

# **Accreditation and Learning Outcomes in Engineering Technology: Student-Centered Assessment**

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## Abstract

Engineering Technology programs are accredited through ABET. This accreditation includes eleven general criteria for student learning outcomes. The criteria's main purpose is to ensure students are learning more than the technical skills typically taught in engineering technology. Many of these learning outcomes required are then applied in a culminating experience, or capstone course, during a student's final semester(s) in a bachelor's degree program. This study aims to understand the student's assessment of these learning outcomes as reported through the Student Assessment of their Learning Gains Instrument within engineering technology programs capstone courses.

## Introduction

There is a driving need for accountability and quality measurement in the higher education system within the United States. As a result, universities and programs look towards accreditation, third party peer review systems ensuring the quality and holding educators accountable. The Accreditation Board for Engineering and Technology (ABET) is the group that provides accreditation to engineering, engineering technology, and other engineering related programs throughout institutions in the United States.

Aft (2002) describes basic steps of the ABET accreditation process, where each program: (1) formally requests accreditation; (2) undergoes self-study and completes self-study documentation; (3) goes through visitation by ABET assessors who then draft a detailed report, and (4) receives a formal decision granted by the accreditation agency. This process is then repeated on a six-year cycle (Aft, 2002). Aft (2002) provides several examples of benefits of ABET accreditation, which include assurances to prospective students and parents that a given program meets minimum standards, evidence to employers the graduates are prepared for jobs, and accountability to taxpayers that their money is well-spent. Thus, as Aft (2002) puts it, accountability process leads to tangible benefits for the accredited programs, such as formal communication of accountability and quality assurance evidence to those entering ABET accredited programs.

However, given that employers and industry are the ones to gain the most benefit by hiring graduates from accredited programs, accreditation also gives employers the most staying power in what goes into the accreditation process as well as accreditation focus and content. In particular, employers drove a major shift in the focus of accreditation of programs for ABET. Employers contributed their input not only into the need of accreditation process as a quality assurance mechanism, but also into the content of program accreditation. In other words, they wanted to emphasize what exactly programs needed to produce and demonstrate as a valuable

program outcome. For example, feedback from employers included the need for engineers with “strong technical capability... skills in communication and persuasion, an ability to lead and work effectively as part of a team, an understanding of the nontechnical forces that profoundly affect engineering decisions, and a commitment to lifelong learning” (Prados, Peterson, & Lattuca, 2005, p. 168). This emphasis on employee skills caused ABET to respond to the industry demands in changing the model for accreditation to have a more complete picture of the student learning outcomes within any given program to include the various non-technical skills detailed above.

Measuring student experiences and learning outcomes in engineering and engineering technology higher education programs has become an important aspect in program specific accreditation. ABET developed and implemented a mandatory revised criteria for the accreditation of engineering technology programs under the Engineering Criteria 2000 (EC2000) in 2001 (Prados, Peterson, & Lattuca, 2005). This new set of criteria focused on program objectives and learning outcomes and not on specific engineering technology disciplines (Prados, Peterson, & Lattuca, 2005).

The Engineering Technology Commission (ETAC) for ABET, accredits programs under the engineering technology umbrella (Prados, Peterson, & Lattuca, 2005). The EC2000 criteria guidelines for engineering technology programs, as detailed in the 2016-2017 criteria, provides 11 general criteria for student outcomes (Accreditation Board for Engineering and Technology, 2016). These 11 student outcomes tie closely to those needs indicated by employers of graduates.

On a broader reach, accreditation is something that constantly pushes at engineering technology programs. Accreditation is extremely important for graduates that go on to gain professional licensure and certifications in their fields of expertise. This professional emphasis on student preparation makes the student learning outcomes much more important. Therefore, not surprisingly, the EC2000 criteria model centers on learning outcomes, self-assessment, and continuous improvement. However, the accreditation reporting model of the learning outcomes is built only on faculty perspective on existing teaching practices as well as their emphasis on assessment that may serve as a better indicator of achieved learning outcomes (i.e. particular exam questions pass rate, written reports, etc.) and it does not take into account the learning process itself that the student has had during their course(s). In other words, assessment-centric self-study reports are not concerned with existing pedagogical practices and data on how and why engineering and technology students learn (or do not learn) desired skills and professional competency and achieve (or do not achieve) required outcomes. Thus, this study aims to examine student-learning outcomes reported by students and measured by the Student Assessment of their Learning Gains instrument.

