Introducing a Tool for ABET Course Assessment (A.C.A) for a New Engineering Program

Monika Bubacz, Robert Rabb, Jason Howison and Kevin Skenes
The Citadel, Charleston, SC

Abstract

The Citadel School of Engineering initiated a Bachelor's of Science in Mechanical Engineering program in the fall 2014. During the first semester various classes have been offered to freshmen, sophomores and juniors. The School of Engineering has two ABET accredited programs (Civil and Electrical) and will apply for accreditation of the new Mechanical program as soon as the first mechanical engineering students graduate, which is expected in May 2016. The new program courses have been prepared using the ABET engineering accreditation criteria, and the new team of mechanical engineering faculty is working on collection, assessment and evaluation of the courses in order to provide a quality educational experience for students. This paper will describe an ABET assessment procedure that uses the previously proposed and already incorporated Tool for Evaluating Course Outcomes in addition to grades approval form, student evaluations and faculty feedback to fully evaluate the course after it is finished. The procedure will allow the ME faculty to assess, analyze and suggest improvements that can be implemented in the future offerings. This form of evaluation is currently being used by the ME faculty to identify areas in need of improvement in all ME courses. The authors hope that this new assessment tool will provide a better, unified, consistent, efficient and transparent evaluation and reporting across all courses in the new program.

Keywords

ABET accreditation, course objectives, new engineering program

ABET Accreditation

ABET is a non-profit and non-governmental accrediting agency for academic programs in the disciplines of applied science, computing, engineering, and engineering technology.[1] ABET is a recognized accreditor in the United States by the Council for Higher Education Accreditation. ABET accreditation provides assurance that a college or university program meets the quality standards established by the profession for which the program prepares its students. To date, ABET has accredited over 3,400 applied science, computing, engineering, and engineering technology programs at nearly 700 colleges and universities in 28 countries worldwide.

The ABET accreditation gives an assurance that the professionals that serve the population have a solid educational foundation and are capable of leading the way in innovation, emerging technologies, and in anticipating the welfare and safety needs of the public. Thus the accreditation impacts students, programs and institutions, businesses, industry, government and the public.

The ABET accreditation is a process where educational programs or institutions are reviewed to determine if they meet certain standards of quality. The accreditation is not a ranking system but an assurance that a program or institution meets established quality standards. The ABET engineering accreditation criteria cover all aspects of program evaluation, from high level institutional program educational objectives down to individual program outcomes, including evaluation of a program's continuous improvement processes.[2]

- Program Educational Objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program educational objectives are based on the needs of the program's constituencies.

- Student Outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills, and behaviors that students acquire as they progress through the program. Student outcomes should be defined in order for faculty to have a common understanding of the expectations for student learning and to achieve consistency across the curriculum, as measured by performance indicators. Performance indicators represent the knowledge, skills, attitudes or behavior students should be able to demonstrate by the time of graduation that indicate competence related to the outcome.

- Assessment is one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes and program educational objectives. Effective assessment uses relevant direct, indirect, quantitative, and qualitative measures as appropriate to the outcome or objective being measured. Appropriate sampling methods may be used as part of an assessment process.

- Understanding the alignment between educational practices and strategies promotes efficient and effective assessment practices. This can be accomplished by mapping educational strategies (which could include co-curricular activities) to learning outcomes.

- Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment processes. Evaluation determines the extent to which student outcomes and program educational objectives are being attained. Evaluation results in decisions and actions regarding program improvement.

The New Mechanical Engineering Program at The Citadel

The Citadel School of Engineering has had a proud record of significant contributions at The Citadel since its inception in 1842.[3] The Civil and Environmental Engineering Department was established in 1912 and became accredited in 1936. The Electrical and Computer Engineering Department was established in 1941 and became accredited in 1976. The Mechanical Engineering Program was added in 2014 with the first mechanical engineering courses (MECH) offered in the fall. The School of Engineering will apply for accreditation of the new Mechanical program as soon as the first mechanical engineering students graduate, which is expected in May 2016.

The new Mechanical Engineering Program of Study offers focused tracks in Power and Energy, Manufacturing, Aeronautical Systems, Materials (Composites), and Mechatronics. It is available to the cadet population as well as to the evening students transferring from partnering community and technical colleges (2+2 programs). The full-time evening Mechanical Engineering program mirrors the current full-time evening 2+2 programs in Civil and Electrical Engineering.

