Institutional Effectiveness Report
2018-19

Program: Computer Science BS

College and Department: College of Engineering – Computer Science

Contact: Doug Talbert

Mission: "Our mission is to be widely recognized for enabling students to have global impact through innovative and quality programs, through research that emphasizes collaborative partnerships, and by enabling the success of a diverse student, faculty, and alumni community."

This mission is consistent with the University's mission to "provide leadership and outstanding programs in engineering, the sciences, and related areas that benefit the people of Tennessee and the nation" and with the University's commitment to the life-long success of students and to enrich the lives of people and communities in the Upper Cumberland region of Tennessee.

It is also consistent with Flight Plan, the University's strategic plan, and it's focus on improving student experience, transforming technology, and creating distinctive programs.

Program Goals:

1. *Professionalism:* Our graduates will exhibit the clear communication, responsible teamwork, commitment to quality, personal self-organization, professional attitude, and ethics needed to engage in successful careers in industry, academia, and public service.

2. *Leadership:* Our graduates will exhibit technical, personal, ethical, and professional leadership in their businesses, professions, and communities

3. *Technical Proficiency*: Our graduates will exhibit the technical proficiency and problem-solving skills required to positively impact organizations, people, and processes at the local and global levels

4. *Life-long Learning:* Our graduates will exhibit an ability to be self-motivated, life-long learners who adapt to new technologies, tools, and methodologies to maintain the ability to respond to the challenges of a changing environment.

Student Learning Outcomes

1. Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.

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.

3. Communicate effectively in a variety of professional contexts.

4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.

5. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

6. Apply computer science theory and software development fundamentals to produce computing-based solutions.

A departmentally developed curriculum map can be found in Appendix 1 that shows the connections between courses and student learning outcomes.

Assessment Methods

1. *Faculty Course Reflections (all courses**):*** Each faculty member is asked to complete a course reflection at the end of each semester. The reflection allows a faculty member to summarize the results of the course, map the appropriate objectives and outcomes to the course and identify successes from the semesters, opportunities for improvement, puzzles (i.e., questions to be resolved), suggested changes, issues with facilities, technology issues, and other reflections.

2. *Yearly Faculty/Staff Retrospective (program/department level):* At the beginning of each academic year the faculty engage in a retrospective covering the previous year. These retrospectives include identification of successes, opportunities for improvement, questions people have that need resolving, and creation of action items for improvement.

3. *Direct Assessment of Student Work (direct)**:*** Several courses are assessed every semester. These assessments directly examine student work based on traits (performance criteria) created specifically for each student outcome. The measurement rubric used for direct assessment uses a four-level rubric: Excelling, Practicing, Apprentice, and Novice (E/P/A/N).

4. *Pre-Post Surveys (Pre-Post)**:*** Pre-post surveys are conducted for courses in which a direct assessment is scheduled. The pre-post survey is administered twice: once at the beginning of a semester and again at the end of a semester.

5. *Senior Student Exit Surveys (Exit):* We have developed our own internally specified student exit survey conducted each semester and administered to graduating seniors. Several questions are asked that are related to specific course outcomes. This indirect assessment is conducted as a supplement to the direct assessments that examine student work. In this case, the students self-assess their perception of learning.

6. *Major Field Test (MFT):* Nationally-normed ETS Exam (global assessment) – We have administered the ETS Computer Science exam for several years as a supplemental data point for the program by mapping the three parts of the exam to two specific student outcomes

    a. Outcome 1: Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions,

    b. Outcome 6: Apply computer science theory and software development fundamentals to produce computing-based solutions

7. *California Critical Thinking Skills Test (CCTST*): The CCTST is a nationally normed test that measures problem solving and decision making through formation of reasoned judgements. We use the CCTST

as a supplement to the direct and indirect assessments we conduct for Student Outcome 1: Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.

8. *External Advisory Board Review:* We conduct a review of Program Educational Objectives on a two-year cycle. These reviews allow us to determine whether the results are consistent with the expectations of these industrial stakeholders.

Assessment Tools, Frequency of Measurement, Applicability, and Attainment

Assessment Tool	Frequency	Applicability	Attainment Expectation
Course Reflections	Semester	General	N/A
Retrospectives	Yearly	General	N/A
Direct Assessments of Student Work	Semester	1 – 6	Summative: 70% in E/P Formative: 70% in E/P/A
Pre-Post Surveys	Semester	1 – 6	Shift in mean
Senior Exit Surveys	Semester	1 – 6	70%
Major Field Test	Semester	1 and 6 only	70th percentile
CA Critical Thinking Test	Semester	1	19 or higher
Board Review	Yearly and Mid-cycle	PEOs	N/A

Results:

Student Outcome 1: Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.

