Assessment Plan

Computer Science Undergraduate Program

Version 1.3

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Assessment Plan

Computer Science Undergraduate Programs

Abstract

In order to ensure the relevancy of the education of students enrolled in the undergraduate degree programs in computer science, we regularly assess the program's progress against its objectives. Our assessment plan evaluates data collected from the faculty, students, alumni, and employers. We use the assessment results to identify program improvements and to modify the program's objectives. This report describes the underlying foundation of our comprehensive assessment plan and presents the plan in its totality. This plan was originally developed in 2000-01 in order to bring our program in alignment with ABET Criteria 2000 and to improve upon the assessment plan in place at that time. This update (version 1.3) includes changes made to the program for Fall of 2007 (see changes log at the end of this document).

Assessment Plan

Computer Science Undergraduate Programs

1. Introduction

The faculty of the Department of Computer Science at the University of Minnesota Duluth care about its educational programs. Since the inception of the BS-CS degree program in 1980 and the BS-CIS (now renamed Computer Information Systems or CIS) program in 1999, we have periodically assessed these programs and made changes to them based on the results of these assessments. Over the years this process led to both major and minor improvements, producing dynamic programs in tune with our constituents[1]. However, the faculty felt that the assessment process could be improved, and in 2000-01, we developed a more formalized approach to assessment.

The underlying philosophy of assessment is based on determining the extent to which we achieve our desired goals. In order to develop a comprehensive assessment plan that supports continuous program improvement, we needed to revisit our objectives, articulate them more clearly, and establish how to assess them. We accomplished this task by taking the following steps:

- Evaluating our mission statement and modifying it to reflect our primary role at the University.
- Modifying our educational program objectives to ensure consistency with the mission statement and to reflect major curricular changes that occurred in 1999-00.
- Defining program outcomes that support our objectives.
- Evaluating the curricula and aligning it with our program objectives and outcomes.
- Determining measurable student performance criteria for each course outcome.
- Identifying methods for collecting data that may be used to measure the degree of student achievement for each program outcome and objective.
- Developing a plan for data collection and evaluation.
- Developing a comprehensive assessment plan for continuous program assessment and improvement.

Over time, this report has been updated to deal with changes made to the program and to our program objectives and outcomes and to account for changes in the ABET criteria. This version represents the plan as of the date shown at the top and a change log is included at the end of the document to outline what changed with each version of the document.

In this report, we elaborate on our development of an assessment plan. We describe program objectives, program outcomes, and course outcomes, and illustrate the relationship between objectives, outcomes and the curriculum. We then describe our complete assessment plan, including the structure of the web site that contains documentation supporting and resulting from the annual assessment process. Appendices contain samples of all forms used in the assessment process.

2. Mission Statements

A. University of Minnesota Duluth

[1] Our constituents include the faculty, students, alumni, and employers.

The University of Minnesota, founded in the belief that all people are enriched by understanding, is dedicated to the advancement of learning and the search for truth; to the sharing of this knowledge through education for a diverse community; and to the application of this knowledge to benefit the people of the state, the nation, and the world. The University's mission, carried out on multiple campuses and throughout the state, is threefold:

Research and Discovery—Generate and preserve knowledge, understanding, and creativity by conducting high-quality research, scholarship, and artistic activity that benefit students, scholars, and communities across the state, the nation, and the world.

Teaching and Learning—Share that knowledge, understanding, and creativity by providing a broad range of educational programs in a strong and diverse community of learners and teachers, and prepare graduate, professional, and undergraduate students, as well as non-degree-seeking students interested in continuing education and lifelong learning, for active roles in a multiracial and multicultural world.

Outreach and Public Service—Extend, apply, and exchange knowledge between the University and society by applying scholarly expertise to community problems, by helping organizations and individuals respond to their changing environments, and by making the knowledge and resources created and preserved at the University accessible to the citizens of the state, the nation, and the world.

In all of its activities, the University strives to sustain an open exchange of ideas in an environment that embodies the values of academic freedom, responsibility, integrity, and cooperation; that provides an atmosphere of mutual respect, free from racism, sexism, and other forms of prejudice and intolerance; that assists individuals, institutions, and communities in responding to a continuously changing world; that is conscious of and responsive to the needs of the many communities it is committed to serving; that creates and supports partnerships within the University, with other educational systems and institutions, and with communities to achieve common goals; and that inspires, sets high expectations for, and empowers the individuals within its community.

B. College of Science and Engineering

The College of Science and Engineering has a fourfold mission: help each student develop a foundation for a career by learning the substance and methods of an academic discipline; participate fully in the liberal education mission of the campus; foster significant scholarly research; and serve the well-being of the community, state, and region. The college offers students a broad range of curricula covering the natural sciences, mathematical sciences, engineering, and technology.

Each student is provided the opportunity to develop competence in a special field of knowledge by learning its principles and perspectives, mastering its methods, and acquiring much of its accumulated knowledge.

In addition to offering formal coursework, the college is committed to providing students with opportunities to learn through participation in research, honors programs, individual study, and special seminars. Such programs, which emphasize undergraduate education, are enhanced and complemented by high quality graduate programs. These graduate programs form an integral component of our commitment to scholarship.

C. Department of Computer Science

The mission of the Department of Computer Science is four-fold: (1) to conduct scholarly research; (2) to provide an instructional environment that leads to careers and research in computer science and information systems; (3) to contribute to the liberal education mission of the University; (4) to serve the community, state, region, and the profession.

3. Program Objectives and Outcomes

The Department of Computer Science offers two undergraduate degree programs: the Bachelor of Science in Computer Science and the Bachelor of Science in Computer Information Systems. The educational objectives of these programs complement and support the mission statements. The program objectives are as follows:

Within 3 to 5 years of graduation, our alumni should be:

1. Working as productive professionals in the computing field or pursuing graduate/professional education;
2. Participating as members of the computing field and in their general community;
3. Beginning to take leadership roles in their chosen profession;
4. Working effectively as a member of a team; and
5. Pursuing life-long learning opportunities.