## Accreditation and ABET

Accreditation within higher education is a two-fold system. Accreditation, which is a peer review process of education, happens at both the institutional level as well as a specialty level. At the institutional level, accreditation reviews just that, the quality of the institution itself. However, at the specialty level, educational programs are evaluated as to how well graduates are

prepared to enter the profession for which they have been studying. (Aft, 2002; Prados, Peterson, & Lattuca, 2005)

Accreditation, at either level, provides substantial benefits to the specific program, institution, students, employers, and taxpayers (Aft, 2002). Accreditation, especially at the specialty level, has seen a movement towards an outcomes based assessment criteria (Duff, 2004). Duff (2004) describes how utilizing outcomes based assessment even helps make ties between accreditation programs, especially when one program is accredited through multiple agencies. London, Caldwell, and Patsavas (2013) have also concluded the importance of alignment of learning outcomes criteria across accrediting bodies and the impacts of engineering education. Furthermore, outcomes assessment provides a means to determine (1) what is being done, (2) what is said is being done, and (3) what should be done (Duff, 2004). Outcomes assessment, as a part of accreditation, provides a systematic way of determining the effectiveness of the educational process (Duff, 2004). It is important to point out that outcomes assessment becomes most successful when everyone involved is fully vested in the process and there is continuous improvement woven throughout the process (Duff, 2004).

ABET developed the Engineering Criteria 2000 (EC2000) for the outcomes assessment model in 1995 and had its full implementation for all programs by 2001 (Prados, Peterson, & Lattuca, 2005). The EC2000 provides both general criteria requirements that apply to all accredited programs and program criteria, which are discipline specific (Accreditation Board of Engineering and Technology, 2016). ABET shifted to outcomes assessment based upon employers of engineering graduates expressing the perceptions that graduates lacked skills in communication, team work, and nontechnical forces that influence engineering decisions (Prados, Peterson, & Lattuca, 2005). The general criteria that EC2000 requires for all accredited programs include both application of technical knowledge as well as the development of the student to be able to have skills in teamwork, ethics, communication, and life-long learning (Prados, Peterson, & Lattuca, 2005; Accreditation Board for Engineering and Technology, 2016).

Based upon the multi-year study by Prados, Peterson, and Lattuca (2005), the data suggested that as programs transitioned to the new criteria there were improvements in engineering education. Volkwein, Lattuca, Harper, and Domingo (2007) provided further analysis of the original data. It was reaffirmed that the application of the EC2000 criteria was working (Volkwein, Lattuca, Harper, & Domingo, 2007). Furthermore, the new criteria did not impact the overall program specific technical knowledge of graduates, though there could be external influences that could also be adding to the improvement in graduates (Volkwein, Lattuca, Harper, & Domingo, 2007).

#### Addressing the Skills Gap with Learning Outcomes

The transition to the EC2000 criteria had much to do with addressing the skills gap. Prados, Peterson, and Lattuca (2005) indicated “the engineering science emphasis had produced graduates with strong technical skills, but these graduates were not nearly so well prepared in other skills needed to develop and manage innovative technology (p. 167).” However, even with

the transition to the new outcomes based accreditation criteria, there are recent studies still showing the existence of a skills gap of graduates.

A study performed by Chegg (2013) concluded that there continues to be something missing at the intersection of higher education programs and workforce preparedness. The study showed that there is disconnect in what employers are seeking and what skills graduates believe they possess. For instance, hiring managers felt that graduates lacked communication and teamwork skills. While those hiring graduates in Science, Technology, Engineering, and Mathematics (STEM) fields versus non-STEM fields indicated those students were better prepared, there was still a gap. (Chegg, Inc., 2013).

Feutz and Zinser (2012), further emphasized this statement by pointing out to the instance of when graduates of a Career and Technical Education program indicated that the communication course that they took while in school benefited them the most upon graduation. These graduates also indicated a project management driven curriculum could better prepare them for the workforce (Feutz & Zinser, 2012). However, is it just up to a specific program or higher education institution to better prepare students for the workforce? Ejiwale (2014) indicates that all stakeholders, including students, educators, and the hiring industry need to take part in addressing the skills gap issue.

Students need to take initiative and responsibility in recognizing what employers in their field want. Educators, at both the K-12 level and higher education, must play a role in transitioning students into college and then into the workforce. Industry should be included as a part of the higher education curriculum development. Industry must define to those in higher education what their specific needs are in a given field (Ejiwale, 2014). This employer emphasis reaffirms the importance in outcomes assessment criteria and the need to have all stakeholders be fully vested in the process (Duff, 2004).