Outcome 1 is directly assessed along two specific traits (e.g., performance criteria):

- Students can identify and define the computing requirements appropriate to its solution
- Students can analyze and weigh trade-offs related to computing problems

In Course Direct Assessment Details

We use the general rule of thumb of attainment of 70% of students falling in the Excelling and Practicing levels of achievement as a marker for identifying potential action items for strategic and tactical changes to the curriculum.

Semester	Course	Trait	E	P	A	N	E/P	E/P/A	Action
Sp 2019	1310	1	85	3	1	12	88	89	None
			20	27	35	19	47	81	Flag
			64	1	1	35	65	66	Observe
		2	19	38	18	27	56	74	Flag
			54	28	7	13	81	88	None
			36	20	17	29	55	72	Flag
Fa 2018	4610	1	71	21	5	4	92	97	None
			42	27	19	12	69	88	Observe
			87	13	0	0	100	100	None
		2	81	19	0	0	100	100	None
			78	21	0	1	99	99	None

The table show that students have for the most part attained acceptable levels of achievement, although some exam questions on 1310 show that students are still developing in this skill. As this is a lower-division course, we expect that these skills will continue to develop.

The Major Field Test sub scores for two areas are used as a direct assessment of performance. We use the general rule of thumb of the 70th percentile for the program. For Outcome 1 we look to two-year windows for two sub scores:

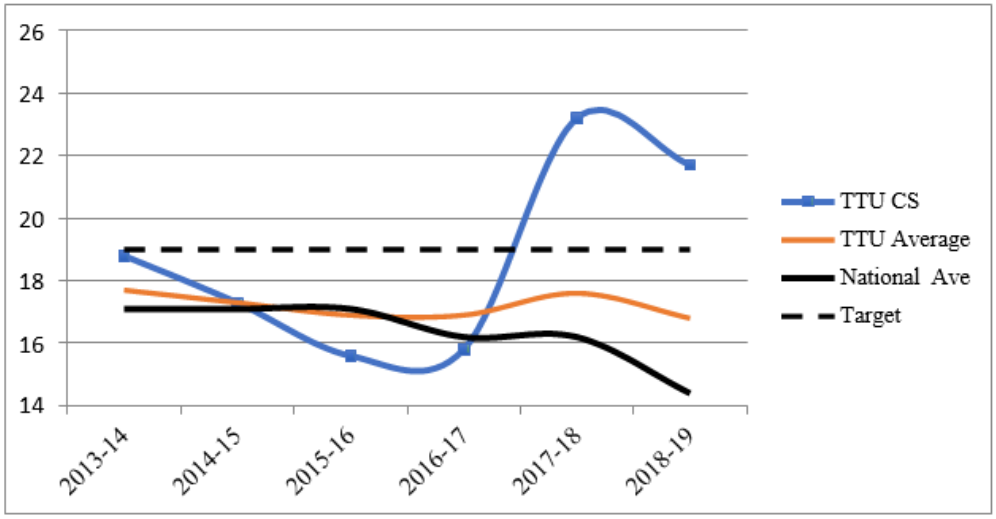
- Operating Systems, Architecture, Networks, and Database
- Mathematics and Algorithms

For several of the measurement windows from the Major Field Test, our students have achieved scores well above the 70th percentile attainment level.

Major Field Test

	Cohorts			
Category	F14 - S16	F15 - S17	F16 - S18	F17 - S19
OS, Arch, Nets, DB	80	90.2	96.1	90.9
Math, Alg	87.1	90.2	90.6	94.3
Overall	82.9	89.4	93.2	93
Satisfactory	70	70	70	70