The first two objectives align with the mission of the university, our college and department in that we intend to transfer knowledge to our students and for them to develop capabilities that will allow them to become productive members of their field and their community. Our third and fourth objective addresses our belief that our students should become future leaders and interact productively in their professional and personal lives and that their education will help achieve them that objective. Our fifth objective represents our belief that our students should receive a thorough basis in their chosen field of endeavor and that their education at UMD should help them to continue to grow and evolve after they leave us. [DON, what do you think?]

These objectives embrace outcomes-based learning. The skills, knowledge and behavior that students acquire as they move through this program (that is, the expected program outcomes for students graduating with an undergraduate degree in Computer Science or in Computer Information Systems) are delineated below. In particular,

1. Students understand the mathematics and statistics that underlie scientific applications.
2. Students can design, develop, and analyze significant software systems.
3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and programming languages.
4. Students can apply computer science principles and practices to a variety of problems.
5. Students can work independently and also work effectively in teams.
6. Students can communicate effectively both orally and in writing.
7. Students understand social, professional and ethical issues related to computing.
8. Students are knowledgeable of contemporary issues in the arts, social sciences, and humanities.
9. Students understand the scientific method and can apply this mode of inquiry in a laboratory setting. (CS Program)
9. Students have a broad perspective of the business world. (CIS Program)

We map these outcomes to our program objectives shown in Table 1. We believe that the outcomes for students of our program will address core capabilities that will give our students the necessary foundation to achieve the objectives of our program as shown in this table.

CS Outcomes Vs. CS Objectives	Within 3 to 5 years of graduation, our alumni should be (1) working as productive professionals in the computing field or pursuing graduate / profession education	(2) participating as members of the computing field and in their general community;	(3) beginning to take leadership roles in their chosen profession;	(4) working effectively as a member of a team; and	(5) pursuing life-long learning opportunities.
1. Students understand the mathematics and statistics that underlie scientific applications.	X	X			X
2. Students can design, develop, and analyze significant software systems.	X	X	X		
3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and programming languages.	X	X			X
4. Students can apply computer science principles & practices to a variety of problems.	X	X	X		
5. Students can work independently & also work effectively in teams.	X	X		X	
6. Students can communicate effectively both orally and in writing.	X	X	X	X	X
7. Students understand social, professional and ethical issues related to computing.	X	X	X		X
8. Students are knowledgeable of contemporary issues in the arts, social sciences, and humanities.		X	X		X
9. Students understand the scientific method and can apply this mode of inquiry in a laboratory setting.	X				X
9. Students have a broad perspective of the business world. (CIS Program)	X	X	X		X

Table 1. Mapping from Computer Science Outcomes to Objectives.

In addition to our program outcomes, note that ABET has recently established a specific set of outcomes that are used in assessing programs. These criteria are shown below:

The program enables students to achieve, by the time of graduation:

(a) An ability to apply knowledge of computing and mathematics appropriate to the discipline;

(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;

(c) An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs;

(d) An ability to function effectively on teams to accomplish a common goal;

(e) An understanding of professional, ethical, legal, security, and social issues and responsibilities;

(f) An ability to communicate effectively with a range of audiences;

(g) An ability to analyze the local and global impact of computing on individuals, organizations and society;

(h) Recognition of the need for, and an ability to engage in, continuing professional development;

(i) An ability to use current techniques, skills, and tools necessary for computing practices.

For computer science programs:

(j) An ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices;

(k) An ability to apply design and development principles in the construction of software systems of varying complexity.

To demonstrate that these criteria are being met we have introduced the following articulation matrix to map from the Computer Science outcomes to the ABET outcomes (shown in Table 2). We believe that our outcomes cover the ABET outcomes via this mapping, and thus if our students achieve the CS outcomes they will be achieving the ABET outcomes. Note that this mapping is provided only for our Computer Science program, as it is the only program that is accredited at this time. Our faculty and advisory board have discussed the possibility of seeking accreditation of our CIS program under ABET using the CAC information systems or information technology track, but have chosen not to as of yet. This decision will be reevaluated as the program is reevaluated.

CS Outcomes Vs. CAC Outcomes	*(a) An ability to apply knowledge of computing and mathematics appropriate to the discipline;*	*(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;*	*(c) An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs;*	*(d) An ability to function effectively on teams to accomplish a common goal;*	*(e) An understanding of professional, ethical, legal, security, and social issues and responsibilities;*	*(f) An ability to communicate effectively with a range of audiences;*	(g) An ability to analyze the local and global impact of computing on individuals, organizations and society;	*(h) Recognition of the need for, and an ability to engage in, continuing professional development;*	*(i) An ability to use current techniques, skills, and tools necessary for computing practices.*	*(j) An ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices;*	*(k) An ability to apply design and development principles in the construction of software systems of varying complexity.*
1. Students understand the mathematics and statistics that underlie scientific applications.	X									X	
2. Students can design, develop, and analyze significant software systems.	X	X	X						X	X	X
3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and prog. languages.	X		X						X	X	X
4. Students can apply computer science principles & practices to a variety of problems.	X	X	X					X	X	X	X
5. Students can work independently & also work effectively in teams.				X							
6. Students can communicate effectively both orally and in writing.						X					
7. Students understand social, professional and ethical issues related to computing.	X				X		X		X		
8. Students are knowledgeable of contemporary issues in the arts, social sci., and humanities.					X		X				
9. Students understand the scientific method and can apply this mode of inquiry in a laboratory setting.					X		X				

Table 2. Mapping from Computer Science Outcomes to ABET Outcomes.

