Increasing Assessment Effectiveness in a Time of Decreasing Budgets

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***Abstract* – Challenged by the current economic downturn, engineering programs lack room in their budgets to increase efforts for improving assessment, yet still face pressures from accreditation and educational stakeholders to do so. This paper presents an innovative practice focused on promoting engineering-classroom assessment of student learning with efforts to overcome these challenges. The practice proposes a solution from three angles: establishment and use of lean assessment techniques, an implementation process that maximizes intrinsic motivation, and taking advantage of the efficiency of the assessment methodology. The idea of lean assessment is discussed, and a collection of techniques is presented which builds on previous work and offers novel methods for classroom assessment. Early results are discussed for assessment techniques currently in use, including an innovative feedback tool. Those seeking ways to improve teaching and learning through assessment will find effective tools as well as implications of ABET accreditation. Future work includes evaluation of the assessment techniques currently being piloted and research implications for integrating assessment into the culture of engineering education departments.**

Index Terms – Assessment, Student Learning, Motivation, Recession

INTRODUCTION

Since accreditation criteria were redefined by ABET, assessment has become an increasing priority for engineering educators nationwide. The change marked a shift from input-based to outcome-based assessment, leading to an amplified focus on student learning and its measurement both in and out of the classroom. However, few engineering faculty members receive training in educational measurement and thus find it difficult to adapt to complex assessment and accreditation requirements [1]-[2]. Moreover, current economic woes compound the situation. Budgets have no allowance for hiring an assessment expert or rationing significant time for knowledgeable faculty to head up assessment efforts; further, many faculty members are seeing this amplified by greater demands to bring in research funding. Even experienced faculty who are currently using assessment techniques in their classrooms are being challenged, as economic downturns lead to spikes in enrollment and therefore larger classes, increasing the number of students to assess, grade, and manage [3].

Seemingly paradoxical, these crises collectively may create an opportunity to improve assessment effectiveness. From one angle, lean assessment techniques, which are optimized and time-efficient methods focused on the engineering classroom, prove useful. From another angle, tapping into faculty members' existing desires to improve classroom teaching and learning can be used to improve intrinsic motivation for assessment. A third angle is that the assessment methodology, when properly executed and widely applied, can actually decrease time invested in many teaching duties, including assessment itself. The convergence, seeking to increase assessment effectiveness, is illustrated in Figure 1.

This work provides an innovative approach to improve assessment effectiveness by considering all three angles concurrently. First, a collection of lean assessments is provided, derived from established, modified, and novel classroom assessment techniques and aimed to be simple, efficient, and effective. Second, a simple implementation procedure is presented, which is designed to be used by faculty with minimal assessment background. Informed by motivation theory, the implementation focuses on creating, maintaining, and restoring autonomy and competence in assessment duties - essential needs for intrinsic motivation [4]. Third, the assessment methodology and concept of backwards design are discussed for their role in maximizing efficiency of assessment in the classroom. Further, ABET accreditation requirements are considered and the use of lean assessment techniques towards these requirements is briefly discussed.

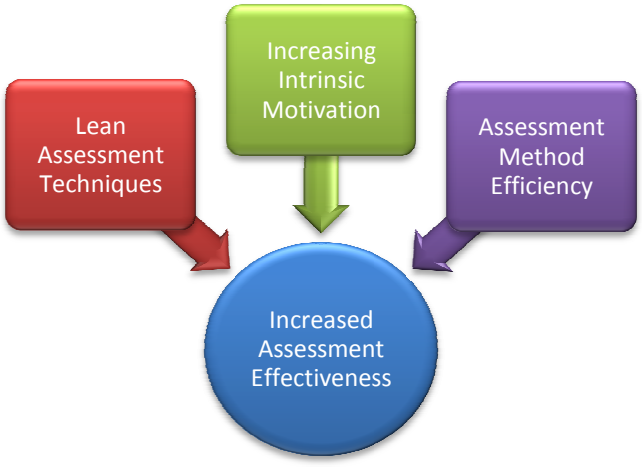

FIGURE 1
CONVERGENGE TO IMPROVE ASSESSMENT EFFECTIVENESS

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BACKGROUND

I. Assessment Basics

The term "assessment" has various uses in engineering education for grading assignments, in accreditation, for accountability, and in research and grants; clearly, assessment has many definitions and applications. One popular, broad definition is that of Angelo [5]. This work focuses on assessment of student learning that occurs in the classroom and how it relates to accreditation; it may have implications for grading, accountability, and educational research, but these are not the focus. As such, assessment can be defined here by taking select parts of Angelo's definition:

> Assessment is an ongoing process aimed at understanding and improving student learning. It involves making our expectations explicit; systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards; and using the resulting information to document, explain, and improve performance.

