Department of Computer & Electrical Engineering
and Computer Science
California State University, Bakersfield

Computer Science
SELF-STUDY AND PROGRAM PLAN

2017-2018

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I. Self-Study

A. Introduction

The Department of Computer and Electrical Engineering and Computer Science (CEE/CS) is housed in the School of Natural Sciences, Mathematics, and Engineering (NSME). This review specifically addresses the Computer Science (CS) program within the department. The CS program began as the Computing Track in the Mathematics degree and was elevated to its own department in 1986. The CS program currently offers three concentrations within the B.S. in Computer Science degree:

- Traditional: This concentration balances the hardware, software, and theoretical aspects of computer science education. The curriculum follows the international standards for computer science programs as given in the ACM/IEEE 2013 Computer Science Body of Knowledge and the ABET Computing Accreditation Commission (ABET/CAC) curricular requirements for both computing (general) and computer science (specific) programs.
- Computer Information Systems (CIS): This concentration focuses on the software and human-computer interaction aspects of computer science education. It does not have as strong of an emphasis on theoretical computer science, so it does not require calculus or higher level mathematics cognates. It also does not require any hardware-focused CMPS courses, so there is no physics cognate, as there is with the Traditional concentration.
- Information Security (InfoSec or IS): This concentration balances both the software and theoretical aspects of computer science, with a focus on cybersecurity. It requires a Global Intelligence and National Security cognate to expose students to the geopolitical and socioeconomic aspects of cybersecurity, along with the technical aspects. This concentration was added in Fall 2013.

Prior to the creation of the Computer Engineering program in Fall 2011, the CS program offered the Hardware Track. That track was last available in the 2009/11 catalog. Students following the Hardware Track who had not graduated by Summer 2011 had the option of continuing on the Hardware Track or switching to Computer Engineering. The last group of Hardware Track students graduated in the 2011/12 academic year.

The mission of the CS program is expressed through the Program Educational Objectives (PEOs), as listed in Table 1. The PEOs reflect the broad, long-term objectives that graduates should obtain three to five years after graduation. The PEOs were developed in consultation with program constituents, including faculty members and industrial advisory board members. The PEOs also incorporate CSUB's and NSME's missions.

Table 1: Program Educational Objectives for Computer Science

PEO	Description
(2a)	Engage in the productive practice of computer science to identify and solve significant real world problems across a broad range of application areas.
(2b)	Ethically apply their computer science knowledge and skills with an understanding of realistic constraints for the overall benefit of a diverse society.
(2c)	Enhance the economic well-being of both Kern County and the State of California through a combination of technical expertise, social responsibility, leadership, and entrepreneurship.
(2d)	Effectively define, lead, and manage computer science projects to deliver timely results.

B. Response to and Changes since Previous Review

<u>1. Response to Previous Review</u>

The following is a brief response to the major themes in recommendations that were given in the 2010/11 Computer Science (CS) program review that are relevant to the CS program. Items from the 2010/11 review that are relevant to the Electrical and Computer Engineering (ECE) programs were covered in last year's ECE Program Review. More detailed responses can be found in Appendix E – Previous Program Review.

UPRC Report

The major themes of the previous UPRC program review related to the development of the new Computer Engineering degree, assessment, and the overall units for the CS degree. The UPRC had concerns with the Computer Engineering degree (previously known as the CS Hardware Track) that were addressed in the ECE Program Review and are repeated in the appendix for reference. Most points highlighted by the UPRC are no longer relevant because the Hardware Track was elevated to its own major as a part of the creation of the engineering programs.

The assessment recommendations reflected a possible misunderstanding of the nature of ABET accreditation, assessment and guidance provided by following ABET assessment, and the importance of ABET accreditation for computing majors. ABET assessment is not simply a perfunctory checklist, but rather a fundamental process of introspection and improvement within the program. ABET literature emphasizes the importance of teaching effectiveness and expects that the program will look at the overall assessment results for the program, not just individual course results, to engage in a continuous cycle of improvement aimed at improving teaching effectiveness and student learning outcomes. While the CS program is not ABET accredited, we follow the ABET assessment plan as an international standard for the program. This also simplifies course-level assessment for courses taken by both CS and ECE majors, as this enables both sides of the department to follow the same standards.

The UPRC narrative also touched on budgetary issues that were relevant at that time, shortly after the disastrous 2008 budget. Again, related to the misunderstanding of the nature of ABET, many of the observations blamed ABET for “an overly rigorous curriculum”. It is important to note that ABET curricular requirements derive from international faculty and professional recommendations published by the Association of Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE), the professional societies for CS and ECE programs. Following these guidelines may indeed result in a rigorous program, but to avoid rigor simply to save money at the cost of program quality was not a route the department was willing to pursue.

External Reviewer Report

The external reviewer, Dr. George Georgiou, wrote an extensive report of observations and recommendations in the following areas: assessment, student support, faculty, curriculum, facilities, and institutional support. These align with the major areas reviewed by ABET during a site visit for accreditation. The student support, facilities, and institutional support recommendations were followed, and are detailed in the appendix.

The recommendations for assessment were mostly followed, except for those areas which our ABET consultant noted were not required for ABET accreditation and which would have resulted in an increase in faculty and/or staff workload. Given the budget constraints after the 2008 budget cuts, avoiding an increase in faculty/staff workload was seen as a more effective method by which to save money.

Most of the faculty recommendations were followed, except for the recommendations to provide additional faculty professional development and to reduce faculty workload. These recommendations were too costly at the time due to the budget cuts. As the funding situation has improved in recent years, new programs for NSME and for CSUB have been put in place which meet these remaining recommendations.

The curricular recommendation to split the pre-calculus-based Computer Information Systems (CIS) concentration from the calculus-based CS concentrations has not been followed due to budgetary constraints and a focus on completing the initial ABET accreditation for the engineering programs. This is part of our long-term plan for CS as outlined in the Program Plan section. Separating calculus-based students from non-calculus-based students in some of the more mathematically intensive CMPS courses would allow faculty to go more in-depth on the mathematical topics in the calculus-based courses without disadvantaging any of the students in the courses.

2. Other Relevant Changes

The quarter-to-semester conversion was announced at the same time that the updated CS curricular recommendations, the ACM/IEEE CS 2013 Body of Knowledge, were being finalized. This provided CSUB with the rare opportunity to be on the cutting-edge of computer science curriculum within the CSU. We were the first CS program within the CSU to transform the CS-Traditional concentration curriculum to meet all of the core guidelines from the Body of Knowledge. We also used the Q2S transformation to align to the lower-division to the Transfer Model Curriculum for Associate Degrees for Transfer, to meet the 60-unit limit after transfer from SB 1440, and to meet the overall 120 semester unit limit. Additionally, we aligned the CS-Information Security concentration with the most recent recommendations from NSA/DHS for Centers of Academic Excellence in Cyber Defense/Information Assurance for four-year degrees.

This forward-thinking curricular transformation during Q2S has better prepared our students for modern computing careers and makes them competitive with graduates from more well-known programs. Additionally, ABET has recently revised the curricular requirements for a CS degree to align to the CS 2013 Body of Knowledge and is currently working on cybersecurity requirements that are heavily based in the NSA/DHS recommendations. Since our curriculum already follows these frameworks, we do not anticipate needing to make major curricular changes should we seek ABET accreditation for CS or seek designation as an NSA/DHS Center of Academic Excellence in Cyber Defense.

C. Program's Role in Relationship to the University

1. Mission, Goals, and Objectives

The program educational objectives (PEOs), as described in Table 1, were developed to support the university's and school's mission statements. Engaging in the productive practice of computer science supports CSUB's mission to advance the intellectual and personal development of students and NSME's mission to prepare students for entry into the workforce and graduate programs. Ethically applying computer science knowledge for the benefit of society supports CSUB's commitment to diversity and global awareness and NSME's mission to promote STEM education to improve the human condition.

Enhancing the economic well-being of the region through leadership and entrepreneurship is in line with CSUB's mission to support the region's economic development and enhance its quality of life and NSME's mission to prepare students for leadership roles in the community. Effectively leading computer science projects also supports NSME's mission to prepare students for leadership roles. Table 2 gives the alignment of the PEOs to these portions of CSUB's and NSME's mission statements.

Table 2: Mapping of CS Program Educational Objectives to CSUB and NSME Mission Statements

CSUB's Mission Statement	**PEO 2a**	**PEO 2b**	**PEO 2c**	**PEO 2d**
Advance the intellectual and personal development of its students	X			
Commitment to scholarship, diversity, service, global awareness and life-long learning		X		
Increase the region's overall educational attainment, enhance its quality of life, and support its economic development	X		X	
NSME's Mission Statement	**PEO 2a**	**PEO 2b**	**PEO 2c**	**PEO 2d**
Promote science, engineering, and health education for the purpose of improving the human condition.		X		
Foster scientific integrity in all professional endeavors.		X		
Prepare students for entry into the workforce in science, technology, engineering and mathematics (STEM), and healthcare services.	X			
Prepare students for admission to graduate programs in science, mathematics, engineering, and nursing.	X			
Prepare students for leadership roles in the community.			X	X

The PEOs reflect broad, long-term goals for graduates of the program while the student learning outcomes (SLOs) reflect the skills students obtain during the program. ABET Computing Accreditation Commission (CAC) has specific student outcomes required as part of Criterion 3, which are collectively referred to as the ABET CAC 3a through 3k student outcomes. The SLOs are given in Table 3.

Table 3: Student Learning Outcomes for CS Students (based on ABET Criterion 3 for Computer Science)

SLO	Description
3a	an ability to apply knowledge of computing and mathematics appropriate to the program's student outcomes and to the discipline
3b	an ability to analyze a problem, and identify and define the computing requirements appropriate to its solution
3c	an ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
3d	an ability to function effectively on teams to accomplish a common goal
3e	an understanding of professional, ethical, legal, security and social issues and responsibilities
3f	an ability to communicate effectively with a range of audiences
3g	an ability to analyze the local and global impact of computing on individuals, organizations, and society
3h	a recognition of the need for and an ability to engage in continuing professional development
3i	an ability to use current techniques, skills, and tools necessary for computing practice
3j	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.
3k	an ability to apply design and development principles in the construction of software systems of varying complexity

The SLOs support the eventual attainment of the PEOs as indicated in Table 4.

Table 4: Mapping of CS Student Learning Outcomes to CS Program Educational Objectives

Mapping of SLOs to PEOs	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	3k
2a. Productive computer science practice	X	X					X			X	X
2b. Ethical application for diverse society					X		X			X	
2c. Enhance local/state economy						X		X	X		
2d. Project development and management			X	X		X					X

The SLOs are the foundation of the assessment and continuous improvement plan, which is described in Section D of this document.

<u>2. Relationship to University Learning Outcomes</u>

The ABET/CAC student learning outcomes map to the ULOs as indicated in Table 5.

Table 5: Mapping of CS Student Learning Outcomes to CSUB's University Learning Outcomes

Mapping of SLOs to ULOs	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	3k
Goal I: Students will show critical reasoning and problem solving skills	X	X	X	X	X	X	X	X	X	X	
Goal II: Students will be able to communicate orally and in writing	X	X				X					
Goal III: Students will demonstrate discipline-based knowledge and career-based learning	X	X	X					X	X	X	X
Goal IV: Students will possess numerical literacy	X		X							X	

Goal V: Students will become engaged citizens				X	X	X		X			
Goal VI: Students will develop a well-rounded skill set	X	X	X				X			X	

3. Relationship to Curriculum

The curriculum supports the attainment of the SLOs as shown in the following tables. Table 6 shows how the quarter-system courses support the attainment of SLOs and Table 7 shows the same for the semester-system courses. Both tables use the Introduced (I), Developed (D), Competent (C) scale used at CSUB for course alignment with student outcomes. As part of the Q2S transformation of the curriculum, some of the mappings for the semester courses were updated to reflect the updated curriculum under semesters.

Table 6: Mapping of CS Student Learning Outcomes to Quarter-System Courses

Quarter-System CMPS Courses	**3a**	**3b**	**3c**	**3d**	**3e**	**3f**	**3g**	**3h**	**3i**	**3j**	**3k**
CMPS 211 – Web Design I (CIS only)	I	I							I		I
CMPS 221 – Programming Fundamentals	I	I			I				I		I
CMPS 222 – Object-Oriented Programming	I	I	I	I					I		I
CMPS 223 – Data Structures	I	I	I				I	I	D	I	D
CMPS 224 – Assembly (Traditional & Info. Sec.)	D			I		I		I	D	D	
CMPS 295 – Discrete Structures	D	D					I			D	
CMPS 312 – Algorithm Analysis	C	C								C	
CMPS/ECE 320 – Digital Circuits (Traditional)	C								D	D	
CMPS 321 – Computer Architecture (Traditional)	C								D	C	
CMPS 335 – Software Engineering		C	C	C		C					C
CMPS 342 – Databases		D	C		I	C				D	
CMPS 350 – Programming Languages	D				I				C		
CMPS 356 – Artificial Intelligence (Trad. & CIS)	C	D	D		D		D	I	D	C	
CMPS 360 – Operating Systems	C									C	
CMPS 371 – Computer Graphics (CIS only)	D	D	D	D		D				D	D
CMPS 376 – Computer Networks	C				C		D				
CMPS 396 – Internet/Mobile Prog. (CIS only)	D		C	D		D			C		C
CMPS 490A & 490B – Senior Project I & II	C	C	C	C	C	C	C	C	C	C	C
Math cognate: Pre-calculus or calculus sequence	I										
Math cognate: Statistics or Probability Theory	D										
MATH 230 or 330 – Linear Algebra (Traditional)	D										
PHYS 221 & 222 – Physics I & II (Traditional)	I										
GE Physical Science (CIS & Info. Security)	I										
PHIL 316 – Professional Ethics					D						

Table 7: Mapping of CS Student Learning Outcomes to Semester-System Courses

Semester-System CMPS Courses	**3a**	**3b**	**3c**	**3d**	**3e**	**3f**	**3g**	**3h**	**3i**	**3j**	**3k**
CMPS 2010 – Programming I: Fundamentals	I	I	I	I	I				I		I
CMPS 2020 – Programming II: Data Structures	I	I	I	I					D		D
CMPS 2120 – Discrete Structures	D	D					I			D	
CMPS 2240 – Comp. Arch. I: Assembly (Trad. & IS)	D			I		I		I	D	D	
CMPS 2680 – Web Programming I (CIS only)	I	I			I				I		I
CMPS 3120 – Algorithm Analysis	C	C	D						C		
CMPS 3140 – Theory of Computation (Trad. & IS)	C								C		
CMPS 3240 – Comp. Arch. II: Organization (Trad.)	C							D	C		
CMPS 3350 – Software Engineering		C	C	C		C	D	D			C
CMPS 3390 – Internet/Mobile Prog. (CIS only)	D		C	D		D			C		C
CMPS 3420 – Databases		D	C	D	D	C	D		C	D	

CMPS 3500 – Programming Languages	C				D				C	D	
CMPS 3560 – Artificial Intelligence (Trad. & CIS)	C	C	D		C			D	D	C	
CMPS 3600 – Operating Systems	D								C	D	
CMPS 3620 – Computer Networks	C	C			C						
CMPS 3640 – Distributed & Parallel Computation					C	D					
CMPS 3680 – Web Programming II (CIS only)	D	D			D				D		D
CMPS 4910 & 4928 – Senior Project I & II	C	C	C	C	C	C	C	C	C	C	C
Math cognate: Pre-calculus or calculus sequence	I										
Math cognate: Statistics or Probability Theory	D										
GE Physical Science (CIS & Info. Security)	I										
PHYS 2210 & 2220 – Physics I & II (Traditional)	I										
Math/Science Elective Course (Traditional)	I										
PHIL 3318 – Professional Ethics					D						

4. Other Relationships

The CS side of the department offers one dedicated service course: CMPS 120/1200 Basic Computer Skills. This course is an introduction to the use of Microsoft Office programs and the Windows operating system. Under the quarter-system, CMPS 120 was a cognate course for Liberal Studies and Business students. Under the semester-system, CMPS 1200 is only an elective course for Liberal Studies students, as changes to the teaching credential requirements reduced the number of units available in that concentration of the Liberal Studies major. Business decided to focus on an Excel course under semesters, rather than a general Microsoft Office course. These changes under semesters have decreased the number of students enrolled in the course.

Under the quarter-system, we offered one dedicated General Education Theme 1 course: SCI 353 Computers and Society. While a semester-equivalent version of this course was developed during Q2S, GECCo did not approve it. The only GECCo approved GE course for the CS side of the department under semesters is CMPS 4928 Senior Project II, which is approved as a Capstone course and also a major-specific course. Since this course is restricted to CS students, it has no impact outside of the CS program. Due to these changes, we no longer have a GE-only course offered by the department under semesters.

Several of the CMPS courses are also cognate courses for other NSME majors. Under the quarter-system, Mathematics, Physics, Computer Engineering (CE), and Electrical Engineering (EE) majors took CMPS 221 Programming Fundamentals as a cognate. CMPS 224 Assembly Language Programming was a cognate for Computer Engineering and Electrical Engineering majors. Computer Engineering majors also took CMPS 223 Data Structures and Algorithms, CMPS 295 Discrete Structures, CMPS 321 Algorithm Analysis & Design, and CMPS 360 Operating Systems.

The number of majors taking the equivalent semester CMPS courses as cognates has decreased. CMPS 2010 Programming Fundamentals I covers the materials of CMPS 221 and some of CMPS 222. Under semesters, Physics does not require CMPS 2010 as a cognate and Mathematics restricted the CMPS 2010 cognate to their Pure Math, Teaching, and Blended Teaching concentrations. Currently, CMPS 2010 is a cognate for CE and EE majors, and some Math majors.

Additionally, CMPS 224/2240 was removed as a cognate for CE and EE majors due to insufficient units available in those majors. Additionally, the equivalent C-ID.net course is not part of the model curriculum for engineering majors. CE students still have required cognates in CMPS 2020, 2120, 3240, and 3600, which cover similar materials to the quarter-system CMPS 223, 295, 321, and 360 cognates courses for CE majors.

Overall, the semester conversion reduced the number of courses that the CS side of the department offers to majors outside of the department. The majority of the CMPS FTES are from majors within the department, rather than from service or GE offerings, as shown in Figure 1.