The new program courses have been prepared using the ABET engineering accreditation criteria, and the new team of mechanical engineering faculty is working on collection, assessment and evaluation of the courses in order to provide a quality educational experience for students. The authors believe that a transparent, well-understood process of continuous data collection and course assessment and evaluation is crucial for the success of the new program. Also, early improvement and goal-oriented changes will keep the program viable in the long term.

The new mechanical engineering courses are already thoroughly described and approved by the South Carolina Commission on Higher Education. Each one has a list of course outcomes which are being used to evaluate the courses. Once a course is taught, it is critical that each faculty member reviews and critiques the assessment instruments and assessment indicators used to evaluate the course. This ensures the validity of not only the course material, but the evaluation material as well[2]. The course evaluation materials will be archived and used in the program evaluation process for the future ABET accreditation.

The Tool for ABET Course Assessment (A.C.A)

A year ago The Mechanical Engineering Program faculty members proposed to use a unified tool for evaluating MECH course outcomes which was called TECO[4]. The tool has been based on a tool used by the United States Military Academy to assess their Mechanical Engineering Program and Engineering and Technology outcomes.[5] Each course outcome is evaluated by using embedded indicators which consist of selected graded events that are contained within the course. Each embedded indicator is described, and the average grade, the standard deviation of the individual grades and the number of points possible for the graded event are recorded. The data for each embedded indicator is then entered into the appropriate course outcome column. Once all data is entered into the spreadsheet, it automatically computes the average and standard deviation for each course outcome.

TECO has been used as a backbone to a new, more thorough assessment tool, A.C.A., consisting of four documents:

1. Grades Approval Form
2. Course Assessment Data spreadsheet, which contains TECO
3. Faculty and Students Feedback spreadsheet, which contains students course evaluation results
4. Course Assessment Report, which summarizes and discusses the outcomes of the prior documents, and compares the results to outcomes of previous offerings.

Grades Approval

The Grades Approval form combines student data related to final grades. It looks at student incoming and outgoing GPA for the semester the course is taught. It also contains information about final examination scores and final grades. There is a table containing scores for different problems or sections which will also contain historical data and comments. An example of such final exam results comparison for a Dynamic Systems course (MECH 350 Modeling and Analysis of Dynamic Systems with Lab) is presented in Table 1.

Table 1. Sample Final Examination Summary

Problem	Description	Semesters offered				Comments
		Spring 15	Spring 16	Spring 17	Spring 18	
1	Short Answer	89.3%				
2	Modeling	86.7%				
3	Root Locus	80.0%				
4	Frequency Response	90.0%				
5	State-Space	91.1%				
	Average	**89.5%**				**200 pts evenly distributed**

A historical comparison of final exam grades, GPAs and recommended grades will be added and updated as the years progress.

Course Assessment Data

Course Assessment spreadsheet compiles course outcome with ABET outcomes. The instructor or program director subjectively rates how strongly the course outcomes support the ABET outcomes using the Likert scale from 1 - strongly disagree to 5 - strongly agree. At The Citadel these values come from the ABET course description. At the end of semester the instructor evaluates the values, and if they do not match or are close, a change to the course syllabus and ABET description may be suggested. An example of course outcome vs. ABET outcome can be found in Table 2.

Table 2. Sample Course Outcome vs. ABET Outcome Assessment

ME Program Outcomes	Post Instruction Assessment	Subjective Rating	Course Objectives			
			1. Model ...	2. Analyze …	3. Design …	4. Connect …
(a) an ability …	4.00	4.00	2	4	4	3
(b) an ability …	4.00	4.00	3	4	4	2
(c) an ability …	4.00	4.00	3	4	4	2
⋮						

A corresponding chart containing Post Instruction Assessment for the ABET outcomes is presented in Figure 1.