In the classroom, evidence collected from assessment is used as a feedback mechanism to inform the effectiveness of teaching and learning, and also for measuring student progress towards key learning objectives (i.e., outcome-based assessment); these uses are examples of formative and summative assessment, respectively. Formative assessment is a process for measuring student learning toward intended instructional outcomes in the midst of a course or program, with the intention of making improvements while in progress [6]. Summative assessment is, by contrast, evaluative evidence sought at the end of a course or program to examine whether or not educational objectives were achieved, and therefore does not have opportunity to improve teaching and learning while in progress [7]. It follows that formative and summative assessments are not entirely defined by how they are constructed but rather in how the assessment data is used; that is, assessment data *can* be used in formative or summative manners, although this should be considered up front during assessment planning.

Using collected assessment data for improving teaching and learning is not trivial, but the process can be summarized in a simple form. The assessment process can be effectively compared to that of a typical class assignment, as in Figure 2. When an assignment is given, the typical process is to teach on a given topic, create an assignment relative to the information, have the student complete and turn in the assignment, and then grade it and return it to the student with comments on their performance. This can be effective for the student's learning, but does not inform the instructor on the effectiveness of the assignment or instruction; assessment, however, incorporates the feedback path to the instructor whereby this effect is considered. Once the feedback path is incorporated, specific assessment techniques prescribe different types of data and actions for application. The lean assessment techniques presented here are intended to apply directly to these assessment purposes.

II. Accreditation

ABET accreditation requires an ongoing, summative assessment of how well program objectives are being attained by students and demonstration that assessment evidence is being used in a formative manner to improve the program [8]. For example, Criterion 3 of EC-2000 provides a set of student learning outcomes which all engineering programs should work toward. These outcomes are largely attained in the engineering classroom, and hence regularly appear in course objectives with well-defined specificity. This is the intersection of formative classroom assessment and summative program assessment (for accreditation): formative classroom assessments are aimed at improving the teaching and learning of program outcomes, which is later assessed in a summative manner. In this work, lean assessments provide data that can be used for either purpose, so long as plans for the assessment clearly target summary items, like learning outcomes.

In general, faculty have gotten involved in accreditation duties and hold favorable views on them. Prados, Peterson, and Lattuca [2] measured changes from the initiation of EC-2000, and found that most faculty reported they had at least some involvement in their program's accreditation efforts, and most program chairs reported the majority of their faculty were supportive of efforts to improve curriculum and teaching through assessment. This indicates favorable progress with involvement and attitudes toward accreditation, but the same has not been true for assessment effectiveness – the study also found that the majority of faculty are not using assessment data in decision-making. The result has been that continuous improvement efforts have resorted to collecting excessive amounts of assessment

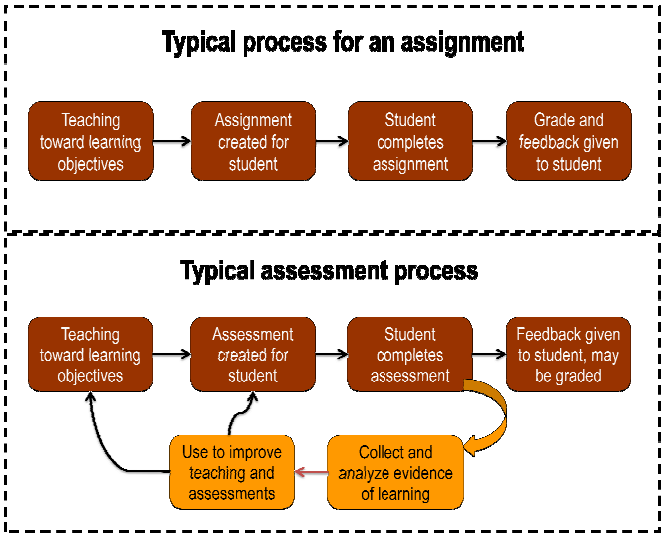

FIGURE 2
COMPARATIVE DIAGRAMS FOR TYPICAL (A) ASSIGNMENT PROCESS AND (B) ASSESSMENT PROCESS.

