AC 2010-625: INTEGRATING COMPUTER SCIENCE AND ENGINEERING TECHNOLOGY TO IMPLEMENT AN ABET ACCREDITED PROGRAM

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Integrating Computer Science and Engineering technology to implement an ABET accredited Program

Abstract: We are a four years Computer Science and Engineering Technology program (CSET) having around 250 undergraduate students. The program was originally designed to give students hands-on experience in computer engineering technology. As the program grows, we found that Computer Science foundations are essential to prepare our students for more advanced technologies. Teaching our students theoretical foundation in Computer Science and teaching engineering technology with hands-on lab experiments turned out to be beneficial in improving our student's education and in improving the program outcomes. The program is now dual accredited by ABET TAC (Technology Accreditation Committee) and CAC (Computer Science Accreditation Committee).

1. **Introduction**.

The Computer Science and Engineering Technology (CSET) program was created in January of 1999 when approval was received from the Ohio Board of Regents (OBR). The program had its first graduates in May of 2000. The initial accreditation visit by TAC/ABET took place in October of 2000. The program has been continuously accredited since that time.

We selected the program name Computer Science and Engineering Technology for a number of reasons. First, it was a natural pairing with our existing CSE (Computer Science and Engineering) program. We already had programs that formed natural pairings, e.g., EE and EET for electrical, ME and MET for mechanical as well as CE and CET for civil/construction. The CSE and CSET pairing for computing followed this pattern and made it easier for students and parents to understand that we were offering both traditional engineering and engineering technology programs in each of these areas. These pairings have helped the College with recruitment and retention by providing students with options based on their interests, learning styles and academic preparation.

As the CSET program grew and established an identity in the region our graduates found employment in the discipline and/or went on to graduate school in computer science or closely related areas. In some cases, computer science background of our graduates allow them pursue professional careers and graduate education in computer science. We believe that the computer science component leads to increased opportunities for our graduates. CSET graduates fill a niche positioned between the purely technical and the purely theoretical.
As we prepared for our general review in the fall of 2006, we were contacted by ABET headquarters and notified that, because of an agreement between ABET and CSAB, our CSET program would be required to be reviewed by CAC as well as TAC. The alternative was to change the name of the program. After consultation with our industrial advisory committee and a careful (but somewhat naïve) review of the CAC Criteria we elected to move forward with the joint review. We felt that changing the program name would adversely affect marketing, recruiting and placement of CSET graduates.

In order to receive dual accreditation, the department has undertaken a series of significant curriculum modification to meet both TAC and CAC Criteria since fall 2006. We prepared a CAC supplemental questionnaire as well as the TAC self study. The program shifted from "technology" focus to a combination of computer technology and science.

The process has been an exercise in continuous improvement for us – resulting in strengthening the computer science components of the CSET program – producing graduates who are better computing professionals. With respect to the faculty and curriculum standards, we have reached the point of full implementation. With respect to having the entire curriculum "touch" every CSET student, this is a work-in-progress. All of our students are affected by the curriculum changes. Each student is subject to the revised course content in the courses they encounter as they move through the curriculum.

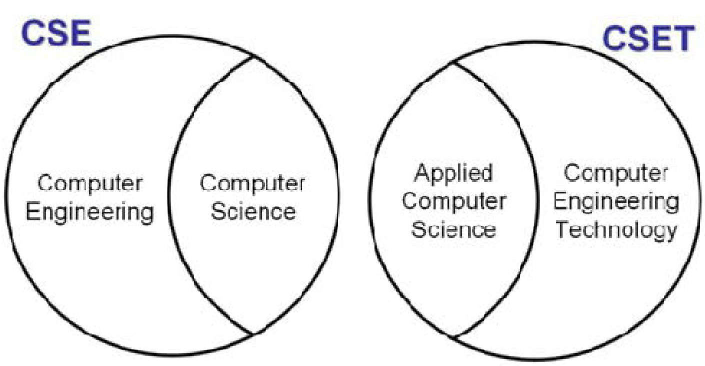
All programs in the College of Engineering are scheduled for the "next general review" in the fall of 2011. By that time all of the CSET curriculum changes will have "touched" every student.