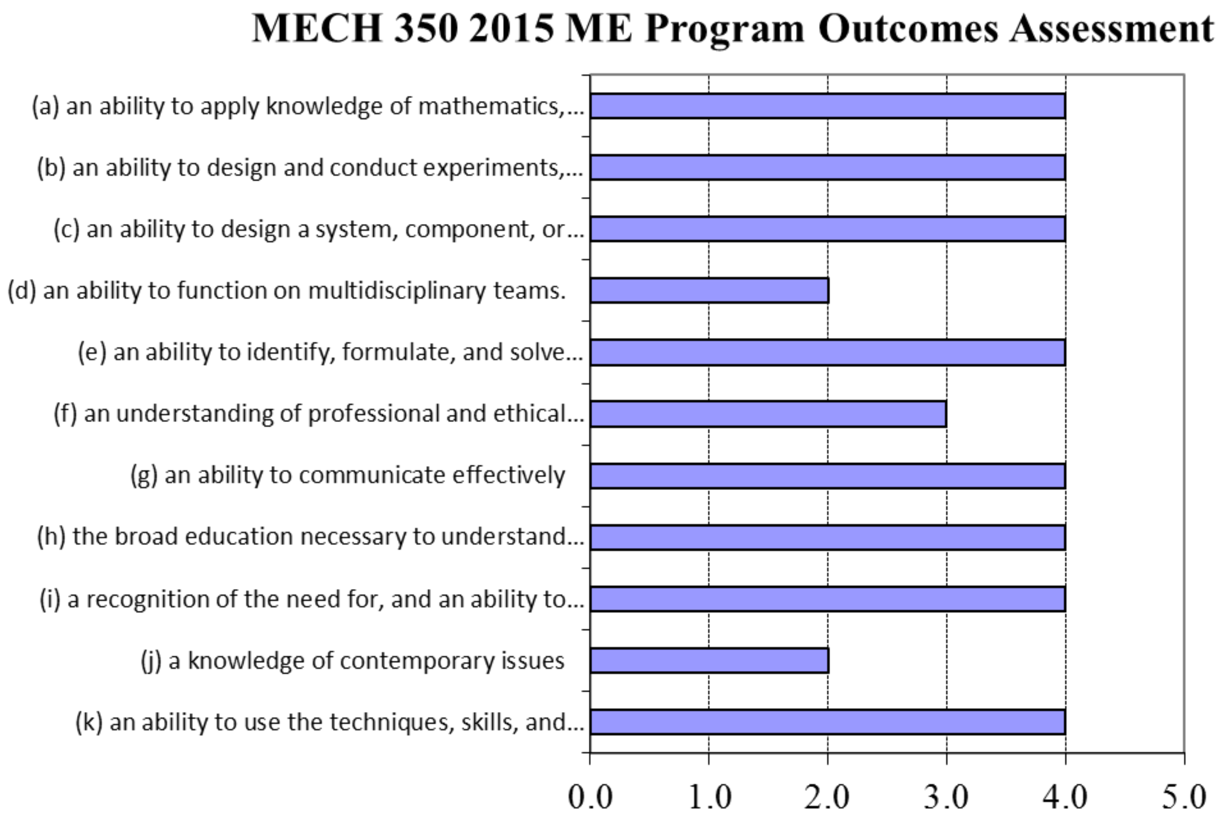

Figure 1. Post Instruction ABET Outcomes Assessment

The previously introduced TECO spreadsheet is modified to include objective and subjective ratings. The faculty member(s) teaching the course determine the course outcomes that most strongly support the program outcomes. The Maximum Level of Support indicates how strongly the specific course outcome supports the program outcome(s). The Objective Rating is a scaled score (0-5) based on the student performance of the graded events or embedded indicators. The combination of the subjective faculty evaluation with the embedded indicators create a rating of how well students in a particular course are meeting the program outcomes. The resulting evaluation of graded events combines the strengths of objective graded evaluation and subjective faculty assessment. Table 2 shows modified TECO matrix.