data – focusing on quantity instead of quality – and overly relying on indirect measures of student learning – both of which can hurt assessment effectiveness and validity [2]. One possible cause for this is that faculty are not using assessment to inform their *own* teaching and hence are not sure what is useful to collect, and instead are collecting as much as possible to 'cover all the bases' as well as gravitating to familiar methods (e.g., surveys). The obvious solution to this would be to increase faculty development efforts toward assessment and accreditation. However, as discussed previously, this is not as affordable in the current economic downturn; fortunately, the tools of motivation theory can be of assistance.

III. Motivation

At the root of all human behavior lie psychological factors like perception, cognition, emotion, and personality. Motivation involves these factors as determinants of one's drive to engage in a given task or behavior. Studying one's motivation-related factors can be of great assistance in improving engagement in any effort – including assessment. For instance, in self-determination theory, Deci and Ryan [4] establish three basic needs as foundational to attaining intrinsic motivation in individuals. That is, when circumstances support these needs, the person will increasingly internalize their motivation to engage in the behavior, with the goal of becoming intrinsic. These foundational needs are: *autonomy,* the desire for experiences and behaviors to be controlled by and harmonious with the self; *competence,* the belief in one's ability to complete a task; and *relatedness,* the desire to feel reciprocally connected to and appreciated by others.

In assessment, differing perspectives on its role in education create a divide, affecting the motivation to engage in assessment activities. These differing perspectives are philosophically-based and diverge at the point of beliefs about whether or not learning can be observed and measured [9]. Addressing this would require significant efforts; this work will instead take this to mean that these perspectives will lead some faculty to view assessment duties as fully external and therefore be extrinsically motivated. From that position, self-determination theory can serve as a basis for facilitating the internalization of these duties with the hope of *some aspects* of assessment becoming fully intrinsic.

INNOVATIVE PRACTICES

Presented in this work are three particular angles which converge to increase assessment effectiveness: lean assessment techniques, an implementation process informed by motivation theory, and consideration for the efficiency of existing assessment methodology. This section will explore each in turn.

I. Lean Assessment Techniques

Lean assessments are simple, efficient, and effective classroom assessment techniques – key qualities to improving classroom assessment efforts. Building on the idea of lean manufacturing, lean assessments aim to get more valuable data and information with less work by using the most productive and easy-to-implement methods. Angelo and Cross [10] provide an excellent resource for classroom assessment techniques, and many of the lean assessment techniques presented here are based on their collection. Some directly qualify as lean assessments and are repeated, and some others are modified for use in engineering. Yet other techniques presented here are based on other works, or they are original and are being piloted currently in engineering courses.

The present collection of lean assessment techniques is shown in Table I. Techniques provided include basic descriptions, purpose, and time requirements of use. When one is applied, resulting data need to be analyzed to inform future teaching, learning, and assessment activities. Due to variance in the types of data obtained, a summary process is difficult to provide; instead, a case study example will be highlighted to briefly illustrate the process.

Last semester, an upper-level instructor used a rubric to grade and assess written reports. Summing across all rubrics, severe deficiencies were noted in key areas; following, a discussion with the instructor of a prerequisite course revealed that *teams* were required to write reports but not each individual. In response, the prerequisite course added an individual report requirement as an assessment to both build on this skill and track student progress; the technique is included in Table I. Feedback from the assessment is provided to students for their team reports and is being used to assess the instructional revision.

An additional innovative practice was created from this, as well. When the individual report was added, the overall time investment increased greatly. To minimize this, the free, screen-capturing software IOJ, available at www.ioj.com, is being used. After initiating a screen recording, the electronic report document is read through for key points, and audible comments are captured as part of the video. The audio/video file is then shared with the student, where they can replay instructors' comments in a sort-of virtual, recorded, one-on-one session. Report review time was cut in half from 10 minutes to less than five, and student feedback on the process has been very positive; even more rewardingly, report-writing skills have also seen a significant improvement.