2. **Curriculum and program flowchart**.

Our Curriculum combines traditional engineering technology with modern computer science theories. In contrast to traditional engineering and computer science programs, our program give students hands-on experience in computer science and engineering technology first and then gradually introduce math and theory which leads to more advanced technological projects.

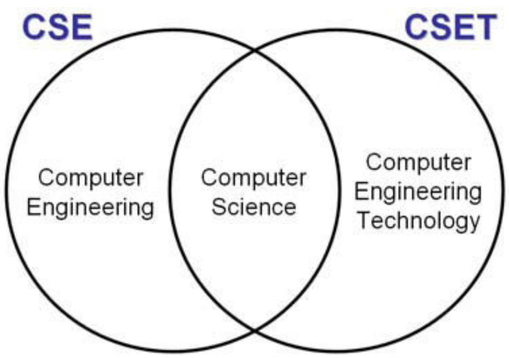
At The University of Toledo, the College of Engineering (COE) offers three computer-related programs of study; Computer Science and Engineering (CSE), Computer Science and Engineering Technology (CSET) and Information Technology (IT). The IT program is offered in partnership with the College of Business Administration (COBA).

The CSE program grew out of the EE curriculum and resides in our Electrical Engineering and Computer Science (EECS) department. Thus, it draws from the tradition of EE and EAC/ABET accredited programs. Our CSE program has been EAC accredited since 1988 and CAC accredited since 1991. The CSET program grew out of the ET curriculum and resides in our Engineering Technology (ET) department. It draws on the tradition of ET and TAC/ABET accredited programs. The CSET program has been TAC accredited since 2000 and CAC accredited since 2006.



Our original view of the CSE and CSET programs is illustrated by the diagram at the right and below. It illustrates that we thought of the CSE and CSET programs as completely separate – in all aspects – somewhat parallel in coverage but with very different objectives and learning outcomes. The programs appealed to different student constituencies; those who preferred an applications oriented curriculum chose CSET while those who preferred a more traditional approach chose CSE. Transfers were common between the two programs with the dominant direction being from CSE to CSET.

This is the view of the program that we held at the time of the October 2006 visit by CAC. The diagram at right and below illustrates what we now believe to be the ideal relationship between the CSE and CSET programs. This view results from our interactions with CAC evaluators and others and has led to the recent curriculum revisions.



It shows that we have come to see the two programs as overlapping in terms of the computer science content. This overlap is conceptual more than actual as the two programs do not currently share a common list of computer science courses. Rather, the computer science content for the CSET program is delivered in a series of courses that are tailored to the backgrounds and learning styles of our students.

As the diagram above shows, the CSET program focuses on two complementary disciplines; Computer Science and Computer Engineering Technology. The Computer Engineering Technology content of the program draws from the tradition of engineering technology programs in that it is primarily applications oriented with a focus on hands-on education. This content is a major component of the CSET program that satisfies TAC/ABETS Criteria[1]. The Computer Science content of the program has been enhanced and redesigned to meet CAC/ABET *Criteria*[2]. Figure 1 is our program major flowchart.