California Critical Thinking Skills Test

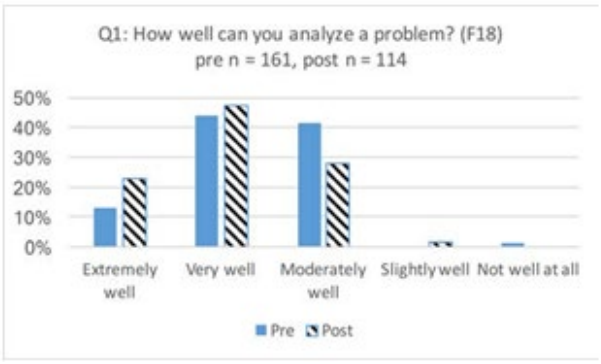


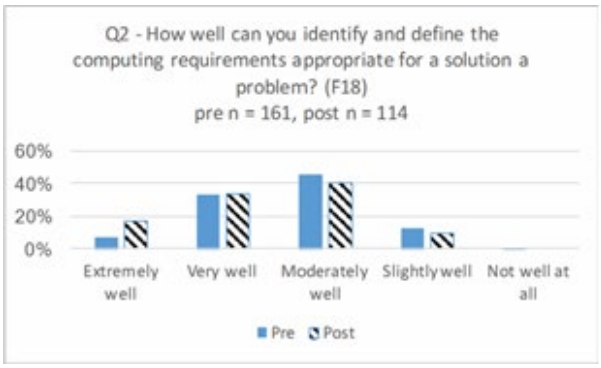
Insight Assessment, the company responsible for the CCTST, state that a score of 19 is considered 'strong.' Thus, our goal is a score of 19. In the periods of measurement for this test, our students have experienced a sharp upturn, averaging 23.2 and 21.7 in 2017-18 and 2018-19, respectively. While we have various hypotheses on the reasons for the upturn, the primary event corresponding with these changes has been the discontinuation of the IT concentration. Note that we do not currently have the ability to differentiate this data by concentration, so we will be continuing to monitor this measure.

Indirect Assessments

We conduct pre-post surveys in courses in which we directly assess student work to determine student perceptions of learning. In general, we are interested in the mean changes in a given semester. There was a statistically significant change in the means as measured using the Student's T-Test. While the chart shown here is aggregated, the statistical analysis is disaggregated by course and in every case shows a "positive" increase in the means indicating that students perceive an increase in knowledge.

Pre-post Survey





The senior exit surveys, conducted when students complete the program, ask three identical questions to the pre-post surveys. The results of the surveys are below with the percentage of students responding either “Excellent” or “Good”.

In general, this points to students’ perception that they have gained the ability indicated by the outcome.

Senior Exit Survey

Outcome 1	
F16 – S18	F16 – S19
94%	94%

Student Outcome 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.

Outcome 2 is directly assessed along two specific traits:

- Students can identify and design a computing-based solution to meet a given set of computing related computing requirements.
- A running and usable software system was developed.

In Course Direct Assessment Details

We use the general rule of thumb of attainment of 70% of students falling in the Excelling and Practicing levels of achievement as a marker for identifying potential action items for strategic and tactical changes to the curriculum.

Semester	Course	Trait	E	P	A	N	E/P	E/P/A	Action
Sp 2019	4620	1	7	53	20	20	60	80	Observe
		2	100	0	0	0	100	100	None
			67	33	0	0	100	100	None
			87	13	0	0	100	100	None
Fa 2018	2310	1	69	1	4	26	70	74	None
			64	15	4	17	79	83	None
			78	10	3	9	88	91	None
			32	29	14	24	61	76	Observe
Sp 2018	4620	1	27	47	20	7	74	94	None
		2	93	0	7	0	93	100	None
			87	13	0	0	100	100	None
			93	0	7	0	93	100	None

The direct assessments for the CSC 4610 / 20 Software Engineering I and II courses provide a view of the ability of students to produce software products for internal and external customers. The evaluation was split into two components: faculty assessment of student work through execution of student software, and faculty / TA assessment of student software through observation of student run demos (either delivered directly or via video). The assessments indicate that students, for the most part, attain Excelling/Practicing levels in self- produced demonstration of their work.

Assessment of student achievement in CSC 2310 provides a formative assessment of student abilities midway through the program. CSC 2310 (object-oriented programming and design) shows most achieving an apprentice level. As this course is more formative in nature, we have found no major actions necessary.