4. Course Outcomes[2]

The undergraduate curriculum in computer science is consistent with the program's documented objectives. In fact, the expected outcomes 1-9 that are contained in our program objectives are achieved primarily through activities associated with the courses taken by our students. Hence, in our program's assessment plan, a major emphasis is placed on specific courses and the outcomes associated with them.

Computer Science faculty have identified course outcomes for each of the required courses in our undergraduate programs. These outcomes are documented online. As specifically noted therein, the course outcomes are related directly to intended program outcomes and in fact represent activities students experience through various levels of learning - that is, from understanding to evaluation and synthesis - in the areas identified as program objectives. As might be expected, a given course generally contributes to several of the program outcomes.

How does each course contribute to the program objectives? Do our required courses in total support all the program outcomes? We will address the latter question first by demonstrating that there exists a clear mapping between course outcomes and program outcomes. We will then show that the normal sequence of courses in our undergraduate program provides activities supporting the program objectives. These mappings support our contention that the program includes activities that produce the desired outcomes and objectives. Before introducing the mappings, we need to understand the degree requirements of the BS-CS and BS-CIS degrees. These requirements are delineated in Tables 3 and 4.

In the following two tables, Tables 5 and 6 we indicate which CS outcomes each course contributes to (as shown in our course descriptions available online at http://www.d.umn.edu/cs/asse/desc). For the purpose of these mappings we have grouped certain sets of courses:

For Computer Science the following courses are grouped:

- The 3 advanced Breadth/Elective courses are chosen by the student, but as a group achieve certain outcomes.
- The Mathematics and Statistics courses Math 1296, 1297, 2326 and Stat 3611 as the material they cover is considered as a group.
- The year of lab science and additional science course as they establish breadth and a familiarity with the scientific method.
- The composition courses Writ 1120 and Writ 3130/3150 as together they develop students' capabilities for writing.
- Liberal Education courses as they help broaden a student's interests.

For Computer Information Systems the following courses are grouped:

- The Mathematics and Statistics courses Math 1296 and Stat 3611 as the material they cover is considered as a group.

[2] In the remainder of this report, reference to the computer science curriculum or the computer science program will refer to both the CS and CIS degree programs interchangeably. If a distinction is necessary, reference to the actual degree program will be made.

Bachelor of Science in Computer Science

Degree Requirements

2007-09

A. COMPUTER SCIENCE REQUIREMENTS

1. CORE

CS 1511 - Computer Science I	
OR	
CS 1581 - Honors: Computer Science	5
CS 1521 - Computer Science II	5
CS 2511 - Software Analysis and Design	4
CS 2521 - Computer Organization and Architecture	4
CS 3111 - Computer Ethics	4
CS 3512 - Computer Science Theory	4

2. ADVANCED

REQUIRED COURSES

CS 5631 - Operating Systems	4
CS 5621 - Computer Architecture OR	4
CS 5651 - Computer Networks	4

ADDITIONAL REQUIREMENTS - 3 Breadth/Elective courses (with at least 1 chosen from the Breadth list)

BREADTH		ELECTIVES	
CS 4511 - Theory of Computation	4	CS 4821 - Computer Security	4
CS 4521 - Algorithms and Data Structures	4	CS 5721 - Computer Graphics	4
CS 4531 - Software Engineering	4	CS 5741 - Object- Oriented Design	4
CS 4611 - Database Management Systems	4	CS 5751 - Intro to Machine Learning	4
CS 5541 - Artificial Intelligence	4	CS 5761 - Intro Natural Language Processing	4
CS 5551 - User Interface Design	4	CS 5831 - Information & Text Processing	4
CS 5621 - Computer Architecture*	4		
CS 5641 - Compiler Design	4		
CS 5651 - Computer Networks*	4		

B. MATHEMATICS REQUIREMENTS

MATH 1296 - Calculus I	5	MATH 2326 – Intro to Linear Algebra	4
MATH 1297 - Calculus II	5	STAT 3611 - Probability & Statistics	

C. SCIENCE REQUIREMENTS

Lab Science Sequence**	8-12	Approved Science Elective	

D. OTHER REQUIREMENTS

WRIT 1120 - College Writing	3	COMM 1112 - Public Speaking	3
WRIT 3130 - Advanced Writing: Eng OR		ECE 1315 - Digital System Design	4
WRIT 3150 - Advanced Writing: Science	3	Liberal Education (CAC)	21

*Students may count one of 5621 or 5651 as an Additional Required course *ONLY* if they have taken both courses.

**The lab science sequence must be chosen from one of the following sequences:

1. BIOL 1011-1012 - General Biology I & II (10)
2. CHEM 1151-1152 - General Chemistry I & II (10) or 1161-1162 (Honors: Chemistry I & II)
3. GEOL 1110 - Introductory Geology (4), GEOL 2311 - Mineralogy (4), GEOL 2312 - Petrology (4)
4. PHYS 2011-2012 - General Physics I & II (8)

Table 3. Requirements for the Bachelor of Science in Computer Science.

Bachelor of Science in Computer Information Systems

Degree Requirements

2007-2009

A. Major Requirements

1. Core Courses

CS 1511: Computer Science I (5)
CS 1521: Computer Science II (5)
CS 2511: Software Analysis and Design (4)
CS 3011: Information Technology Hardware and Software (4)
FMIS 2201: Information Technology in Business (3)*

2. Advanced Courses

CS 3111: Computer Ethics (4)
CS 3121: Interactive Multimedia Technology (4)
CS 3211: Database System Concepts (4)
CS 3221: Operating Systems Practicum (4)
CS 4411: Data Communications and Network Technology (4)
CS 4531: Software Engineering (4)

B. Additional Requirements

Minor in Business Administration§

COMM 1112: Public Speaking (3)
WRIT 1120: College Writing (3)
WRIT 3121: Advanced Writing: Business and Organizations (3) *OR*
WRIT 3130: Advanced Writing: Engineering (3) *OR*
WRIT 3150: Advanced Writing: Science (3)
MATH 1296: Calculus I (5)
STAT 3611: Intro to Probability and Statistics (4)*

C. General Education Electives including the additional Liberal Education Requirements (21)#

TOTAL (120)

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*Counts toward the Business Administration minor for non-SBE students.

