The Value of ABET Accreditation to Computing Programs

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Abstract

Institutional accreditation by regional or national accreditation organizations provides assurance that a university as a whole provides quality education. However, it does not look specifically at the quality of each individual degree program. Program-level accreditation is needed to ensure that degree programs meet established standards that are set by accrediting bodies, based on disciplinary guidelines in areas as diverse as curriculum, faculty expertise, student admission and graduation requirements, available facilities and financial resources. In particular, program-level accreditation focuses on the quality of both the degree program and the characteristics of its graduates.

For programs in computing, engineering and engineering technology, as well as applied and natural science, ABET is the accrediting body. Within ABET, the Computing Accreditation Commission (CAC) is charged with accrediting computer science, information systems, information technology, cybersecurity, and other computing programs, initially in the United States but now in more than 20 countries across the world. In computing, program accreditation has been viewed as optional, unlike in engineering, where nearly all American engineering programs are accredited through the Engineering Accreditation Commission (EAC) of ABET, both because graduates from an ABET-accredited program find it easier to get licensed as a Professional Engineer and because of wider acceptance of the accreditation process by the engineering communities. Despite the lack of mandatory accreditation, an increasing number of institutions seek accreditation for their computing programs each year, suggesting that the community is finding value in accreditation. These programs can state that they have passed a rigorous review and that their graduates have learned what they need to know about their discipline. Moreover, graduates of ABET accredited programs also gain global acceptance due to its conformance with the Seoul Accord which provides mutual recognition of accredited academic computing programs that prepare graduates for professional practice.

Based on the authors' experiences, both as faculty associated with accredited and non-accredited computer science programs and as program evaluators for ABET, this paper examines the process and requirements for achieving ABET accreditation for computing programs, and discusses the

value of computing accreditation for students, faculty, institutions, program constituents and global society at large.

***Index terms*—** Computing accreditation, program accreditation, best practices, quality improvement.

1 Introduction

ABET[1] is the main accreditation body for programs in Computing, Engineering, Engineering Technology, and Applied and Natural Science in the United States. Currently, ABET accredits 3,709 programs at 752 universities in the United States and 29 other countries[2]. ABET is organized into four commissions that carry out accreditation activities in their respective discipline areas of applied and natural sciences, computing, engineering, and engineering technology. To be accredited, a program must satisfy ABET's criteria that are centered on what students actually learn, whether the curriculum, faculty and facilities are appropriate, and determining whether the program meets quality standards for producing graduates who will enter and succeed in the global workforce as educated professionals.

Within ABET, the Computing Accreditation Commission (CAC) accredits at least one program in 305 separate institutions in the US. The CAC only accredits 4-year undergraduate programs at present, that is, it accredits neither 2-year programs nor Master's programs. In 2012, there were 2,870 4-year institutions in the US[3]. Of these, 678 are public institutions and 2,192 are private. Of the private institutions, 1,543 are non-profit and 649 are for-profit. There are no readily available numbers to indicate what proportion of these institutions have a computer science program that would be eligible for consideration for accreditation, but it is reasonable to assume that the number of institutions offering computing programs exceeds the number of institutions with an accredited program. This is in stark contrast to Engineering, where almost all US engineering programs are accredited through the Engineering Accreditation Commission (EAC) of ABET. With Engineering, the additional impetus for accreditation is that licensing as a Professional Engineer is easier, or only possible, for graduates from ABET-accredited programs. On the other hand, accreditation is voluntary for computing programs (note that both Software Engineering and Computer Engineering are considered engineering programs and are accredited by the EAC), and there are no professional licensing requirements for graduates to work in the computing field. However, an increasing number of institutions seek accreditation for their computing and IT programs each year, which suggests that the community is finding value in accreditation.

Like all ABET commissions, CAC requires a quality improvement life-cycle that involves constituent engagement, as well as data collection and analysis. Many accredited programs report that they have benefited from employing a well-crafted assessment and evaluation process to gather meaningful data that provides insightful information about the extent to which program goals are being achieved and serves as the basis for making informed decisions regarding program improvement. Some programs seek accreditation believing that it will help them improve their assessment and evaluation process. Other programs dislike, or shy away from, accreditation for reasons[4] that include a view that accreditation is a time-consuming and data-intensive process that is not worth the time and effort, or the perception that accreditation restricts creativity in program design.