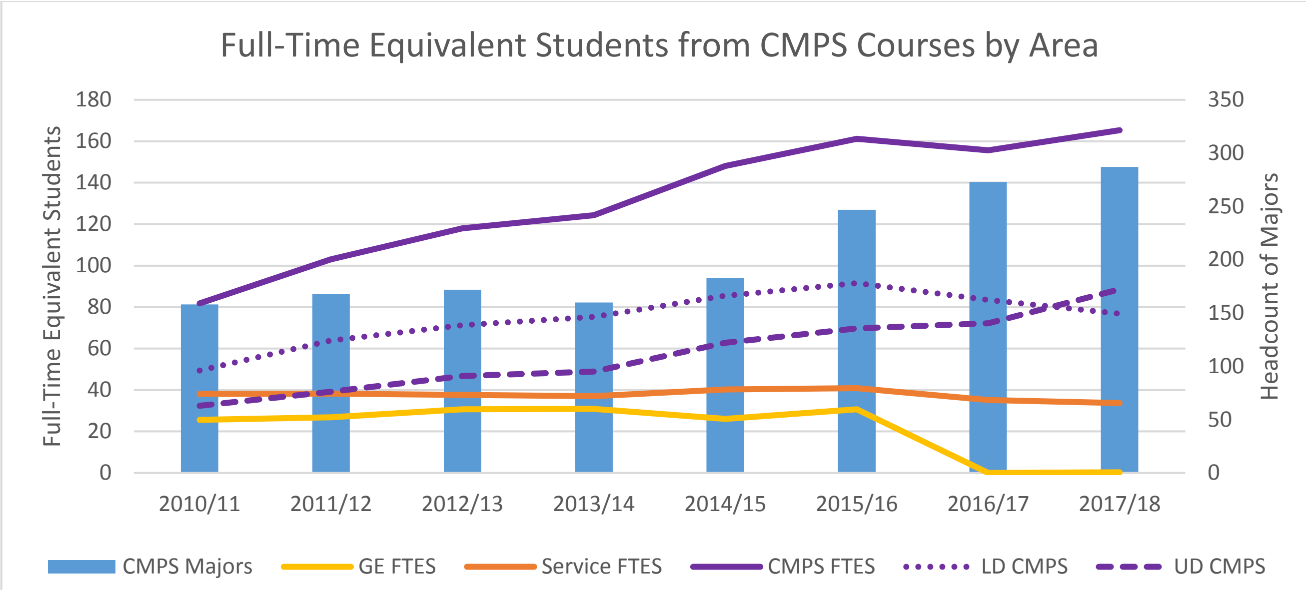

Figure 1: Full-Time Equivalent Students for CMPS Courses Broken Down by Course Area

Another quarter-to-semester conversion issue affected the lower-division CMPS FTES. Under the quarter system, the lower-division CMPS programming sequence (CMPS 221, 222 and 223) consisted of three 5-unit courses. After the transition, this sequence was transformed into two 4-unit semester-system courses (CMPS 2010 and 2020). This was not a mathematically equivalent conversion. Two 5-unit semester-system courses would have been the mathematical equivalent of our quarter-system programming sequence, but this would have required too many units for the CS, CE, and EE majors. So, within the department's majors, there was a loss of FTES due to this conversion issue.

D. Evidence of Program Quality

A major challenge in designing the CS degree is balancing the various requirements that affect the program: ACM/IEEE international standards for CS programs (the CS Body of Knowledge), California SB 1440 unit restrictions on units after transfer for the associate's degree for transfer (ADT) students, the California CS transfer model curriculum for ADT students, General Education requirements, and the overall 180 quarter-units/120 semester-units restriction. Additionally, while the CS degree is not ABET accredited, it is designed to comply with ABET curricular requirements.

As part of the quarter-to-semester transition, the department developed comprehensive Q2S transition plans for all CS concentrations to keep students on-track for graduation while maintaining program quality. Lower-division sequences, such as three quarters of programming, were transformed into a two-semester sequence covering the same year-long sequence of topics. Upper-division courses were converted to an equivalent semester course on a one-by-one basis. Courses cross-listed between CMPS and ECE were reviewed and outdated cross-listings were removed. Courses cross-listed between CMPS and MATH were also reviewed, with Mathematics faculty taking lead on those courses under semesters.

During the Q2S transition, the department faculty members looked closely at the prerequisite structure and updated prerequisites to improve program quality. Departments offering cognate courses similarly developed Q2S transition plans and updated prerequisites for the cognate courses. Transition plans for all CS concentrations were provided to students and updated advising checklists for the 2013-15 catalog were provided that note the semester-equivalent courses to the 2013-15 degree requirements. These are available on the department website at https://www.cs.csub.edu/degree-info.php

1. Evidence of Alignment to International Standards for Program

With the GE modifications the CS program received beginning in the 2013-15 catalog, a delicate balance was achieved between the competing requirements outlined above. This balance was maintained under the semester catalog with the GEMs approved for the department by GECCo.

All three concentrations for the semester CS degree are 120 total semester units. The CS – Traditional concentration, which is subject to the ADT requirement, has exactly 60 semester-units after transfer for ADT students. The degree requirements for the three CS concentrations are summarized in Table 8.

Table 8: Summary of Computer Science Degree Requirements under Semesters for All Concentrations

Course	Traditional (CS / Trad.)	Computer Information Systems (CIS)	Information Security (IS / InfoSec)
Computer Science core courses			
CMPS 2010 – Programming I: Programming Fundamentals	Core	Core	Core
CMPS 2020 – Programming II: Data Structures	Core	Core	Core
CMPS 2120 – Discrete Structures	Core	Core	Core
CMPS 2240 – Computer Architecture I: Assembly	Core	Elective	Core
CMPS 2680 – Web Programming I		Core	
CMPS 3120 – Algorithm Analysis	Core	Core	Core
CMPS 3140 – Theory of Computation	Core	Elective	Core
CMPS 3240 – Computer Architecture II: Organization	Core	Elective	
CMPS 3350 – Software Engineering	Core	Core	Core
CMPS 3390 – Internet & Hand-held Device Programming (Java)	Elective	Core	
CMPS 3420 – Database Systems	Core	Core	Core
CMPS 3500 – Programming Languages	Core	Core	Core
CMPS 3560 – Artificial Intelligence	Core	Core	
CMPS 3600 – Operating Systems	Core	Core	Core
CMPS 3620 – Computer Networking	Core	Core	Core
CMPS 3640 – Parallel and Distributed Computing	Core	Core	Core
CMPS 3680 – Web Programming II		Core	
CMPS 4910 – Senior Project I	Core	Core	Core
CMPS 4928 – Senior Project II (also GE Capstone)	Core	Core	Core
Elective courses (selected from list in catalog)	8 units	16 units*	12 units
Cognate courses			
PHIL 3318 – Professional Ethics	Core	Core	Core
MATH 1040 (or 1050+1060) – Pre-calculus I & II		Core	
MATH 2200 – Statistics		Core	
MATH 2310 or 2510 – Calculus I	Core	Elective	Core
MATH 2320 or 2520 – Calculus II	Core	Elective	Core
MATH 3200 – Probability Theory	Core		Core
PHYS 2210 – Physics I	Core	Elective	
PHYS 2220 – Physics II	Core		
GE Area B1 – Physical Sciences		Core	Core
Math/Science elective	3-4 units		
Global Intelligence and National Security cognate			12-13 units

* 4 units of CIS electives must be from a 4000-level CMPS course, 12 units can be CMPS courses or a minor

The primary international standard for computer science programs is the ACM/IEEE Computer Science Curriculum Recommendations, also referred to as the CS Body of Knowledge. ACM and IEEE have been publishing curricular guidelines for computing programs approximately once a decade since 1968. These guidelines are developed and reviewed by faculty members at various universities and by industry representatives. The curriculum guidelines are divided into “core” topics and “elective” topics. Programs are expected to cover the majority of the core topics and sufficient elective topics for breadth and depth.

The quarter-system CS-Traditional concentration was aligned to the CS 2001 guidelines and the semester-system CS-Traditional concentration is aligned to CS 2013 guidelines. The quarter-to-semester conversion was announced when the CS 2013 guidelines were being finalized, which gave us the unique opportunity to be on the cutting-edge of curriculum standards within the CSU system.

ABET also has curriculum requirements for computing programs in general, and computer science programs in particular. The requirements for CS programs beginning in the 2019/20 review cycle mirror the recommendations of the ACM/IEEE CS 2013 Body of Knowledge.

A summary of the alignment of the semester curriculum to the CS 2013 guidelines is in Table 9. Detailed information about the ACM/IEEE Body of Knowledge, ABET requirements, and how our curriculum aligns to these standards can be found in Appendix F. Program Standards.

Table 9: Alignment of CS-Traditional Concentration to ACM/IEEE CS 2013 Body of Knowledge

Course (+ indicates an elective course)	AL – Algorithms & Complexity	AR – Architecture & Organization	CN – Computational Science	DS – Discrete Structures	GV- Graphics & Visualization	HCI – Human-Computer Interaction	IAS – Information Assurance & Security	IM – Information Management	IS – Intelligent Systems	NC – Networking & Communication	OS – Operating Systems	PBD – Platform-Based Development	PD – Parallel & Distributed Computing	PL – Programming Languages	SDF – Software Devel. Fundamentals	SE – Software Engineering	SF – Systems Fundamentals	SP – Social Issues & Professional Practices
2010							C								C			C
2020	C						C							C	C			
2120	C			C													C	
2240		C					C							C			C	
3120	C,E			C											C			
3140	C,E																C	
3240		C,E															C	
3350					C	C	C					E			C	C,E		
3420							C	C,E										
3500							C							C,E				
3560			C,E						C,E									
3600							C				C,E						C	
3620							C			C							C	
3640							C						C,E				C	
4910																		C,E
4928																		C,E
PHIL 3318																		C
3390+						E						E						
3480+					E													
4210+		E											E					
4350+						E										E		

Course (+ indicates an elective course)	AL – Algorithms & Complexity	AR – Architecture & Organization	CN – Computational Science	DS – Discrete Structures	GV- Graphics & Visualization	HCI – Human-Computer Interaction	IAS – Information Assurance & Security	IM – Information Management	IS – Intelligent Systems	NC – Networking & Communication	OS – Operating Systems	PBD – Platform-Based Development	PD – Parallel & Distributed Computing	PL – Programming Languages	SDF – Software Devel. Fundamentals	SE – Software Engineering	SF – Systems Fundamentals	SP – Social Issues & Professional Practices
4420+								E										
4450+			E					E	E									
4490+					E							E						
4500+	E													E				
4510+							E											E
4560+			E						E									
4620+							E											E
ECE 4470+									E									
MATH 3300+			E															
MATH 4300+							E											

KEY: C = Core Topic E = Elective Topic

2. Student Learning Outcomes and Program Assessment

a. SLO Data and Program Quality

The department developed assessment schedules for both the ECE and CS sides of the department, using the ABET Student Learning Outcomes from Table 3 as the basis for the CS assessment. SLOs are only assessed in courses where the students should be proficient at the skills reflected in the SLO (e.g. “Competent” on the IDC scale). However, to prevent undue assessment burden on faculty, each course only assesses a handful of SLOs, even if students are expected to be proficient in more SLOs. The assessment schedules are posted on https://www.cs.csub.edu/abet/abet_plan.html

Within the CS side of the department, the primary assessment tools are the course-level assessment reports using the above assessment schedule and the Major Field Test in Computer Science (MFT-CS). The MFT-CS is administered at the end of each Spring term to CS-Traditional students enrolled in the Senior Project course and it is a required assignment for that course.

For course-level assessment reports, faculty members can choose to use a 4-point rubric (4=exemplary, 3=proficient, 2=apprentice, 1=novice) or the direct score on an assignment or exam problem. The faculty member uses the individual student data to determine whether or not the students in a given major Exceeded (E), Met (M), Conditionally Met (CM), and Failed to Meet (F) the SLO. In the early days, each faculty member could set their own criteria for this mapping. Beginning in the Fall 2015 term, the criteria for the “Met” condition has been standardized to the following: at least 70% of the students are at the “Proficient” level or higher (for the courses that use rubrics) or have scored a 70% or higher (for courses that use direct scores).

The course assessment report summarizes the method(s) used to measure the SLO(s) for the course, the detailed outcome(s) for the students in the specified major (including the number of students in that major), the E/M/CM/F rating for each outcome, and any comments the instructor wishes to leave about the course and/or potential future actions if the students were not performing at the expected level. Beginning in 2013/14, this data was disaggregated by concentration for most reports, although some faculty still reported only for the CS major overall.

The MFT-CS is a nationally-normed exam provided by ETS that assesses the program's overall score and specific assessment scores in the areas of Programming, Theory, and Systems. The overall score is provided on a scale of 120-200. Each assessment score is provided as a "percent correct" for the test population. The overall score and assessment scores are mapped to a nationally-normed percentile using the annual score report provided by ETS in late summer. The expected result is that the nationally-normed percentile is the 50th percentile for the overall score and each of the three assessment areas.

<u>Assessment Results</u>

Course-level assessment results for the CS major overall are given in Figure 2. This reflects 72 valid assessment reports from CMPS courses that were filed from 2010/11 to 2017/18 following the assessment plans for each year listed on the department website. These reports are also filed on Taskstream in the BS in Computer Science - Academic Majors area. Overall, students have consistently met expectations in all assessed courses.

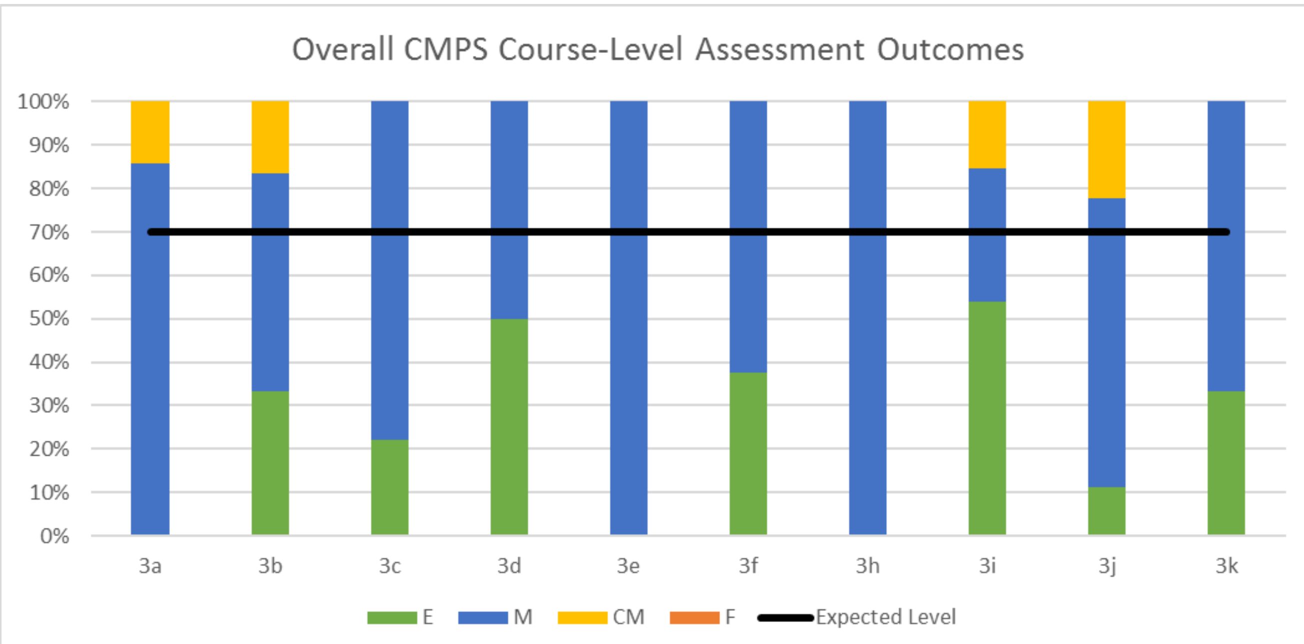

Figure 2: Overall Course-Level Assessment Results for CS Students from 2010/11 to 2017/18.

For those courses where the assessment results noted the students only conditionally met expectations, faculty members made additional recommendations, which are listed in Table 10. Most of the reports are from earlier on in the review period because CS faculty members are not required to give a reflection on assessment reports. This data primarily comes from a few individual faculty members well-versed in assessment who have since retired or moved to administrative positions in recent years. New faculty members are still being trained on providing more feedback in their assessment reports.

Instructors discussed the differences between the concentrations in their feedback in Table 10. Differences between the concentrations were also apparent in the 15 valid reports filed that separated CS-Traditional student results from CS-Computer Information Systems (CIS) student results. Table 11 compares the Traditional students to the CIS students for three outcomes covered by these reports, where the average reflects an average on a 4-point scale. We expect the students to perform at a 3.0 or higher on this scale, which reflects a proficient or exemplary performance.

Table 10: Course-Level Instructor Comments from CS Assessment Reports

SLO	Issue Noted	When	Action Plan / Reflection	Timeline / Results
3a	CMPS 376 instructor noted that students struggle with applying statistical methods.	2010/11	Retool the statistics lecture with more examples at next course offering.	Students in the next offering of the course improved performance.
3a	CMPS 295 instructor noted that students lack mathematical maturity for proofs.	2010/11	Include more work on proofs in course and in prerequisite mathematics courses.	Students in the next offering of the course improved performance.
3j	CMPS 320 instructor noted that the embedded question used to assess this outcome was one of the hardest problems on the test.	2010/11	Reconsider which embedded exam question is used to assess this outcome in future course offerings.	Students in the next offering of the course improved performance.
3b	CMPS 360 instructor noted that many students did not complete all stages of the project used to assess this outcome.	2012/13	Emphasize importance of completing all stages with students in future offerings of the course.	Students still had issues with completion of phases in next offering (see note below for 2013/14 CMPS 360 offering).
3a	CMPS 376 instructor notes that CIS students still struggle with mathematical questions, even with additional lectures, examples, and assignments.	2013/14	Changes to CIS mathematics cognate to require both Pre-calculus I and Pre-calculus II should give students more mathematical maturity in future.	CIS students still struggle to apply statistical formulas to networking, but there are insufficient units remaining to add more math cognates. Continue to provide support and observe.
3i	CMPS 360 still noted issues with completion of all the phases of projects, as originally noted for 3b in 2012/13.	2013/14	Emphasize importance of completing all stages with students in future offerings of the course.	Students still had issues with completion of phases in next offering (see note below for 2014/15 CMPS 360 offering).
3i	CMPS 376 instructor noted that CIS students were more likely to not complete the programming assignments used to assess this outcome.	2013/14	Emphasize importance of completing all programming assignments in future offerings.	Data gathered in 2016/17 indicates that students are now completing most assignments in the course.
3i	CMPS 360 instructor notes that the early phases were too easy and the later phases of the project were too hard, so few students completed later stages.	2014/15	Redesign the phases to make the difficulty of each phase more equivalent.	Data gathered in 2016/17 indicates that students are now completing most assignments in the course.
3j	CMPS 321 instructor notes that all of the CIS students struggled with basic concepts, while most of the CS students mastered basic concepts. This seemed to be related to a weaker assembly background with CIS students.	2014/15	CS students are required to take CMPS 224 Assembly while CIS students only take CMPS 224 as an elective course. Add CMPS 224 as a prerequisite so students have a better understanding of assembly before trying to learn how a computer processes assembly.	CIS students still struggle with the course, but they have a stronger understanding of Assembly with the prerequisite change.