II. Implementation Process

Some of the lean assessment techniques have been available for decades; alone, they do not solve the problems associated with improving assessment in engineering education. To be successful, what is needed along with these tools is an implementation process that considers motivation. As discussed previously, self-determination theory provides an excellent framework for addressing motivation, by which engagement in assessment duties can be improved, shifting motivations from extrinsic to intrinsic as much as possible. This is accomplished by evaluating and addressing the three

TABLE I
LEAN ASSESSMENT TECHNIQUES

Technique:	*Time Requirement:*	*Purpose:*	*Description:*	*Notes:*	*Source (if applicable):*
Rubrics (for various activities)	*MED; LOW if shared development*	*Categorize important assessment and grading criteria; set up structure to summarize performance; provide clear expectations to students*	*Important criteria are categorized and assigned point values in a table, then performance levels (e.g. novice, expert) described; rubric provided to students to clarify expectations and guide excellent performance*	*Many resources available online for pre-defined or custom rubrics; coordinating with other faculty can decrease time investment and increase consistency of course/material*	*Many – e.g. Popham [11], Spurlin, Rajala, & Lavelle [12]*
One-minute problem summary	*LOW*	*Evaluate student understanding of assigned problems and underlying concepts*	*At the end of a problem, the student takes one minute to explain what major concepts were used and what was learned*	*Good to prompt students with leading question to answer in problem summary*	*Modified "one-sentence summary" from Angelo and Cross [10]*
Quiz/exam question review	*MED*	*Assess understanding through performance on key quiz/exam questions and effectiveness of assessment itself*	*Specific questions are used in quiz/exam that focus on key aspects/outcomes; classical test theory used to analyze effectiveness of questions*	*Classical test theory uses only simple statistical analysis of proportions and correlations; statistical software can easily perform these tasks*	*(novel approach)*
Muddiest point	*LOW*	*Finding which point is most confusing from a lecture, lesson, or activity*	*At the end of lecture, students are asked to identify the most confusing, or muddiest, point of the lecture on a note card or online survey*	*For clarity and accountability, it is best to ask students to explain what they do and don't understand about the topic*	*Angelo and Cross [10]*
Prior-knowledge assessment	*MED; LOW if shared development*	*Identify deficiencies in student knowledge and abilities at beginning of course term*	*Construction of a quiz is one option; however, collecting final exam questions from prerequisite courses could simplify this process*	*This can have two outcomes: establish a baseline to measure learning, and/or identify students who need remediation*	*Modified "background knowledge probe" from Angelo and Cross [10]*
Student-developed exam questions	*MED*	*Identify what students find important; assess understanding of various topics*	*After significant points in the course, students are asked to develop thoughtful test questions for use on midterm/final exam*	*Students should be given guidance with what content and level of difficulty to base questions*	*Slightly modified "student-generated test questions" from Angelo and Cross [10]*
Individual project reports (in team project)	*MED*	*Assess individual report-writing abilities*	*When team reports are required, have each student submit individual report at least one week preceding*	*Reviewing 3-5 times as many reports can be time consuming; a rubric should be used and specific aspects of reports focused on*	*(novel – being tested in current course)*
Individual, oral exams	*LOW and can reduce time*	*Assess oral abilities and allow for deeper probing of key topics; mimic business meeting*	*Students present and discuss project instead of written exam/project, one-on-one with instructor; oral questions provide richer evidence of knowledge and learning; grade is given before leaving meeting*	*A form of authentic assessment, abilities are tested in a more realistic manner that closely reflects real-world; time can be less than administering and grading exams/ projects*	*Janesick [13], Race [14]*

needs of competence, autonomy, and relatedness, as discussed previously.

Competence is one important aspect of self-determination that is likely to be lacking in assessment duties, as most engineering faculty lack sufficient training in assessment methodology; this can challenge self-efficacy and perceived competence [4]. The lean assessments presented above can assist with this significantly, offering effective techniques that transcend all assessment-skill levels. Assistance and support from others is also important, as social constructivism is effective in building competence. These contributions to competence were carefully considered when developing the implementation process presented here.

Autonomy is another essential need for an individual to internalize motivations, and can be a fragile one pertaining to assessment responsibilities. Inevitably, when duties are handed down to faculty, autonomy can be infringed regardless of whether tasks are perceived to be from an internal entity such as a department head or from an external agency like ABET. Therefore, it is crucial to make efforts to restore this autonomy to assessment, or internalization will not be possible [4]. The lean assessments presented above can assist with autonomy when presented and implemented

properly; the key is that they are used to achieve goals that the faculty themselves have for improving classroom learning. Accordingly, the implementation process presented here suggests a brief interview or survey with faculty members to facilitate matching of desires and requirements.