§NOTE: In addition to the courses noted above, the Business Administration minor requirements include:

1) ACCT 2001: Principles of Financial Accounting (3) or ACCT 2005: Survey of Accounting (3)
2) ECON 1003: Economics and Society (3) OR
   ECON 1022: Principles of Economics – Macro and ECON 1023: Principles of Economics – Micro (6)
3) FMIS 3301: Production and Operations Management (3)
4) FMIS 3601: Corporation Finance (3)
5) MGTS 3401: Organizational Behavior and Management (3)
6) MGTS 3701: Principles of Marketing (3)
7) MGTS 3801: Human Resource Management (3)

Electives are subject to departmental approval

Table 4. Requirements for the Bachelor of Science in Computer Information Systems.

Courses Vs. CS Outcomes	1. Students understand the mathematics and statistics that underlie scientific applications.	2. Students can design, develop, and analyze significant software systems.	3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and prog. languages.	4. Students can apply computer science principles & practices to a variety of problems..	5. Students can work independently & also work effectively in teams.	6. Students can communicate effectively both orally and in writing.	7. Students understand social, professional and ethical issues related to computing.	8. Students are knowledgeable of contemporary issues in the arts, social sci., and humanities.	9. Students understand the scientific method and can apply this mode of inquiry in a laboratory setting. (CS)
CS 1511: CS I		X	X	X					
CS 1521: CS II		X	X				X		
CS 2511: Software Design/Analysis		X	X	X	X				
CS 2521: Comp Org & Arch	X		X	X					
CS 3111: Computer Ethics						X	X		
CS 3512: CS Theory	X		X	X		X			
CS 5631: Operating Systems		X	X	X	X				
CS 5621 (Arch) or CS 5651 (Netwrks)		X	X	X					
3 Breadth/Elective CS Courses		X	X	X					
ECE 1315: Digital System Design	X		X						
MATH 1296,1297, 2326, STAT 3611	X								
Lab Science seq, Add Sci course									X
WRIT 1120/3130/3150:						X			
COMM 1112: Public Speaking						X			
Liberal Education								X	

Table 5. Mapping from CS Course Requirements to CS Outcomes.

Courses Vs. CIS Outcomes	1. Students understand the mathematics and statistics that underlie scientific applications.	2. Students can design, develop, and analyze significant software systems.	3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and prog. languages.	4. Students can apply computer science principles & practices to a variety of problems..	5. Students can work independently & also work effectively in teams.	6. Students can communicate effectively both orally and in writing.	7. Students understand social, professional and ethical issues related to computing.	8. Students are knowledgeable of contemporary issues in the arts, social sci., and humanities.	9. Students have a broad perspective of the business world. (CIS Program)
CS 1511: CS I		X	X	X					
CS 1521: CS II		X	X				X		
CS 2511: Software Design/Analysis		X	X	X	X				
CS 3011: IT Hardware & Softw	X		X	X					
CS 3111: Computer Ethics						X	X		
CS 3121: Interact Multimedia		X		X					
CS 3211: DB Systems		X		X					
CS 3221: OS Practicum		X	X	X					
CS 4411: Data Comm & Netwrks		X	X	X					
CS 4531: Software Engineering		X		X	X				
MATH 1296, STAT 3611	X								
Minor in Business Admininstration									X
WRIT 1120, 3121/3130/3150						X			
COMM 1112: Public Speaking						X			
Liberal Education								X	

Table 6. Mapping from CIS Course Requirements to CIS Outcomes.

- The minor in Business Administration, which includes a number of courses including the upper division requirements shown in Table 4 and FMIS 2201, an Accounting course and an Economics course is considered as a group of courses.
- The composition courses Writ 1120 and Writ 3130/3150 as together they develop students' capabilities for writing.
- Liberal Education courses as they help broaden a student's interests.

Tables 5 and 6 compare the course outcomes with the program outcomes. When all required courses are considered, it is evident that all program outcomes are addressed.

This mapping also clearly indicates that in all cases, more than one course contributes to a single program outcome. Courses contributing to a given outcome typically contribute at different levels. For example, freshmen-level courses provide the foundation for meeting outcomes, including acquisition of knowledge and development of basic skills. Sophomore course activities reinforce comprehension or understanding of the material. Advanced courses typically apply and use computer science principles and practices and support analysis and synthesis of the material. Table 7 illustrates, for each program outcome, the sequence of courses required for a student to meet that outcome.

Finally, combining information from Tables 2 and 5, Table 8 presents a mapping of our course outcomes to ABET outcomes, to show the relationships of our courses to the ABET outcomes more directly.

Our assessment plan measures the extent to which students satisfy the course outcomes. If our assessment plan verifies that graduates of the program are meeting the defined outcomes, then the program outcomes and objectives are being met. In addition, since the curriculum as a whole contributes to the achievement of the outcomes corresponding to our objectives, then the curriculum is consistent with the program's documented objectives.