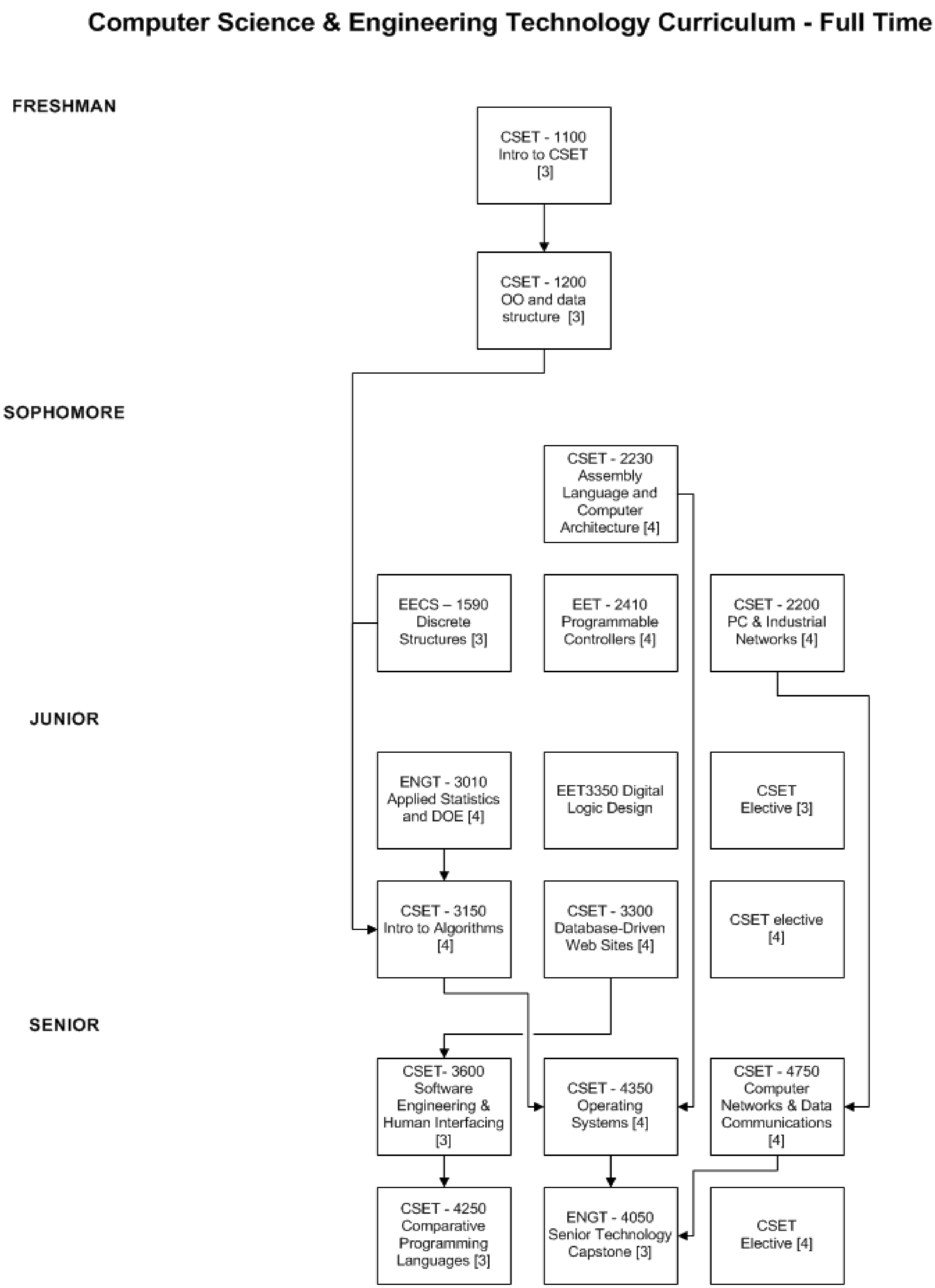


Figure 1 Program flowchart

3. **Combination of computer science and technology**.

Nearly all major courses have hands-on practical labs associated. Computer Science theories are gradually introduced later in the curriculum. The higher level courses are still focused on giving students hands-on experiences. These experiences let our students be more competitive in job market and enhance student's theoretical foundation as well. Examples of some developed courses are introduced using a few examples.

Introductory courses: CSET1100

CSET student's very first course in major is CSET1100. This course teaches fundamental computer science literature and fundamental concepts. Most of the course is focused on teaching programming as an introduction to computer science. Over the years, this course has changed from teaching C to Python. Students not only learned programming but also had fun. Most importantly, they learned more about computer science by practicing programming and some Unix scripting.

Example of mid level theoretical courses: Database design

While covering theory, our courses focus on applications as well. Taking database course as example, half of the course introduces students to database design theories and student implement database using PHP and MYSQL in the other half of the course. This is typical in our course design, a combination of theory and practical technology.

Example of mid level theoretical courses: Introduction to Algorithms as theoretical foundation

An algorithm is one of the most important courses in computer science curriculum. Still, the learning by doing is used in this course. Students need to write C++ program to implement the algorithms learned from this course. This approach ties the practicality of computer science with real world applications.

