Analysis of ABET Accreditation as a Software Process

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ABSTRACT

The ABET assessment process is highly complex and is emphasizes the use of assessment to improve programs. Since the process is complex, it has a considerable overhead. This paper will present some models for estimating the added overhead of such assessment. The models can be used to help determine if any other activities must be curtailed because of the increased overhead of assessment. The models suggest which categories of colleges and universities will be affected most adversely by the overhead of the ABET accreditation process.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**.]: Computer science education, Curriculum

General Terms

Management, Documentation, Economics, Standardization

Keywords

Software engineering education, accreditation, software process

INTRODUCTION

ABET is the primary organization responsible for the accreditation of engineering and technology programs in the United States [1]. From the perspective of departments undergoing accreditation, the ABET accreditation process has evolved over the years from a largely prescriptive process into one which is heavily based on assessment. The first large-scale emphasis on assessment in ABET accreditation came with the advent of the ABET 2000 criteria. This paper focuses on the ABET process for accrediting programs in Computer Science, although the issues raised here will affect most accredited engineering programs. Computer Science programs were originally accredited by the Computer Science Accreditation Board (CSAB) under the aegis of the Computer Science Accreditation Commission (CSAC). CSAC was subsumed into ABET in 2001. CSAB serves currently as a participating body of ABET with two members on the ABET Board of Directors [2].

The Department of Systems and Computer Science at Howard University had its first ABET accreditation visit in 2002, with preparation taking place in 2001 in one of the first cycles of ABET accreditation; the previous accreditation visits and subsequent accreditation had been done by CSAB. The department's program has been accredited continuously since 1987. The author was department chair for nine years, including the period of transition from CSAB to ABET accreditation.

There were some transitional issues when ABET obtained responsibility for accreditation of Computer Science programs. The author had learned a considerable amount about the ABET assessment process from discussion with other chairs of engineering departments at Howard University, attending various sessions at the SIGCSE and Frontiers in Education conferences, reading literature, and by participating in specialized ABET accreditation workshops. As was expected, the department worked hard to develop detailed goals and objectives; collect course materials as needed; base curricular changes on evaluation of surveys from alumni and graduates, as well as examination of our courses' outcomes; and to help prepare the self-study report. Even though the department was prepared and collegial, there was considerable unease about the process that would be used to evaluate the department's program.

An extremely valuable insight came from a comment of the previous department chair that the ABET assessment was just like software metrics. Putting the process in that perspective made it easy to lead the development of the department's goals and objectives, and to taxonomies to distinguish exposure, competence, and mastery for all the major topics in the multi-course sequences. Fortunately the department was successful in its ABET accreditation efforts and has continued to be accredited.

However, the success appears to have had a considerable cost, which does not seem to be addressed adequately in the literature. A simple Google search performed on October 18, 2007 with the search terms "ABET" and "effort to prepare" identified the four comments listed below (There were 4250 results from this search, but most focused on the preparation of students).

- From a Professor: "I am leading our department effort to prepare for our next ABET visit. This is very time consuming since we will be evaluated under the new criteria." [3]
- From a Chair: "Both Kyriakos and Brian Mitchell put in countless hours of selfless effort to prepare the documentation …" [4]
- From a Dean: "Our dedicated faculty and staff will be contributing a large amount of effort to prepare reports for the accreditation visits." [5]
- From a Chair: "Since it was the first time a visit was conducted under the ABET Criteria 2000, … faculty and staff spent considerable time and effort to prepare." [6]

Compare this to the more than 550,000 matches to the terms "ABET" and "assessment" in a second Google search. Many of the search results on the first page of results returned listed responsibilities of departmental assessment committees; one included a flowchart of the process; such results were not examined farther. The 5,500 or so accredited programs generated

an average of over 100 relevant web pages. This suggests that there is a non-trivial overhead to ABET assessment.

At Howard University, the self-study report increased from 165 pages when prepared under CSAB standards to 235 pages to meet the criteria in place at the time of the first ABET site visit. The demands of the time-sensitive ABET accreditation process on the author as department chair required that the author to suspend temporarily his research publication agenda during the preparation period. A perusal of the 80-ply publications on the author's CV suggested that this temporary suspension of research activities did not appear to have been necessary during preparation for the previous visits under CSAB. Thus, there was additional concern about the overhead of the ABET accreditation process.