As shown in Table 11, CIS students were significantly weaker than Traditional students in Outcomes 3a and 3i. CIS students were also weaker in Outcome 3j – Apply math and computer science theory, but there was only one measurement for this outcome so it may reflect that particular course rather than an overall trend. CIS and Traditional students were performing at about the same level on Outcome 3c though, indicating the CIS students do achieve proficiency in general computing principles such as designing a computing system. Overall, the department has noted that the CIS students struggle to obtain proficiency in mathematically-based tasks since the CIS concentration is not calculus-based.

Table 11: Comparison of Course-Level Assessment Results by Concentration

	3a – Apply math	**3c – Design system**	**3i – Current skills**
CS Traditional	M (3.0 avg)	M (3.0 avg)	M (3.14 avg)
Computer Information Systems	CM (2.33 avg)	M (3.3 avg)	CM (2.6 avg)

The Major Field Test overall scores, on a scale of 120-200, compared to the national mean as reported by ETS are given in Figure 3. The graph shows the CSUB mean score as a blue dot, the minimum and maximum scores as the long, thin blue lines, and the standard deviation as the shorter, thicker blue lines. The national mean is the dotted orange line. For most years, except 2011/12 and 2013/14, the average CS score was at or above the national mean score, which meets the department expectations. Only six students took the exam in 2011/12 so this may be why the CSUB results are slightly below the national mean that year. In 2013/14, twelve students took the exam, but there was a very low overall score, a very low “high” score, and very low results in the three assessment areas, as shown in Figure 4. The department is unsure if this reflected a particularly difficult test that year, a weaker group of students taking the test, or some combination of these two factors. Since the student performance improved in future years, we consider this year to be an anomaly.

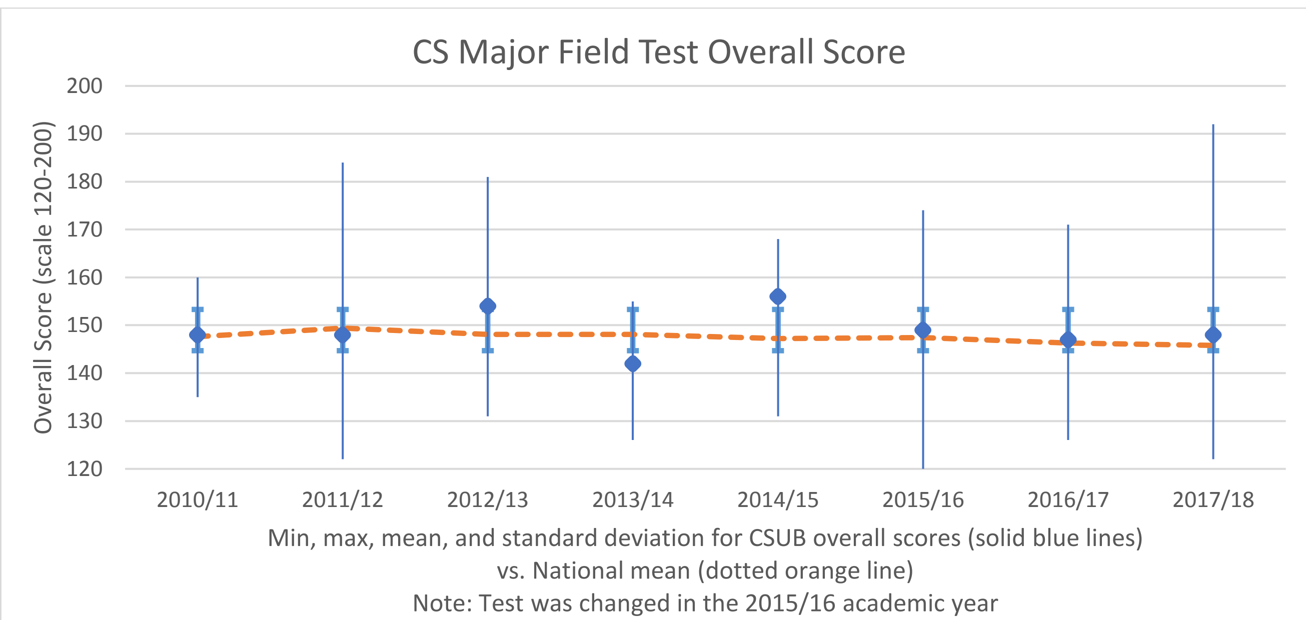

Figure 3: Computer Science Major Field Test Overall Scores compared to National Mean Overall Scores

The MFT-CS percentile results since 2010/11 for the three assessment areas are given in Figure 4. These results are also mapped to Taskstream in Outcome 3i for the Systems assessment, Outcome 3j for the Theory assessment, and Outcome 3k for the Programming assessment. The MFT-CS results are not graphed in Figure 2, as that figure reflects purely the course-level assessment results.

Programming results have been consistently near the 50th percentile, other than in 2013/14, with an average of 50.4. The department is keeping an eye on Programming assessment results though, due to the decline observed over the past four years. Faculty members plan to require more programming-intensive assignments throughout the upper-division core courses to reinforce programming fundamentals. This is particularly important as the department accepts more transfer students from a wide variety of California community colleges, where the foundational preparation may vary in quality.

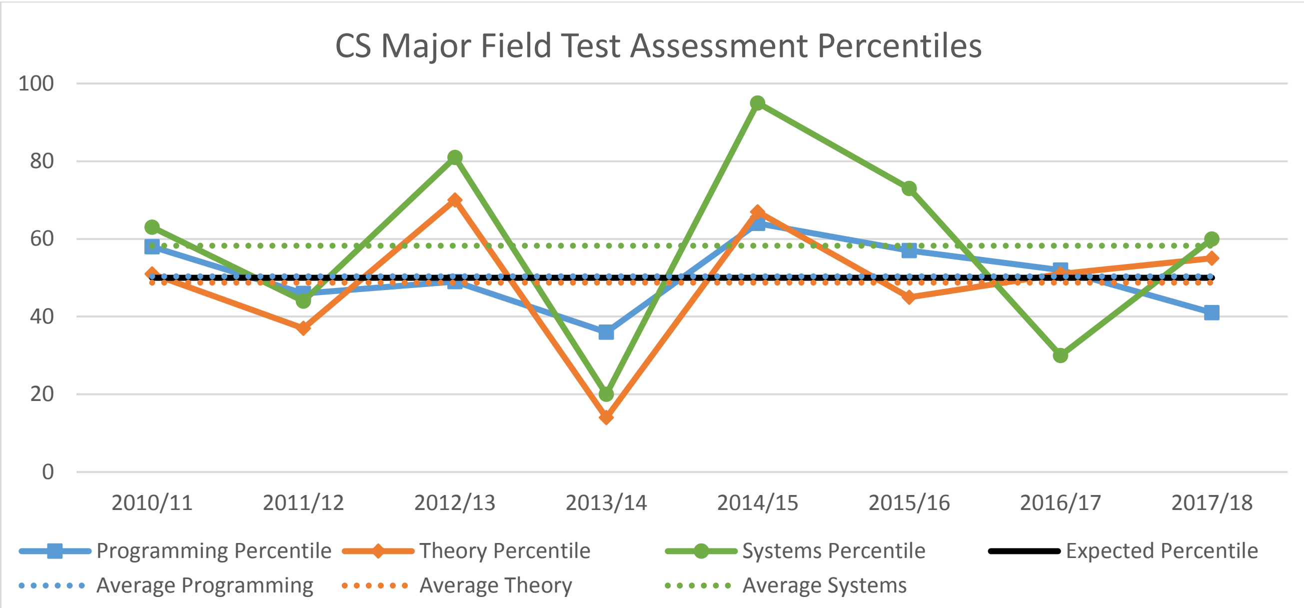

Figure 4: Computer Science Major Field Test Results for the Three Assessment Areas

Theory results have been more inconsistent over the observed period, with an average of 48.7, which is below the expected percentile. Theory results have been improving in the past two years with the addition of CMPS 3140 Theory of Computation under semesters and have been more consistently close to the expected percentile. The department will continue to monitor this area to see if the average improves to the 50th percentile as more students take CMPS 3140.

Systems results have been consistently strong, with an average of 58.2. Systems courses such as Databases, Computer Architecture, Networking, and Operating Systems are the strength of our program and help distinguish us from other programs that focus purely on software development. The dip in 2016/17 appears to be due to the semester conversion, as fewer students in that cohort had completed all of their Systems classes at the time the exam was administered. Since CMPS 4928 is offered only in Spring term, but some semester-system students will be graduating in Fall term, this will remain a potential issue with the administration of the MFT-CS. This was also possible, but less pronounced, under the quarter-system, as a single quarter reflects only one-third of a year of material, while a single semester reflects one-half of a year of material.

b. Changes in Curriculum due to Assessment

The department meets at least once annually to review CMPS and ECE course assessment reports, MFT-CS results, Fundamentals of Engineering Exam results for ECE students, indirect assessment data, and instructor-suggested action plans. Additional meetings may be held throughout the academic year to discuss assessment results, to modify assessment schedules, or to discuss action plans. For the last two academic years, the department has had two meetings devoted to assessment: one during University Week and one on “grades due” day for Spring term. There is also a standing assessment item on the department meeting agenda.

As a result of these discussions, under the quarter-system, the department added MATH 192 Pre-calculus II to the mathematics cognates for the CIS concentration in the 2013-15 catalog due to the issues CIS students were having with mathematically intensive computer science problems in the course-level assessment results.

Faculty members were also concerned about the low Theory area results from the MFT-CS for several years of discussions. Under the quarter-system, there were not enough free units to add a Theory of Computation course, which was part of the older ACM Body of Knowledge and is an expected course for students going on to graduate school. During the Q2S process, the CS faculty members carefully considered which upper-division courses needed to be 4-unit courses due to heavy content and which courses could be 3-unit courses. This freed up sufficient upper-division units to require CMPS 3140 Theory of Computation for both of the calculus-based concentrations (Traditional and Information Security) under semesters. Freeing up these units also allowed us to add CMPS 3640 Distributed and Parallel Computation to support the new ACM 2013 Body of Knowledge requirements and the Systems area of the MFT.

Additionally, under the quarter-system, ECE 320 Digital Circuits was a shared course between computer engineering, electrical engineering, and computer science students. The course covers logic design and some circuit analysis. Since the computer science students did not take ECE 207 Electric Circuits, it was not a prerequisite for ECE 320 under the quarter system. This caused poor outcomes for the other ECE upper-division courses. The ACM 2013 Body of Knowledge no longer requires a digital circuits course, so this course was removed from the CS curriculum under semesters and made an ECE-only course. This allowed us to change the prerequisites on ECE 3200 Digital Circuits to require ECE 2070 Electric Circuits, which was better-suited for the engineering program. CS students who stayed on the 2013-15 catalog were allowed to take either CMPS 3140 Theory of Computation or CMPS 3640 Distributed and Parallel Computation as a standing substitution for ECE 320, if they had not taken ECE 320 prior to the semester conversion.

c. Placement of Students

CS graduates have gone on to careers in industry, to careers in government, and to graduate programs across the country. There is no formal mechanism to track students at the department level after graduation and previous attempts to query this data from the CSUB Alumni Association were unsuccessful. However, given the technical nature of our degree program, many graduates have updated LinkedIn profiles that can be used to glean this information. Some students also informally keep faculty members updated about their careers.

General placement of graduates by employment sector is given in Figure 5. There were 220 CS graduates from the 2010/11 academic year until the 2017/18 academic year. Placement information for 152 graduates (69%) was determined, including those who currently noted themselves as unemployed. There is no major difference between concentration for the general employment sector of our graduates. The vast majority of our alumni have careers in various industries.

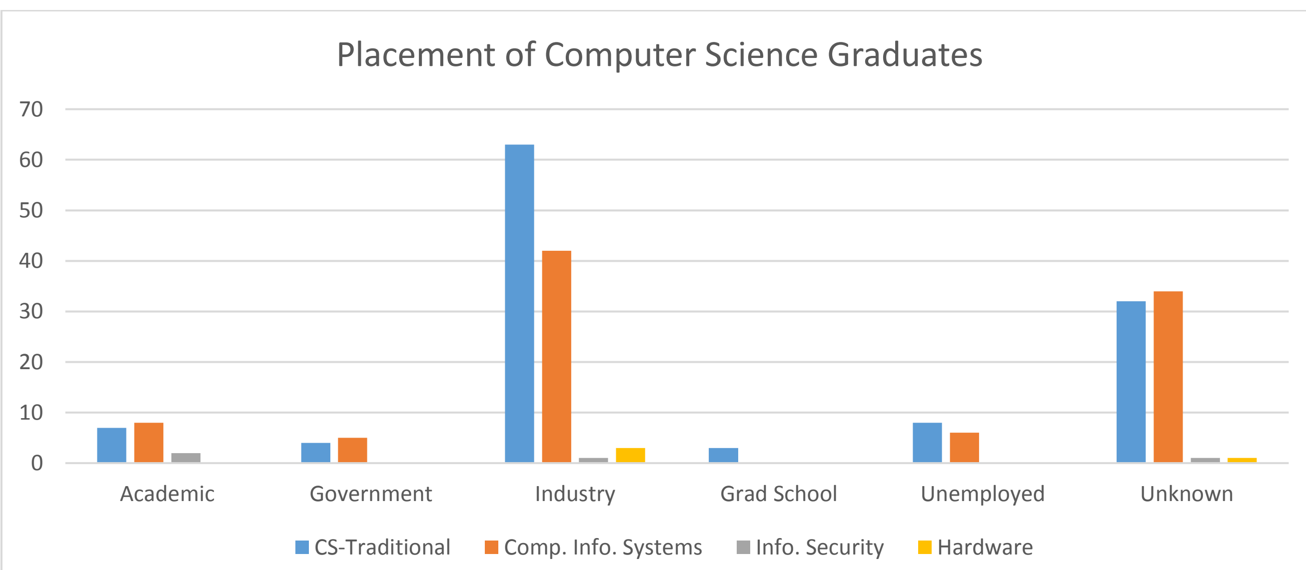

Figure 5: Placement of Computer Science Graduates by Concentration and Employment Sector

Placement of graduates by job category is given in Figure 6. Most of our graduates have a programmer job (including software engineer and developer positions) or an administrator, analyst, or technician job. Within this data, we see different employment trends for the different concentrations. Most of the graduates with a programmer job have a CS-Traditional degree while the majority of the graduates with an administrator, analyst, or technician job have a CIS degree. This is expected from the curricular preparations of these two concentrations. As a calculus-based concentration, CS-Traditional better prepares students for more rigorous software engineering positions, but talented CIS students can also be successful in that area. The CIS students on the other hand have the option of taking an elective course in system administration, which better prepares them for administrator, analyst, and technician positions.

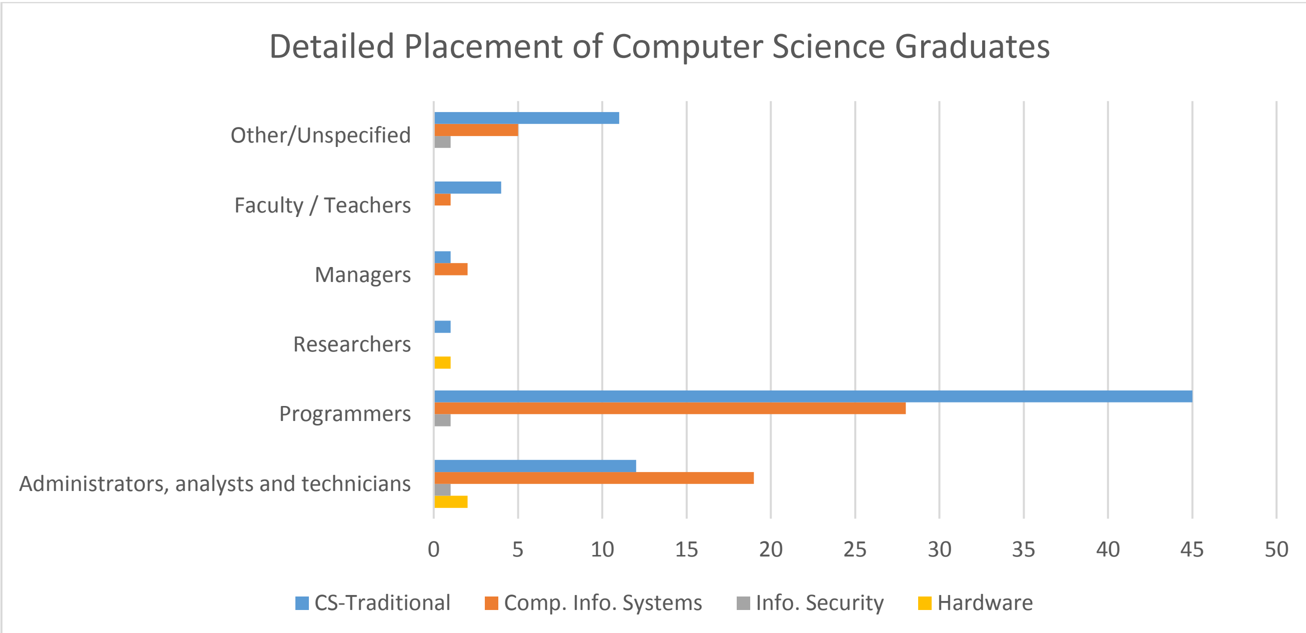

Figure 6: Detailed Placement of Computer Science Graduates by Concentration and Job Category

Due to the length of this data, specific details about placements for Computer Science students who graduated since the last program review are listed in Appendix G. Detailed Graduate Placements.