Ideally, program accreditation is a demonstration of a commitment to a quality improvement process, to transparency through peer review, and accountability to the program's stakeholders, while meeting minimum requirements in each of the accreditation criteria. Accreditation is not about job placement, salary of graduates, or admission into graduate school, although such metrics may be factors that a program uses to illustrate success in achieving its program outcomes.

This paper examines the *value* of computing accreditation to the institution and addresses some of the common reasons against seeking accreditation. The next section examines the top 20 Computer Science programs in the United States, using the US News & World Report global ranking system[5]; the paper uses Computer Science programs as an exemplar for computing programs in general. Section 3 discusses the motivation for computing programs to seek accreditation while Section 4 discusses the accreditation requirements for a Computer Science program. To provide a view of the *cost factors* of accreditation, Section 5 briefly describes the accreditation process. Section 6 considers the benefits of accreditation to the institution and to the program's stakeholders, and also examines some common impediments for not seeking accreditation. The paper concludes with a few final remarks.

2 Accreditation Status of US News & World Report Top 20 US Computer Science Programs

As noted earlier, not all computer science programs are accredited. Unlike engineering programs where accreditation is considered necessary to produce graduates that can become licensed professional engineers, no such licensing requirements exists for computer science or computing programs. Therefore, accreditation for computer science programs is entirely voluntary[6]. The ABET web site[2] provides a comprehensive list of all accredited programs. Table 1 shows the accreditation status for computer science programs at the top 20 US universities as ranked by U.S. News & World Report[5]. A little more than one-half of these programs do not have their Computer Science program accredited, although most if not all of these institutions have engineering programs accredited through ABET. Hence, one could conclude that some institutions deliberately elect not to seek ABET accreditation for their computer science programs because they do not feel there is sufficient value in it for themselves.

Several of the institutions on the list have a sufficiently high-profile that they may feel that accreditation provides no additional benefit to them. Potentially, these institutions believe that they have sufficient cachet that accreditation is not necessary. This may be true; who would not hire a Stanford University graduate simply because the computer science program at Stanford University is not accredited by ABET? At the same time, conforming to accreditation standards and peer review would have helped Stanford or University of Texas avoid headlines that revealed that their computer science students have been graduating without taking course work in ethics, something ABET accreditation standards have required for decades[7]. In contrast, several high-profile and prestigious programs such as MIT are accredited. In this case, presumably, the program or the institution has seen value in the accreditation process, or even perhaps to signal to lesser programs that accreditation is still worthwhile. While some states may chose to force public institutions to seek, and maintain, programmatic accreditation where such accreditation exists, this is clearly not

Table 1: US News & World Report Top 20 US Computer Science Programs (alphabetical order)[5].

Institution	Accreditation Status
Brown University	✗
California Institute of Technology	✗
Carnegie Mellon University	✗
Columbia University	✗
Georgia Institute of Technology	✓
Harvard University	✗
Massachusetts Institute of Technology	✓
New York University	✓
Princeton University	✗
Purdue University, West Lafayette	✓
Stanford University	✗
University of California - Berkeley	✓
University of California - Los Angeles	✓
University of California - San Diego	✗
University of Illinois Urbana-Champaign	✓
University of Maryland, College Park	✗
University of Michigan, Ann Arbor	✓
University of Southern California	✓
University of Texas at Austin	✗
University of Washington	✗
University of Wisconsin - Madison	✗

the case in California, for example, as there are examples of state universities with accredited and unaccredited computer science programs. Table 1 includes both private and public institutions that are accredited and not.