The continued movement by ABET towards assessment-based accreditation, with increased emphasis on precise learning objectives, evaluation of how well students perform in meeting these objectives, and the measurement of how well the program does in achieving these objectives appears to be quite time-consuming, at least at first glance. However, a suspicion that a process "appears to be quite time-consuming" does not represent a contribution to the accreditation process.

There is a rule of thumb in software development projects, dating from before the advent of the CMM, that a systematic program of software measurement with metrics-based program improvement costs from 5 to 15 % of the total cost of development of the software. (These estimates do not consider the costs of operations or maintenance of the software.) If the analogy between metrics-based software management and metrics-based assessment holds to any extent, there is a considerable amount of departmental effort the assessment process that must be accounted for by the faculty and administration of the department.

Some faculty colleagues at Howard University and at other schools have expressed envy when discussing institutions for which Computer Science programs do not undergo the ABET accreditation process. These faculty members claim that the overhead of preparing for ABET accreditation is an onerous task and that faculty elsewhere may have more time to devote to what they consider their core activities: teaching and research. Unfortunately, such anecdotal information does not advance the cause of research into the overhead of the assessment process.

This paper will attempt to answer the following questions:

- Are faculty members correct in their assessment of the overhead of ABET accreditation correct?
- Is the ABET accreditation process complex, but beneficial?
- Is the ABET accreditation process simply onerous, with few benefits to programs?

This paper also will present some process models that suggest a range of values for the added overhead of following the ABET assessment process. Different models will be developed for several different categories of colleges and universities.

THE ASSESSMENT PROCESS AS A SOFTWARE ENGINEERING PROCESSES

Considerable guidance in the assessment of many companies' software engineering programs has been provided by the availability of the Capability Maturity Model (CMM), which was intended to improve software development [7]. The higher levels in the CMM process reflect greater degrees of improvement in the production of software, in both quality and efficiency of product development. The goal is to obtain measurable improvements in both the quality of software products and in the efficiency of the process in which they are developed. Any changes in the software process are suggested by the collection, analysis, and use of metrics to provide data that is deemed appropriate for the development organization. The more the feedback from the data analysis is used to improve the development process, the higher the CMM level. We note that the CMM model has been superseded in industry to a degree by the newer Capability Maturity Model-Integration (CMM-I) [8]. The CMM-I program reflects the importance of integration of existing software components into systems, even if the components were developed outside the organization being evaluated.

At Howard University, modeling the assessment process by analogy with approaches to software metrics data collection and analysis has continued to be useful in the current preparation for the next ABET visit. The ABET assessment process requires continuous program improvement, as measured against the programs achievement of overall program goals and objectives, with the program goals reflected in the learning objectives in each course, and the demonstration of the degree to which each of the learning objectives is met by each student in each relevant course in the degree program being accredited.

The ABET assessment process requires identification of stakeholders, who contribute to the evaluation by external assessment tools such as surveys and focus groups. Stakeholders can include alumni, employers with experience hiring program graduates, potential new employers, and representative of graduate programs. A program's Industrial Advisory Board (IAB) can be a wealth of information about industry needs and long-term trends. Hence, the IAB can be important stakeholder. Survey data is often collected from prospective graduates, asking them for a frank assessment of what they perceive as the strengths and weaknesses of their educational program.

Creating inputs for the ABET process does not seem to be unusually demanding for external stakeholders. In part, this is because the interactions are limited, to, say, filling out a questionnaire, or attending a meeting of an IAB that the IAB member has already agreed to. In the next section, we consider briefly the overhead of external assessment.

CONTINUOUS PROGRAM IMPROVEMENT

A major theme of the ABET accreditation process is continuous program improvement based on the results of assessment. Programs should change based on analysis of the results obtained from both external and internal sources. As discussed previously, the external sources include major stakeholders. Survey information, collected and analyzed on a regular, systematic basis is critical, but is not considered especially burdensome by most departments, since the mailing lists can be organized by student workers, on-line surveys can have results provided automatically, and the input from an IAB is not especially time-consuming.

Departments always have committees responsible for changes to the curriculum. Prior to the ABET accreditation process, there were meetings to determine the program objectives and to make sure that courses are in place to insure that the program's objectives were met. The additional work to insure that the

program objectives map to the objectives (often referred to as "a through k") that are part of any ABET process requires a few meetings, which represents a level of effort typical of a moderately energetic departmental curriculum committee.