Notable Computer Science alumni achievements for graduates covered in prior program reviews are:

- Jeanie Barnett (CS, 1994) was the 1994 Outstanding Graduating Senior in Computer Science. She is currently a Senior Systems and Application Manager at D.A. Davidson. She was previously a Senior Software Development Engineer at Tecplot, a Senior Computer Scientist at Jason A CGG Company, a Senior Software Engineering at GE Healthcare, a Senior Applications Engineer at Chevron, and a Senior Systems Analyst at Chevron.
- Joe Holloway (CS, 1996) was the 1996 Outstanding Graduating Senior in Computer Science. He is currently a Senior Technician at Toshiba. He was previously an IT Specialist at IBM.
- Herman “Stoney” Jackson (CS, 1998) received his Ph.D. in Computer Science from UC Davis in 2004. He is currently a Professor of Computer Science at Western New England University and was previously the chair of the Computer Science and Information Technology Department at that university.
- Edward Elliot (CS, 1998) was the 1998 Outstanding Graduating Senior in Computer Science. He received his M.S. in Computer Science from UC San Diego and his J.D. from UC Berkeley. He is currently Intellectual Property (IP) Information Officer for the World Intellectual Property Organization (WIPO). He was previously an Expert Advisor for the U.S. Patent and Trademark Office, with part-time assignment as an IP Advisor to the White House, and an attorney specializing in patents for Silicon Valley clients.
- John Bohan (CS, 1999) received his M.E. degree in Petroleum Engineering from Texas A&M University. He is currently a Petroleum Engineer for Aera Energy and an instructor of technology courses for University of Phoenix.
- Paul Schoberg (CS, 2001) was the 2001 Outstanding Graduating Senior in Computer Science. He received his M.S. degree from the Naval Postgraduate School. He is currently a scientist for the U.S. Navy and has previously come back to CSUB to talk to students about career opportunities.
- Josh Hobson (CS, 2003) was the 2003 Outstanding Graduating Senior in Computer Science. He got his M.S. in Engineering from Arizona State University. He is currently a Lead Graphics/Rendering

Programmer at Santa Monica Studio and has previously held multiple programming positions at various game design companies.

- Casey Langen (CS, 2006) was an instructional student assistant for the department while at CSUB. He is currently a Mobile Phone Developer at NerdWallet. He was previously a Staff Engineer at MyFitnessPal and a Senior Software Development Engineer at Amazon.
- Carl Bloomquist (CS, 2006) was the 2006 Outstanding Graduating Senior in Computer Science. He received an M.S. degree in Petroleum Engineering from USC. He is currently an Operations Supervisor for Chevron, where he has worked since receiving his M.S. degree.
- Brian Jones (CS, 2007) received his M.S. in Computer Science from Georgia Institute of Technology. He is currently an Enterprise Architect for Aera Energy, where he has worked in a variety of roles since receiving his degree from CSUB.
- Fred McHale (CS, 2007) was a research student while at CSUB. He is currently the Co-Director of the School of Web Design & New Media at the Academy of Art University. He was previously a Software Engineer and Program Manager at Cisco and a Web Application Programmer for the Kern County Auditor's Office.
- Joe Sutton (CS, 2007) was the 2007 Outstanding Graduating Senior in Computer Science. He was a lecturer for the department for two years after receiving his B.S. degree. He received his M.S. degree in Computer Science from USC. He is currently a Senior Technical Leader at Cisco. He was previously a Principal Platform Engineer at GlassLab, a Senior Software Engineer at Intertrust Technologies Corporation, and a Game Service Engineer at Electronic Arts.
- Gary Pollock (CS, 2008) was the 2008 Outstanding Graduating Senior for Computer Science. He is currently a Senior SQL Developer for the Texas Association of Counties. He was previously a Developer for Goldsmith International, a SQL Developer for ETC Processing Technologies, and a Programmer Analyst for Wesco Aircraft Corporation.
- Christopher Gutierrez (CS, 2009) was active in the McNair Scholar, MARC U*STAR, and LSAMP research programs while at CSUB. He received his M.S. in Computer Science from CSU Northridge in 2011, where he was also a LSAMP scholar. He received his Ph.D. in Computer Science from Purdue in 2017, where he was co-advised by one of the eminent cybersecurity researchers, Eugene Spafford. He is now a Research Scientist for Intel Labs and he has been selected as the NSME Rising Runner for the 2018/19 academic year.
- Jonathan Berling (CS, 2010) was a research student for the McNair Scholar program from 2008-2010 and an instructional student assistant for the department while at CSUB. He is currently a Senior Software Engineer at NVIDIA and was previously employed as a Software Engineer at Qualcomm.

d. Student Involvement in Scholarship

CS students have been active in publishing their research at local, national, and international conferences, as well as participating in student-based venues such as the CSUB Student Research Competition and student conferences. The following are just some highlights of undergraduate student research accomplishments since the last program review:

- Mabelle Cruz, a current CIS student, was research student for Dr. Lei's CSU COAST project in 2016/17.
- Anna Poon, a current CS-Traditional student, participated in an NSF Research Experience for Undergraduates in Summer 2018 at Cal Poly Pomona. She is currently conducting research in image processing with Dr. Cruz.
- Andy Koumane (CS-Traditional, Spring 2018) was a research student for Dr. Bianchi and Dr. Cruz. He also worked on a CSU COAST project with Dr. Lei in 2016/17.
- Alex Rinaldi (CS-Traditional, Fall 2017) worked with Dr. Cruz and Dr. Bianchi on natural language processing and image processing research. He has numerous research achievements: 2018 Outstanding CS Graduating Senior, 2018 NSME Outstanding Research Student, first place in the CS division of the 2017 CSUB Student Research Competition, multiple peer-reviewed research papers published, and co-inventor on a patent application with Dr. Cruz and Dr. Bianchi. He is currently pursuing a Ph.D. in Computer Science at UC Santa Cruz.
- JoAnn Tuazon (CIS, Spring 2017) and Omar Oseguera (CIS, Fall 2017) presented two peer-reviewed

abstracts on natural language processing research at the HCI conference with Dr. Cruz as faculty mentors and Mr. Rinaldi as a co-author.

- Frank Madrid (dual degree in CS-Traditional and MATH, Spring 2015) was a research student for the NSF SFS cybersecurity grant with Dr. Lam and Dr. Danforth. He is currently a Ph.D. student at UC Riverside in the Computer Science program.
- Robert Morning (CS-Traditional, Spring 2014) was a McNair Scholar from 2010 to 2012 with Dr. Danforth as a mentor. He received his M.S. in Computer Science from UC Davis. He is currently a Scientist at Los Alamos National Laboratory.
- Tian "Tina" Gui (CS-Hardware, 2011) was a research student under the mentorship of Dr. Danforth. She received her M.S. and Ph.D. in Computer and Information Science from University of Mississippi. She is currently a Global Data Scientist for Anheuser-Busch InBev.

e. Other Evidence

Our students and alumni have also been active in the burgeoning startup culture in Bakersfield. The first place teams for all three Startup Weekend events hosted in Bakersfield have had one or more CS students on the team. Our students have also been participating in the Kern Innovation Technology (KIT) Community hackathons and in the public health Hackathons hosted at BC. Several CS alumni are also involved with Cimulated, a virtual reality center that recently opened on Easton Drive.

Our faculty members have also been forming collaborations with BPA faculty members and students. As part of the class activities for CMPS 4350 Advanced Software Engineering in Fall 2016, Gordon Griesel paired student teams up with CSUB "clients" to give them real-world experience at developing software projects. One of those projects, involving two CS students and a Business student, was nurtured by the CSUB Small Business Center and signed its first client in September 2018. The department has also been very supportive of the Empower With Code (EWC) non-profit organization started by an MBA student to encourage women and minority K-12 students to pursue technology careers.

3. Evidence of Faculty and Program Effectiveness

a. Measures of Degree Completion

The number of CS degrees awarded each year since the last program review are listed in Figure 7. As described in the Introduction, the CS-Hardware Track existed prior to the creation of the Computer Engineering degree in Fall 2011. The last graduates from that track were in 2011/12. The CS-Info Security concentration was added in Fall 2013 and had its first graduate in 2015/16.

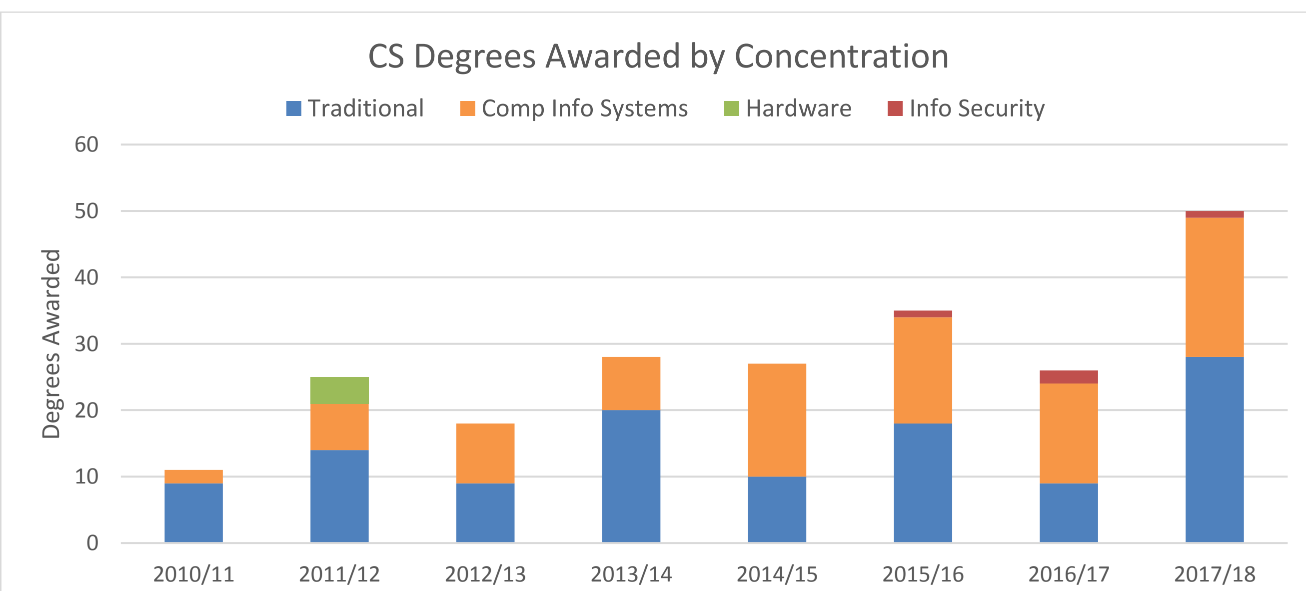

Figure 7: Computer Science Degrees Awarded since Last Program Review by Concentration and Year

The time to degree by concentration and admission type is given in Figure 8. CS-Info Security and CS-Hardware are not listed separately in this figure due to the small number of graduates in those concentrations. However, the CMPS Overall numbers include CS-Hardware and CS-Info Security students. There is no significant difference in the median time to degree for the CS-Traditional and CIS concentrations.

Upper-division transfer students took longer than 2 years to graduate because only 13% of those students (11 out of 83) had completed one year of programming and the lower-division mathematics cognate courses for their concentration at the time of transfer. This means they had to complete additional lower-division CMPS, MATH, and other cognate coursework before they could begin the upper-division CMPS core courses, which extended their time to degree significantly. This issue has improved over time. Before 2015/16, none of the upper-division transfer students were ready for upper-division CMPS coursework. As CSUB has worked with BC to improve transfer pathways, more students have transferred to CSUB with the required lower-division major coursework. We expect that this will improve as more community college students transfer with the ADT in Computer Science.

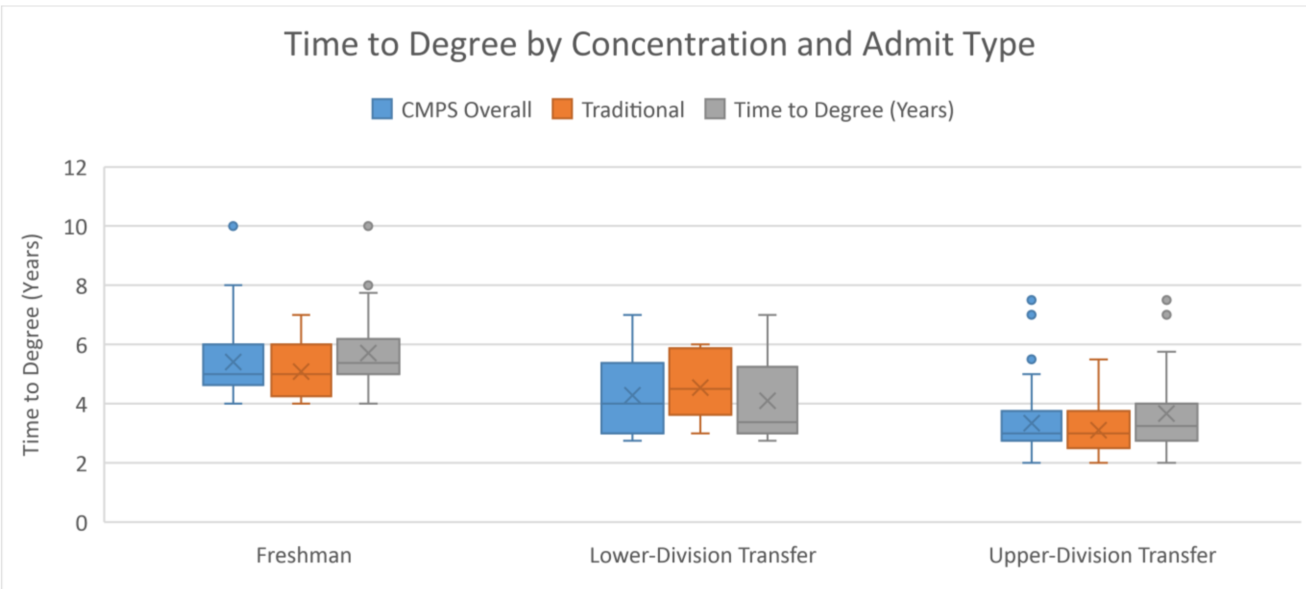

Figure 8: Time to Degree for CS Graduates from 2010/11 to 2017/18 by Concentration and Admit Type

For retention rate data, the CSU Dashboard website provided by the Chancellor's Office was used as a source of data from Fall 2011 to now. For freshman students who declare CS as a major, one-year retention rates within the CS major average about 59% and one-year retention rates for any CSUB major average around 73%, as shown in Figure 9.

The retention within the CS major is not unexpected, as many students enter college unaware of the true nature of the CS program. Common misconceptions about CS are that it is about repairing computers, technology/system administration, or designing games and mobile apps. Often, students have selected a CS major with the incorrect belief that it is a math-free alternative to other engineering majors. Students with these misconceptions are unprepared for a mathematically rigorous program. The first year is when most of the freshman students are introduced to the true nature of the CS program and make the decision about whether the major is a good fit for them. However, the first-year retention at CSUB in any major is close to the CSUB overall one-year retention rate, so most of the students who leave the CS major switch to another major at CSUB rather than leaving CSUB entirely.

Similar trends are noted for the two-year freshman retention rate, as shown in Figure 10. The second year is when most CS students are in the calculus and physics cognates for the Traditional and Information Security concentration, so we would again expect the retention rate within the CS major to be lower than the overall CSUB rate. There was a lower retention rate with the Fall 2016 cohort, both within the CS major and within any CSUB major. It is unclear if this is an effect of the semester conversion, a one-off anomaly, or a trend that requires intervention. It will require further monitoring.

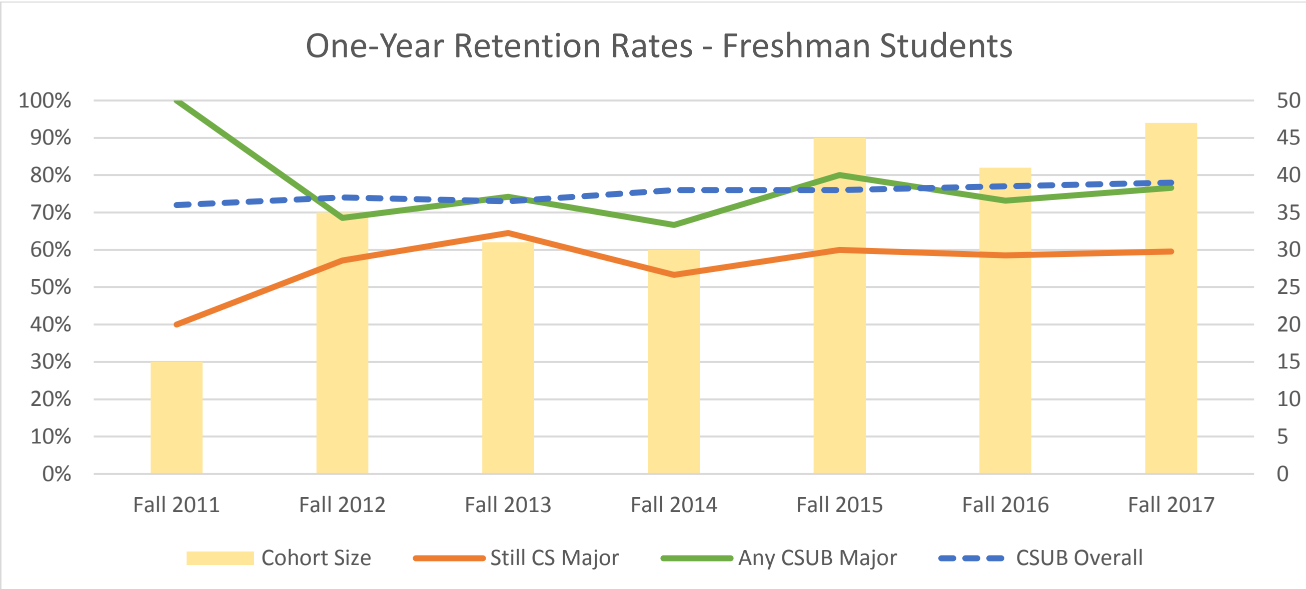

Figure 9: One-Year Retention Rates for CS Freshman Students (Data from CSU Dashboard)

