:

- Currently, sophomore level laboratories are offered twice a year and junior level laboratories are offered once a year; each laboratory is initially evaluated twice in a row;
- If the feedback is positive, then the laboratory evaluation will be conducted every other year;
- If the feedback for any laboratory is negative, then the laboratory evaluation will be carried out after the appropriate committee's recommendations have been implemented.

### Action:

- The Assessment Committee reviews the feedback;
- Any concerns or negative feedback are referred to the Curriculum Committee and the Laboratory Equipment Committee to act upon and provide recommendations.

## Engineering Students' Fora

The student chapters of the engineering professional societies organise fora to which all engineering students are invited. The Department Chair and the Dean of the School attend the meeting. The purpose of such fora is to bring issues and concerns to the attention of the Department and the School. This feedback is very important and can help the Department to achieve the programme outcomes and hence the educational objectives.

### Frequency:

- A forum is held once a semester.

### Action:

- The Chair of the Department conveys students' feedback to the faculty;
- Any concerns or negative feedback are referred to the appropriate committee to act upon and provide recommendations.

## Exit Interview

All graduating seniors are required to complete an exit survey at the end of their last semester. One component of the exit survey is devoted to assess the achievement of the programme's outcomes.

### Frequency:

- The exit survey is conducted every fall and spring semester in which there are graduating senior(s).
- The exit survey is sent to the graduating seniors at least two weeks before the end of the semester and is returned before the last day of the semester.

### Action:

- The Assessment Committee reviews the feedback;
- Any concerns or negative feedback are referred to the mechanical engineering Curriculum Committee and/or Senior Design Committee to act upon and provide recommendations.

## Fundamental of Engineering (FE) Examination

The FE examination is conducted by the National Council of Examiners for Engineering and Surveying (NCEES). It is held in two four-hour sessions: the AM session tests the lower division subjects and the PM session tests the upper division subjects.

Subjects covered by the FE examination can be mapped or correlated to several ABET programme outcomes, such as *a*, *c*, *e* and *f*. Thus, students' performance on the FE examination can be used as a tool to assess the achievement of some of the programme's outcomes.

### Frequency:

- The graduating seniors of the mechanical engineering programme at the IPFW are strongly encouraged to take the FE examinations.
- The FE examinations are usually held at the IPFW campus during the spring semester (in April).
- The NCEES sends the results to the corresponding institutions by August.

### Action:

- The Assessment Committee reviews the feedback;
- Any concerns or negative feedback are referred to the Curriculum Committee to act upon and provide recommendations.

## Co-op Educational Coordinator Report

A number of mechanical engineering students are enrolled in the co-op education programme. At the end of each session, co-op students and their employers submit written reports about their experiences.

Components of these reports relate to some programme outcomes. A faculty member in the Department is designated as the co-op coordinator. Currently, the number of mechanical engineering students enrolled in this programme is very small.

### Frequency:

- Because of the importance of industrial feedback, the co-op coordinator submits a summary report to the assessment committee every semester.

Action:

- The Assessment Committee reviews this feedback.
- Any concerns or negative feedback are referred to the appropriate committee to act upon and provide recommendations.

ASSESSMENT REPORTS

The Assessment Committee prepares *Assessment Reports* for each engineering programme that summarise the assessment results in each semester. These reports are completed by 1 February and 15 September for the fall and spring semesters, respectively.

CONCLUSION

The assessment plan outlined in this paper is extensive and comprehensive. The plan requires that the results be documented and applied for the further development and improvement of the mechanical engineering programme at the IPFW. The assessment process presented in this paper describes in detail how programme outcomes are measured.

ACKNOWLEDGEMENT

The author would like to thank Dr Hossein Oloomi, Dr Carlos Pomalaza-Raez and Dr Nashwan Younis for their valuable feedback.