OUTCOME	Freshman Year	Sophomore Year	Junior Year	Senior Year
1. Students understand the mathematics and statistics that underlie scientific applications.	ECE 1315 MA 1296 MA 1297	MA 2326 ST 3611		
2. Students can design, develop, and analyze significant software systems.	CS 1511 CS 1521	CS 2511	CS 3xxx CS 4xxx CS 5xxx	CS 3xxx CS 4xxx CS 5xxx
3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and programming languages.	CS 1511 CS 1521 ECE 1315	CS 2511 CS 2521	CS 3011 CS 4xxx CS 5xxx	CS 3xxx CS 4xxx CS 5xxx
4. Students can apply computer science principles and practices to a variety of problems.			CS 3xxx CS 4xxx CS 5xxx	CS 3xxx CS 4xxx CS 5xxx
5. Students can work independently and also work effectively in teams.		CS 2511	CS 3xxx CS 4xxx CS 5xxx	CS 3xxx CS 4xxx CS 5xxx
6. Students can communicate effectively both orally and in writing.	COMM 1112 COMP 1120		COMP 3150	CS 3111
7. Students understand social, professional and ethical issues related to computing		CS 2511		CS 3111
8. Students are knowledgeable of contemporary issues in the arts, social sciences, and humanities	Lib Ed	Lib Ed	Lib Ed	Lib Ed
9. Students understand the scientific method and can apply this mode of inquiry in a laboratory setting. (CS)	Lab Science	Lab Science		
9. Students have a broad perspective of the business world. (CIS Program)	ACCT 2001 ECON 1003		FMIS 3xxx FMIS 3xxx	MGTS 3xxx MGTS 3xxx

Table 7. Sequence of Outcome-Supporting Courses

CS Courses Vs. ABET Outcomes	*(a) An ability to apply knowledge of computing and mathematics appropriate to the discipline;*	*(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;*	*(c) An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs;*	*(d) An ability to function effectively on teams to accomplish a common goal;*	*(e) An understanding of professional, ethical, legal, security, and social issues and responsibilities;*	*(f) An ability to communicate effectively with a range of audiences;*	(g) An ability to analyze the local and global impact of computing on individuals, organizations and society;	*(h) Recognition of the need for, and an ability to engage in, continuing professional development;*	*(i) An ability to use current techniques, skills, and tools necessary for computing practices.*	*(j) An ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices;*	*(k) An ability to apply design and development principles in the construction of software systems of varying complexity.*
CS 1511: CS I	X	X	X						X		
CS 1521: CS II	X	X	X						X		
CS 2511: Software Design/Analysis	X	X	X	X				X	X	X	X
CS 2521: Comp Org & Arch	X	X							X		
CS 3111: Computer Ethics					X	X	X				
CS 3512: CS Theory	X	X	X						X	X	
CS 5631: Operating Systems	X	X	X	X				X	X	X	X
CS 5621 (Arch) or CS 5651 (Netwrks)	X	X	X					X	X	X	X
3 Breadth/Elective CS Courses	X	X	X	X				X		X	X
ECE 1315: Digital System Design	X		X								
MATH 1296, 1297, 2326, STAT 3611	X		X							X	
Lab Science seq, Add Sci course					X						
WRIT 1120/3130/3150:						X					
COMM 1112: Public Speaking						X					
Liberal Education					X		X	X			

Table 8. Mapping from CS Courses to ABET CS Outcomes

5. Program Assessment Methods

We use a variety of methods to measure the achievement of our program objectives and outcomes, including:

- Course Assessment
- Surveys
  - Senior Surveys
  - Alumni Surveys
  - Employer Surveys.

Most of these tools are used to evaluate program outcomes. However, as previously noted, there is a direct correlation between the educational objectives of the program and expected outcomes.

A. Course Assessment

Course assessment is the foundation of our program assessment plan. A primary means of assessing student performance is to measure how well course outcomes are met. Each computer science course in the undergraduate degree program has a set of expected outcomes associated with it (these can be found online). Corresponding to each outcome is a set of measurable performance criteria, that is, standards or tasks that must be met in order for the expected outcome to be met. The performance criteria identify more clearly what is meant by each outcome and represent the metrics used to determine achievement of the outcome. The performance criteria enable us to identify the data to be collected in evidence of student achievement.

As part of the overall assessment plan, faculty members conduct assessments of designated courses each semester. All core courses are evaluated every other year and advanced courses at least once every third year. Assessments are based on the evaluations of data collected for each performance criterion established for the course outcomes.

B. Surveys

Although course outcomes are particularly important measures for assessing our program, we also employ a combination of survey methods. Surveys are used to understand the perspectives of our students, alumni and employers. We ask each graduating student to assess his/her own skills, attitude, and behavior, as well as provide feedback in terms of his/her views of the quality of the program. We solicit from our alumni assessments of how well their educational experiences support their professional responsibilities; that is, we ask if the program adequately prepared them for their jobs and how the quality of education received at UMD compares with that of their co-workers. Employer surveys are designed to determine two factors: (1) how the CS program serves their purposes and (2) the degree to which our individual program outcomes are relevant to their needs. Copies of the formal surveys are included in Appendix B.

Senior Surveys

Each year we conduct a written survey of graduating seniors. This survey asks for their perspectives on the program and solicits a self-assessment of the skills and knowledge gained from their educational experiences. The survey includes both open-ended and forced-choice questions. The latter consist of 20 questions that are based on our specific program objectives, including the 1-9 program outcomes. The other 10 questions are more general in nature and relate to quality and accessibility of the faculty, physical facilities, the strengths and weaknesses of the program overall, and the student's plans for the immediate future. To ensure 100% response to this survey we made completion of the survey a requirement for both degrees.

Alumni Surveys

Every third year we survey those alumni receiving their degrees during the past two to four years. Alumni are surveyed to ascertain their professional growth and the extent to which they have utilized the skills and knowledge acquired in our program. The survey solicits information about job responsibilities and computer expertise. In addition, we seek more in-depth information to determine how well our program objectives and outcomes have been met. Although alumni surveys generally have low rates of return, the results still have a significant impact on the program.

Employer Surveys

Employers are constituents of our program, and thus their assessments of the program are critical. However, most employers do not respond to program surveys. To solve this problem, we conduct two types of employer-related surveys: recruiter surveys and internship surveys. Each year, recruiters who interview senior computer science students are asked to complete a survey that reveals whether our program outcomes are compatible with their needs. The form takes only a few minutes to complete and is completed during the recruiter's visit to campus. Career Services collects the surveys and returns them to the program. As a result, we have close to 100% recruiter participation each year.