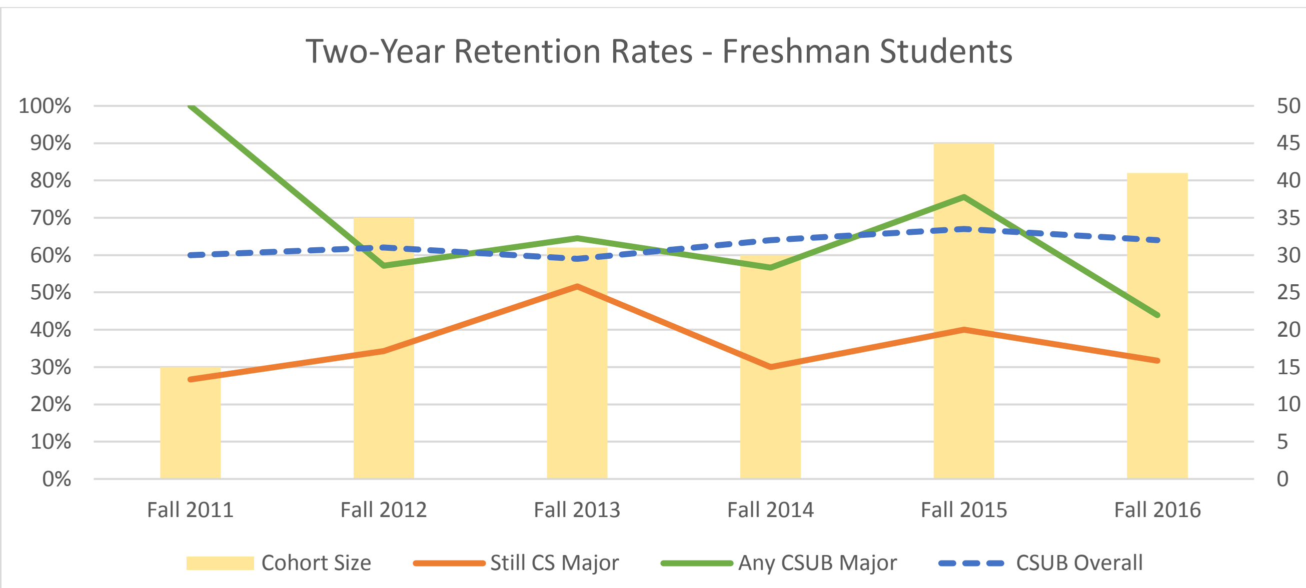

Figure 10: Two-Year Retention Rates for CS Freshman Students (Data from CSU Dashboard)

Retention rates for transfer students with the CS program are much closer to the CSUB overall retention rates for transfer students. One-year retention rates are shown in Figure 11 and two-year retention rates are shown in Figure 12. Retention rates within the CS program are slightly lower than within any CSUB major, but this reflects a difference of one or two students by headcount, so it is not significant. And as noted above in the time to degree discussions, all transfer students prior to Fall 2015 transferred to CSUB with significant gaps in the lower-division CMPS and cognate coursework, which means they could experience the same lack of awareness about the true nature of the CS program as the freshman students.

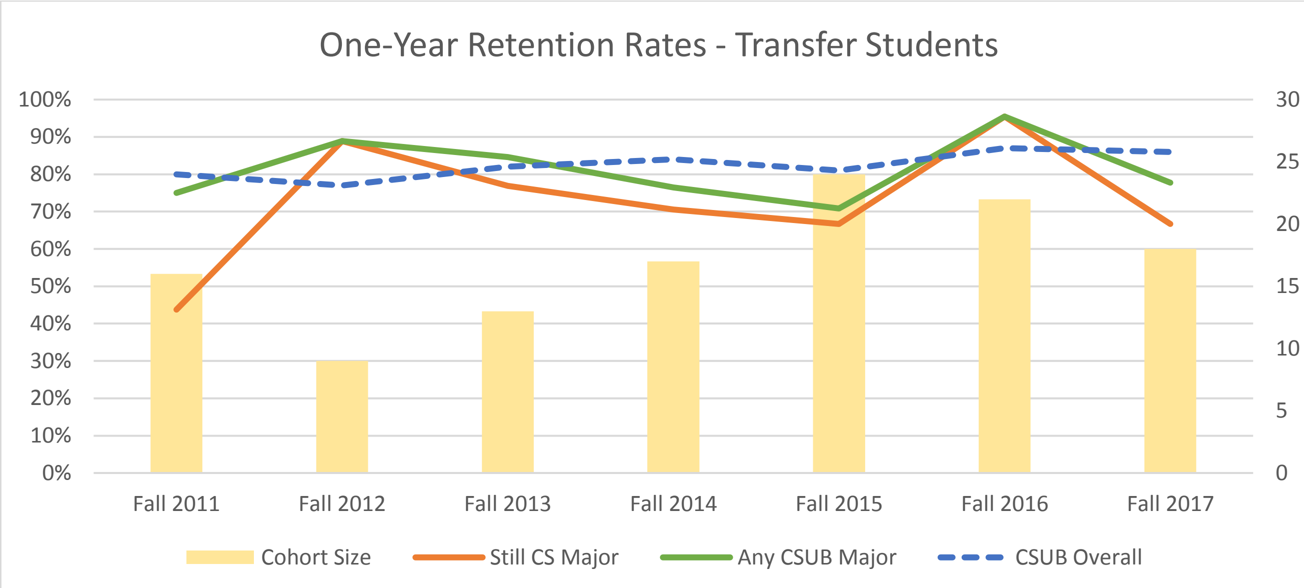

Figure 11: One-Year Retention Rates for CS Transfer Students (Data from CSU Dashboard)

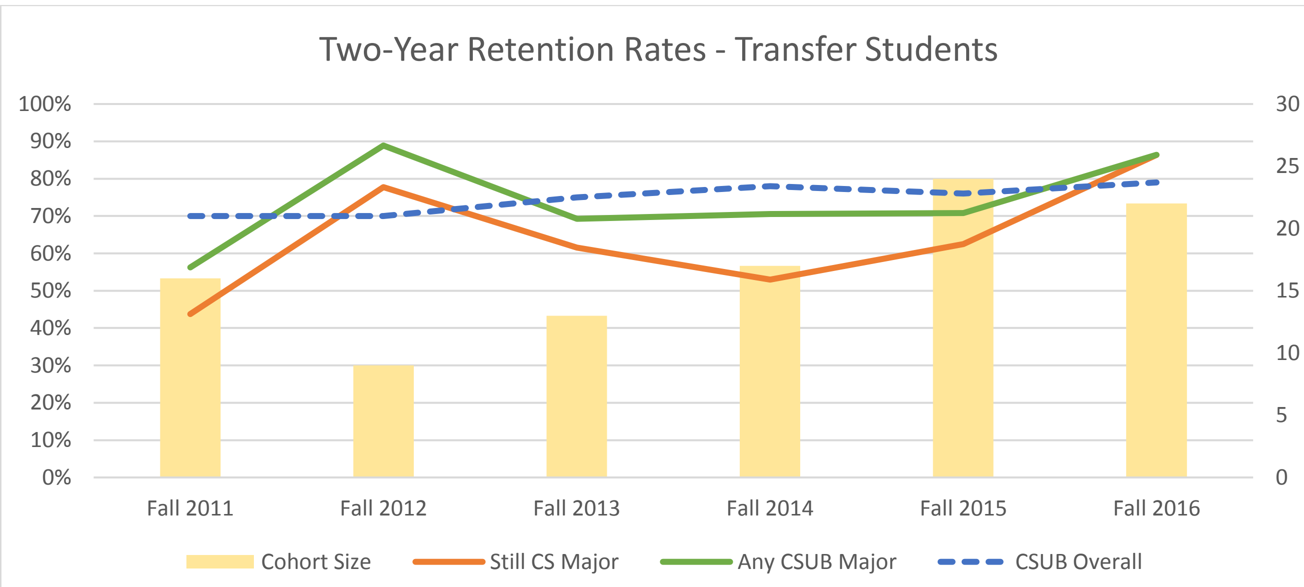

Figure 12: Two-Year Retention Rates for CS Transfer Students (Data from CSU Dashboard)

The CSU Dashboard also provides a visualization of where students go when they change majors from CS to another CSUB major. This data is just for students who graduated between 2015 and 2017. It does not reflect students who are still at CSUB or earlier graduating cohorts. The top three "destination" majors are Business Administration, Criminal Justice, and Computer Engineering. The visualization also shows when students switch from another major and graduate with a CS degree. Our top three "feeder" majors are Computer Engineering, Undeclared, and Chemistry. The combination "To/From Major" visualization is given in Figure 13, which shows that most of the CS graduates in that time frame began as CS majors (the large blue bar).

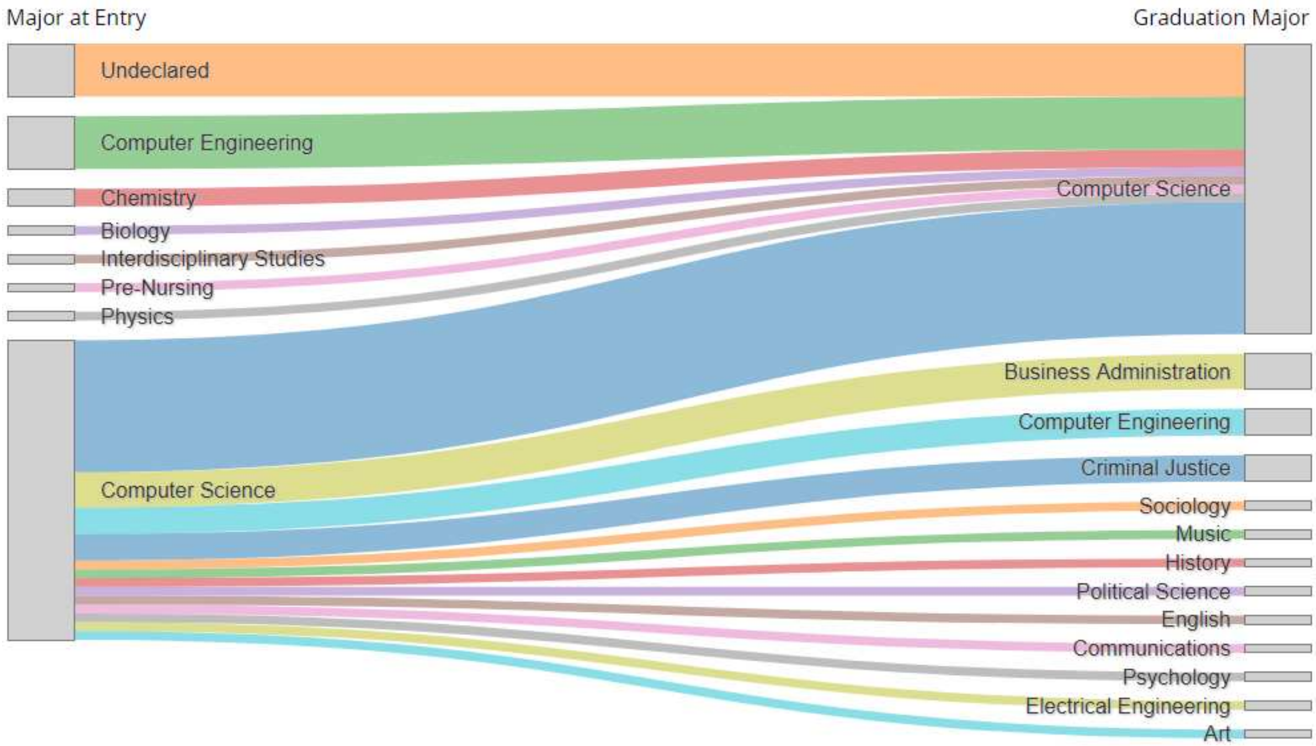

Figure 13: Flow of Majors to and from CS for 2015 to 2017 Graduates (From CSU Dashboard)

b. Comparison to Similar Programs

We compared the CS-Traditional concentration to similar CS programs at other CSUs. Since we were the first CSU to update our CS curriculum for the CS 2013 Body of Knowledge, we focused our comparison on other CS programs within the CSU that have ABET accreditation. These programs will need to update their curriculum to be compliant with the CS 2013 Body of Knowledge before their next ABET site visit to maintain their accreditation. These eight campuses are Chico, Dominguez Hills, Fullerton, Sacramento, San Diego, Long Beach, Cal Poly Pomona, and Cal Poly SLO. An overview of the curriculum is given in Table 12, which gives a count of the number of campuses that require the area as either a core or elective. The details of the comparison are given in Appendix H. Curriculum Comparison to Other CSUs.

Table 12: Summary Comparison of Curriculum Areas for CS-Traditional Compared to Other CSUs

Course Area	**Requirements**	**Core Count**	**Elective Count**	**CSUB Type**	**Notes**
Lower Division					
Prog. I: Fundamentals	ADT	8	--	Core	
Prog. II: Data Struct.	ADT	8	--	Core	Several have extended sequence
Discrete Structures	ADT & ABET	8	--	Core	
Arch I: Assembly	ADT	8	--	Core	Content varies by campus
Calculus sequence	ADT & ABET	8	--	Core	
Science sequence	ADT & ABET	8	--	Core	Physics or Chem. Some allow Bio.
CS First-year course		2	0		Cal Poly SLO & Long Beach
Lower-Div. Elective		2	0		Dominguez Hills & Fullerton
Upper Division					
Probability / Statistics	ABET	8	--	Core	Taught by Math, CS, or ENGR
Ethics / Society	ABET	8	--	Core	Taught by CS, PHIL, or ENGR
Algorithm Analysis	ABET	8	--	Core	
Arch II: Organization	ABET	8	--	Core	
Operating Systems	ABET	8	--	Core	
Programming Lang.	ABET	7	1	Core	Elective at Sacramento

Software Engineering	ABET	7	1	Core	Elective at San Diego
Theory of Comp.	ABET	5	3	Core	
Databases	ABET	4	4	Core	
Comp. Networking	ABET	4	3	Core	No clear course at Doming. Hills
Systems Prog.		4	1		Not as common across CSU
Artificial Intelligence		2	6	Core	Required at Chico & Fullerton
Distributed & Parallel	ABET	2	5	Core	Required at Chico & Long Beach
Computer Security		2	6	Elective	Required at Chico & Long Beach
Computer Graphics		1	7	Elective	Required at Sacramento
Research Methods		1	1		Required at Long Beach
Other Comparisons of Note					
CS Core Units	Range 43 to 75 units. Median 55 units.				We require 63 units
Senior Project	Range 1 to 6 units. Median 3 units.				We require 4 units
Technical Electives	Range 6 to 19 units. Median 12 units				We require 8 units
Cognate Units	Range 23 to 32 units. Median 29 units.				We require 23-24 units
Math/Sci Elective	Range 0 to 12 units. Median 3 units.				We require 3-4 Math/Sci units
Linear Algebra	Only required at three campuses.				One of Math/Sci elective options
Physics Sequence	Three require Physics. Elective at remainder.				Required at CSUB

As to be expected with the ADT in CS, the required lower-division core and cognate courses for most of the other CSUs are similar to ours. However, Dominquez Hills, Fullerton, Sacramento, San Diego, Cal Poly SLO, and Long Beach all have an extended programming sequence with at least one additional course, which provides students with a gentler introduction to programming. We had a longer sequence under quarters, but, as discussed above, we did not have sufficient units in the semester curriculum to purse a longer 10-unit freshman programming sequence. Students must take the initiative and go to the department tutoring center to get additional support, rather than gain that experience through the curriculum.

Cal Poly SLO and CSU Long Beach also have a major-specific first-year GE course. The department has discussed submitting a CS-specific first-year seminar sequence to GECCo under semesters. Ideally, we would want a full-time faculty member teaching such a course to continue their mentorship with students throughout the students' academic careers at CSUB. However, until we address the unmet demand in the upper-division CMPS courses, we do not have sufficient faculty members to pursue such an option. Even when we do have sufficient faculty members, it may be more flexible to offer CS-specific sections of CSUB 1009 and 1019 rather than develop our own sequence, in case the staffing issues reappear in the future.

The structure of the upper-division core is more variable across the CSU. Besides CSUB, only Chico and Long Beach have updated their curriculum for the new "distributed and parallel computing" area in the CS 2013 Body of Knowledge, even though it is now an ABET requirement to cover this area in the curriculum as either a stand-alone course or embedded in another course. The campuses that do not have this area in their core do not have their next ABET site visit until Fall 2020 or later, so they may still be in the process of updating their curriculum to comply with the new requirements.

Most of the other campuses, except for Chico and Fullerton, have Artificial Intelligence as an elective instead of a core class. Given the rising use of artificial intelligence in many segments of the economy, we feel it is very important for this class to be in the core. This course is also important to local employers, such as Chevron and Aera, who need qualified students for their growing data analytics operations. This will better prepare our students for a large, and rapidly growing, segment of the job market.

Having Databases as a stand-along course is also mixed across the CSU. Chico, Fullerton, Sacramento, and Long Beach have this area as a stand-alone course within their core, while the other campuses have it as an elective. This class is very important to the local job market within Kern County, as many local employers ask specifically for students with SQL (the query language for databases) knowledge for their jobs. It is also an important area to support data mining and data analytics, along with the Artificial Intelligence course.

The nature of the culminating experience is fairly consistent across the CSU. Most of the other campuses require a team-developed project, similar to our CMPS 4910 and 4928 Senior Project sequence. Fullerton requires a single design class without teamwork. Cal Poly Pomona and San Diego State have a seminar class.

With respects to the number of units, our CS-Traditional core units are a bit above the CSU median, but our technical elective units and cognate units are a bit lower than the CSU median. This is due to our decision to require Databases, Artificial Intelligence, and Distributed and Parallel Computation in our core rather than include them in the list of elective courses.

Overall, our CS-Traditional program is consistent with other CSU programs. It is also on the leading-edge of CS education by incorporating the CS 2013 Body of Knowledge and high-interest areas to both the region and the profession as a whole.

We also looked at other CSUs for the CIS and Information Security concentrations. For the CIS concentration, there are only two other CSUs that have a CIS concentration or degree within the CS area: Chico and San Marcos. The lower-division core is similar at all three campus, with one year of programming, discrete structures, and web design as required courses. The upper-division core varies across the three programs. Chico and San Marcos also require a Business cognate/minor, while our CIS students have the option to take any discipline-based minor in lieu of 12-semester units of general elective courses. This gives students greater flexibility. For example, a student interested in a career in game programming or web design could take a minor in Communications to learn about digital media and graphic design. The most popular minors for CIS students are Business, Communications, and Philosophy.