REFERENCES

1. Mendelson, M. and Noorani, R., Lessons learned from a successful EC2000 accreditation visit. *Proc. Inter. Conf. on Engng. Educ.*, Oslo, Norway, 7D8 1-6 (2001).
2. Miller, R. and Olds, B.M., Using portfolios to assess student writing. *Proc. 1997 ASEE Annual Conf. & Expo.*, CD-ROM, Milwaukee, USA (1997).
3. Besterfield-Sacre, M.E., Shuman, L.J., Wolfe, H., Atman, C.J., McGourty, J., Miller, R.L., Olds, B.M., and Rogers, G., Defining the outcomes: a framework for EC 2000. *IEEE Trans. on Engng. Educ.*, 43, 2, 100-110 (2000).
4. McGourty, J., Assessing and enhancing student learning through multi-source feedback. *IEEE Trans. on Engng. Educ.*, 43, 2, 120-124 (2000).
5. McGourty, J., Reynolds, J.J., Shuman, L.J., Besterfield-Sacre, M.E. and Wolfe, H., Using multisource assessment and feedback processes to develop entrepreneurial skills in engineering students. *Proc. 2003 ASEE Annual Conf. & Expo.*, CD-ROM, Nashville, USA (2003).
6. Dahm, K.D., Newell, J.A. and Newell, H.L., Rubric development for assessment of undergraduate research: evaluating multidisciplinary team projects. *Proc. 2003 ASEE Annual Conf. & Expo.*, CD-ROM, Nashville, USA (2003).
7. Litzinger, T., Wise, J., Lee, S.H. and Bjorklund, S., Assessing readiness for self-directed learning. *Proc. 2004 ASEE Annual Conf. & Expo.*, CD-ROM, Salt Lake City, USA (2004).
8. Accreditation Board for Engineering and Technology (ABET), Engineering Accreditation Criteria, Criterion 3: Program Outcomes and Assessment (2005), <http://www.abet.org>.

APPENDIX: Assessment form

Assessment Form\*  
 Mechanical Engineering Program  
 Indiana University-Purdue University Fort Wayne

OUTCOME: (a) an ability to apply knowledge of mathematics, science, and engineering

Course #: \_\_\_\_\_ Course Title: \_\_\_\_\_  
 Semester: \_\_\_\_\_ Year: \_\_\_\_\_  
 Instructor: \_\_\_\_\_ Section: \_\_\_\_\_ Number of Students: \_\_\_\_\_

1. Outcome Measures: *(please check all that apply)*  
 Homework  Quizzes  Exams  Projects  
 Final Exam  Lab Reports  Presentations  
 Others (specify) \_\_\_\_\_
2. In general, was the outcome achieved (based on the rubrics listed below)?  
 YES \_\_\_\_\_ NO \_\_\_\_\_  
 Comments: \_\_\_\_\_
3. Do any of the necessary topics needed to be emphasized upon more?  
 YES \_\_\_\_\_ NO \_\_\_\_\_  
 If yes, please list them. \_\_\_\_\_
4. Textbook: Do you recommend changing the textbook in order to better achieve the outcome? If yes, which textbook do you recommend?  
 \_\_\_\_\_
5. Please list any of the outcome measures listed in item (1) which you have not used in the current assessment of this outcome but you recommend using next time around.  
 \_\_\_\_\_

-----  
 If the answer for item (2) is NO, please outline a plan (solution) that will help in achieving this outcome. *(Please use a separate sheet)*  
 -----

RUBRICS:

1. Ability to apply the knowledge of mathematics and science to formulate and analyze engineering problems
2. Ability to apply the knowledge of mathematics, science, and engineering to design components and systems
3. Ability to apply the knowledge of engineering in assembling and testing engineering systems
4. Ability to apply the knowledge of engineering to carry out the tasks impacting engineering systems such as reliability, safety, and environmental issues
5. Others, please specify

---

\* No data, information, or inferences drawn from this assessment form shall be used for activities related, or leading, to the performance review, reappointment, tenure, promotion, or administrative appointment of the faculty.