Scholl and Olsen (2014) took the assessment process a step further in measuring the student learning outcomes of a program through the use of the Student Assessment of Learning Gains (SALG). It was found there was a significant increase indicated by students in their development of research and evaluation skills as well as their overall perception of integration of learning (Scholl & Olsen, 2014). Scholl and Olsen (2014) concluded that the SALG instrument is an effective way to measure the student learning outcomes and could be further tested for usefulness in accreditation outcomes assessment.

#### Overview of the Student Assessment of Learning Gains Instrument

According to SALG (2017), the instrument was developed in 1997 and further revised in 2007 by Stephen Carroll, Elaine Seymour, and Tim Weston. The revisions were intended to broaden the instrument beyond chemistry, which it was initially created for. The SALG has respondents self-report their own learning (SALG, 2017). The instrument includes five overarching questions and sub-questions or items that are customized. The five SALG questions are as follows:

1. How much did the following aspects of the course help you in your learning? (Examples might include class and lab activities, assessments, particular learning methods, and resources.)
2. As a result of your work in this class, what gains did you make in your understanding of each of the following? (Instructors insert those concepts that they consider most important.)
3. As a result of your work in this class, what gains did you make in the following skills? (A sample of skills includes the ability to make quantitative estimates, finding trends in data, or writing technical texts.)
4. As a result of your work in this class, what gains did you make in the following? (The sub-items address attitudinal issues such as enthusiasm for the course or subject area.)
5. As a result of your work in this class, what gains did you make in integrating the following? (The sub-items address how the students integrated information.) (SALG, 2017)

These overarching questions provide a basis for determining a student's perspective of their learning outcomes. Particularly those learning outcomes tied to ABET accreditation.

## Methodology

Accreditation by ABET for specific programs is extremely important, particularly for programs that have professional licenses or certifications tied to them (Aft, 2002). Accreditation relies heavily on the learning outcomes detailed in Criteria 3 a-k. This study aims at providing answers to the following questions: What is the student achievement of the learning outcomes detailed in EC2000 (Criteria 3 a-k), as reported through student perceptions' data?

ABET (2016) curriculum requires an integration of content in a culminating experience for the student to apply technical and non-technical skills to solve problems. The culminating experience is typically found within a capstone courses. Capstone courses are for students typically within their final semester(s) prior to graduating. While each individual program curriculum of their capstone course differs slightly, the focus is a project-based assignment throughout the course where the student has the capability of applying all of the technical knowledge learned during their progression through their specific engineering technology program.

In order to answer the above question, this study utilized the capstone courses of two different ABET-TAC accredited engineering technology programs. Within these courses, the baseline Student Assessment of Learning Gains (SALG) was used to determine how well the students assessed themselves in relation to the Criteria 3 a-k. The baseline instrument was administered at the beginning of the semester to the two different capstone courses. Students responded to the instrument through its online portal.

## Results

The baseline SALG instrument provides students with six choices in their response using a Likert scale: 1 - not applicable, 2 - not at all, 3 - just a little, 4 - somewhat, 5 - a lot, and 6 - a

great deal. Since the focus of this study is primarily on the learning outcomes detailed in ABET Criteria 3 a-k, Table 1 details the means of the student self-assessment of their present capabilities on the learning outcomes. Since there were two programs evaluated, mean 1 and standard deviation (SD) 1 are associated with the same program and correspondingly, mean 2 and SD 2 are associated with the second program evaluated. Program 1 consisted of 29 student responses and Program 2 had 17 responses.

Table 1				
<i>Assessment of ABET Criteria 3 a-k Conceptual Understanding Means and Standard Deviations</i>				
<u>Presently I understand</u>	<u>Mean 1</u>	<u>Mean 2</u>	<u>SD 1</u>	<u>SD2</u>
How to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities	4.6	5.0	0.73	0.61
How to select and apply a knowledge of math, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies	4.7	4.9	0.72	0.75
How to conduct standard tests and measurements; analyze and interpret experiments; and apply results to improve processes	4.5	5.0	0.91	0.87
How to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives	3.9	4.8	1.00	0.90
How to function effectively as a member or leader on a technical team	5.3	5.3	0.71	0.77
How to identify, analyze, and solve broadly-defined engineering technology problems	4.6	4.9	0.94	0.66
How to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature	4.8	5.2	0.90	0.56
Understand the need for and ability to engage in self-directed continuing professional development	5.1	4.6	0.83	0.94
Commitment to address professional and ethical responsibilities including respect for diversity	5.0	4.6	1.00	1.06
Impact of engineering technology solutions in a societal and global context	4.4	4.5	1.15	0.94
Commitment to quality, timeliness, and continuous improvement	5.2	5.2	0.80	0.81

Note: Likert Scale: 1-not applicable, 2 - not at all, 3 - just a little, 4 - somewhat, 5 - a lot, and 6 - a great deal

Another important part the courses surveyed is that they are the capstone courses for the program and meet the ABET criteria for the culminating experience. As discussed previously, this experience must tie together and apply technical and non-technical skills in order to solve problems. Table 2 provides the means and standard deviations of the student’s responses associated with their integration of learning in this culminating experience.