3 Motivation for Seeking ABET Accreditation

Accreditation projects both the image and reality of a commitment to continuous improvement, a commitment to adequate resources, and a commitment to deliver a curriculum that includes the foundational and advanced topics that the computer science community has identified as essential. Accreditation may also provide these institutions with a competitive advantage over peer institutions when it comes to recruiting students. Peterson's offers the following advice to students inquiring about the value of accreditation:

> Accreditation is a form of endorsement that college and universities use to let potential students know that their program offers a valid education that is officially recognized by the U.S. Department of Education.[8]

Peterson's goes on to state:

> The Council for Higher Education Accreditation (CHEA), a private, nongovernmental

> agency, also recognizes accrediting organizations, including some of the same accrediting agencies that the Department of Education recognizes. To be eligible for CHEA recognition, accrediting organizations must demonstrate that their mission and goals are consistent with those of CHEA[9].

ABET is recognized by the Council on Higher Education Accreditation (CHEA), but not by US Department of Education (DoE). While this may appear contrary to the advice offered by Peterson's the ABET web site[10] offers additional insight:

> Public commentary has also obscured differences between accrediting groups recognized by the US Department of Education as Title IV "gatekeepers," and others—like ABET—who choose not to be subject to DoE oversight, since we have no role in monitoring an institution's compliance with federal student loan program requirements.[10]

CHEA provides further description of the characteristics of accreditors[9] such as ABET:

- Advance academic quality.
- Demonstrate accountability.
- Encourage, where appropriate, self-scrutiny and planning for change and needed improvement.
- Employ appropriate and fair procedures in decision making.
- Demonstrate ongoing review of accreditation practice.
- Possess sufficient resources.

This clarifies ABET's role as one of accrediting programs through a focus on continuous improvement, curriculum, student outcomes, skilled faculty, and adequately resourced programs. The accreditation criteria discussed above makes that clear. While compliance with federal laws is important, it is not regarded as an indication of a commitment to continuous improvement and excellence in education. Furthermore, since ABET accredits programs internationally, the enforcement of US laws is not relevant. Hence, one of the benefits of ABET accreditation is that programs are evaluated on things that they control (i.e., curriculum, and student outcomes), or have a direct influence on their ability to deliver a modern program of study (i.e., resources). Programmatic accreditation is not lost as a consequence of external factors such as federal student loan compliance, even though this may affect institutional accreditation through regional accreditation bodies.

ABET is also a signatory to the Seoul Accord[11] that provides for mutual recognition for computer science and information technology related programs across several agencies. The impact of the membership in the Seoul Accord is discussed in Section 6.1.

4 Accreditation Requirements for Computing Programs

For the most part, all four commissions of ABET follow a harmonized set of accreditation requirements. These requirements differ in Student Outcomes ("describe what students are expected to know and be able to do by the time of graduation"), Curriculum and Faculty criteria, as these tend to be most connected with the program's discipline. The computing accreditation criteria are thus composed of eight categories divided into two parts: (a) general criteria, and (b) program-specific criteria. The CAC program-specific criteria require that the general criteria be met, and provide up to three additional requirements for criterion 3 (student outcomes), criterion 5 (curriculum) and criterion 6 (faculty). ABET currently has program-specific criteria for computer science, information systems, and information technology [12]. Program-specific criteria for cybersecurity are currently under development [12]. The eight criteria for accreditation are summarized in Table 2.

The student outcomes now prescribed by the CAC are listed in Table 3. The first five student outcomes are part of the general criteria and must be satisfied by all computing programs. The sixth student outcome must be attained by all programs accredited under the computer science program criteria (this would include all programs with "computer science" in the name of the program). Programs are free to add additional student outcomes for their programs if they choose. An important and essential part of the accreditation process is measuring the extent to which students attain the student outcomes and then utilizing this data on a systematic basis as part of the continuous improvement process. That is to say, it is important to know where the program is heading, and measuring the extent to which the program achieves those goals.

As presented in Table 4, there are specific curriculum requirements, which are generally informed by the 2013 ACM Computer Science curriculum guidelines [13], and input from the computer science community. The mathematics and science requirements are not found in the ACM Computer Science curriculum guidelines, but were identified by the computer science community as necessary for a computer science graduate, and a distinguishing feature between a program accredited under the computer science program criteria (e.g., BS in Computer Science) as opposed to one accredited under the general criteria (e.g., BS in Computer Networks). Industry representatives were particularly vocal in wanting to retain the mathematics and science requirements during feedback sessions at numerous venues as part of the criteria revision process between 2015 and 2017.