Examples of as high level courses:

By the time students are taking higher level course, they are ready to apply their theoretical foundation and practical skills to learn more complicated computer science topics. As example, Interconnection Network and Network Security are designed to teach advanced computer science theories and technologies. In these courses, it is impossible for a student to fully understand and apply these techniques without the theoretical foundation laid out throughout the curriculum.

4. Course evaluation process and results.

Although CSET students' background varies, most of them can handle computer science theories well given the approach we took. Students appreciate the importance of computer science in the context of real world applications. We hold high standard in our outcome criteria and we carefully designed our assessment process to ensure continuous improvement.

Many papers published about methods in ABET assessment [3, 4,5,6,7]. The assessment process in our department has been in place since 2000 and has evolved to its present form. Meaningful assessment data have been collected since 2004 and are on file. Various program and course changes resulting from the assessment program occurred during the period from 2004 to 2006 and documentation for these changes is on file. It includes a discussion of the quantitative data collected, forms used to record the assessment data and the instructor's evaluation of that data, procedures for analysis of all data associated with a specific program outcome, and recommendations for action. Figure 2 shows an example of the assessment matrix.

The assessment process is occurring on a regular schedule. In its current form, our assessment process calls for a meeting of the CSET and EET faculty (together or independently) after each assessment period (semester) to analyze the assessment data collected during the preceding period and determine any necessary actions. These meetings normally occur in the spring semester for fall assessment data and in the summer or fall semester for spring assessment data.

Approaches to Assessment

The CSET program utilizes an assessment process that relies on multiple measures and multiple evaluators. Data used to demonstrate achievement include but are not limited to:

- course grades (each term)
- representative samples of student work (periodically)
- co-op surveys of students and employers (each semester, an increasing number of students)
- placement data (employment and graduate school) (annually)
- class surveys (each semester)
- senior capstone projects and reports
- graduate exit survey (each semester)
- feedback from alumni (annually)

The assessment process follows the basic procedures as follows:

- Course Assessment Data
- Responsible Personnel: Program Faculty
- Frequency: Each Semester

Each faculty member collects course assessment data consistent with the Master Syllabi and provides an analysis of course assessment data related to the program outcomes for each course taught in a semester. This analysis is documented and collected each term for each of the a-k program outcomes. This data is used to assess achievement of program outcomes.

Exit Interview Data

Responsible Personnel: Department Chairman and Program Director
Frequency: Data is collected each semester and summarized annually

Educational Benchmarking, Inc. (EBI) surveys are conducted annually by the Department Chairman. Currently, the EBI surveys are distributed and collected as part of the Senior Technology Capstone (ENGT4050) course.

The Department Chairman conducts senior exit interviews each semester in an informal setting where students are asked open ended questions about their perceptions, experiences and satisfaction with their educational experience at UT. This data is used to assess achievement of Program Educational Objectives.

Graduate and Employer Survey Data
Responsible Personnel: Program Director
Frequency: Annually

Graduate surveys and Employer surveys are sent to students on an annual basis. Graduates and Employers are solicited to participate in an on-line survey. Surveys are also electronically mailed to graduates. This data is used to assess achievement of Program Educational Objectives.

Co-operative Education Surveys
Responsible Personnel: Co-operative Education Director
Frequency: Each Semester

Students participating in co-operative education and their employers are each required to complete on on-line survey in order to receive credit for co-op participation. Information from this survey is used to assess achievement of program outcomes.

Issues that are identified through the collection and analysis of assessment data are discussed and acted upon by the faculty of the department in conjunction with the program's industrial advisory committee. Course changes are implemented at the prerogative of the faculty member. Program changes follow a formalized approval process as outlined by Faculty Senate.