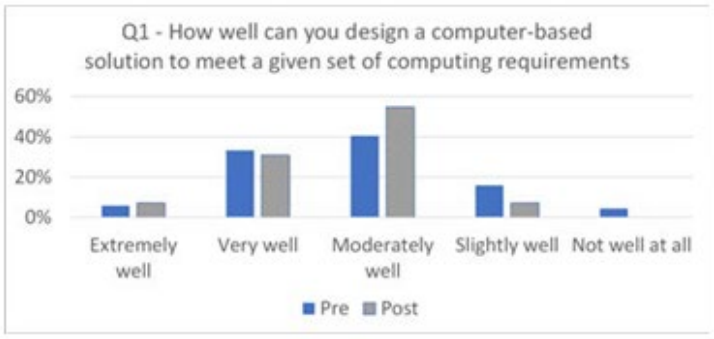
Indirect Assessments

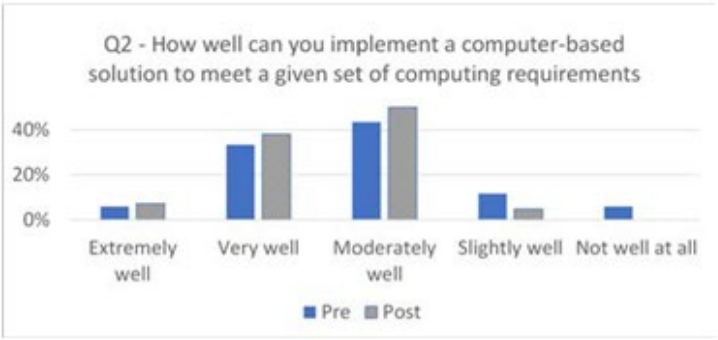
We conducted two different levels of indirect assessments: pre-post surveys for selected courses, and senior exit surveys. The pre-post surveys measure student perceptions of learning based on three different questions posed to the students at the beginning and end of the semester:

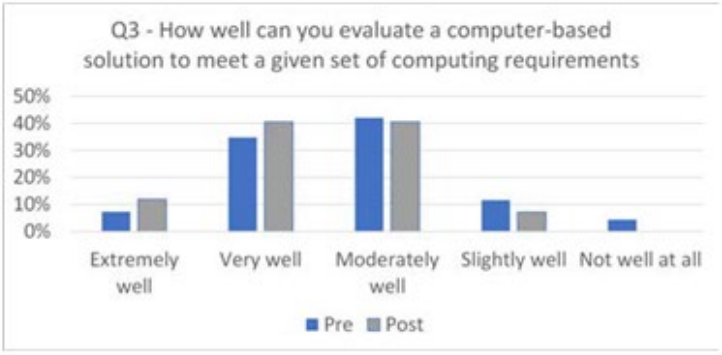
- Q1 - How well can you design a computer-based solution to meet a given set of computing requirements?
- Q2 - How well can you implement a computer-based solution to meet a given set of computing requirements?
- Q3 - How well can you evaluate a computer-based solution to meet a given set of computing requirements?

For each question, there is a decrease in the means for the responses, indicating an increased perception of learning by the students. The statistical results for these surveys using a one- tailed Student's T-Test shows no significance in the change in Spring 2019. Nonetheless, the shift does indicate a change.

Pre-Post Spring 2019 - CSC 3300







The senior exit surveys, conducted when students complete the program, ask three identical questions to the pre-post surveys. The results of the surveys are below with the percentage of students responding either “Excellent” or “Good”.

In general, this points to students’ perception that they have gained the ability indicated by the outcome.

Senior Exit Survey

Outcome 2	
F16 – S18	F16 – S19
96%	89%

Student Outcome 3: Communicate effectively in a variety of professional contexts.

Outcome 3 is directly assessed along three specific traits:

- Students can effectively communicate information regarding their experiences in a professional context.
- Students can effectively present technical information to an audience.
- Students can effectively summarize and communicate technical information and ethical arguments in a written form.

In Course Direct Assessment Details

We use the general rule of thumb of attainment of 70% of students falling in the Excelling and Practicing level of achievement as a marker for identifying potential action items for strategic and tactical changes to the curriculum.

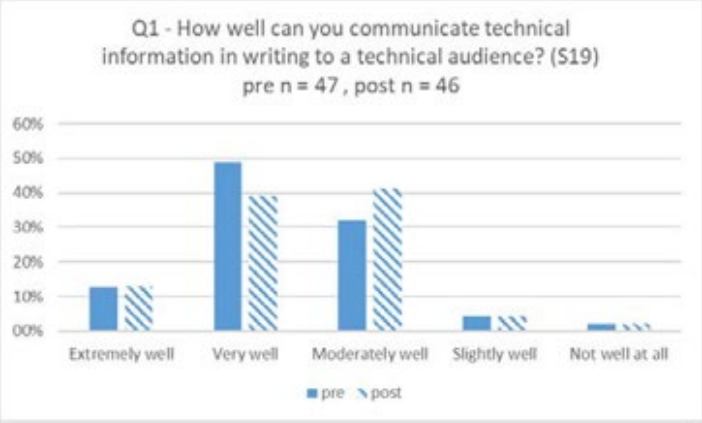
Semester	Course	Trait	E	P	A	N	E/P	E/P/A	Action
Sp 2019	3040	1	88	12	0	0	100	100	None
			71	12	0	0	83	83	None
		2	81	12	3	3	93	96	None
		3	60	26	9	5	86	95	None
Sp 2019	4620	1	66	27	7	0	93	100	None
			74	13	13	0	87	100	None
			80	7	13	0	87	100	None
		2	76	18	8	0	94	102	None
			62	23	15	0	85	100	None