In fall of 2007, an interview process was developed during efforts to advance assessment culture in an engineering education department, and was revisited for this work. The full questionnaire can be viewed in the paper [15], but questions specifically related to this work include:

2. What kinds of assessment do you think the department should be doing?
4. What other assessment … questions regarding the department do you have that you want answered?
5. Do you feel the dept needs a way to share collected data? What suggestions do you have for this?
7. What do you feel the culture [pertaining to assessment] of [this department] should be?

The study data from these questions encompassed wide, sweeping assessment issues from re-evaluating program objectives to specific aspects like the effectiveness of teamwork. Most faculty highlighted interests in preparing students for their upper-level courses and working in industry, and almost all mentioned some aspect of improving teaching and learning; these are the responses that this work focuses on. Later in this section, this will be integrated into the complete picture.

Relatedness is the third need stated in self-determination theory toward internalization of motivations. This is more challenging to address, as each person must be considered individually for whose connections they value; in this implementation, it is suggested that the relationship with students be the focus. It is important to share expectations for assessment and grading with students, and faculty can use this as an opportunity to build a more team-oriented environment in their classroom. Students greatly appreciate when they their learning and success are valued and adversarial relations can be greatly reduced. This connection with students also builds momentum as the positive relationship can encourage faculty to further develop assessments; inevitably, this is a part of the internalization in self-determination. As well, an open communication channel in the classroom can help faculty to further improve their assessments via open student feedback [4].

Altogether, self-determination theory and the lean assessments presented can be merged to suggest the following implementation process for improving assessment engagement and effectiveness:

1. Review program educational objectives (PEOs), program learning outcomes, and course outcomes established for the program and course(s) of interest.
2. Interview/survey faculty member(s) for their input on classroom assessment and what they would like to improve in their teaching and students' performance in the classroom. Also, review current assignments and assessments being used in their course(s) of interest.
3. Identify lean assessment techniques which: are good for measuring the outcomes from #1; meet goals that faculty name as important to them, both individually (for autonomy) and collectively (toward community) in #2; and which can complement/replace existing assignments and activities in the course(s).
4. Briefly illustrate how the lean assessment techniques match the faculty member's goals and can be used alongside or in place of existing course materials.
5. Assist with familiarization and use of the lean assessments, if necessary, and encourage sharing of the expectations and motives with students, as discussed above.

Overall, this process is aimed at addressing the barriers to increasing assessment effectiveness by considering motivation and time-efficiency in its design. Seeing as previous studies found that engineering faculty generally hold positive views on the use of assessment [2], it is likely that this process would be quite effective. Some engineering departments have assessment committees who could conduct it, or other interested faculty or graduate students may take up the task in efforts to improve their department. A collective effort, however, is best as it would further advance shared efforts of teaching and learning.

III. Assessment Methodology

Assessment methodology, in and of itself, is a highly efficient process and can be generalized well to other activities. Suskie [16] describes the process with four essential steps:

1. Develop clearly-articulated, written statements of expected learning outcomes.
2. Design learning experiences that provide intentional, purposeful opportunities for students to achieve those learning outcomes.
3. Implement appropriate measures of student achievement of key learning outcomes.
4. Use assessment results to improve teaching and learning (p. 4).

The process uses backward design, as described by Wiggins and McTighe [17], which begins with what is typically considered the end: the goals. Once desired results are identified, one determines what constitutes acceptable evidence that those results are achieved, and then plans experiences and instruction to get students to that point.

Many faculty come at instructional design from the opposite direction, planning first what material to teach and then considering evidence and goals much later, if at all. Leaving these as an afterthought could be very time consuming, as problems inevitably arise when goals – like learning objectives – are not considered in the early stages of planning. Achievement is likely to be accidental at best, which may emerge as a belief by the students that the activity *is* the learning lesson rather than the meaning of it. As well, this flawed approach often entails a focus on coverage of material, neglecting deeper cognitive dimensions of the Bloom taxonomy [17]. The result of these

is that students are ill-prepared for application, analysis, and synthesis, which many faculty expect students to be adept at, and this leads to a plethora of frustrating problems in the classroom. Instead, considering instructional design and assessment from a goal-oriented perspective *during planning* can help avoid or minimize bottlenecks and create enriched and meaningful learning experiences for students.