The discussion above demonstrates that accreditation is primarily about continuous improvement, ensuring adequate resources, and ensuring coverage of a set of topics. These topics were identified by the computing community as being necessary for all computer science graduates as they prepare for their professional life. It is important to note that the prescribed topics are a subset of those recommended in the ACM Computer Science curriculum guidelines, as it was important to ABET to ensure that each computer science program could continue to carve out a niche market for itself and distinguish its program from that of competitors. Overly constraining the curriculum also may have the effect of stifling innovation in computer science education. The computer science criteria committee for ABET ensured that the curriculum requirements were not so onerous as to discourage innovation.

It is likely that most would argue that it is highly desirable to offer a high-quality program that is regularly improved to ensure graduates demonstrate desired characteristics. In addition, the program should be adequately and appropriately resourced, and delivered by current and knowledgeable faculty. ABET accreditation demonstrates a commitment to this value proposition which is of interest to constituents including students, faculty, and employers. While accreditation places the responsibility on the program's faculty to deliver a focused, well-rounded, high-quality curriculum, it also places the responsibility to properly fund and resource the program on the institution. Hence programs facing difficulty obtaining appropriate support may be able to use accreditation

Table 2: CAC/ABET Accreditation Criteria[12]

#	*Criterion*	*Overview*
1.	Students	Addresses need to evaluate student progress toward attaining student outcomes, provide advising and career advice. Policies must be in place to ensure the integrity of the admissions and transfer credit process. Programs must have, and enforce, procedures to ensure and document that all students meet graduation requirements.
2.	Program Educational Objectives	There must be published program educational objectives that are consistent with the mission of the institution. These program educational objectives must be reviewed periodically with program constituencies through a documented, systematically utilized and effective process.
3.	Student Outcomes	ABET defines the student outcomes that graduates must attain. These are elaborated in Table 3. Programs need to collect data on the extent to which students meet these student outcomes and use this information periodically as part of the program's continuous improvement process.
4.	Continuous Improvement	Programs must have, and use on a regular basis, appropriate, documented processes for assessing and evaluating the extent to which graduates attain the student outcomes. The results of these evaluations must be systematically used as part of the continuous improvement process.
5.	Curriculum	The accreditation criteria identifies topics that must be covered in the program. It specifically points out the topics do not prescribe courses. A great deal of flexibility is provided to programs to tailor their program to suit their mission and objectives. Programs are expected to have coverage of the fundamentals of some topics and an in-depth examination of other topics. Curriculum requirements are discussed in Table 4.
6.	Faculty	Faculty need to have appropriate expertise and educational background to support the delivery of the program. Collectively the faculty must have the necessary breadth and depth to cover all curricular areas of the program. There must be a sufficient number of faculty and they must have sufficient responsibility and authority to improve and implement the program.
7.	Facilities	All facilities (classrooms, offices, laboratories, and associated equipment) must be adequate to support the attainment of the student outcomes. Modern tools, equipment and resources must be available to the students, and they must be systematically maintained and upgraded.
8.	Institutional Support	Institutional support and leadership must be adequate to ensure the continuity of the program. Institutional resources provided to the program must be adequate to meet program needs. Resources available to the program must be sufficient to attract and retain qualified faculty. Support for professional development and adequate resources to maintain facilities and equipment must be available to the program.

Table 3: Student Outcomes (General Computing and Computer Science)[12]

	Graduates of the program will have an ability to:
1.	Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions. *General Criteria*
2.	Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline. *General Criteria*
3.	Communicate effectively in a variety of professional contexts. *General Criteria*
4	Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles. *General Criteria*
5.	Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline. *General Criteria*
6.	Apply computer science theory and software development fundamentals to produce computing-based solutions. *Computer Science Program Criteria*

as a means to garner additional support.

5 Accreditation Process

Accreditation is both a process and an on-going activity/culture within a program. The process for a computing program to become accredited is based on peer-review, but it is a lengthy one. Programs need to review the computing accreditation criteria[12] and make changes as needed to become compliant. The process requires the collection and effective utilization of data to determine the program's success in attaining its outcomes. These changes and data collection processes may require 1-3 years of work prior to seeking an accreditation visit. In addition, a program must have at least one graduate of the program before accreditation can be sought.