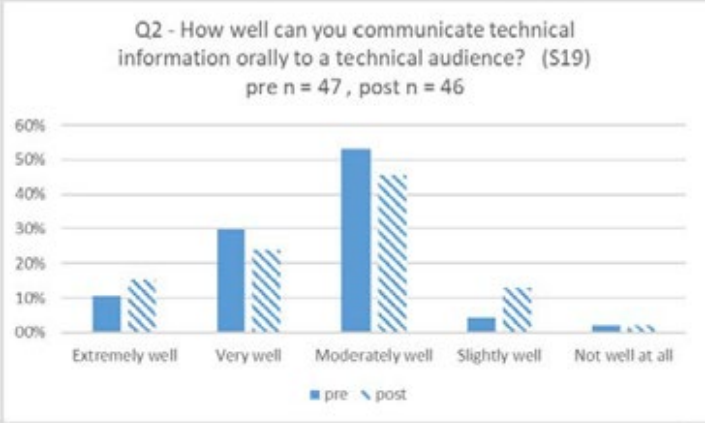
Based on the direct assessments that were performed, students can communicate in a wide variety of forms, including writing, speaking, and visualizations. Instructors in all courses have noted that writing is probably the weakest skill, and implementing more examples and feedback helps. In all courses, students met the levels of attainment that were expected.

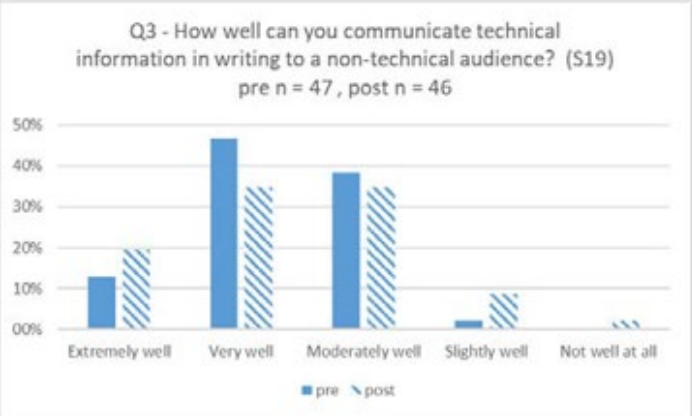
Indirect Assessments

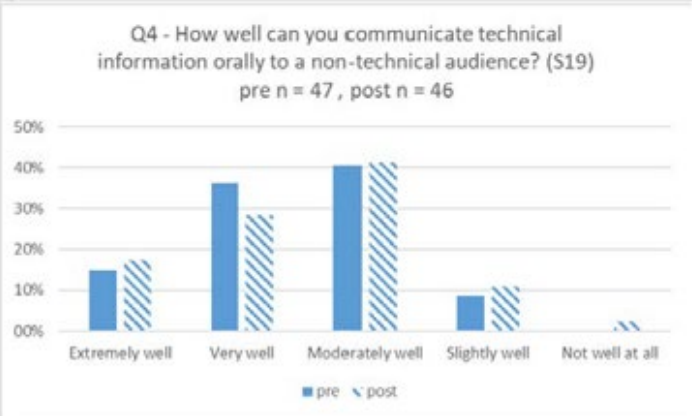
We conduct pre-post surveys in courses in which we indirectly assess student work to determine student perceptions of learning. In general, we are interested in whether the mean changes in a given semester (or across semesters). While the data shows an improvement in student perceptions of learning between the pre and post measurements in CSC 3040, particularly when dealing with communication to technical audiences, an improvement in their perception of communications with non-technical audiences is lower.

Pre-Post Surveys for Spring 2019









The senior exit surveys, conducted when students complete the program, asks four questions. The results of these surveys are below with the percentages representing student responses of either "Excellent" or "Good". In general, this points to students' perception that they have gained the ability indicated by the outcome.

Senior Exit Surveys

Outcome 3	
F16 – S18	F17 – S19
80%	83%

Student Outcome 4: Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.

Outcome 4 is directly assessed along three specific traits:

- Students can recognize, identify, and describe ethical and legal concepts related to computing.
- Students can analyze the challenges associated with ethical and legal concepts in the context of
- Students can apply ethical/legal concepts to assess computing practice.

In Course Direct Assessment Details

We use the general rule of thumb of attainment of 70% of students falling in the Excelling and Practicing levels of achievement as a marker for identifying potential action items for strategic and tactical changes to the curriculum.