The increased department workload on individual faculty caused by internal assessment is another story. Each of the program's objectives must be reflected in the educational objectives for each course in the curriculum. In practice, there must be specific learning outcomes for each course. Of course, the course syllabi must be quite detailed in their descriptions of program objectives. The collected and aggregated measures of the effectiveness of learning outcomes provide a wealth of information on the actual learning of the students in the program.

If a major educational goal of the program is measured by, say, three specific educational outcomes, and the data show that none of these three specific educational objectives are met, than the program must confront what is, clearly, a situation where the program's education must be improved. There are several possibilities for such program improvement:

- The teaching of the educational objectives may be done poorly. This may involve retraining of the instructor or instructors involved. It may mean a switching of instructors from courses that they may have taught for many years; this is likely to be painful for many departments.
- The specific educational objectives may be inconsistent with the program's goals and objectives. This is an internal change that is likely to be relatively easy, since it does not involve any new data or analysis. Only a few new specific educational objectives will have to be changed, together with syllabi and measurement instruments (tests, homework, laboratories, written and oral reports, etc.) This is standard in academic departments.
- The specific educational objectives may be wrong in their details, or the measurement instruments may be in need of improvement. This is standard in academic departments.
- The program's curriculum must be changed. This may mean that the sequencing of courses may need to be changed. In smaller schools, courses that have been offered, say, every other year to juniors and seniors may need to be offered on a yearly basis, because students less far along may have insufficient knowledge of their discipline to succeed in mastering learning objectives in these courses. This may be difficult to do because of resource issues.
- The program's goals and objectives may be wrong, at least for the department and its current resources. These changes must be compared with the data from the inputs of the program's stakeholders before they are changed.

REPORTING

Data must be collected for each course to demonstrate that the course has succeeded in having (at least) a majority of its students master the critical material at the desired level. After the data on mastery of learning objectives has been collected and analyzed for each course, it must be aggregated into reports on how individual learning objectives are met throughout the curriculum.

One way to crate and aggregate this information for ABET accreditation is by a paper-based process. In this process, the original records of each homework, class assignment, research paper, project, or examination are returned to students, with grades and comments indicated in the usual manner. A copy of each of the written assignment turned in by students is kept for each class. Paper copies of evaluations of oral presentations are kept, also. The copies of the student work are then analyzed again and explicit information is kept on each student's mastery of learning objectives associated with the program's objectives.

In addition to the overall grade and the instructor's or grader's comments on the paper copy, each item is examined to determine the degree to which the student's performance on the course's original educational objectives were met. This means that that the data on every learning objective assessed by the item must be kept separately. This implies that every item a student turns in is, in fact, graded twice: once for the traditional grade of the item, and once against the learning objectives.

The recording is much more complex, also. A single grade on a mid-term exam usually will be entered into a spreadsheet or a course management system such as Blackboard. For the ABET assessment process, a much more complex spreadsheet must be set up for each course. There must be places in the spreadsheet, say columns, for the student's name and each of the learning objectives. An entry must be made in this spreadsheet for each student's performance on each item that has an associated learning objective. Since the same learning objective may be measured by multiple items on different tests, homework, exams, etc., there must be entries for each in the spreadsheet. Hence, the spreadsheets are complex than those in normal grade books.

How complicated are these spreadsheets? At Howard University, for example, one student assistant indicated that it took her approximately 40 hours to create a direct assessment Excel spreadsheet for a single course, one taught by the Department Chair. This spreadsheet was then presented to the faculty using the Google group set up for the process as a sample of how to proceed. On this sample spreadsheet, the direct assessment of each of the educational outcomes listed on a single Excel worksheet. The individual worksheets, one per educational outcome, were accessed by tabs at the bottom of the Excel spreadsheet page. The results from the direct assessment of the educational outcomes, entered on the individual worksheets, were automatically aggregated into the worksheet that had overall assessments of all educational outcomes. (The student assistant was a graduate student with good office skills, with a major in a relatively non-technical field. A second student assistant now working on this spreadsheet is a Computer Science major, who may be able to design the spreadsheet more quickly.)

Since the author's educational outcomes were different from the ones on the sample spreadsheet, the sample had to be copied and edited, with new tabs created and labeled for each educational outcome. The editing of the new spreadsheet took the author approximately 6-8 hours per course, including adding the links to the page with the aggregation of data. Others had experiences similar to the author's and, therefore, the spreadsheet was simplified. This required an additional meeting and considerable additional effort by the department chair and student assistants to simplify the spreadsheet.

