Assessment Methods for the Upcoming ABET Accreditation Criteria for Computer Science Programs

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Abstract - The accreditation criteria and assessment expectations for computer science programs are undergoing rapid changes as ABET seeks to normalize the criteria between its EAC and CAC commissions. This paper presents the curricular structure and assessment methods of a new computer science program and describes how it has met ABET/CAC's current criteria. The program adopted a set of outcomes for computer science that are aligned closely with those associated with engineering programs. Faculty connected their courses to the program outcomes with specific course outcomes, which are assessed quantitatively by multiple measurement methods. The end result is a program assessment procedure that fulfills the intent of ABET/CAC's criteria, provides the program with useful and actionable feedback, and does so without imposing an undue burden on faculty. The outcomes originally chosen for this program are a close fit with the program outcomes listed in ABET's recently published “2008-2009 Criteria for Accrediting Computing Programs – New Criteria”, thus the structure presented in this paper may be applicable to programs undergoing a transition to these new criteria.

Index Terms – Accreditation, Assessment, Computer Science, Program Outcomes.

INTRODUCTION

The ABET Board of Directors has mandated that the General Criteria of ABET’s four Accreditation Commissions be restructured so that the various criteria sections occur in the same order. This restructuring also included some editorial revisions to improve the consistency and clarity of the criteria. The Board approved the changes in their March 17, 2007 meeting. Following a transition period, computing programs undergoing reviews during the 2009-2010 accreditation cycle will be required to meet a new set of accreditation criteria [1].

The new computing program accreditation criteria represent a major change from those of the past. Most of the content specific criteria have been eliminated in favor of a set of program outcomes and an expectation of a formal and substantive outcome assessment system. Programs undergoing accreditation reviews during or following the 2009-2010 accreditation cycle will need to examine these criteria several years in advance to ensure a favorable outcome. Time will be required to implement and exercise an appropriate outcome assessment system and to accumulate the assessment data needed to make program improvements as required by the new criteria.

In 2004, a new School of Engineering and Computer Science [2] was established on the Vancouver campus of Washington State University. The school was initially authorized to offer degree programs in mechanical engineering and computer science. In the fall of 2007, WSU’s College of Engineering and Architecture was due for its next ABET review of all its programs, of which the new school was a part. This offered both a challenge and an opportunity to meet the current ABET/CAC criteria for computer science within a period of 3 years, and to put in place a program and assessment system that would adapt easily to the expected changes to those criteria in 2009. This paper describes the program outcomes and assessment methods established for the WSU Vancouver computer science program.

As of the fall of 2007, this computer science program had 45 undergraduate students in the program and 10 graduates, all from the previous May graduation. While this is a new, small and growing program, the faculty sought to establish an assessment system that would scale well as enrollment grows and continue to meet the expectations of accrediting organizations such as ABET.

PROGRAM OUTCOMES

The current “2007-2008 Criteria for Accrediting Computer Science Programs” [3], contains one criterion related to program outcomes as shown in Table 1.
TABLE 1. Current CAC accreditation criterion related to program outcomes.

Criteria for Accrediting Computer Science Programs  
Effective for Evaluations during the 2007-2008 Accreditation Cycle

1. Objectives and Assessments

**Intent**
The program has documented, measurable objectives, including expected outcomes for graduates. The program regularly assesses its progress against its objectives and uses the result of the assessments to identify program improvements and to modify the program’s objectives.

**Standards**
- I-1. The program must have documented, measurable objectives.
- I-2. The program’s objectives must include expected outcomes for graduating students.
- I-3. Data relative to the objectives must be routinely collected and documented, and used in program assessments.
- I-4. The extent to which each program objective is being met must be periodically assessed.
- I-5. The results of the program’s periodic assessments must be used to help identify opportunities for program improvement.
- I-6. The results of the program’s assessment and the actions taken based on the results must be documented.

These criteria do not dictate any particular outcomes or objectives. Also, no definition or distinction is made between outcomes or objectives. Indeed, there has been a great deal of variation in how programs have interpreted these criteria and what kinds of statements have constituted objectives or outcomes.

Knowing that engineering-like program outcomes and outcome assessment were likely to be incorporated into the computing program accreditation criteria, our program adapted the outcomes required for engineering programs [4] to computer science and settled on the set given in Table 2.

To the extent possible, the faculty limited their adaptation of the engineering outcomes to only those changes that appeared required for computer science. Now that the 2009-2010 computing program accreditation requirements have been published, we are gratified that they are a close fit to those we crafted in 2004.