Semester	Course	Trait	E	P	A	N	E/P	E/P/A	Action
Fa 2018	4570	1	73	20	3	3	93	96	None
	3040	1	26	31	30	13	57	87	Flag
			37	26	18.5	18.5	63	81.5	Observe
		2	74	11	11	4	85	96	None
			59	15.5	5.5	17	74.5	80	None
		3	7	24	11	57	31	42	Flag
			7	24	43	26	31	74	Observe

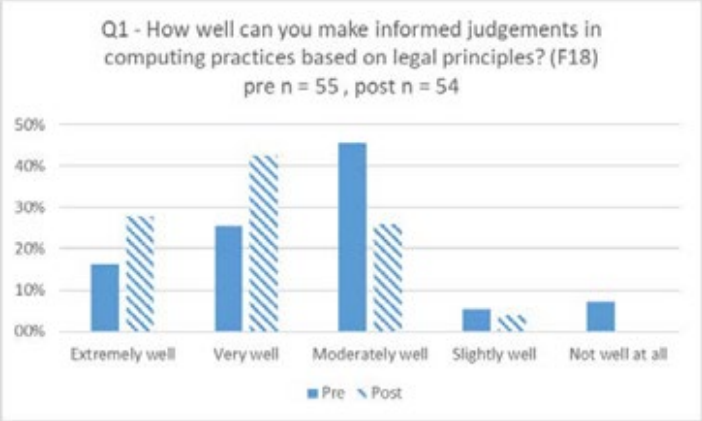
Based on the direct assessments that were performed, students are able to recognize their responsibilities as a computing professional, but they struggle to recognize, analyze, and apply ethical and legal concepts as they relate to computing. Instructors for CSC 3040 noted that students struggled in their performance of activities associated with Trait 3 (applying ethical/legal concepts to assess computing practice) and have identified potential changes to both the presentation of material and structure to the course. A recommendation was made to integrate more explicit examples of Trait 3 throughout the course by exposing students to more scenarios and discussions regarding legal and ethical applications so as to improve students' understanding of the type of thinking and explaining associated with this trait.

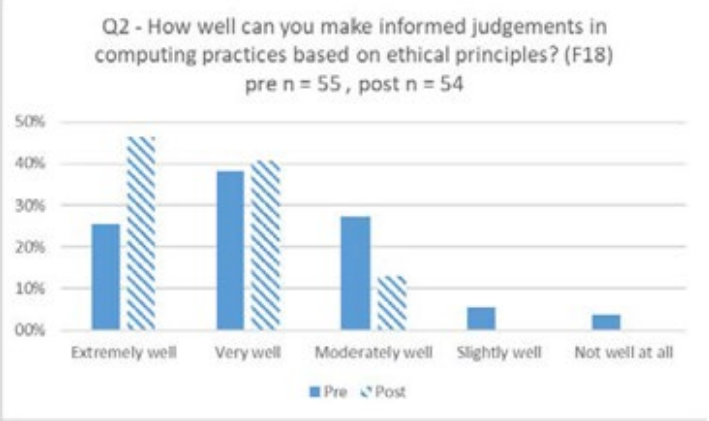
For CSC 4570, students met the levels of attainment that were expected.

Indirect Assessments

We conduct pre-post surveys in courses in which we directly assess student work to determine student perceptions of learning. In general, we are interested in whether the mean changes in a given semester (or across semesters). The charts below indicate a statistically significant change in the means as measured using the Student's T-Test. While the charts shown here are aggregated, the statistical analysis is disaggregated by course and in every case shows a "positive" increase in the means indicating that students perceive an increase in knowledge.

Pre-Post Surveys for F18





The senior exit surveys, conducted when students complete the program, asks two questions. The results of the surveys are below with the percentage of students responding either "Excellent" or "Good". In general, this points to students' perception that they have gained the ability indicated by the outcome.

Senior Exit Surveys

Outcome 4	
F16 – S18	F16 – S19
81	83

Student Outcome 5: Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

Outcome 5 is directly assessed along three specific traits:

- Students can create, track, and manage a plan (assessed by group).
- Students can effectively participate as members of a team.
- Students can produce working deliverables (i.e., a minimum viable product).

In Course Direct Assessment Details

We use the general rule of thumb of attainment of 70% of students falling in the Excelling and Practicing levels of achievement as a marker for identifying potential action items for strategic and tactical changes to the curriculum.

