Outcomes-Based Assessment in Engineering Education: A Critique of Its Foundations and Practice

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Abstract – In the ten or so years since ABET EC2000 and the “new” way of thinking about accreditation were announced, engineering educators internationally have labored dutifully with the difficult, time-consuming and perplexing demands of outcome-based assessment. Without question, ABET EC2000 has captured the attention of engineering administrators and faculty, but it has also dramatically increased the effort required to sustain accreditation in engineering. This essay critically examines key assumptions behind the outcomes-based assessment (OBA) philosophy on which ABET EC2000 is based, and proposes that perhaps as much as engineering education practices, assessment practices should be the subject of assessment and evaluation.

Index Terms – ABET EC2000, accreditation, Behaviorism, outcomes-based assessment.

INTRODUCTION

In the world of engineering education, populated as it is by systematic and analytic people, it is difficult to raise questions about the phenomenon of outcomes-based assessment (OBA), in that it is at both first and second glance highly systematic and analytic. Yet, that is the goal of this paper. To question an approach to assessment that ostensibly is learning centered (rather than teaching centered); objective, rather than subjective; modern, rather than old fashioned; result based, rather than intention based; is to risk coming down on the side of fuzzy, lax, lazy and muddled, when we in engineering education have been presented with an alternative in ABET’s EC2000 (referred to as ABET 2000 in this paper). It is a carefully thought out OBA approach that has been championed by a generation of experts who know something about education and have certainly read the literature on the subject of assessment more thoroughly than I. They have been showing us the way for over ten years, ever since plans for ABET 2000 were unveiled in the late 1990s [1].

I am not one of those experts. I am a long-time engineering educator who can’t help but notice two striking things about outcomes-based assessment, and several less striking but curious things about the movement, all of which deserve mention, and perhaps some thought.

This paper is not an attempt at a logical refutation of ABET 2000 and OBA. It is rather a cautionary tale in the form of an essay (in the true sense, that is “an attempt”). It first looks at assumptions and motivations behind OBA in a questioning way, and then asks for accountability on the part of ABET. In short, it attempts to reveal that there is at least some potential nonsense involved in what has been sold as a nonsense-free approach to the important job of evaluating engineering educational programs.

A BRIEF HISTORY OF OBA

The OBA movement was preceded by at least a decade of educational reform labeled Outcomes Based Education (OBE) [2]. Directed mainly at high schools, and originating mainly from the state level in the US rather than from teachers, OBE has been defined by a proponent as “a comprehensive approach to organizing and operating an education system that is focused on and defined by the successful demonstrations of learning sought from each student.” [3] Elsewhere, OBE is characterized by an advocate as an approach that “specifies the ‘outcomes’ students should be able to demonstrate upon leaving the system. These outcomes are derived from a community vision of the skills and knowledge students need to be effective adults.” [4] Precursors and derivatives of OBE are widespread, but include Mastery Learning, Direct Learning, and every educational methods class that has advocated developing clear objectives for every lesson. Distant antecedents include behaviorist psychologists such as Hull, Skinner, and Thorndike, whose avowal of a strictly empiricist viewpoint is paralleled in the world of philosophy by the logical positivist movement [5].

OBA simply shifts the focus to assessment, specifically to the results of whatever educational process is at hand, not how the learning itself takes place. In the behaviorist tradition, the outcomes assessed in OBA are by definition demonstrable behaviors. “Understanding of…” “knowledge of”… and “appreciation of…” the importance of engineering ethics, for example, may be worthy happenings, but because no observable behavior is specified by such phrases, they cannot, in keeping with the behaviorist/empiricist underpinnings of OBA, be considered as outcomes [6]. Anyone reading this paper who has been involved with an ABET visit, in 2001 or more recently, knows all of the above and much, much more about OBA. The extensive
The literature in engineering education journals has focused almost exclusively on how to comply with ABET 2000 and its focus on outcomes (see ABET’s extensive webpage [7]). This paper instead addresses the “why.” The question has been asked of OBA [8], but not often. In particular, the focus of this essay will be on OBA assumptions about measuring and learning, and on the efficacy of the approach, now that a decade has passed.

**OBA and the Manufacturing Model of Education**

The timing of the launch of ABET 2000, and several of its characteristics, make comparisons with the preceding Total Quality movement in education inevitable. Both assumed that education would benefit from a top-down, data-driven approach, just like business takes. Felder, whose contributions to the literature on OBA in engineering are among the most insightful, points out in an extended analogy the similarities between controlling a manufacturing system and an educational system [9]. He makes these comparisons.