TABLE 2. Computer Science program outcomes at WSU Vancouver.

Graduates of WSU Vancouver will possess:

- A. Firm foundation and knowledge of mathematics, statistics, science, and computing principles, and the ability to apply this knowledge to solving problems.
- B. Foundational knowledge of computer engineering and the methods by which computers are constructed and organized.
- C. Ability to design, implement, test and evaluate a computing system, software component, or algorithm to meet required needs and imposed constraints.
- D. Ability to function on multi-disciplinary teams.
- E. Ability to identify and analyze problems, and synthesize computational solutions.
- F. Understanding of professional and ethical responsibility.
- G. Ability to communicate effectively in writing, orally, and visually.
- H. Ability to understand the global and societal impacts of computing technology.
- I. Recognition of the need for, and an ability to engage in, life-long learning and an ability to adapt to changes and advancements in the field of computer science.
- J. Knowledge of contemporary problems and technologies related to computer science.
- K. Ability to use modern software development tools and languages necessary for professional practice.
EDUCATIONAL OBJECTIVES

Educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve [5]. The primary constituencies considered when developing the educational objectives of the program were the students, alumni, their employers and the program’s industry advisory board (IAB). With the participation of our IAB, we developed the educational objectives shown in Table 3.

TABLE 3. Computer Science educational objectives.

<table>
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<tr>
<th>Performance Criteria</th>
<th>Definition</th>
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<tr>
<td>1. You will be a knowledgeable and skilled computer scientist.</td>
<td>Each graduate’s knowledge will span the fundamental principles of computer science and include an understanding of several advanced specialty areas. Graduates will have practical experience with tools, languages and systems which are representative of those used by regional industries. Analytical problem solving and well-crafted software solutions will be hallmarks of our graduates.</td>
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<td>2. You will exhibit the workplace behaviors expected by employers.</td>
<td>Employers can expect our graduates to communicate clearly, to maintain task commitment, to stay organized, and to overcome obstacles, while working individually or in a team. Graduates will demonstrate these behaviors in their jobs and careers.</td>
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<td>3. You will be committed to high standards of professionalism.</td>
<td>Graduates will embrace a professional code of ethics in their practice of computer science. They will recognize the social impact of their work and respect the intellectual property of others.</td>
</tr>
<tr>
<td>4. You will adapt to the changing landscape of computer science.</td>
<td>Effective computer scientists must regularly update their knowledge and skills. WSU Vancouver graduates augment their knowledge and develop new skills with individual study, classes and other techniques. Some graduates will pursue advanced degrees; others will take advantage of professional development opportunities.</td>
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PERFORMANCE CRITERIA

The performance criteria describe the standards and means by which students demonstrate their achievement of a program outcome and represent the faculty’s interpretation of the outcomes. Thirty-six performance criteria were developed by the faculty to measure student achievement of the 11 program outcomes. In recent years, ABET has emphasized direct measures of student outcomes. The literature contains various approaches to direct measurement of course and program outcomes [6-12]. In our approach we interpret the performance criteria in the context of each course to derive course outcomes. Then, faculty assess achievement of the course outcomes by each student through questions and assignments targeting each course outcome.

The development of our performance criteria started in 2004. We first examined implementations at other institutions. We then studied a framework developed by a group of researchers supported by funding from NSF [12]. It provided Bloom and Krathwohl definitions of levels of learning (knowledge, comprehension, application, analysis, synthesis, evaluation and valuation). It also listed McBeath action verbs corresponding to these levels (such as define, describe, identify, classify, convert, apply, etc.). Using this as a basis, the framework provides levels of learning and outcome elements for each of the ABET outcomes. As an example, Table 4 lists the performance criteria associated with the first program outcome (A):
TABLE 4. Performance criteria for outcome A.

A. Firm foundation and knowledge of mathematics, statistics, science, and computing principles, and the ability to apply this knowledge to solving problems.
1. Chooses or creates an appropriate model for a computer program, system or development process.
2. Describes or uses fundamental computing principles in computer programs and systems.
3. Analyzes the complexity of computer algorithms using fundamental mathematical and computing principles.
4. Analyzes computational problems using mathematical techniques.

In general, several different courses will specify course outcomes targeting each performance criteria. For example, the master syllabus for a senior course entitled “Design and Analysis of Algorithms” specifies the course outcomes given in Table 5. The faculty teaching the course determines the assignments and/or exam questions that enable them to measure the outcome. Additionally, each course outcome is measured indirectly by surveying the students and asking them to what extent they believe they have met each course outcome.