In any event, this is much more time consuming than the typical pattern of copying the electronic class roster into a simple spreadsheet with the items being graded listed in the first row and simple formulas created to compute grades. That process generally takes less than half an hour per course. Clearly, the

preparation of data collection spreadsheets is considerably more time consuming under an ABET process than otherwise; however, the total time is not large, in any case, and might be reduced with greater experience in the creation of such spreadsheets.

The data collection process needed for the direct assessment of educational outcomes under ABET requires more effort than does the more standard approach. Assuming that an examination or homework measures more than one educational objective, not only does the overall score on the examination or homework have to be recorded, but the scores on each individual educational objective must be entered on a spreadsheet. Using the spreadsheets developed at Howard University, for example, there will have to be entries on multiple worksheets, requiring constant switching between tabs in the spreadsheet. The same holds for each item being assessed, including presentations, written documents, and laboratory projects. This greatly increases the recording time for items, possibly by a factor of three or more, regardless of whether a faculty member or a student assistant does the recording. It is clear that the rapid feedback to students will suffer, even though many faculty members believe that rapid feedback is an essential part of the learning process.

Faculty must also collect copies of student work and make sure that specific examples of above-average work, average work, and below-average work are included in the course books needed for the ABET site visit. This is not usually difficult, especially if the faculty member uses electronic submission or a course management system such as Blackboard.

ASSESSMENT OF THE ABET ACCREDITATION PROCESS

Even with the successes of metrics-driven approaches in the experiences of himself and others involved at different levels of ABET assessment, the author has had some unease about the complexity of the assessment process. He had been a (relatively inactive – only sent one E-mail message, attended no meetings) member of the IEEE Software Product Metrics Working Group in the late 1980s, and an observer of material created by the IEEE Software Metrics Process Working Group around the same time. The reason for the unease has finally become clear – there is no metrics-based assessment of the ABET assessment process itself! The reader will note that the assessment of the ABET process was the basis for the research questions mentioned earlier.

The author estimated that preparation of the department's first ABET self-study report took 50% of his time for an academic year, which was 5 % of the total person-hours for the 10-person department faculty that year. While other departments will have different experience, 5% seems a reasonable first approximation to the overhead of the assessment process used prior to 2007.

However, there are added demands in the newest ABET assessment process. The author's experience with the development of syllabi is that creating ones that are consistent with the current ABET process requires much more time than previously, approximately 1-1.5 days more per course, with perhaps additional time for new courses. We saw earlier that the time to create the collection instruments and configure them per course is approximately 4 hours per course, assuming that the initial spreadsheet was created previously as a template. With a teaching load of two courses per semester, with 45 days of class meetings per semester, the load on a faculty member has been increased by 3-4 days, which is a range of 6.7% to 8.9%. (This model assumes that the additional days in which classes do not meet are spent in some combination of service, research, professional development, and consulting.)

The time needed for data recording will double. While the recording, and often the grading, is done by student assistants at many larger, research universities, at many schools the additional recording is done by faculty members themselves. This may require an additional day or two for recording.

We estimate that the total additional effort needed by a department for preparation of ABET materials is, at least, the sum of the 5% observed by the author in 2001, the 3-4 days needed for more complex syllabi and spreadsheets (6.7% to 8.9%) for each faculty member, and the time needed for additional recording, which is estimated as 2.2% (1/3 of 6.7%) for each faculty member. This suggests an increase in load of nearly 15% per 10-person department to create, collect, and analyze the data needed for assessment by ABET. This does not even count the need for additional meetings of the appropriate committee.

To make the calculations easier, and to avoid overemphasis of any biases caused by the author's process, we will use the much smaller value of 10% as the value of the percentage increase of effort that we will use for the analyses presented in the rest of this paper. It would apply to departments smaller than 15 faculty. The percentage of overhead may be much smaller in very large departments.

A reader of this paper may object to the calculation of this overhead, because the collection and analysis of the data on direct assessment of student performance occurs only the year before an ABET site visit. The goal of the ABET process is continual program improvement, so some data collection is necessary, even in the "off-years."

We note in passing that small-group class participation appears to be nearly impossible to assess, although rubrics for the evaluation of team projects are readily available (and used in most engineering departments at Howard University).