CONCLUSION

This work presented innovative assessment practices specifically aimed at overcoming limitations of decreasing academic budgets. This economic barrier to improving assessment effectiveness was addressed from three angles: use of lean assessment techniques; establishment of an implementation process with consideration for motivation; and utilizing the efficiency of backward design inherent in the assessment process. Early implementation results are presented as a case study and an additional innovative practice; future work intends to implement in an engineering department and research the effects for the author's dissertation study. When the assessment techniques presented are used to improve teaching and learning of course outcomes, there is opportunity for use in accreditation, as well. Anyone interested in advancing assessment effectiveness in their program can utilize this approach and find improvements, despite economic challenges and regardless of educational background.

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REFERENCES

[1] M. Borrego, "Conceptual Difficulties Experienced by Trained Engineers Learning Educational Research Methods," *Journal of Engineering Education,* vol. 96, pp. 91-102, 2007.

[2] J. W. Prados, G. D. Peterson, and L. R. Lattuca, "Quality Assurance of Engineering Education through Accreditation: The Impact of Engineering Criteria 2000 and Its Global Influence," *Journal of Engineering Education,* vol. 94, pp. 165-184, 2005.

[3] K. Mangan, "Public Campuses Share Pain of Budget Cuts With Students. (Cover story)," *Chronicle of Higher Education,* vol. 55, pp. A1-A22, 2008.

[4] E. L. Deci and R. M. Ryan, "The 'What' and 'Why' of Goal Pursuits: Human Needs and the Self-Determination of Behavior," *Psychological Inquiry,* vol. 11, p. 227, 2000.

[5] T. A. Angelo, "Assessing (and redefining) assessment," in *AAHE Bulletin*. vol. 48, 1995, pp. 7-9.

[6] S. McManus, "Attributes of Effective Formative Assessment," NC Department of Public Instruction, 2008.

[7] B. M. Moskal, "Using Assessment Results for Improving Student Learning," in *Designing better engineering education through assessment : a practical resource for faculty and department chairs on using assessment and ABET criteria to improve student learning*, J. E. Spurlin, S. A. Rajala, and J. P. Lavelle, Eds. Sterling, Va.: Stylus Pub., 2008, pp. 117-148.

[8] S. Sarin, "Quality Assurance in Engineering Education: A Comparison of EC-2000 and ISO-9000," *Journal of Engineering Education,* vol. 89, pp. 495-501, 2000.

[9] P. J. Gray, "The Roots of Assessment: Tensions, Solutions, and Research Directions," in *Building a scholarship of assessment*, 1st ed. ed. vol. xxii, 339 p. ;, T. W. Banta, Ed. San Francisco :: Jossey-Bass, 2002, pp. 49-66.

[10] T. A. Angelo and K. P. Cross, *Classroom Assessment Techniques: A Handbook for College Teachers. Second Edition*, 1993.

[11] M. Borrego, "Creating a culture of assessment within an engineering academic department," in *Frontiers in Education Conference, 2008*, 2008, pp. S2B-1-S2B-6.

[12] W. J. Popham, *Transformative assessment* vol. x, 150 p. :. Alexandria, VA:: Association for Supervision and Curriculum Development, 2008.

[13] J. E. Spurlin, S. A. Rajala, and J. P. Lavelle, *Designing better engineering education through assessment: a practical resource for faculty and department chairs on using assessment and ABET criteria to improve student learning*. Sterling, Va.: Stylus Pub., 2008.

[14] V. J. Janesick, *Authentic assessment primer* vol. 125 p. ;. New York :: Peter Lang, 2006.

[15] P. Race, *500 tips on assessment*, 2nd ed. ed. vol. xi, 171 p. ;. London ; New York :: RoutledgeFalmer, 2005.

[16] L. Suskie, "Understanding the Nature and Purpose of Assessment," in *Designing better engineering education through assessment : a practical resource for faculty and department chairs on using assessment and ABET criteria to improve student learning*, J. E. Spurlin, S. A. Rajala, and J. P. Lavelle, Eds. Sterling, Va.: Stylus Pub., 2008, pp. 3-22.

[17] G. P. Wiggins and J. McTighe, *Understanding by design*, Expanded 2nd ed. Alexandria, VA: Association for Supervision and Curriculum Development, 2005.