Request for Evaluation. When an institution is ready for an accreditation visit, then a request for evaluation must be submitted by January and the appropriate fees paid. These fees cover the cost of the accreditation visit and the accreditation process in general.

ABET assigns a team chair and typically one program evaluator per program being evaluated with a minimum of two program evaluators assigned for an initial accreditation visit. The team chair and institution negotiate a visit date which is typically scheduled between September and December.

Self-study. The institution then has until July 1 to complete and submit its self-study to ABET, a key aspect of the accreditation process. The institution generates a self-study report that addresses the accreditation criteria directly and is the primary document used by the ABET team to evaluate the program prior to their arrival on campus. It is intended to be a self-reflective document in which programs have the opportunity to examine their own strengths and weaknesses. Although programs are asked to collect and evaluate data regarding their attainment of student outcomes, the

Table 4: Curriculum Requirements–Computer Science[12]

General Criteria—Curriculum: The program's requirements must be consistent with its program educational objectives and designed in such a way that each of the student outcomes can be attained. The curriculum must combine technical, professional, and general education components to prepare students for a career, further study, and lifelong professional development in the computing discipline associated with the program. The curriculum requirements specify topics, but do not prescribe specific courses. The program must include mathematics appropriate to the discipline and at least 30 semester credit hours (or equivalent) of up-to-date coverage of fundamental and advanced computing topics that provide both breadth and depth. The computing topics must include: 1. Techniques, skills, and tools necessary for computing practice. 2. Principles and practices for secure computing. 3. Local and global impacts of computing solutions on individuals, organizations, and society.
Computer Science Program Criteria—Curriculum: The curriculum requirements specify topics, but do not prescribe specific courses. These requirements are: a. Computer science: At least 40 semester credit hours (or equivalent) that must include: 1. Substantial coverage of algorithms and complexity, computer science theory, concepts of programming languages, and software development. 2. Substantial coverage of at least one general-purpose programming language. 3. Exposure to computer architecture and organization, information management, networking and communication, operating systems, and parallel and distributed computing. 4. The study of computing-based systems at varying levels of abstraction. 5. A major project that requires integration and application of knowledge and skills acquired in earlier course work. b. Mathematics: At least 15 semester credit hours (or equivalent) that include discrete mathematics and must have mathematical rigor at least equivalent to introductory calculus. The additional mathematics might include course work in areas such as calculus, linear algebra, numerical methods, probability, statistics, or number theory. c. Science: At least six semester credit hours (or equivalent) in natural science course work intended for science and engineering majors. This course work must develop an understanding of the scientific method and must include laboratory work.

data and its analysis is not necessarily reported in the self-study. Instead, the data and evidence of its evaluation and, potentially, its usage to make programmatic change should be available during the on-site visit. The self-study focuses on the processes the institution has in place, and the accreditation criteria itself. Even though ABET provides a template for the self-study, it is still a significant amount of work. However, the completion of the self-study is a remarkably helpful process to institutions as they examine the attainment of the program's outcomes.

On-site visit. The on-site visit typically starts on Sunday at noon and extends until Tuesday mid-afternoon. The actual visit allows the team to verify the contents of the self-study, to hold discussions with faculty, students, industry partners and administrators. The visit aims to resolve any outstanding questions that might remain. It is also the opportunity for the institution to address any shortcomings that the visit team is foreshadowing and correct any mis-perceptions that the visit team may have. The visit is relatively short and extremely focused. The cost of accreditation[14,15] covers the expenses associated with a visit and the summer commission meeting.

For many institutions and faculty, the on-site visit is the most stressful part of the accreditation process. However, the visit team comes to campus with the intent of helping programs realize and exploit their strengths, and identify areas of opportunity. The entire accreditation process is based on peer-review and the on-site visit provides an opportunity to talk with the team about the observations they have as outsiders to the program.

The visit concludes with the visit team reading an exit statement outlining their preliminary findings to the institution. These findings are not the final word, as discussed next.