There is only one other CSU, Monterey Bay, that has an emphasis or concentration in cybersecurity at the bachelor's level. Their approach in the CS core is similar to ours, but they do not have the Global Intelligence and National Security (GINS) cognate that our Information Security concentration has. Instead, they have students take cybersecurity courses for their elective courses and the remainder of the core is the same as their traditional CS program. We feel that the GINS cognate courses give our students a better understanding of the geopolitical issues surrounding cybersecurity, instead of having a purely technical degree program.

c. Faculty Scholarship and Creative Activity

Appendix D has the brief faculty vita for all of the CEE/CS faculty members using the ABET vita format. The brief CVs highlight important publications and other scholarly activities undertaken by faculty members of the department.

Most of the reputable journals and conferences in CS are run by ACM and IEEE. Peer-reviewed publications in ACM and IEEE venues meet the minimum standards for quality expected by the department. Some publication venues within ACM and IEEE carry more weight than others. For example, the IEEE Transactions journal series is highly competitive and publishes cutting edge research, so a publication in IEEE Transactions carries more weight than most other IEEE venues.

Some research areas within CS also have niche publication venues. For example, the IEEE Symposium on Security and Privacy, also known as the Oakland Conference, is one of the premiere publication venues for cutting edge cybersecurity research, even though it is a conference. USENIX also provides several high-ranking peer-reviewed conferences for various areas of CS research, such as USENIX Security for cybersecurity and USENIX LISA for system administration.

The scholarly activity of CS faculty members greatly involves undergraduate students. Undergraduate research is a high-impact practice that provides the students with hands-on research activities. Undergraduate research also better prepares the students for graduate school and careers. As previously noted, several CS students have published or presented in peer-reviewed venues as a result of their research experiences.

4. Evidence of How Program Serves the Community

a. Applied Learning

Students receive career advising through a combination of discussions with their faculty advisor, informal discussions with faculty members, and career fairs organized by the campus career center. A mailing list of all current and former students is also kept on the department server and is used to send internship and job opportunities to the students. The CEE/CS Department hosts career development seminars targeted towards technical majors, such as the Fall 2015 and Fall 2016 career talks by Google employees and the presentations by LinkedIn and Microsoft employees co-hosted with the CS student club. Instructors for Senior Project and Software Engineering also invite alumni and local companies to come present to the students in their courses.

Career opportunities are also fostered by the NSME Grants and Outreach (GO) department. NSME GO works to connect potential employers with NSME students through internships, job shadowing, and mentorships. NSME GO also coordinates tours of industry facilities and informational sessions with areas of interest to NSME students. Additionally, NSME GO partners with the SWE student club to offer industry partners and potential employers the opportunity to interact with students through the annual Senior Design Expo for engineering and CS students.

Under the semester catalog, students can opt to replace 4 semester-units of technical electives through special topic courses, independent study courses, and experiential prior learning. Special topic courses (CMPS 377x and 477x) cover current topics in CS. Independent study courses can be for CMPS 4800 Undergraduate Research, CMPS 4860 Internship in Computer Science, or CMPS 4870 Cooperative Education. Experiential prior learning credit is awarded under the CMPS 4890 Experiential Prior Learning course. The amount of credit for CMPS 4890 is determined by faculty assessment of the scope and quality of the experience. Students must have support of their faculty advisor and department chair to receive credit for experiential prior learning. A petition for CMPS 4890 credit, with supporting documentation from the student and employer, is signed by the faculty advisor and department chair to indicate their support, then turned in to the Undergraduate Studies office for processing. Students under the quarter-system catalog can also petition the department to use any one of these courses as an elective on the older catalog.

b. Student Recruitment

The department has been highly active in NSME high school outreach efforts. When CSUB was the host for Engineering Day, faculty and students in the department would help with the lab tours to show the high school students our engineering facilities. Department representatives have also given talks about the department and its programs during NSME Open House Night. Some faculty have also gone out to high schools to give talks to high school students, such as discussing the cybersecurity of the energy sector at the Shafter Learning Center. Each summer, one or more faculty members participate in REVS-UP, which brings high school students out to CSUB for a month of research in STEM. The department also recently collaborated with BPA, Kegley Institute of Ethics, KHSD, and County of Kern to host a Big Data Symposium for high school Advanced Placement CS students in Fall 2017. And the department helped advertise the Fall 2018 Communications Department hackathon and BPA Startup Weekend events to the local high schools.

c. Faculty Recruitment

As part of the standard Provost's Office support for tenure-track advertising, position descriptions are placed on a variety of general diversity websites for higher education positions. For CS tenure-track lines, the CEE/CS Department has historically paid for further ad placement in ACM. However, ACM now charges $695 for a 30-day online only ad and $1,095 for a 60-day online only ad. This is cost prohibitive for the department, so we have switched to advertising on Academic Keys with the diversity network option, LinkedIn Jobs, and GlassDoor for the searches being conducted in the 2018/19 academic year. We will evaluate the effectiveness of those advertising venues before placing future tenure-track ads.

E. Evidence of Program Viability and Sustainability

1. Demand and Need for Program

a. Student Demand

In the prior program review, the number of CS majors was between 120-150 students each year. As shown in Figure 14, the department has experienced a sharp increase in the number of majors since 2010/11. The preliminary numbers for Fall 2018, gathered on University Day, showed 311 CS majors. Using this historic data, the department projected the number of CS majors using a variety of statistical tools. The projections that had the best fit with the historic data were the exponential triple smoothing (ETS) algorithm and exponential regression. Those projections are shown in Figure 14. By 2023/24, the algorithms predict between 291 and 421 CS majors, which is a wide range that makes it difficult to accurately predict enrollments and demand.

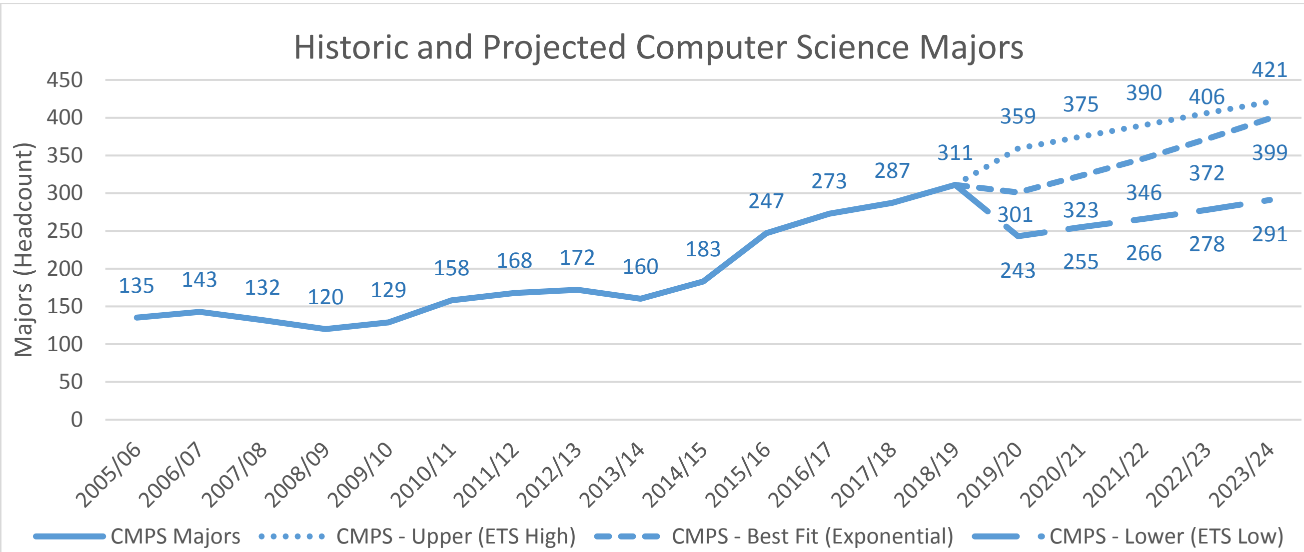

Figure 14: Historic Headcount of Computer Science Majors and Projected Future Headcount

With respects to FTES, as shown in Figure 15, the department experienced a slight "semester dip" in FTES after converting to semesters. This was primarily due to the loss of our general education course, which previously generated 25-30 FTES per year, and due to declining FTES for lower-division CMPS courses. As previously explained in Section C.4, fewer majors take lower-division CMPS courses as cognates under semesters and the Q2S conversion for lower-division programming sequence resulted in fewer overall units.

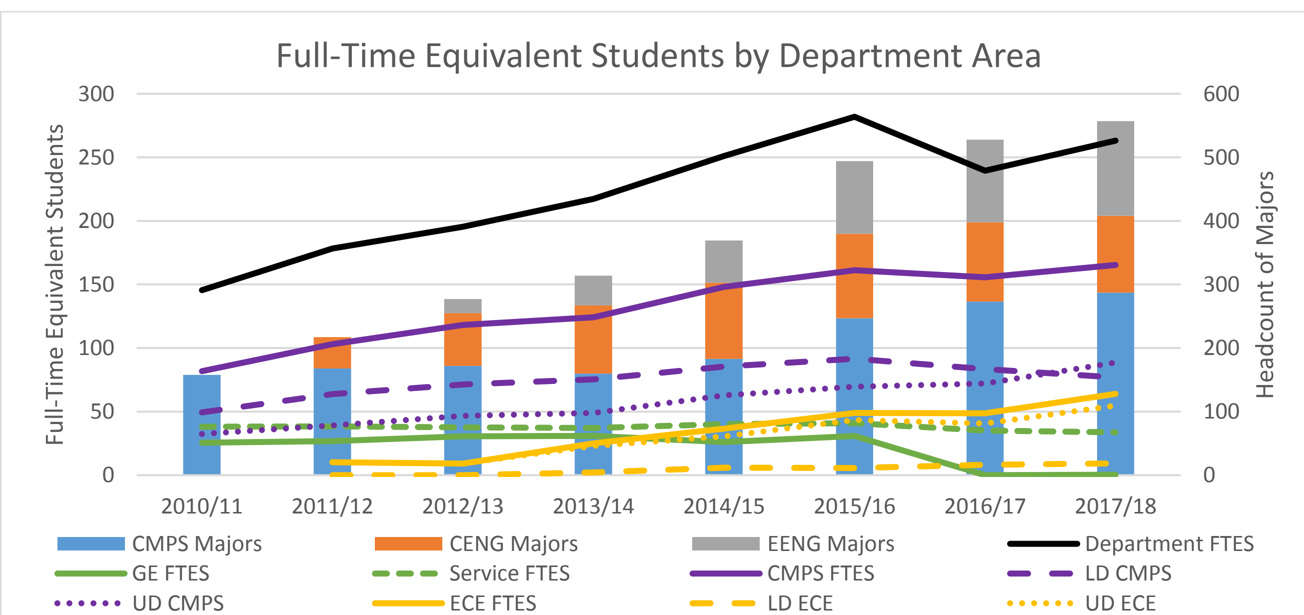

Figure 15: Full-Time Equivalent Students by Department Area for the Entire CEE/CS Department

Additionally, as shown in Figure 16, there was a large dip in the number of students taking 15 units or more per term when CSUB converted to semesters. This was not unique to the CS program, as the same trends were noted among all NSME majors and among all CSUB majors. Since quarter-system courses were almost always 5-unit courses, students who took 3 courses per term under quarters would usually reach 15 units in that term. The semester-system CMPS and cognate courses are a mix of 3-unit and 4-unit courses, while GE courses are primarily 3-unit courses. Therefore, students who take 4 courses per term under semesters will have anywhere from 12 units to 16 units for that term, as shown in the roadmaps in Appendix C. This leads to more students taking 12-14 unit loads under semesters, which is reflected in the CSU Dashboard data.

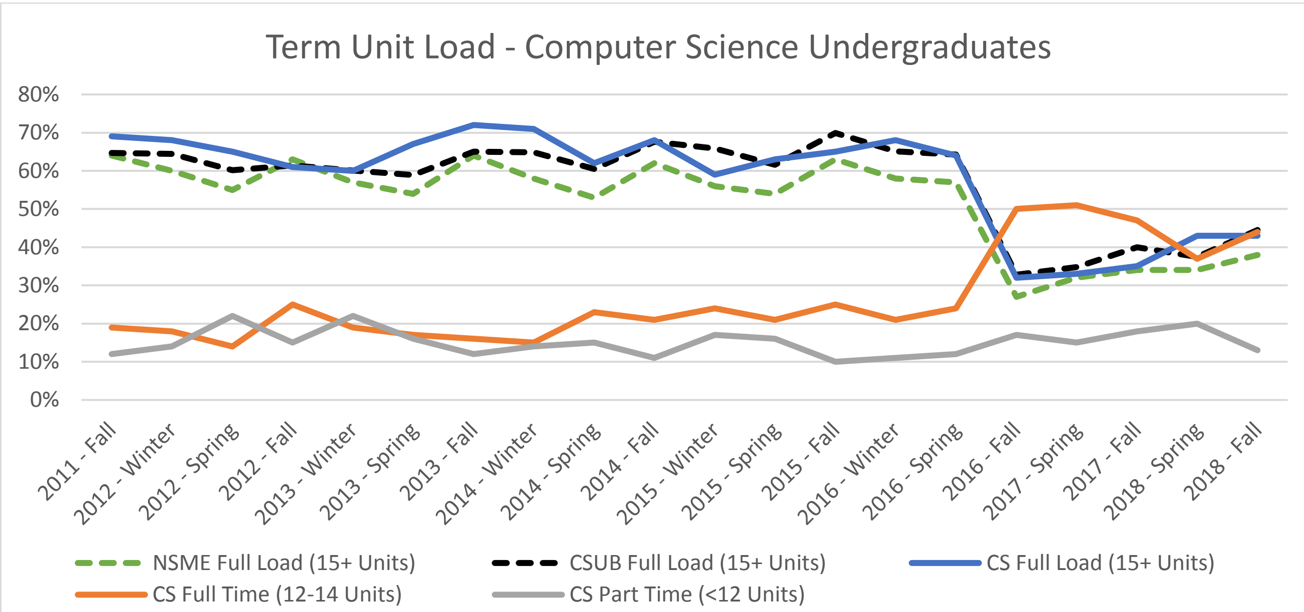

Figure 16: Term Unit Loads for Computer Science Majors (Data from CSU Dashboard)

Another semester conversion issue becomes apparent when looking at the average class sizes, as shown in Figure 17, and the overall number of sections offered, as shown in Figure 18. As previously mentioned in Section C.4, the CMPS 120/1200 service course offered by the department was negatively affected by the semester conversion. The course is no longer a cognate for Business and Liberal Studies has changed it to an elective course. Even though we have continued to offer the same number of sections of CMPS 120/1200 since 2010/11, the average class size has declined greatly under semesters due to these changes.

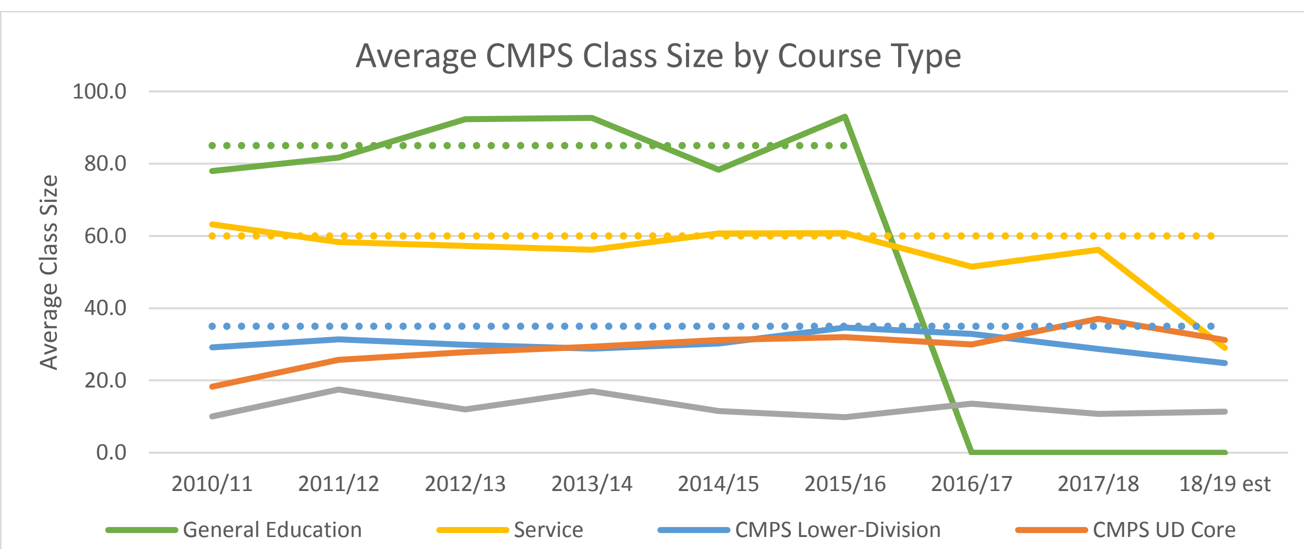

Figure 17: Average Class Size and Maximum Class Size (Capacity) for CMPS Courses by Course Type

For the upper-division core CMPS courses, the average class size in Figure 17 remains close to the 35-student capacity of the CEE/CS Department computer labs. As shown in Figure 18, we have actually had an increase in demand for upper-division core CMPS courses and have had to offer additional sections to meet this demand. There has consistently been unmet demand for upper-division core CMPS courses since the semester conversion. Most of these courses waitlist within the first two weeks of enrollment since we have converted to semesters, with some courses waitlisting as early as Wednesday of the first registration week (e.g. before all Juniors are allowed to register). It is difficult to add new sections when the planned sections waitlist because there are very few people in Kern County with a graduate degree in Computer Science or Software Engineering, which would be needed to teach most of our upper-division core courses. During the program review period, we added one expansion CS tenure-track line and one additional full-time CS lecturer to address the growing demand. We're also currently searching for two CS tenure-track lines in the 2018/19 academic year, which should further help us address the unmet demand for upper-division courses.