Objectives	ABET Criterion 3 Outcomes:	Course Outcomes	Assessment Methods
a	an ability to apply knowledge of mathematics, science, and engineering	Students will acquire knowledge and understanding of analyzing the space/time complexity of both recursive and non-recursive algorithms using analytic techniques (involving O-notation, recurrence equations, the Master Theorem, etc.) and high-level abstractions (abstract data types).	Examinations, quizzes, and homework will measure level of knowledge and understanding.
b	an ability to design and conduct experiments, as well as to analyze and interpret data		
c	an ability to design a system, component, or process to meet desired needs	Students will develop appreciation of design, analysis and algorithmic performance by working on a programming project.	Testing of project performance. Evaluation of written documentation for the design, implementation and final project report.
d	an ability to function on multi-disciplinary teams	Students will acquire an understanding of team dynamics by working in groups on a programming project and a short presentation.	Graded project reports. Evaluate student presentations. Evaluate comments written by students discussing their experiences working in groups.
e	an ability to identify, formulate, and solve engineering problems		
f	an understanding of professional and ethical responsibility		
g	an ability to communicate effectively	Students will improve their communication skills by working in groups, writing a project report, and making a short presentation to the rest of the class.	Graded project reports. Evaluate student presentations. Evaluate comments written by the students discussing their experiences working in groups.
h	the broad education necessary to understand the impact of engineering solutions in a global and societal context		
i	a recognition of the need for, and an ability to engage in life-long learning		
j	a knowledge of contemporary issues	Students will acquire knowledge of contemporary issues in the area of algorithms by giving a short presentation on a contemporary issue to the rest of the class.	Evaluate level of understanding during student presentations. Questions in the final will test student knowledge and level of understanding on the contemporary issues discussed in class.
k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice		

Figure 2. Course evaluation form

Results:
Figure 2 is an example table we used to evaluate course objective for CSET3150 Algorithm course. All the major courses have a table developed for assessment. Over the years, the tables can be modified to meet new requirements for continuous improvement.
Figure 3 shows the evaluation matrix mapped Abet A through K to each course. Course evaluation using a course form maps the result from each course to this matrix. In Assessment meeting, CSET faculties evaluate the whole curriculum. Courses that are not meeting requirement will be improved or modified to close the loop. Minute from 2007 assessment meeting showed that most courses have met the requirement with 80% or more of the students having grade B or above. Some courses needed improvement. Our introduction course CSET1100 as example, had a high attrition rate. The programming language we used was not effective enough. Faculty committee decided to switch to Python, a nicer language with built in Object Oriented feature and multimedia support. Clicker technique was also introduced to the class to improve teacher student interaction in class. The clicker technique turns out to be so popular that we decide to employ it throughout the all the major classes.

The University of Toledo
Computer Science & Engineering Technology Program
Program Courses Mapped to Program Outcomes
2-Apr-07

Required Courses	ENGT 1000	ENGT 2000	ENGT 3010	ENGT 3050	ENGT 4050	EECS 1590	EET 2210	EET 2230	EET 2410	EET 2420	EET 3350	EET 4250	CSET 1100	CSET 1200	CSET 2200	CSET 3150	CSET 3300	CSET 3600	CSET 4100	CSET 4250	CSET 4750
a) Mastery of knowledge, techniques of discipline				•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•
b) Ability to apply current knowledge					•	•	•				•	•	•		•		•	•	•	•	•
c) Ability to conduct experiments				•				•			•	•		•		•					
d) Ability to apply creativity in design					•		•		•		•	•	•		•	•		•	•	•	•
e) Ability to function on teams	•			•	•		•				•	•									
f) Ability to identify, analyze and solve problems			•	•	•	•	•	•		•	•	•	•		•			•	•	•	•
g) Ability to communicate effectively	•		•	•	•		•			•	•	•	•			•		•		•	
h) Recognition of lifelong learning	•				•	•							•								
i) Understand profesional, ethical, social responsibility	•	•			•				•				•					•			
j) Knowledge of profesional, societal, global issues		•			•								•		•	•					•
k) Commitment to quality and improvement		•			•	•		•		•	•	•	•		•			•		•	•

Figure 3. Assessment Matrix

5. **Conclusion.**

Benefitting from the new curriculum change, students are able to achieve more than engineering technology can offer alone. Although it takes more effort for the students to master both theoretical and practical contents, the feedbacks are positive toward the change.

In the spring of 2007, Exit interviews with students in the senior capstone course who planned to graduate from the CSET program in the spring or summer of 2007 showed that many of our graduates are working in computer science field and some applied and admitted to computer science graduate school. Over the recent years, enrollment and student quality are increasing. By the time this paper is submitted, the program is the only ABET TAC and CAC dual accredited program in the nation.

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