Many computer science students work as interns at some point in their academic careers. Companies employing interns are required to provide a letter of evaluation at the end of the internship. The letter addresses how well the student performed his/her assigned tasks/duties and includes an assessment of the skills, knowledge and abilities of the intern. Although not as formal as the other surveys used in our assessment plan, these evaluations are extremely useful in assessing our program objectives and outcomes. They are generally considered a very valuable form of student outcomes assessment, since they provide a direct measure of what has been learned in the program.

The External Advisory Board provides significant input to our program. Our program has now been in existence for over 20 years, and our board has evolved to meet our changing needs. The board now includes more recent graduates to try to increase the variety of perspectives our board can provide. We also continue to focus on more senior alumni and others who have recently recruited our students, as they can give us very useful insight into how well our program is doing.

6. Program Assessment Plan

In order to maintain its relevancy, a program should regularly assess its progress against its objectives and use the results of the assessments to identify program improvements and modify the program's objectives. To support this goal, we implemented an assessment plan that includes two major loops. One loop is conducted annually and represents that part of the plan that evaluates and assesses our course outcomes in relation to our objectives. Execution of this loop typically leads to improvements in the curriculum. The second loop is conducted over a longer, 3-year cycle, and represents the tasks involved in evaluating and assessing our educational program objectives. Information from the annual cycle is fed back into the long-term cycle. Execution of this second loop leads to additional program improvements and, in some cases, changes in our objectives and outcomes. Figure 1 contains a flowchart reflecting our comprehensive assessment plan for continuous program improvement. In this section, we describe how and when data is collected to support this assessment plan.

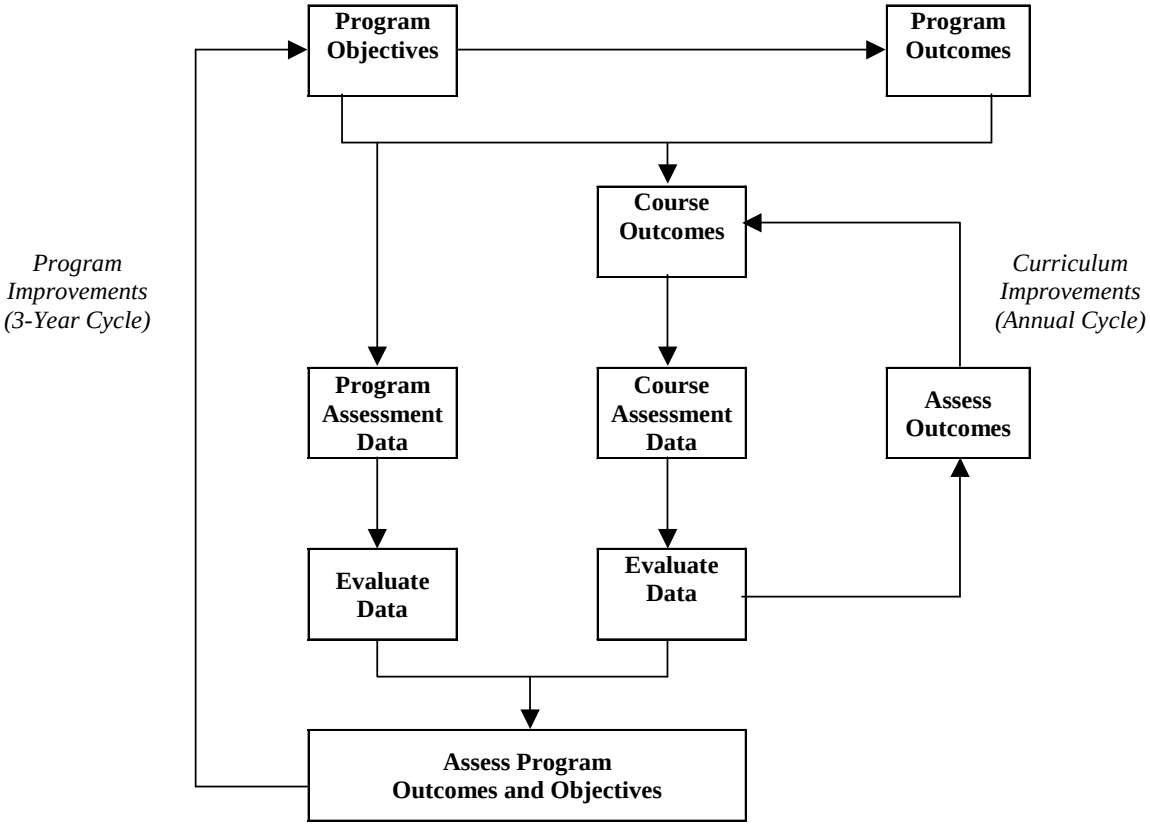

Figure 1. Evaluation and Assessment Plan

A. Loop 1 – Course Assessment Plan

The foundation of our assessment plan for continuous program improvement is based on evaluation and assessment procedures that produce documented results. Evidence gleaned from assessment guides decisions that further the development and improvement of our programs. As previously noted, course assessment is the foundation of departmental assessment. It evaluates student performance outcomes in terms of individual course outcomes. In other words, we measure for each course the extent to which students are meeting the course outcomes and objectives.