After the Visit. After the visit, the team chair leads the preparation of a draft statement that goes through a three-level editorial process to ensure clarity and consistency in the description of the visit findings. After editing, the draft statement is provided to the institution which then has 30 days to respond to any shortcomings that were identified. The team chair reviews the 30-day response and prepares an initial version of the final statement which again goes through the three-level editorial process. Institutions can submit additional materials to the team chair as necessary leading up to the July commission meeting, who continues to revise the final statement.

Commission Meeting and Action. The July commission meeting considers the findings for each reviewed institution. The commission may require additional changes to the final statement. At the end of the commission meeting, a vote is held on the accreditation status of each institution visited in the preceding year, and institutions are provided with the final statement and informed of the accreditation decision in August. The entire process is almost 18-months in duration.

The typical accreditation actions for most programs tend to be either (1) Next General Review (NGR), meaning the program is accredited for the maximum period of six years, or (2) Interim Report (IR) or Interim Visit (IV), meaning that shortcomings exist that require a re-evaluation in two years either by a report or by a visit. Rarer actions could require the institution to show-cause why accreditation should be continued or to deny accreditation.

6 The Value of Computing Accreditation

This section discusses the value of ABET accreditation for computing programs, followed by a discussion of some of the impediments.

6.1 Benefits of Computing Accreditation

Accreditation through ABET demonstrates a commitment by the program and the institution to all of the requirements of the accreditation criteria. Furthermore, it represents an international benchmark sought after by several foreign institutions, typically from regions which do not have a computer science program accreditation agency of their own. For those regions which have their own programmatic accreditation agencies, ABET is a signatory to the Seoul Accord[11] that provides for mutual recognition for computer science and information technology related programs across several agencies. Hence a student graduating from an ABET accredited computer science program will be able to seek employment in countries that place higher value on, or require, licensing of computer science professionals. For example, in the UK, computer science graduates may seek licensing as an Incorporated Engineer and Chartered Engineer[16]. In a global community, and in a field that increasingly has a major impact on society, licensing may become a requirement in some countries, and hence graduation from an ABET accredited program will facilitate students wishing to work abroad. In particular, international students studying in the US, and who wish to return to their home country at some stage, may consequently place much higher emphasis on ABET accreditation than domestic students.

ABET is recognized as the "gold standard" for accreditation[17]. The accreditation criteria for engineering is recognized as so valuable that employers point out that applicant's resumes will not even be considered if their degree is from a non-accredited institution. The computer science accreditation criteria is similar to that for engineering programs in terms of structure and content. Considerable effort has been expended in ensuring that the criteria are aligned as much as possible so that institutions with both computer science and engineering programs do not have more work to do than necessary. Since the requirements for a continuous improvement process, faculty expertise, institutional support, and admission and transfer processes are almost identical, the only significant differences relate to student outcomes and curriculum. ABET's computer science criteria is aligned with the ACM/IEEE Computer Science curriculum guidelines[13] which has had significant community input and represents current best practices, and the student outcomes are aligned where possible with that of engineering, hence by extrapolation, the computer science accreditation criteria also represents the gold standard for computer science.

CHEA identifies the value of accreditation in general[18], ten ways in which accreditation benefits students, society and the public interest[19]. Specifically, CHEA notes that accreditation is:

1. The primary public recognition of higher education for over 100 years,
2. The primary reliable vehicle for recognition by federal and state governments for higher education funding.
3. The primary reliable vehicle for private sector funding of higher education.

4. A major form of protection for students against fraud and abuse.
5. Successful in encouraging innovation while ensuring quality.
6. Cost-effective in the use of resources to achieve its goal.
7. Central to states carrying out licensure of professionals.
8. Essential to international mobility.
9. Responsible in the current climate of higher education accountability.
10. Vital to maintaining key features of higher education that have contributed to making institutions among the best in the world.

Some of these characteristics are more appropriate at the institutional level, but ABET provides value through recognition of the program, international mobility of graduates of accredited programs, provision of public accountability, and maintenance of standards and quality through a continuous improvement process.