“Deciding what you want a manufacturing process control system to accomplish … is relatively straightforward… In an educational system, little is straightforward. Desired outcomes tend to be either vague or controversial; the effects of system changes on learning outcomes are difficult to assess unambiguously (there are always several possible causes for any observed effect); and both the costs of the changes and the benefits of the outcomes are endlessly arguable. Furthermore, few industrialists would argue against attempting to improve product quality or rate of return on investment, but any proposed change in curriculum structure or instructional methods faces almost certain opposition from some faculty members and administrators.”

Felder’s observations of both manufacturing and education are highly accurate (especially his comment on the resistance to curricular change in engineering). He rightly points out that manufacturing outcomes are more easily measured than educational outcomes. I contend, however, that to say that manufacturing control is easier is to miss the important point altogether. He errs in a fundamental way in putting the two processes (manufacturing and education) side by side to start with, for this reason: Manufacturers control what is manufactured in a way that educators cannot (and should not expect to) control what is learned.

Educators who like me lived through the Total Quality Management era of the 1980’s learned some things about statistics, but mainly we learned the importance of removing sources of variation if we want quality results. [10]

However, it is wrong, logically and operationally, to apply this same “eliminate-the-variation” control theory to education. Students come to us with different skills, abilities, and values, and they should leave the same way (as long as ignorance and incompetence are not part of the package). The idea that the engineering programs that ABET accredits are either effective or ineffective processes that stamp, mill, shape and polish raw material into either low- or high-quality finished goods is just a bad way of looking at it, for both educators and students. (A former dean of mine intentionally tormented me by referring to students who left engineering as “defects”, a clear extension of the manufacturing model to engineering education.)

The manufacturing viewpoint makes us want to insure that our lessons have the same predictable effect on every one of our students. In turn, that means we ignore (or at least minimize) the individual differences among our students (a practice Felder would under other circumstances be the first to decry). It means we also assume that our teaching controls (that is, causes, in the same way that a milling machine causes a change in size and shape of an object) in a totally predictable way, the learning that results in our students.

I find nonsense in both assumptions. Having stood in front of scores of classes, small and large, I know the fragile nature of the relationship between what I say and do, and what students learn. The huge differences in the backgrounds, experiences, attitudes, habits and abilities of my students mean I can be sure that some of the students will “get it” better than I. Some, conversely, will be more confused than when they started my course. That fragility is inherent in human behavior, not my teaching, no matter how it might be conducted, or how it might be assessed. My overall success can be improved or worsened, but change cannot be predicted, for individual students or whole classes. I will guarantee that my methods will work better on good students than poor students (that is, students who are either well or poorly suited for my course), but I cannot make guarantees beyond that.

A major tenet of OBA is that it focuses on what the student learns, not what the instructor does, but the self-absorbed professor who cares not what is learned is a straw man, logically speaking, and thus an inappropriate target for the massive mobilization behind ABET 2000. We have been doing that measurement of learning for centuries, of course, in the form of grades, but one of the odd tenets of ABET 2000 is that grades, for the most part, are not an outcome [11]. I assert that we do not need elaborate outcomes-based assessment to make us focus on our students’ learning.

My point is that ultimately the kind of human behavior we are interested in shaping in engineering education is not measurable in a sufficiently precise and reproducible way to allow manufacturing analogies to apply. It is not because of our lack of cleverness or resolve, but because human behavior lacks predictability, the thousands of experiments with rats pressing bars, college freshmen memorizing nonsense syllables, and pigeons pecking keys notwithstanding. A stimulus-response viewpoint of learning may have worked for Pavlov; it doesn’t work for engineering education (or, some would contend, any other form of higher education [12]). Clarifying what an instructor wants the students to know at the end of the course is altogether a good thing, and measuring success is part of the job of teaching, but the OBA assumption that there is a
In summary, education is not like manufacturing. It is inconvenient for educators, but it is the truth.

**OBA and ABET 2000 10 Years Later: Where’s the Payoff?**

The second striking global aspect of ABET 2000, as it has played out over the past decade, is that it has made a great deal of difference in the world of accreditation, and only a little difference in how engineering is taught, or what engineering students learn.

Notice I am not trying to quantify those observations. I can see changes, many positive ones, in the academic experience of the undergraduates I know in engineering. I know how hard they work, how hard their instructors work, and in sum how intense and beneficial their experiences as undergraduates are. Today’s engineering students where I work are more likely to have studied or at least traveled abroad, more likely to have paid work experience, more likely to have taken advantage of student leadership opportunities, and more likely to use academic support services. Engineering education is better than it was ten years ago.