MECH 350 2015 COURSE OUTCOMES ASSESSMENT																				
Embedded Indicators					1. Model the dynamics of various physical systems that include mechanical and electrical components.				2. Analyze a physical system that utilizes a control system and determine its ability to meet performance specifications for stability, steady-state error, and transient response.				3. Design a controller for a physical system to meet a set of performance specifications using Root Locus, Frequency Response, and State-Space methods.				4. Connect and integrate topics from Thermodynamics, Statics, Dynamics, Fluids, EE Fundamentals, Circuit Theory, Basic Electronics, Linear System Theory, and/or Signal Representation Techniques.			
Indicator	**Description**	**Avg Pts Earned**	**Stnd Dev %**	**Pts Possible**	**Pts Earned**	**Stnd Dev %**	**Stnd Dev Pts**	**Pts Possible**	**Pts Earned**	**Stnd Dev %**	**Stnd Dev Pts**	**Pts Possible**	**Pts Earned**	**Stnd Dev %**	**Stnd Dev Pts**	**Pts Possible**	**Pts Earned**	**Stnd Dev %**	**Stnd Dev Pts**	**Pts Possible**
HW 1	Modeling	18.83	0.47%	20	18.83	0.47%	0.09	20												
HW 2	Modeling	18.83	0.24%	20	18.83	0.24%	0.05	20												
LAB 1	1st Order Response	39.67	0.47%	40	39.67	0.47%	0.19	40												
WkBk 1	Eng Calc	5.00	0.00%	10	5.00	0.00%	0.00	10												
Exam 1	Modeling / Eng Calc	94.17	1.93%	100	94.17	1.93%	1.93	100												
HW 3	Root Locus	17.83	0.85%	20					17.83	0.85%	0.17	20	17.83	0.85%	0.17	20	17.83	0.85%	0.17	20
HW 4	Root Locus	17.50	1.87%	20					17.50	1.87%	0.37	20	17.50	1.87%	0.37	20	17.50	1.87%	0.37	20
HW 5	Root Locus / Controller	18.33	0.47%	20					18.33	0.47%	0.09	20	18.33	0.47%	0.09	20	18.33	0.47%	0.09	20
LAB 2	Gain Adjustment	35.67	0.47%	40					35.67	0.47%	0.19	40	35.67	0.47%	0.19	40	35.67	0.47%	0.19	40
WkBk 2	Eng Calc	4.50	0.41%	10					4.50	0.41%	0.04	10	4.50	0.41%	0.04	10	4.50	0.41%	0.04	10
Exam 2	Root Locus / Controller	90.50	7.08%	100					90.50	7.08%	7.08	100	90.50	7.08%	7.08	100	90.50	7.08%	7.08	100
HW 6	Freq Resp	19.67	0.47%	20					19.67	0.47%	0.09	20					19.67	0.47%	0.09	20
HW 7	Freq Resp/Controller	19.67	0.47%	20					19.67	0.47%	0.09	20	19.67	0.47%	0.09	20	19.67	0.47%	0.09	20
LAB 3	PD Control	35.17	0.24%	40					35.17	0.24%	0.10	40	35.17	0.24%	0.10	40	35.17	0.24%	0.10	40
LAB 4	Freq. Resp. System ID	35.00	0.00%	40					35.00	0.00%	0.00	40	35.00	0.00%	0.00	40	35.00	0.00%	0.00	40
WkBk 3	Eng Calc	4.67	0.24%	10					4.67	0.24%	0.02	10	4.67	0.24%	0.02	10	4.67	0.24%	0.02	10
Exam 3	Freq Resp / Controller	88.33	2.46%	100					88.33	2.46%	2.46	100	88.33	2.46%	2.46	100	88.33	2.46%	2.46	100
HW 8	State Space	19.33	0.47%	20	19.33	0.47%	0.09	20	19.33	0.47%	0.09	20					19.33	0.47%	0.09	20
HW 9	State Space / Controller	19.50	0.71%	20	19.50	0.71%	0.14	20	19.50	0.71%	0.14	20	19.50	0.71%	0.14	20	19.50	0.71%	0.14	20
WkBk 4	Eng Calc	5.00	0.00%	10	5.00	0.00%	0.00	10	5.00	0.00%	0.00	10	5.00	0.00%	0.00	10	5.00	0.00%	0.00	10
Exam 4	State Space / Controller	55.00	0.41%	60	55.00	0.41%	0.25	60	55.00	0.41%	0.25	60	55.00	0.41%	0.25	60	55.00	0.41%	0.25	60
LAB 5	Model/RL/FR/SS	34.33	3.30%	40	34.33	3.30%	1.32	40	34.33	3.30%	1.32	40	34.33	3.30%	1.32	40	34.33	3.30%	1.32	40
Final	Model/RL/FR/SS	179.00	10.23%	200	179.00	10.23%	20.46	200	179.00	10.23%	20.46	200	179.00	10.23%	20.46	200	179.00	10.23%	20.46	200
Totals					488.66		24.52	540	699.00		32.98	790	660.00		32.79	750	699.00		32.98	790
Assessment					**90.5%**				**88.5%**				**88.0%**				**88.5%**			
Stnd Dev					**4.5%**				**4.2%**				**4.4%**				**4.2%**			
Max Level of Support					**5.00**				**5.00**				**5.00**				**5.00**			
Objective Rating					**4.52**				**4.42**				**4.40**				**4.42**			
Equiv. Percent					**90.5%**				**88.5%**				**88.0%**				**88.5%**			

Figure 2. New TECO matrix modified with Objective Rating

The Excel file also contains a spreadsheet with internal student evaluation of the course. Part of the end-of-semester in-class evaluation asks students to rate the course objectives using the same 1 through 5 Likert scale. These values are compared to instructor evaluation of the course in the Course Assessment Report.