Computing programs have numerous stakeholders including students, alumni, faculty, employers, and the institution itself. Accreditation helps stakeholders determine if an institution meets or exceeds minimum standards of quality. ABET provides value to each of these stakeholder groups in various ways.

Students benefit by graduating from an accredited program through:

- International mobility.
- Assurance that faculty are suitably qualified and current in the discipline.
- Assurance that the program is suitably and appropriately resourced,
- A public statement by the institution of the student outcomes so that they can compare programs.
- Assurance that a core curriculum covering specific fundamental and advanced topics will be provided.
- Instills confidence in the student that the program was recognized by peers through the accreditation process.

Alumni of an accredited program have all of the benefits identified above, plus the benefit of:

- Pride in knowing that their *alma mater* values quality and employs a process of continuous improvement.
- Knowing that their qualification is internationally competitive and recognized.
- Assurances that they received exposure to a core, industry-valued and endorsed, curriculum to serve them well in their professional career.
- Enhances employment opportunities since some multinational companies require graduation from an accredited program.

- Being engaged as a stakeholder in the accreditation and continuous improvement processes and having an opportunity to share their experiences and opinions to help improve the curriculum.

Faculty teaching in an ABET accredited program find value through:

- The use of a continuous improvement process to ensure an appropriate high-quality program.
- Support for professional development.
- Modern and appropriate tools and equipment to support the program of study.
- Appropriate institutional support to deliver the program of study.
- Recruiting faculty who value accreditation because they themselves graduated from an accredited program.
- A commitment to best practice.
- Utilization of data to know how well the program is preparing students through attainment of the student outcomes.
- Focus on "student outcomes" rather than "teaching points."
- Engaging stakeholders in the accreditation and continuous improvement processes.

Employers hiring graduates of an accredited program see value in the following ways:

- Assurance that graduates satisfy the student outcomes.
- Assurance that graduates have exposure to specific curriculum topics.
- Assurance that faculty have appropriate and up-to-date technical skills.
- Being engaged as a stakeholder in the accreditation and continuous improvement processes and having the opportunity to influence the curriculum.

The institution hosting the ABET accredited program finds value through:

- Assurance that the program utilizes a continuous improvement process.
- Assurance that the program is appropriately funded and resourced relative to peer institutions who are also accredited.
- A tool that may be used to attract new students and faculty.
- Demonstration of a commitment to best practice.
- Engaging stakeholders in the accreditation and continuous improvement processes.

Many of these benefits provide a direct value to the stakeholder, it is also likely that there are indirect benefits. For example, an international institution may partner with an institution (e.g., study abroad agreement) because the institution is accredited.

Each of these benefits has a different perceived value to an institution considering accreditation for the first time.

6.2 Perceived Impediments

Despite the value that accreditation offers, there are clearly some impediments to accreditation that prevent more programs from becoming accredited. These impediments will vary from institution to institution.

A likely primary impediment is a lack of understanding of the accreditation process and the value of accreditation, or an unwillingness to consider accreditation. This is most likely to affect programs that are not currently accredited and who have been successfully awarding computer science degrees for some time. These programs may be unaware of what is involved in accreditation or may have identified a peer set of institutions that are also not accredited.

For those institutions that look into accreditation, two obvious factors present themselves that may be hurdles. The first is the cost of accreditation and the second is the length of time required to become accredited.

The cost of accreditation is not trivial. There is a fee associated with a site visit, and there are annual maintenance fees. There are a number of factors that influence the cost of accreditation and the reader is referred to the ABET web site for specifics[14,15]. Programs need to examine the economics of accreditation and determine its value to them. ABET is a nonprofit, non-governmental organization and does not seek to charge institutions more than is necessary.

As described earlier, the length of time from initially seeking accreditation through the on-site visit until the July commission meeting to vote on the accreditation action is nearly 18 months. This time-frame may appear daunting to some programs. However, it is not really an issue as it is important to develop a culture of self-assessment and a willingness to regularly collect and utilize data for continuous improvement. Once a program is accredited, the data collection and evaluation process should be a normal and expected part of academic responsibilities. Hence, second and subsequent accreditation visits are less impacted by the time factor.