The 2004 ABET report Engineering Change: A Study of the Impact of EC2000 makes similar observations about engineering education, but attributes that improvement to ABET 2000 [19]. The logic followed in that report is that the new accreditation caused changes in curricula, faculty attitudes, and teaching practices, which in turn caused changes in student experiences, which in turn caused improvements in student learning. Based mainly on comparisons of 1994 and 2004 self-reported student opinions of their confidence in their abilities in certain areas, the report states “moderate to strong evidence that EC2000 related changes in program curricula, policies and practices…are, indeed, reshaping students’ engineering-related experiences.” Indeed, the report finds changes in educational practices, and then improved student confidence in problem-solving skills, communication skills, etc. A skeptic (me) need only point to data from the Chronicle of Higher Education [20] showing that the percent of new college students rating their own academic ability in the top 10% of all freshmen rose from 54.8% in 1998 to a truly wince-inducing 66.6% in 2004. It is tendentious for ABET to attribute a growth in engineering student self confidence to its insistence on OBA, in light of what is happening to all college students. One might suspect, in fact, that ABET is guilty of the post hoc, ergo propter hoc fallacy (assuming causation from correlation), the one we warn all our engineering students about in the ABET-required statistics class.

The Engineering Change report also presents data from targeted engineering faculty (less than half of whom responded to the survey); half of the respondents reported “a moderate to significant increase in their use of modern engineering tools…in a course they taught regularly.” Without comment, the report noted that only 28% of the
faculty who responded thought that ABET had a moderate or strong influence on their curricular change.

If other programs are remotely similar to the one I am associated with, OBA has been and will be nearly irrelevant to the improvement of engineering education, so I would have to agree with the 72% of faculty surveyed in the Engineering Change report.

**DO WE NEED BETTER ASSESSMENT OF OUR ASSESSMENT?**

As Felder said in the early days of ABET 2000, “Producing graduates with the specified characteristics and proving that we have done it may be an extremely tough optimal control problem, but engineers are used to solving tough problems and we'll eventually solve this one too.” Indeed, engineering educators have solved the “problem” in that they have met the demands of ABET 2000, and they have learned how better to educate engineers. (I would not say, of course, that they have succeeded in solving education as a control problem, or that ABET changes and better education are related). It appears that on the whole good programs continue to be accredited, and poor programs continue to benefit from the accreditation process.

One possible conclusion: given the complexity of the education process, across so many institutions and over the span of a decade, it is impossible, ironically enough, to attribute reliably measured improvements in engineering education to the accreditation process (in the same way this paper has argued that learning is only loosely connected to curricula). The quality of students coming in to engineering, the resources expended on undergraduate education, and external demands on faculty time and energy (including preparation for ABET visits) over a decade have had much more influence on the quality of engineering education than OBA has had. As an empiricist, I would say that is a falsifiable and therefore valid (if perhaps false) proposition, but I believe the burden is on ABET, not me, to refute it.

A huge amount of effort has been expended on ABET 2000. In the world of engineering, where decisions are made on the basis of effectiveness relative to resources, where is the assessment of our assessment? The Engineering Change report showing improvements in engineering education says nothing to support the OBA philosophy. Likewise, nothing was measured to support the conclusion of the Sustaining the Change report on ABET 2000 [21], which, in an elaborate fashion, simply says that the OBA approach to engineering education must be sustained.

I feel my own college should be looking at the value added by the accreditation process in a more critical way. Are we really getting our money’s worth when the bulk of the feedback we get is on the effectiveness of our process of establishing outcomes and measuring them, with little or no comment on how to improve our curricula and teaching methods? I say no. There is great potential value in a focused third-party evaluation of our programs, but I’m not sure that is what we are currently getting with ABET.

**CONCLUSION**

To paraphrase Felder, developing a logical, cost-effective accreditation process may be a tough problem, but engineers are used to solving tough problems. The point of this paper has been to question both the assumptions and the efficacy of ABET 2000. It was inspired not by knowledge of assessment, or by happy experiences with the old accreditation system or unhappy experiences with ABET 2000 (I’ve had neither), but by the simple observation that ABET 2000 has all the trappings of other educational fads such as direct instruction, contextual math, whole learning and TQM. It oozes zealotry, bewildering vocabulary, unexamined tenets, reliance on imperatives rather than indicatives, irrefutable claims, and support from administrators and politicians, not practitioners.

Engineering education deserves better. If ABET 2000 has clearly caused improvements in engineering education in proportion to the effort expended, then refutation should be easy in the hands of our measurement experts in the assessment business. That refutation will be welcomed all around: by ABET 2000’s originators, its proponents, and by those who labor to fulfill its mandates. We all want to make engineering education better.

**ACKNOWLEDGEMENTS**

I gratefully acknowledge the help of Diana Wheeler in gathering information for this paper. The views expressed in this paper are solely mine, and do not represent the views of the College of Engineering at UW-Madison or the university itself.

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