Faculty and Students Feedback

Faculty and Students Feedback spreadsheet explores students' course evaluations. The responses are divided into sections related to general course questions, instructor evaluation and course objectives assessment and graphed for better visualization of results.

Course Assessment Report

The assessment report contains the course catalog description, times offered and enrollment, location and textbooks. It lists course objectives, detailed course content and specifies what topics support what objectives – see Table 3. The report also summarizes grading requirements.

Table 3. Sample Lesson Schedule

Lesson	Title / Topic	Supported Course Outcomes
1	Introduction to Controls/Math Review	1
	Modeling Electrical Systems	1
2	Modeling Mechanical Systems	1
	Modeling Systems with Gears	1
⋮		
27	**Lab #5 –** PID Control	2, 3, 4
	End of Course Review I	1, 2, 3, 4
28	End of Course Review II	1, 2, 3, 4
	End of Course Review III	1, 2, 3, 4

Course outcome assessment for the instructor or director, if there are many sections, and students are compare and discussed – see Table 4.

Table 4. Sample Course Outcomes Assessment

Course Outcome	Course Director Assessment	Student Assessment	Remarks
1. Model ...	4.52	4.67	Students learn modeling at the beginning of the course and are out of practice at the end of course review lessons.
2. Analyze ...	4.42	4.67	
3. Design ...	4.40	4.67	
4. Connect …	4.42	4.33	

Charts with results are presented in the reports together with evaluation of classrooms, laboratories, physical models, textbooks; and proposed changes to catalog description, course outcomes, lessons, laboratories, grading. Appendices will contain historical data comparison and any other supporting documents like narrative feedback from students' course evaluations.

A course needs additional work, which may include restructure and redesign of a particular section, when the objective indicators fall below 75%. This 75% line is a faculty set line for the MECH program. Given limited resources, instructors, and facilities, a complete redesign of the course should be the last option. With these assessment tools in place, the faculty can monitor trends and adjust course content and delivery cyclically and in more manageable loads.

Conclusions

The A.C.A. provides a detailed tool for course evaluation across the entire new Mechanical Engineering program, adds ease-of-use and transparency to the evaluation efforts, and produces a concise, useful set of course evaluation data that will be presented to ABET program evaluators. The authors hope that A.C.A. will provide increased program visibility, more consistent reporting across all courses in the program, and a greatly improved process of on-going data gathering, analysis, and program evaluation.

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Monika Bubacz

Dr. Monika Bubacz is an Associate Professor in the Department of Engineering Leadership and Program Management at The Citadel. She received both her B.S. and M.S. in Mechanical Engineering from Poznan University of Technology in Poland, and the Ph.D. in Engineering and Applied Science from the University of New Orleans. Before her current appointment she has worked for Mercer University, Center for NanoComposites and Multifunctional Materials in Pittsburg, Kansas and Metal Forming Institute in Poznan, Poland. Her teaching and research interest areas include materials science, polymers and composites for aerospace applications, nanotechnology, and environmental sustainability.

Robert Rabb

Dr. Robert Rabb received his B.S. in Mechanical Engineering from the United States Military Academy and his M.S.E. and PhD in Mechanical Engineering from the University of Texas at Austin. He taught at the United States Military Academy at West Point, NY and has worked for the U.S. Army Corps of Engineers. His research and teaching interests are in mechatronics, regenerative power, and multidisciplinary engineering. He is an Associate Professor in the Department of Engineering Leadership and Program Management at The Citadel.

Jason Howison

Jason Howison is an Assistant Professor in the Department of Engineering Leadership and Program Management at The Citadel. He earned an M.S. in Mechanical and Aerospace Engineering from the University of Virginia and a Ph.D. in Aerospace Engineering from the University of Tennessee. His research areas include computational fluid dynamics, boundary layer transition, wind turbine aeroelasticity, and engineering education.

Kevin Skenes

Kevin Skenes is an Assistant Professor in the Department of Engineering Leadership and Program Management at The Citadel. He received his B.S., M.S., and Ph.D. in Mechanical Engineering from the Georgia Institute of Technology. His teaching and research interests include manufacturing, non-destructive evaluation, causes and effects of residual stress, and solar energy.