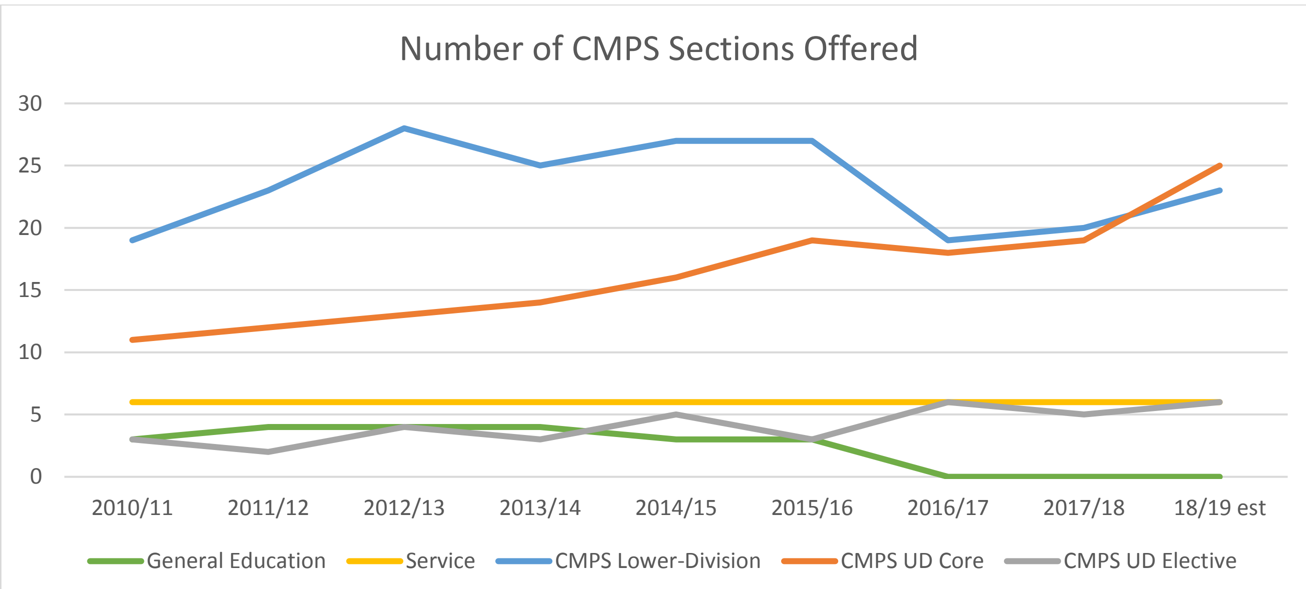

Figure 18: Number of Sections Offered for CMPS Courses by Course Type

Overall, the data in Figure 15, Figure 17, and Figure 18, show that under semesters most of the student demand within the department is driven by CS and ECE majors, not by general education or service courses. However, we are still planning to resubmit our Computers and Society general education course to GECCo for approval as an upper-division Area B course, since NSME is having difficulty meeting the demand for upper-division Area B general education courses. The topics in this course are also important for the new California supplemental authorization in Computer Science, which we are developing in conjunction with Brittney Beck and other SSE faculty as part of their new TQP grant. It would be beneficial for the credential students to take a course that double-counts for both a GE requirement and towards their credential.

<u>b. Market Needs and Demands</u>

To keep our CS program current, department faculty regularly speak with local companies and with colleagues about trends in CS. This allows us to tailor elective courses to meet those trends and to match to faculty specialty areas. Additionally, as part of planning for the M.S. degree in CS, Extended Education paid for a market survey which also highlighted areas in high-demand across California and the nation. Strong job growth is predicted in both Kern County and California in the areas of information security / cybersecurity, software development / software engineering, computer system analysts, and database programmers / administrators. Additionally, data science, data analytics, and artificial intelligence are major areas of growth within CS research and cutting-edge product development. All of these areas are represented in the current CMPS elective course list.

<u>2. Faculty Resources</u>

<u>a. Faculty Ranks and Workload</u>

The department has experienced a great deal of change in the faculty ranks since the last CS program review. In addition to recruiting the ECE faculty members to support the new engineering programs, many faculty members have retired. The only continuing T/TT faculty members since the prior review are Dr. Huaqing Wang, Dr. Wei Li, and Dr. Melissa Danforth and the only continuing lecturer is Steve Garcia. All of the other faculty members in the department have been hired during the time period covered in this program review.

The full list of faculty members in the CEE/CS Department for the 2017/18 academic year is given in Table 13 and the workloads (WTUs) for each faculty member are listed in Table 14. The "other" column in Table 14 indicates both service release time for tenure-track faculty and miscellaneous, non-research-related, release time. The tables also divide the workload by the CS and ECE sides of the department.

Table 13: CEE/CS Department Faculty Members for 2017/18 Academic Year

Faculty Name	Highest Degree Earned- Field and Year	Rank	Years at CSUB as of 2017/18 AY	Primary Area	Overall Effort for 2017/18 AY		
					Purely CS	Purely ECE	Both CS and ECE
Reza Abdolee	Ph.D. ECE 2014	Assist.	2 yr	ECE	0%	100%	0%
Anthony Bianchi	Ph.D. EE 2014	Assist.	2 yr	CS	45%	17%	38%
Alberto Cruz	Ph.D. EE 2014	Assist.	4 yr	CS	63%	0%	37%
Melissa Danforth (Chair)	Ph.D. CS 2006	Prof.	12 yr	CS	43%	25%	32%
Saeed Jafarzadeh	Ph.D. EE 2012	Assist.*	6 yr	ECE	0%	100%	0%
Chengwei Lei	Ph.D. CS 2014	Assist.	2 yr	CS	100%	0%	0%
Wei Li	Ph.D. ECE 1991	Prof.	17 yr	ECE	0%	100%	0%
Vida Vakilian	Ph.D. EE 2014	Assist.	4 yr	ECE	0%	100%	0%
Huaqing Wang (FERP)	Ph.D. CS 1988	Prof.	30 yr	CS	100%	0%	0%
J. Antonio Cardenas-Haro	Ph.D. CS 2010	FTL	2 yr	CS	37%	0%	63%
Gordon Griesel	MBA 2006	FTL	5 yr	CS	67%	0%	33%
Derrick McKee	B.S. CS 2012	FTL	6 yr	CS	50%	0%	50%
Ehsan Reihani	Ph.D. ME-EE 2015	FTL+	2 yr	ECE	0%	100%	0%
Steven Garcia (FT staff)	B.A. Physics 1978	PTL	14 yr	CS	100%	0%	0%
Jason Forsythe	B.S. CS	PTL	1 yr	CS	100%	0%	0%
Weiguo (James) Luo	Ph.D. Civil Eng. 2005	PTL	2 yr	ECE	0%	100%	0%
M. Jay Manibo	B.S. CS 1997	PTL	5 yr	CS	0%	0%	100%
Stephen Mellor	B.S. CS	PTL	1 yr	CS	100%	0%	0%
Walter Morales	M.S. Petro. Eng. 2015	PTL	3 yr	CS	0%	0%	100%
Edward Rangel	M.S. Soft. Eng. 2015	PTL	2 yr	CS	0%	0%	100%
Michael Sarr	B.S. CS 2004	PTL	7 yr	CS	0%	0%	100%
Shahrzad Sheibani	MBA	PTL	1 yr	CS	0%	0%	100%

* Saeed Jafarzadeh was promoted to Associate Professor of Engineering at the end of 2017/18
+ Ehsan Reihani was converted to Assistant Professor of Engineering in Fall 2018

Table 14: CEE/CS Department Faculty Workloads by Area of Responsibility for 2017/18 Academic Year

Faculty Name	CS Only			ECE Only			Both CS and ECE		
	Teach	Research	Other	Teach	Research	Other	Teach	Research	Other
Reza Abdolee				9	9	12			
Anthony Bianchi	7.5		6	5			4.5	6	1
Alberto Cruz	13		6				5	5	1

Melissa Danforth	4	3	6			7.5			9.5
Saeed Jafarzadeh				19	5	6			
Chengwei Lei	18	6	6						
Wei Li				15	8	7			
Vida Vakilian				13	5	12			
Huaqing Wang	10		5						
Antonio Cardenas	11						19		
Gordon Griesel	20						10		
Derrick McKee	10		5				15		
Ehsan Reihani				30					
Steven Garcia	7.5								
Jason Forsythe	5								
Weiguo (James) Luo				16					
M. Jay Manibo							20		
Stephen Mellor	18								
Walter Morales							4.5		
Edward Rangel							10		
Michael Sarr							10		
Shahrzad Sheibani							4.5		

Note that while most of the ECE faculty have primarily ECE duties, many of the CS faculty have duties that overlap both sides of the department. For example, Dr. Bianchi and Dr. Cruz conduct research in image processing and computer vision, which overlaps both sides of the department. Dr. Bianchi and Dr. Cruz also alternate teaching duties for the related ECE elective courses. The department chair, Dr. Danforth has service responsibilities to both sides of the department as part of the normal chair duties, but also has service responsibilities specific to the CS side of the department (e.g. CS advising) and to the ECE side of the department (engineering grant release time for ABET purposes).

Additionally, most lower-division CMPS courses are taken by ECE students, so faculty members assigned to those courses are teaching for both sides of the department. Most of the part-time lecturers are teaching those courses, so they are supporting both sides of the department even though they are primarily assigned to the CS side of the department. Approximately 30% of the enrollments in CMPS 2010, 2020, 2120, and 2240 come from ECE students, so faculty who teach just these four courses are considered to have a 70% CS and 30% ECE weighted effort.

b. Tenure-Track Density

The tenure-track density and full-time equivalent faculty numbers by primary area of responsibility is illustrated in Figure 19. Historic data from the prior CS program review is also given in that figure to provide a better long-term picture of the faculty body in the department. There has been a sharp decline in tenure-track density on the CS side of the department. Since 2013/14, the tenure-track density has fallen below 50% for the CS side of the department. The overall department tenure-track density is higher due to the higher tenure-track density on the ECE side of the department.

Additionally, despite the increase in demand from CS majors, particularly at the upper-division level, the overall number of CS faculty members has barely increased. For most of the time from 2005/06 to now, except during the height of the budget crisis from 2008/09 to 2011/12, we have had 8-9 full-time equivalent faculty members for the CS side of the department. We expanded our part-time CS lecturer pool in 2017/18 by hiring Mr. Mellor, Mr. Forsythe, and Ms. Sheibani, which brought us up to slightly over 10 FTES of CS faculty members for that year. We have also added a new full-time CS lecturer for the 2018/19 academic year, Dr. Vincent On. However, it bears noting that the number of CS majors has more than doubled since the prior program review and our current CS hiring is still playing “catch up” with this growth. The search for two CS tenure-track lines in 2018/19 will help tremendously in meeting this growth and we recognize that we are fortunate to have received one of the six expansion lines allocated to the campus in 2018/19.

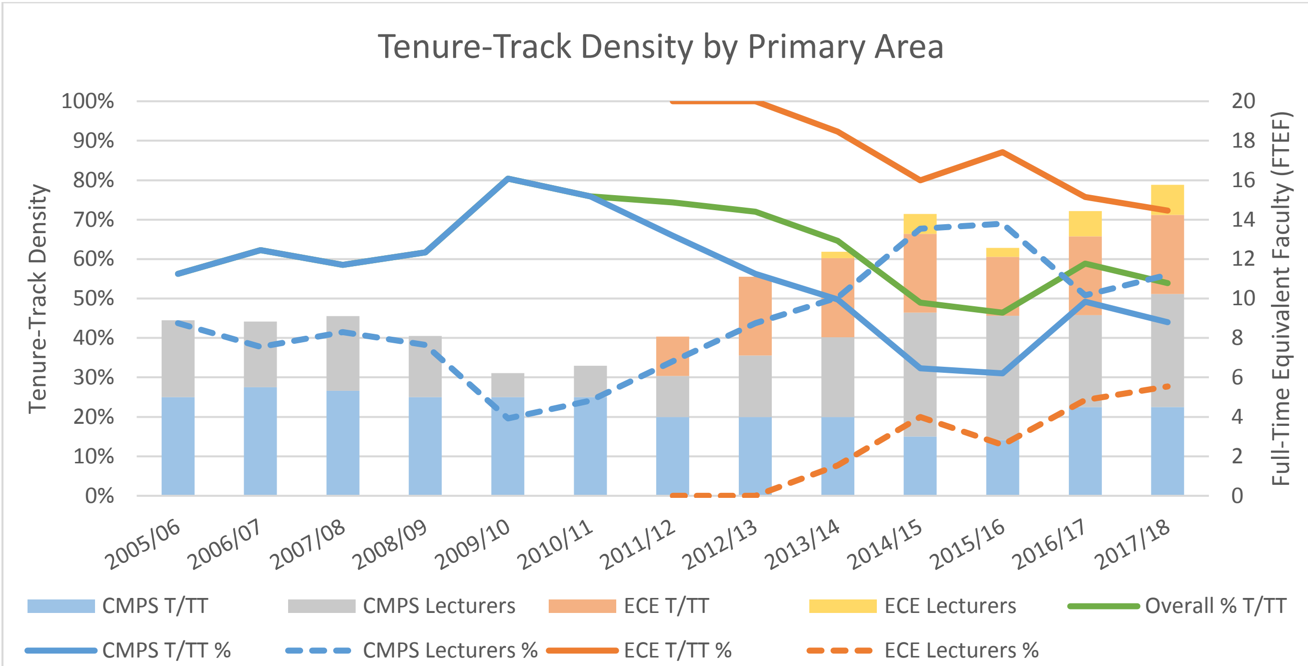

Figure 19: CEE/CS Department Tenure-Track Density by Primary Area of Responsibility for Faculty Members

As noted above, many faculty members with primary responsibility to the CS side of the department also support the ECE side of the department. Figure 20 adjusts the tenure-track density by weighted effort of each faculty member. This slightly improves the tenure-track density for the CS side of the department, as the CS lecturers provide more teaching support to the ECE side of the department than the tenure-track CS faculty members. But the tenure-track density is still lower on the CS side of the department than on the ECE side of the department.

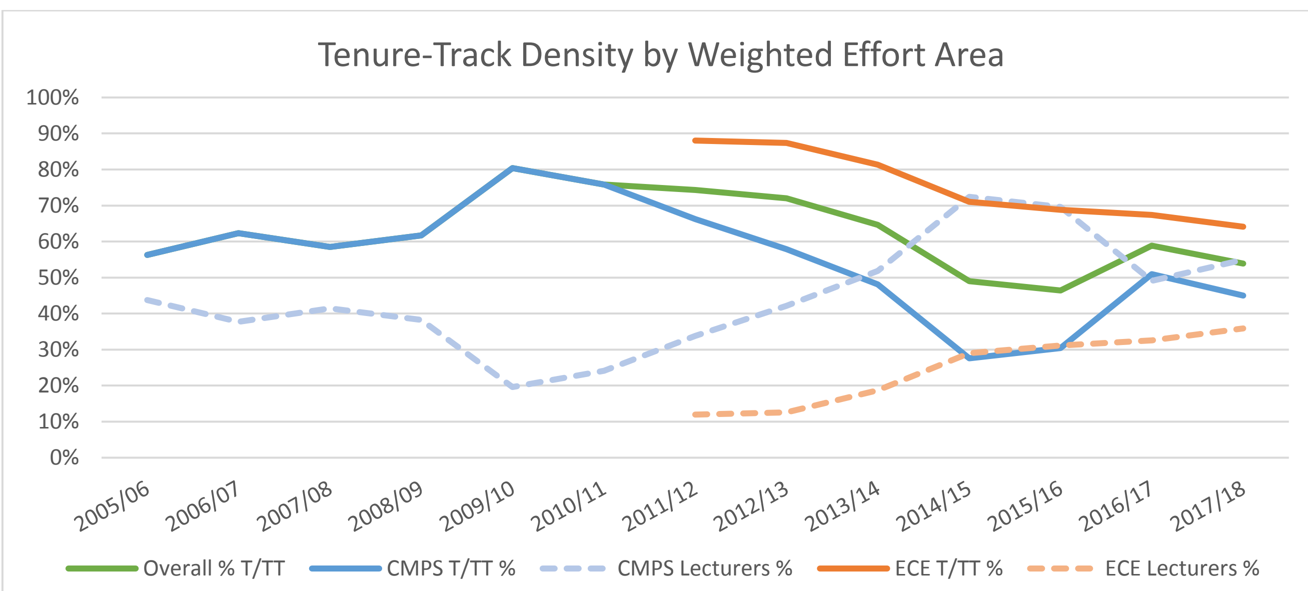

Figure 20: CEE/CS Department Tenure-Track Density by Weighted Effort

The department conducted a search for a CS tenure-track faculty member in 2017/18, but the person under contract withdrew from the contract in June 2018. One of the lines for the current 2018/19 tenure-track search is to replace this person.

c. Areas of Specialization

Tenured and tenure-track faculty members have primary or secondary research specializations that cover most of the elective areas. We do not currently have a Ph.D. faculty member specializing in software engineering and related areas (animation, graphics, etc.), so this is one of our target areas for the 2018/19 tenure-track search. We also do not have a tenure-track faculty member specializing in operating systems or networking. This is the second target area for our current search.

Algorithms, Theory, and Programming Theory

- Dr. Melissa Danforth (secondary specialization)
- Dr. Chengwei Lei (secondary specialization)

Architecture and Organization

- Dr. Alberto Cruz (secondary specialization)
- Dr. Antonio Cardenas-Haro (full-time lecturer)
- Core courses in this area can also be taught by Dr. Danforth

Software Engineering

- Core and elective courses taught by Mr. Gordon Griesel (full-time lecturer)

Computer Vision and Image Processing

- Dr. Anthony Bianchi (primary specialization)
- Dr. Alberto Cruz (primary specialization)

Databases, Data Mining, Data Science, and Artificial Intelligence

- Dr. Anthony Bianchi (primary specialization)
- Dr. Alberto Cruz (primary specialization)
- Dr. Chengwei Lei (primary specialization)
- Dr. Huaqing Wang (primary specialization)

Parallel and Distributed Computation

- Dr. Anthony Bianchi (secondary specialization)

Operating Systems and Networking

- Dr. Melissa Danforth (secondary specialization)
- Dr. Antonio Cardenas-Haro (full-time lecturer)
- Core courses in this area can also be taught by Dr. Cruz and Dr. Bianchi

Cybersecurity

- Dr. Melissa Danforth (primary specialization)
- Dr. Antonio Cardenas-Haro (full-time lecturer)
- Dr. Charles Lam (Mathematics, teaches CMPS/MATH 4300 Applied Cryptography course)

d. Professional Development and Mentorship

Faculty members make use of campus resources for professional and leadership development, including the Provost's travel support, mini-grants and workshops from the TLC, RCU grants, and other workshops and support. Faculty members also use sabbatical and difference in pay leave to support their scholarly activities.