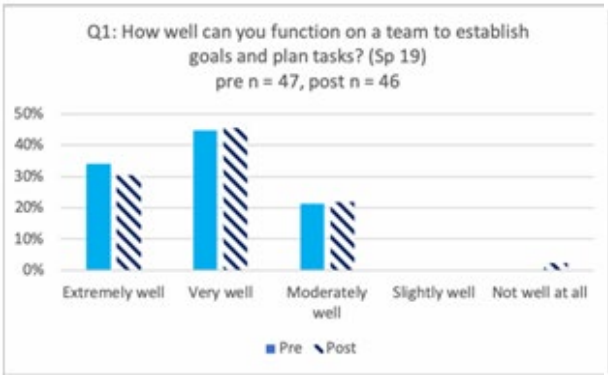
Semester	Course	Trait	E	P	A	N	E/P	E/P/A	Action
Sp 2019	4620	1	53	47	0	0	100	100	None
			82	15	3	0	97	100	None
		2	30	33	18	18	63	81	Observe
			61	13	8	19	74	82	None
		3	73	13	13	0	86	99	None

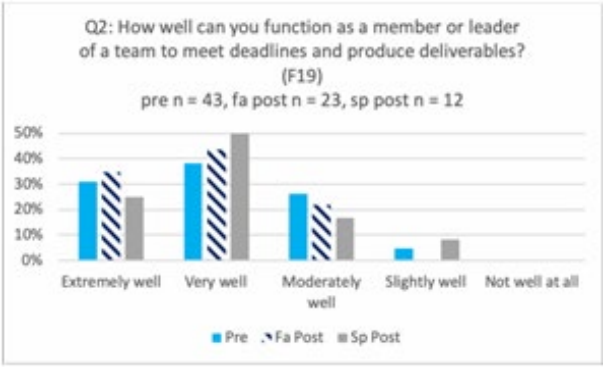
In general, student teams in CSC 4620 attained the requisite 70% threshold for all traits. The only exception was within the peer evaluation component of Trait 2, students can effectively participate as members of a team. The instructor assessment for this trait, however, indicated successful attainment. The instructor recommended expanding the peer reviews to inquire if teammates are contributing to the self-organization of the team to better capture whether the students are engaging in teamwork (not just contributing to the project). The instructor also noted that attainment might be better measured by assessing only the iteration reports from later in the course in addition to capturing data about team conflict, both strategies that might help assess attainment.

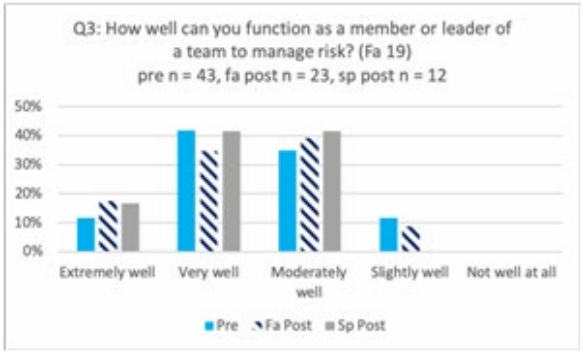
Indirect Assessments

We conduct pre-post surveys in courses to directly assess student work to determine student perceptions of learning. Regarding this outcome, we did not see a statistically significant change in the means present as measured using the Student's T-Test in any of the survey questions. Given the current survey format, it is difficult to know if this reflects on students' perception of knowledge gained in the course or if it means that the students realized that their initial estimates of their abilities (as scored on the pre-survey) were incorrect.

Pre-Post Surveys for in Sp19







The senior exit surveys, conducted when students complete the program, asks three questions. The results of the surveys are below with the percentage of students responding either "Excellent" or "Good". In general, this points to students' perception that they have gained the ability indicated by the outcome.

Senior Exit Survey

Outcome 5	
F16 – S18	F16 – S19
85%	87%

Student Outcome 6: Apply computer science theory and software development fundamentals to produce computing-based solutions.

Outcome 6 is directly asses along two specific traits:

- Students can apply theory in the design of computer-based solutions.
- Students can apply theory in the implementation of computer-based solutions.

In Course Direct Assessment Details

We use the general rule of thumb of attainment of 70% of students falling in the Excelling and Practicing levels of achievement as a marker for identifying potential action items for strategic and tactical changes to the curriculum.

Semester	Course	Trait	E	P	A	N	E/P	E/P/A	Action
Sp 2019	2310	1	18	45	27	9	64	91	Observe
			48	32	16	5	80	95	None
			39	34	16	11	73	89	None
		2	36	43	11	9	79	91	None
			30	32	23	16	61	84	Observe
	4575	1	93	0	6	0	93	99	None
			65	26	9	0	91	100	None
		2	78	17	4	0	95	99	None

During their sophomore year, students in CSC 2310 show some problems with outcome attainment, but by the time they reach CSC 4575, a senior-level course, the data indicates that attainment on all assessments is well above our 70% threshold.