A contributing factor to the perception that the accreditation process is onerous may come from institutions that do not regularly collect and use data, or who try to collect too much data on a too frequent basis. There are institutions that only collect data immediately prior to a visit. In these cases the faculty are overburdened with data collection and analysis leading up to a visit, and then they relax and fail to collect data after the visit. If data is collected on a regular and planned schedule, then the workload is distributed across the time between on-site visits and can be better managed. Some institutions attempt to collect data on every student outcome in every course during every semester. This is unnecessary; collecting data on a student outcome every second year is sufficient and helps reduce the data collection overhead.

Possibly the single greatest impediment to programs seeking accreditation is the faculty in the program. Some faculty are concerned that the program self-assessment and data collection will be used for review of individual faculty, and some simply worry about the accountability. It is important for faculty to recognize that the data being gathered is about the students' attainment of student outcomes. Data is typically aggregated so that all computer science students across all sections of a certain subject are treated as a single cohort. Therefore it is often difficult, if not impossible, to tie any observation to a single instructor. Furthermore, computer science courses often have long prerequisite chains and student outcomes are usually measured in upper division courses. Therefore, any opportunity to improve the attainment of a student outcome may result in a change in a course upstream of the course in which the student outcome is measured. It is also not uncommon to measure a student outcome in multiple places making it even more difficult to identify an individual faculty member. This impediment can be addressed to a large degree by the department head announcing and ensuring that student outcomes assessment data is never tied to annual faculty evaluations.

Faculty are highly protective of their time and tend to resist activities such as data collection and analysis when it is perceived to be taking time away from activities seen to be more helpful for tenure and promotion. This can be mitigated to a point by collecting data on a schedule so that each student outcome is assessed every second year, for example. The data collection process must be manageable and appropriate for the number of faculty within a department.

There are some faculty that regard accreditation as "not their job." In an era of public accountability and the need for transparency in what is happening inside programs, this perspective is simply not sustainable. Accreditation is a way of affirming to the public that a program and its faculty is committed to high-quality education, continuous improvement, and transparency through a peer-evaluation process.

Finally, not all programs satisfy the computer science curriculum requirements. Programs named "computer science" must seek accreditation under the computer science program criteria and this include requirements for mathematics and science. Some institutions feel that they cannot meet the mathematics requirements because their student population is ill-prepared for mathematics, or they feel that they would lose students if they required higher levels, or a greater number of credits, in mathematics. With the new computer science program criteria coming into effect in 2018/19, this should be less of a concern. The criteria is now clear that the required mathematics needs rigor equivalent to introductory calculus, but it does not need to be calculus. Programs are free to select mathematics courses appropriate to their program. However, it is worth noting that industry was a large stakeholder in the accreditation criteria that insisted on the need for and the value of, mathematics to students pursuing a computer science career.

Some programs claim that accreditation is simply not relevant or applicable to them. Some institutions have a reputation such that their graduates will be hired with or without accreditation. However, relatively few programs can shun accreditation on the basis that their reputation is sufficient to ensure their graduates will be hired. There are also some programs that are atypical computer science programs and may be a blend of computer science and another discipline, or may have a heavy emphasis on an area such as artificial intelligence at the expense of some of the core curriculum topics identified in the accreditation criteria. Such programs may be better named something other than computer science to reflect their emphasis. A name other than computer science would allow that program to be evaluated under the general criteria only and still be ABET accredited.

7 Conclusion

This paper discusses the role and value of ABET accreditation for computing programs. To facilitate a detailed discussion, it specifically focused on computer science as an exemplar, but similar lessons can be drawn for other computing programs such as information systems, information technology and cybersecurity that are accredited by CAC.

Accreditation might not be for every computing program. However, accreditation provides value to its stakeholders and to institutions. It helps maintain standards and ensures a rigorous and honest self-reflection of the program on a regular basis. Accreditation helps provide and maintain accountability to constituents. In an age of public accountability and many questions regarding the value of higher education, accreditation helps provide needed transparency thorough a peer-review process.

Accreditation does not mean that all programs are the same and that a degree from one accredited institution is identical to a degree from another accredited institution. The accreditation criteria has ample room for programs to identify their own niche market and to deliver the program in an innovative manner.

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