Rather than doing a formal analysis of each course each year, we have gathered related courses into groups of manageable size. Courses in most groups are evaluated every other year; advanced courses are evaluated once every third year. The courses are clustered as follows:

1. CS 1511/1521
   Computer Science Fundamentals
2. CS 2511/2521
   Software Analysis & Design
   Computer Organization & Architecture
3. CS 3111/3512
   Computer Ethics
   Computer Theory
4. CS Breadth and Elective Courses
   Subgroup 4.1 – 4511/4521
      Theory/Automata/Data Structures
   Subgroup 4.2 – CS 4531/5741
      Software Engineering/OO Design
   Subgroup 4.3 – CS 5541/5751/5761/5831
      AI/Machine Learning/Natural Language Processing/Information & Text Processing
   Subgroup 4.4 – CS 5551/5721
      User Interface Design/Computer Graphics
   Subgroup 4.5 – CS 5621/5631/5651
      Computer Architecture/Operating Systems/Computer Networks
   Subgroup 4.6 – CS 4611/4821/5641
      DBMS/Compiler Design/Computer Security
5. CIS Courses
   Subgroup 5.1 – CS 3121/3211
      Interactive Multimedia Technology/DB Systems
   Subgroup 5.2 – CS 3221/4411
      OS Practicum/Networks
   Subgroup 5.3 – CS 3011
      Information Technology Hardware & Software

Table 9 contains the timeline for evaluating course outcomes. The average number of courses evaluated each year is 10.

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Group 1 1511/1521		Group 1 1511/1521		Group 1 1511/1521	
	Group 2 2511/2521		Group 2 2511/2521		Group 2 2511/2521
Group 3 3111/3512		Group 3 3111/3512		Group 3 3111/3512	
Group 4.1 4511/4521	Group 4.2 4531/5741	Group 4.3 5541/5751 5761/5831	Group 4.1 4511/4521	Group 4.2 4531/5741	Group 4.3 5541/5751 5761/5831
Group 4.4 5551/5721	Group 4.5 5621/5631/5651	Group 4.6 4611/4821/5641	Group 4.4 5551/5721	Group 4.5 5621/5631/5651	Group 4.6 4611/4821/5641
Group 5.1 3121/3211	Group 5.2 3221/4411	Group 5.3 3011	Group 5.1 3121/3211	Group 5.2 3221/4411	Group 5.3 3011

Table 9. Cycle for Course Assessments

At the end of a semester, each faculty member evaluates the courses scheduled for his/her review during the current cycle. Evaluations of student outcomes are made in comparison with the outcomes previously established for the courses. A formal assessment of each such course is prepared using a course assessment form. Course assessment includes the following:

- Course Catalog Description
- Grade Distribution
- Course Modifications and Impact
  - Changes that were made to the course as a result of the previous course assessment.
  - Impact of the course modification.
- Course Outcomes Assessment
  - Listing of the course outcomes.
  - An indication of the extent to which each outcome was assessed during the semester.
  - Instruments used to assess each outcome.
  - Degree to which the class as a whole met each outcome.
- Program Outcomes Assessment
  - Listing of program outcomes.
  - An indication of what was done during the course to contribute to the meeting of each program outcome.
- Faculty Reflections
  - Faculty assessment of the course in general – what worked and what didn't.
  - Student assessment of the course.

- Extenuating circumstances that may have affected student performance.

- Suggestions for Course Improvement
  - Faculty recommendations for course improvement or changes.

When all course assessments have been completed (at the end of a semester), they are presented to the Steering Committee[3], which reviews results and prepares a summary report for the faculty as a whole. The faculty makes a final assessment of the degree to which the outcomes are being met and identifies course improvements.

B. Loop 2 – Program Assessment Plan

In general, program outcomes and objectives are formally assessed every three years. However, much of the data that is evaluated to assess outcomes and objectives is collected annually. Tables 10 and 11 list the data that is collected for these purposes. The Steering Committee is responsible for analyzing the data on an annual basis and reporting its results to the faculty as a whole. The faculty may recommend program changes at that time. Every third year, when the alumni surveys are analyzed, the committee prepares a report based on the 3 years of accumulated data. It includes recommendations to the faculty for maintaining, modifying or otherwise improving the curriculum, program, and the assessment plan, including modifications to the outcomes and objectives. These recommendations are discussed with the Advisory Board in the fall semester.

OBJECTIVE	HOW IT IS MEASURED	WHEN IT IS MEASURED
Within 3 to 5 years of graduation, our alumni should be: (1) Working as productive professionals in the computing field or pursuing graduate/professional eduction;	Recruiters/Employers Alumni Surveys	Annually Every 3rd Year
(2) Participating as members of the computing field and in their general community;	Recruiters/Employers Alumni Surveys	Annually Every 3rd Year
(3) Beginning to take leadership roles in their chosen profession;	Recruiters/Employers Alumni Surveys	Annually Every 3rd Year
(4) Working effectively as a member of a team; and	Recruiters/Employers Alumni Surveys	Annually Every 3rd Year
(5) Pursuing life-long learning opportunities.	Recruiters/Employers Alumni Surveys	Annually Every 3rd Year

Table 10. Data Collection for Assessment of Program Objectives

[3] The Steering Committee consists of the Head, Associate Head, and the Director of Graduate Studies.

OUTCOME	HOW IT IS MEASURED	WHEN IT IS MEASURED
1. Students understand the mathematics and statistics that underlie scientific applications.	Senior Surveys Alumni Surveys	Upon Graduation Every 3rd Year
2. Students can design, develop, and analyze significant software systems.	CS 1511/1521/2511 CS Advanced Courses Senior Surveys Alumni Surveys Employer Surveys	Annually Annually Upon Graduation Every 3rd Year Annually
3. Students understand the fundamentals of computer organization and architecture, data structures and related algorithms, and programming languages.	CS 1511/1521/2511/2521 CS Advanced Courses Senior Surveys Alumni Surveys Employer Surveys	Annually Annually Upon Graduation Every 3rd Year Annually
4. Students can apply computer science principles and practices to a variety of problems.	CS Advanced Courses Senior Surveys Alumni Surveys Employer Surveys	Annually Upon Graduation Every 3rd Year Annually
5. Students can work independently and also work effectively in teams.	CS 2511 CS Advanced Courses Senior Surveys Alumni Surveys Employer Surveys	Every Other Year Annually Upon Graduation Every 3rd Year Annually
6. Students can communicate effectively both orally and in writing.	CS 4993 Senior Surveys Alumni Surveys Employer Surveys	Every Other Year Upon Graduation Every 3rd Year Annually
7. Students understand social, professional and ethical issues related to computing	CS 1511/2511/3111/4993 Senior Surveys Alumni Surveys Employer Surveys	Annually Upon Graduation Every 3rd Year Annually
8. Students are knowledgeable of contemporary issues in the arts, social sciences, and humanities	APAS Certification	Upon Graduation
9. Students understand the scientific method and can apply this mode of inquiry in a laboratory setting. (CS)	APAS Certification Senior Surveys Alumni Surveys	Upon Graduation Upon Graduation Every 3rd Year
9. Students have a broad perspective of the business world. (CIS Program)	APAS Certification Senior Surveys Alumni Surveys	Upon Graduation Upon Graduation Every 3rd Year