Table 2				
<i>Capstone Course Integration of Learning Means and Standard Deviations</i>				
<u>Presently, I am in the habit of...</u>	<u>Mean 1</u>	<u>Mean 2</u>	<u>SD1</u>	<u>SD2</u>
Connecting key ideas I learn in my classes with other knowledge	4.7	4.8	1.22	0.75
Applying what I learn in classes to other situations	4.7	4.8	1.13	0.95
Using systematic reasoning in my approach to problems	4.7	4.8	0.84	0.81
Using a critical approach to analyzing data and arguments in my daily life	4.7	4.9	0.88	0.97

Note: Likert Scale: 1-not applicable, 2 - not at all, 3 - just a little, 4 - somewhat, 5 - a lot, and 6 - a great deal

In addition to the descriptive statistics, students were also able to provide long form written responses. One of the questions was “Comment on how you expect this material to integrate with your studies, career, and/or life?” Several of the responses tied back to both ABET Criteria 3 a-k as well as the concept of the culminating experience. Some feedback from students included:

“This project design class is a rare opportunity to replicate the engineering process, in some ways it is similar to my internship except the project are more wholely [sic] in your control.”

“To help me learn as a student, become more prepared as a professional, and able to have a more knowledgeable base for my life.”

“Learn soft skills needed to be more successful in field”

“I expect that I will be able to use the concepts presented to me in this course to be most successful in my career. I feel the concept of this class is practical and applicable to common situations that I will encounter in my career path.”

As observed from the data, students consistently reported as understanding the concepts from ‘somewhat’ to ‘a lot’ on the scale. This is also true of the students reporting of the integration of learning scores. The question then becomes how high do students need to score on their self-assessment of the learning outcomes to satisfy those employers reporting the skills gap? How well does a student’s self-assessment correlate with that of the faculty assessment of the student?

## Conclusions

Given that many engineering technology programs are accredited through ABET, the general criteria 3, items a-k are all applicable to these programs. This study provides a look into the student's perspective of their personal achievement of the ABET Criteria 3 a-k. This could be useful in the students' own reflection of their learning as they prepare to enter the workforce upon graduation. This data and student perspective will give engineering technology programs useful information as to how well the ABET student learning outcomes are being achieved.

Since the data collected was limited in sample size, future research should include larger samples of students within their capstone course as well as understanding how well students' progress on the ABET student learning outcomes during their bachelor's degree program.

Accreditation is a vital aspect in higher education. This is especially important when accreditation is tied to professional licensure and certifications when graduates enter into industry. Ensuring that students are achieving the learning outcomes is a key part of accreditation. By having student feedback on their perceptions of their learning outcomes will only strengthen a program and their graduates through the continuous improvement process.

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### Biographical Information

Virginia Charter is a graduate of the Oklahoma State University's Fire Protection & Safety Engineering Technology program and went on to earn a master's degree in Fire Protection Engineering from Worcester Polytechnic Institute. She is currently pursuing a Doctor of Philosophy in Educational Leadership and Policy Studies at OSU. Her research is focused on Student Learning Outcomes in Engineering and Engineering Technology.

Prior to returning to OSU, Ms. Charter was a Senior Consultant for the Las Vegas office of Rolf Jensen & Associates, Inc. (RJA). She has been involved in the preparation of performance specifications and conceptual drawings for fire alarm and automatic sprinkler systems, as well as construction design documents including fire protection reports, code equivalencies, and general code consulting for many projects across the nation and abroad. In addition, Ms. Charter has valuable technical knowledge in egress and smoke control analysis, including the production of exiting and smoke control diagrams. Also, she has been involved with special inspection services for the commissioning of smoke control systems as required by the local authorities and construction management. Ms. Charter has been the lead project manager for several large developments and specializes in hotel/casino projects. She was highly involved in providing fire protection and life safety consulting for the massive CityCenter development in Las Vegas. She has also worked on multiple military bases throughout the U.S as well as in healthcare facilities. She is a licensed Fire Protection Engineer in Nevada, California, and Oklahoma.

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