The Major Field Test sub-scores for one area is used as a direct assessment of performance for this outcome. We use the general rule of thumb of the 70th percentile for the program. For Outcome 6 we look to two-year windows for the Programming sub-score. For several of the measurement windows from the Major Field Test, our students have achieved scores well above the 70th percentile attainment level.

Major Field Test

Cohorts				
Category	F14 - S16	F15 - S17	F16 - S18	F17 - S19
Programming	75.8	82.6	88.4	90
Overall	82.9	89.4	93.2	93
Satisfactory	70	70	70	70

Indirect Assessments

We conduct pre-post surveys in course to directly assess student work to determine student perceptions of learning. A problem administering the Spring 2019 pre-post survey invalidated its results.

The senior exit surveys, conducted when students complete the program, asks three questions. The results of the surveys are below with the percentage of students responding either "Excellent" or "Good". In general, this points to students' perception that they have gained the ability indicated by the outcome.

Senior Exit Surveys

Outcome 6	
F16 – S18	F16 – S19
85%	89%

Modifications for Improvement:

The Department of Computer Science applies the use of a Plan-Do-Study-Act on a three-year cycle. The 2018-2019 AY is part of the "Do-Study" phase. In regards to our 6 outcomes, we observed minor areas requiring further observation, none of which resulted in needing to "flag" major action. We have noted a decrease in achievement in the major field test (impacting Outcomes 1 and 6) and will continue to observe student performance in this area.

Appendices

1. Curriculum Map

Appendix 1: Curriculum Map

Computer Science – Student Learning Outcomes and Curriculum Map

1. Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.
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.
3. Communicate effectively in a variety of professional contexts.
4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
5. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
6. Apply computer science theory and software development fundamentals to produce computing-based solutions.

	Outcome Relevancy Level (L = Low or None, M = Medium, H = High)					
	1	**2**	**3**	**4**	**5**	**6**
CSC 1200 - Principles of Computing	H	H	L	L	L	L
CSC 1300 - Intro to Problem Solving and Computer Programming	H	H	L	L	L	L
CSC 1310 - Data Structures and Algorithms	H	H	L	M	L	H
CSC 2310 - Object-Oriented Programming and Design	H	H	L	L	L	H
CSC 2400 - Design of Algorithms	H	H	L	L	L	M
CSC 2500 - Unix Laboratory	L	L	L	L	L	L
CSC 2560 Networks for Information Technology	H	H	L	L	L	H
CSC 2700 - Discrete Structures for Computer Science	L	L	L	L	L	L
CSC 3020 Numerical Methods	H	H	L	L	L	M
CSC 3040 – Professionalism, Communication, and Research in Comp	L	L	H	H	L	L
CSC 3220 Fundamentals of Data Science	H	H	M	M	M	L
CSC 3230 Healthcare Data Analytics	H	H	M	H	L	H
CSC 3300 - Database Management Systems	M	M	L	L	L	M
CSC 3410 - Computer Organization and Assembly Lang Programming	H	M	L	L	L	M
CSC 3710 - Foundations of Computer Science	M	M	L	L	L	M
CSC 4010 Programming Languages	H	H	L	L	L	H
CSC 4040 Undergraduate Computing Research Experience	H	H	M	M	L	H
CSC 4100 (5100) - Operating Systems	M	L	L	L	L	H
CSC 4200 (5200) – Computer Networks	M	M	L	L	L	H
CSC 4220 Data Mining and Machine Learning	H	H	M	M	M	L
CSC 4240 Artificial Intelligence	M	L	L	M	M	L
CSC 4320 (5320) - Computer Architecture	M	L	L	L	L	M
CSC 4400 Analysis of Algorithms	H	M	L	L	L	M
CSC 4570 IT Security	H	L	M	H	H	L
CSC 4575 Information Assurance and Cryptography	H	L	H	H	H	L
CSC 4580 Software Reverse Engineering	H	H	L	L	L	H
CSC 4610 - Software Engineering I	H	H	H	H	H	H
CSC 4620 - Software Engineering II	H	H	H	H	H	H
CSC 4710 Design and Development of Human/Web Interfaces	H	H	M	M	M	H
CSC 4750 Computer Graphics	H	M	L	L	L	H
CSC 4760 Parallel Programming	M	H	L	L	L	H
CSC 4770 Distributed and Cloud Computing	M	H	L	L	L	L
CSC 4990 Computer Science Internship	M	M	H	H	H	M