Table 11. Data Collection for Assessment of Program Outcomes

7. Documentation of the Process

The assessment plan is labor and time intensive, involving extensive data collection, data analysis, course and program assessment, program modification, and impact analysis. In order to manage this process, to facilitate faculty involvement, and to make the results of the on-going process available, we created an assessment web site. The site map is presented below. It contains two directories – one with links to public information and one with links to information restricted to faculty.

A. Public Access – CS Assessment

- ABET BS-CS Program Certification
- ABET CAC Home Page
- Departmental Mission Statement
- Program Objectives and Outcomes
- Course Descriptions including course outline and outcomes
- Constituents
- External Advisory Board
- Assessment Plan (a copy of this report)

B. Restricted Access

- Survey Results
    - Annual Survey of Graduating Seniors
    - Annual Survey of Recruiters
    - Annual Survey of Intern Employers
    - Tri-annual Survey of Alumni
- Course Assessment Results
- Annual Advisory Board Report
- Annual Assessment Report
- Templates and Directions

The public site contains information that represents the foundation of our assessment plan. This information is fairly static and gives our stakeholders insight as to the nature of our programs and how they are assessed.

The restricted site contains all the data generated annually by the assessment process and provides complete documentation of our plan. Backward links to previous results are maintained for every link. For each survey, we provide the raw qualitative and quantitative data and our analysis of the data. Course assessment results are provided in their entirety, including assessment of the impact of any modifications made to the courses that year. Our annual assessment reports provide a summation of the results of the assessment process and approved changes to the program.

8. Changes

A. Version 1.1, Fall 2004 – this version reflects the following changes

1. As a result of our accreditation visit in 2003 we made several changes to the CS program. The first change was to require more theory as part of the degree. To do

this we introduced a new course, CS 3511, Introduction to Computer Theory (3 credits) which is required of all CS students.

2. Also as a part of our accreditation visit we now require that all CS students take CS 5631 (Operating Systems) and a hardware oriented course (CS 5621 – Computer Architecture or CS 5651 – Computer Networks).

3. The requirement of CS 3511, CS 5631 and CS 5621 or CS 5651 necessitated a revision of our upper division requirements. The original requirements were 6 upper division CS courses including 3 breadth courses. Under our new scheme, students must take 3511, 5631, 5621 or 5651 and 3 upper division CS courses including at least one breadth course.

4. The School of Business and Economics altered its requirements for the Business Administration minor for non SBE-students. The new minor replaces FMIS 1201 and 3201 with FMIS 2201. In addition, the original minor allowed students to choose four of five upper division business electives. The new minor requires all five.

5. As the focus of the Information Systems and Technology had somewhat changed, focusing more on the systems and software aspect, the department decided to change the name of the IS&T major to Computer Information Systems, which we felt more accurately reflected the degree.

B. Version 1.2, Fall 2006 – this version reflects the following changes

1. The department felt that students were not getting a consistent enough experience with regards to computer ethics material and also felt that our students would benefit from the oral presentation and writing components of CS 3111, so we dropped the alternative to CS 3111 of Phil 3242 and required all students to take CS 3111.

2. As students were now required to get a more consistent ethics experience and would have to make written and oral presentations in that class we dropped the requirement of CS 4993.

3. To ensure that students still completed the Senior Surveys we made these surveys a requirement for graduation.

4. We felt that the material presented in Math 3355 and CS 3511 had far too much overlap. Given that we had had some difficulties guaranteeing coverage of key aspects of the material formerly in Math 3355 we chose to increase by one credit CS 3511, making a new course CS 3512 (4 credits) covering some of the lost material. We also requested that the Math department teach a new course, Math 2326, Introduction to Linear Algebra and Mathematical Reasoning. This course includes some of the material formerly covered in 3355 but also has significant coverage of linear algebra, which the faculty felt was very useful for many of our upper division courses.

5. For the Computer Information Systems major, the requirements of Math 1297 – Calculus II and Math 3355 – Discrete Mathematics were dropped, as the faculty felt the courses in this major do not build on this core.

C. Version 1.3, Fall 2007 – this version reflects the following changes

1. We moved to require advanced writing as a requirement for CS 3111 (Computer Ethics). We believe that our ethics course should serve to refine the written skills of our students and as such moved to make this a requirement for the course.

2. As ABET is adopting a new set of criteria included a set of outcome criteria that must be met the department met and review its outcomes, objectives and the ABET criteria. We adopted a new set of educational objectives that seem to be in keeping with the ABET approach of setting goals about what alumni might achieve in the future. This required a formulation of a matrix mapping CS Outcomes to ABET Outcomes. At this time we also reviewed and updated our Outcomes matrices to match changes to course outcomes noted in our assessments and course descriptions.
3. In addition, we chose to retain our existing set of program outcomes and chose to map our outcomes to the ABET criteria (mapping contained in this document).