TABLE 5. Sample course outcomes.

1. Describe the meaning, use & limitations of asymptotic analysis and notation. *(Contributes to performance criterion A-2)*
2. Analyze asymptotic complexity of algorithms. *(Contributes to performance criterion A-3)*
3. Design new data structures and algorithms to meet particular performance specifications. *(Contributes to performance criterion E-2)*
4. Describe the relations between complexity classes: P, NP, and NP-Complete. *(Contributes to performance criterion A-2)*

ASSESSMENT SYSTEM

The educational objectives and program outcomes require periodic assessment. In this paper, we present a 4-level assessment approach (Figure 1). The performance criteria level is critical, as it ties course outcomes to program outcomes.
Each year, the various assessments made in each course, both faculty assessments and student surveys, focus group data and senior exit surveys are compiled to generate a score for each performance criterion and program outcome. Figure 2 shows sample data for Performance Criterion A-1.

![Figure 2. Compilation of Performance Criteria Data.](image)

![Figure 3. Compilation of Program Outcome Data.](image)

We add the normalized percentages in Figure 3 for categories 5, 4 and 3 to determine an outcome score. In the case of Program Outcome A, the score is 84%. We track this score for each outcome over the years. Figure 4 shows the track record for program outcome A (2005-06 and 2006-07 data).

![Figure 4. Track record for Program Outcome A.](image)

The curriculum assessment committee collates the data, produces the track records and compiles all instructor recommendations to produce a program report for the faculty. Each year at the end of the spring semester, the faculty get together in a “close-the-loop” meeting where this report is discussed. Recommended actions are approved and course changes are planned for the upcoming academic year.

A question naturally arises, what does the score mean? It is a dimensionless quantity and it may not be clear what the score is a measure of. We think the best interpretation of the score (84% in the example cited) is to regard it as the percentage of the opportunities given to students to demonstrate their achievement of an outcome where they met or exceeded the faculty’s expectations. Faculty should set goals for each outcome and must take action to improve the outcome scores to meet ABET’s accreditation criteria. When scores drop, it is usually a simple matter to determine what performance criteria and/or course outcomes were responsible.

In the system we established at WSU Vancouver, we noticed fluctuations in the scores due to changes in key course assignments, issues in a prerequisite course, changes in instructors (and their standards) and due to a change in the mix of elective courses offered. Our experience to date has taught us that each performance criterion should have 6 to 9 measurements, usually supplied by the assessment of course outcomes. This prevents outcome scores from becoming overly sensitive to minor perturbations in the delivery of a single course.

The establishment of this assessment system required considerable time and effort from the faculty. The determination of performance criteria and setting up course outcome to measure them was particularly time consuming. However, once established, the system has been simple to operate, requiring only minor additional effort from faculty. Once course instructors have determined how they will measure a given course outcome, the effort in making the assessment adds little to their instructional burden.
There are two activities in this assessment system that determine the level of burden placed on the faculty. Each academic year, the data from course outcome assessments, senior exit surveys and focus groups must be gathered and entered into the computation of the program outcome scores, as seen in the examples of Figures 2 and 3. This activity can be accomplished following the end of spring courses and clerical personnel can accomplish much of it. Of course, the interpretation of the data must lie with the faculty and one or two faculty meetings are usually required to reach an understanding of the assessment data and to take actions based on it. Of most concern is the burden placed on instructional faculty in assessing individual course outcomes. This burden is directly related to the number of course outcomes assigned to each course. We found that assigning more than 6 course outcomes to a course was problematic.

**Conclusions**

In this paper we presented a 4-level assessment approach. One of these levels is the performance criteria level which ties course outcomes to program outcomes. The performance criteria describe the standards and means by which students demonstrate their achievement of a program outcome and represent the faculty’s interpretation of the outcomes. In our approach we interpret the performance criteria in the context of each course to derive course outcomes. Then, faculty assess student achievement of the course outcomes by each student through questions and assignments targeting each course outcome. These assessments are the direct measures. Data collected in each course and through other sources, including exit and student course surveys and focus groups, are assembled to arrive at a percentage score for each program outcome. Based on these scores and the data, faculty may make changes in the curriculum to “close the loop”. The outcomes originally chosen for our program are a close fit with the program outcomes listed in ABET’s recently published “2008-2009 Criteria for Accrediting Computing Programs – New Criteria”, thus the structure presented in this paper may be applicable to programs undergoing a transition to these new criteria.

**REFERENCES**