SUSTAINABILITY OF THE ABET ACCREDITATION PROCESS

ABET accredits programs in the areas of engineering and technology in universities and in two- and four-year colleges. Let's look at the general characteristics for each institution type and the likely effect of ABET on the workload. We begin by listing the types of institutions that are least likely to be affected by the overhead of the ABET accreditation process. We will use the newest Carnegie Commission classification nomenclature.

- For two-year colleges, for whom faculty size is often driven directly b enrollments, the course loads typically range from four to five courses per semester. In some cases, reduced teaching loads may be granted. It is likely that additional adjuncts may have to be hired. Some committee responsibilities may have to be put on hold.
- For Carnegie "Research Universities (very high research activity)" institutions (formerly known as "Doctoral Extensive") there is likely to be little effect. The teaching loads are typically very low and there are ample resources that can be redirected towards supporting the accreditation

effort. In some cases these institutions, although their programs are highly regarded both nationally and internationally, do not choose to undergo the ABET accreditation process.

The situation may be more slightly difficult for institutions in the next two groups. In general, these institutions wish to rise in class to the level of the very high research activity research institutions. There is considerable pressure on faculty to publish and to obtain external research funding.

- For Carnegie "Research Universities (high research activity)," institutions formerly known as "Doctoral Extensive," faculty may resent the increased overhead of the ABET accreditation process. Time spent on the accreditation effort may be seen as taking away from what the faculty and the institutions' leadership see as their primary mission. There is also a concern that the typical approach to extending faculty resources by the use of adjuncts; however, it is unlikely that more than a very few adjuncts will do the type of data collection and analysis needed for ABET. Also, some graduate students may get discouraged by the data collection and analysis they and their faculty mentors have to do that they will opt for careers in industry rather than in teaching.
- For Carnegie "Doctoral/Research Universities," institutions formerly known as "Doctoral Intensive" or "Master's I," the situation is likely to be even worse, because the resources tend to be more limited, but the goals are those of schools in the same category as above.

The next two categories have other problems.

- For institutions formerly called "regional comprehensive," that typically grant only Masters degrees, the same problems apply. Some of these institutions have faculty members characterized (at lest informally) as teaching faculty. It is likely the additional load of ABET preparation will fall greatly on them. Since in many cases, these faculty members are older, they may wish to retire rather than take on increased workloads. The option of forgoing ABET accreditation may be appealing, especially if there is no engineering school and ABET is not an entrenched stakeholder in the institution.
- For four-year colleges, there may be serious resource problems in small departments. Released time may not be available and professional development may be sacrificed to meet ABET accreditation needs. Many such institutions will forgo pursuit of ABET accreditation.

CONCLUSION

The data and analyses presented in this paper provide the following answers to the research questions given above

- Are faculty members correct in their assessment of the overhead of ABET accreditation correct? Yes. There is considerable effort involved, not just for department chairs and assessment committees. The overhead of the assessment process is much lower in those members of the top levels of research universities who participate in ABET accreditation.
- Is the ABET accreditation process complex, but beneficial? There is strong agreement that it is complex. The nature of the benefits may vary, depending on the type of institution. As far as the author is aware, there have bee no studies of the benefits, particularly when any benefits are weighed against the resources required for compliance with the process.
- Is the ABET accreditation process simply onerous, with few benefits to programs? This is likely to be a common view of faculty at universities that emphasize research and wish to move up in research rank, but which do not have the resources in house to provide all needed support. Faculty will perceive the ABET accreditation process as an uncompensated burden.

FUTURE WORK

The migration from CMM to CMM-I as a model of an organization's software development was based on the recognition that many software components used in systems have been developed outside that organization and must be integrated within systems. There are parallels in education, also, with the increasing use of tutorials from Sun, Microsoft, IBM/Rational and other vendors, public domain web sites, and on-line education (such as is available from, say, ACM) replacing traditional textbooks. There is a balance between meeting the needs of industry for professional certified in particular technologies vs. a more balanced overall education. Perhaps the changes in the CMM models to reflect increased integration have a parallel in the potential for increased integration of non-traditional education into the standard academic program of study.

It would be interesting to revisit this research on measuring the overhead and effectiveness of the ABET assessment process as these non-traditional educational approaches become more acceptable in the academic world. Certainly, a survey of faculty attitudes toward the ABET accreditation process would provide useful information.

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