With respects to mentoring, the department does not have a formal mentoring program for junior faculty members. New faculty members receive regular feedback on their performance through annual reviews at the department and school level and through the annual classroom observation reports. Informal mentoring does occur to train new faculty members in advising. New tenure-track faculty members are encouraged to shadow an existing faculty member during advising to learn more about the advising process. Staff advisors from the

NSME Student Center have also come to department meetings to give training on how to use GradesFirst and myCSUB for advising, at request of the department.

3. Financial Resources

a. Operational Budget

Analyzing the fiscal costs of the department is difficult since the IRPA provided salary data in the annual program profile is greater than the salary data in CFS Data Warehouse by anywhere from $15,000 to $80,000 each year since 2011/12. Since CFS provided the most transparent source of data, it was used as the basis for this section, with manual adjustments for lecturers hired under the grant sister fund. Figure 21 shows department salaries broken down by primary area of responsibility to the department. This roughly corresponds to the breakdown provided in the most recent IRPA annual program profile. The dip in 2015/16 reflected a year where two full professors and one full-time lecturer retired, one assistant professor for the ECE side of the department was on unpaid leave, and Dr. Wang began FERPing.

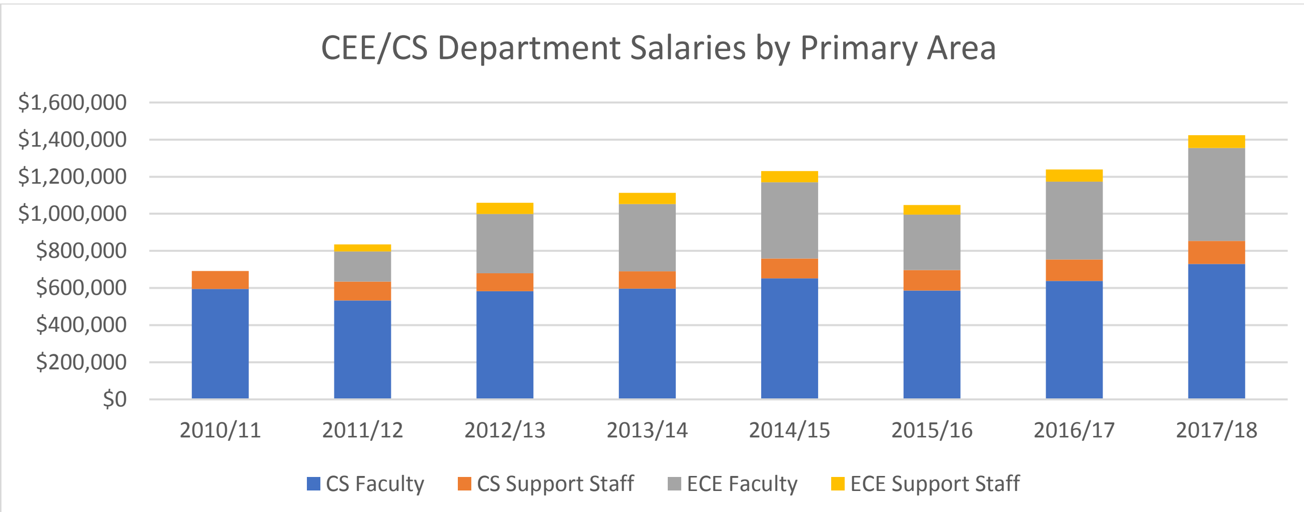

Figure 21: CEE/CS Department Salaries by Primary Area for Faculty Members and Support Staff

As previously noted with the full-time equivalent faculty numbers, Figure 21 shows that the department spending on the CS side of the department has stayed relatively stagnant over the program review period. There was an increase in 2017/18, corresponding to the hiring of several part-time lecturers and the GSI salary increases for existing faculty members. When these numbers are adjusted by weighted effort, as shown in Figure 22, it becomes clear that funding dedicated purely to the CS side of the department has decreased since the addition of the engineering programs.

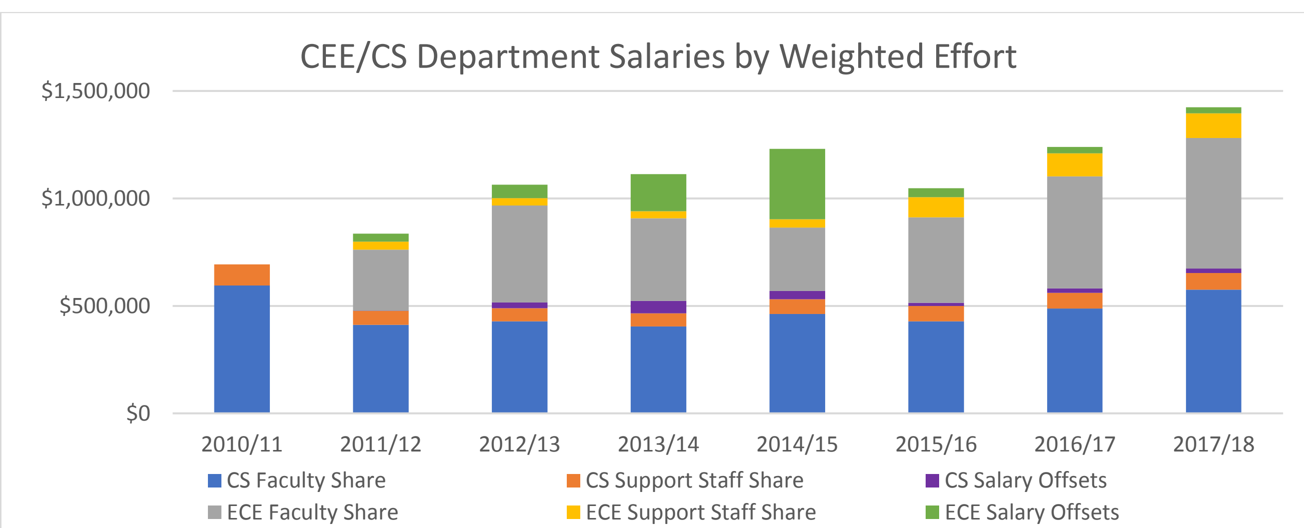

Figure 22: CEE/CS Department Salaries by Weighted Effort to CS and ECE Sides of the Department

The cost per full-time equivalent student by weighted effort is given in Figure 23. The cost per FTES for the CS share includes general education and service teaching, as these courses are taught by CS faculty members. Again, there is a discrepancy between the adjusted CFS data and the data provided by IRPA on the annual department reports. But overall, the cost per FTES for the CS side of the department has remained relatively stagnant over the program review period.

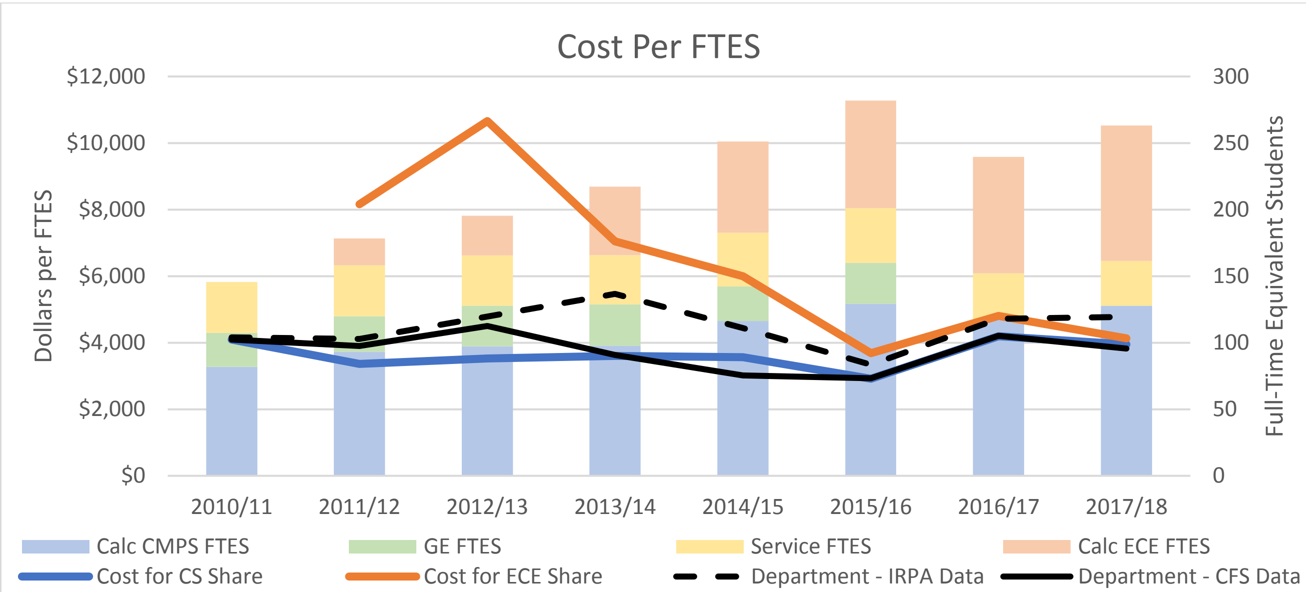

Figure 23: Cost per FTES for the Department Overall and by ECE and CS Areas

b. External Funding

Faculty within the department are active at seeking funding. CS faculty members have been PI or co-PI on funding for research grants (internal and external funding), Chancellor's Office research grants, and pedagogy grants (external funding), as shown in Figure 24. The research grants have primarily involved CS, ECE, and MATH students. The pedagogy grants have been for the benefit of all NSME students, not just students within the department. Further details can be found in Appendix D – Faculty Abbreviated CVs on page 128.

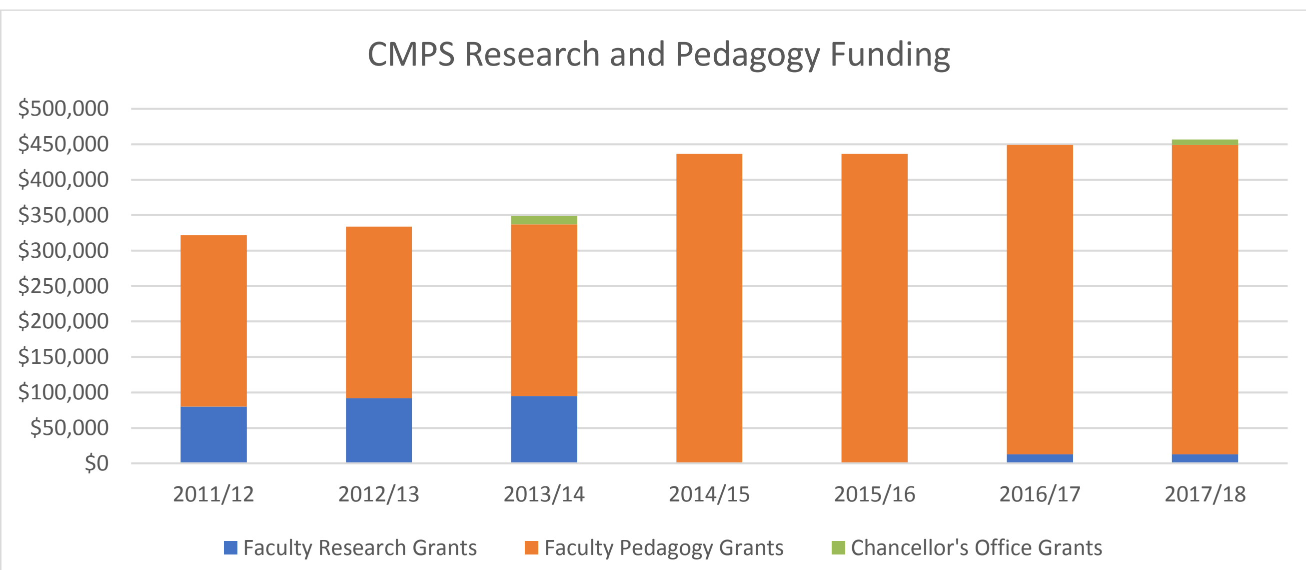

Figure 24: Internal, External, and Chancellor's Office Funding Generate by CS Faculty Members

4. Supplies, Equipment, and Other Resources

The CEE/CS Department maintains extensive technology resources and dedicated facilities to support the CS and ECE programs. The department currently has the following computer and technology facilities:

- Three computer labs in Science III that primarily support teaching CMPS courses at all levels
- One computer lab in Science III for department tutoring, primarily for lower-division CMPS courses
- One research lab in Science III that supports the CS side of the department
- One research lab in Science III that supports both the ECE and CS sides of the department
- One server room in Science III that supports both sides of the department and also hosts servers for other NSME departments
- One research lab in Science II, shared with Biology, that supports the ECE programs
- One research lab in Science III, shared with Physics & Engineering (P&E), that supports the ECE programs
- One teaching lab in Engineering Complex, shared with P&E, that supports the ECE programs
- Four teaching/research labs in Science III that primarily support the ECE programs

a. Information and Technology Resources

The department provides most of the IT support for the computers in its dedicated facilities in Science III. We have a dedicated full-time Systems Analyst, Steve Garcia, who is responsible for this work. Henry Lin, the department Equipment Technician, is primarily responsible for supporting the ECE side of the department. Campus ITS provides hardware repairs for the computers that are still under warranty with Dell and for the projector systems.

The department also maintains its own server room in Science III. The teaching servers are used extensively in CMPS courses at both the lower-division and upper-division level. Students can access the servers from any Internet-connected device using free SSH software, then complete their assignments using open-source tools. This means there is no cost to the students for most of the CMPS courses, other than having access to an Internet-enabled computer.

In addition to the teaching servers, the department server room hosts research servers for CEE/CS faculty members and faculty members in other NSME departments. The department servers also hosts several license servers to support NSME software such as MATLAB and Mathmatica. Steve Garcia works with ITS to coordinate which license servers the CEE/CS Department will host. He also coordinates with ITS in other technology matters that affect the department infrastructure.

The software resources listed in Table 15 are provided by either the CEE/CS Department or by NSME. CS students use the MATLAB, VMware, and Microsoft products most frequently. The other products are used primarily by the ECE students. This software is available in the department-supported computer labs in Science III, as supported by the operating system (i.e. Linux workstations will not have Windows-only software available unless that software runs well under virtualization or emulation).

Table 15: CEE/CS and NSME Software Products

Description	Seats
National Instruments LabVIEW, Multisim, and Ultiboard software package	Unlimited
Cadence University Program	Unlimited
Altera Quartus II	Unlimited
Xilinx ISE WebPACK	Unlimited
MATLAB and Simulink (base system)	45
- General toolboxes: Communications, Computer Vision, DSP, Embedded Coder, Fixed-Point, Fuzzy Logic, Global Optimization, Image Processing, MATLAB Coder, MATLAB Compiler, MATLAB Compiler SDK, Neural Network, Optimization, Partial Differential Equation, Signal Processing, Simulink Coder, Statistics and Machine Learning, Symbolic Math	30 – 40
- Specialty: Bioinformatics, Control System, Curve Fitting, Data Acquisition, HDL Coder, HDL Verifier, Image Acquisition, Instrument Control, Simscape, Simscape Power, Wavelet	10 – 15
Autodesk AutoCAD	30

SOLIDWORKS ("Network" educational license plan)	2000
Linguistic Inquiry and Word Count Semantic Analysis software	8
VMware Workstation (research license)	50
VMware Academic Program (educational use by faculty and students)	Unlimited
Microsoft Azure Dev Tools for Education (educational use by faculty and students)	Unlimited

b. Equipment and Facilities

Table 16 lists the department space that is primarily used for supporting the CS side of the department. The department has complete control over the scheduling of these spaces, and they are primarily used for department courses, tutoring, and research. Unless otherwise noted, the PCs in the CS computer labs run the Linux operating system.

Table 16: Computer Science Teaching, Tutoring, and Research Laboratories

Room	**Capacity**	**Description**
Sci. III 240 972 sq. ft. Last upgraded: Summer 2017 (5yr warranty)	35	General teaching computer lab (upgrade funded by Chevron donation) • 35 Dell Precision workstations with NVIDIA video cards • HD Projector • Linux and Windows dual-boot Used by all CMPS courses Also used for the annual PLTW Design Challenge event sponsored by Chevron
Sci. III 311 1020 sq. ft. Last upgraded: Summer 2018 (5yr warranty)	35	General teaching computer lab • 35 Dell Precision workstations with ATI/AMD video cards • HD Projector Courses which require ATI/AMD video cards have priority scheduling for this room, but it is used by all CMPS courses
Sci. III 315 1011 sq. ft. Last upgraded: Summer 2014 (5yr warranty)	35	Advanced workstation computer lab (upgrade funded by State Farm donation and U.S. Department of Education grant) • 35 advanced Dell Precision workstations with NVIDIA video cards • 30" high-resolution monitors on articulating arms • HD projector Courses which require higher GPU or CPU support have priority scheduling for this room, but it is used by all CMPS courses
Sci. III 324 794 sq. ft. Last upgraded: Early 2008 (original to Science III)	30	CEE/CS Tutoring Center • 21 Dell computers • Table space and charging ports provided for personal student laptops • HD Projector Tutoring primarily provided for lower-division CMPS courses. Additional CMPS or ECE tutoring may be provided, depending on the background and training of the tutor(s) on duty.
Sci. III 314 301 sq. ft. Last upgraded: Winter 2011	n/a	Isolated Network and Cybersecurity Research Lab (supported by grants) • Multiple Dell PowerEdge servers for isolated network infrastructure • 7 Dell workstations • Two mini GPU clusters for password security Also has the ITS networking rack for the third floor of Science III
Sci. III 328 612 sq. ft. Last upgraded: Fall 2016 (5yr warranty)	n/a	Computer Perception Research Lab (shared with ECE, supported by grants and a Chevron donation) • 8 Dell computers with CameraLink cameras • 8 BeagleBone Black boxes with HD cameras • 2 Raspberry PIs with infrared thermography cameras Used for computer vision, image processing, and artificial intelligence research on CS side of the department.

5. Oversight and Management of Required Resources
The department is responsible for maintenance of the above equipment and computers that support the CS program, as well as all of the equipment and computers that are used to support the ECE programs.

Decisions involving the overall budget and strategic direction are handled by the NSME dean in conversation with the department chair and the provost. Operating expenses are managed at the department level. Current and projected expenses are reported to the dean's office on a monthly basis and the department chair and administrative support coordinator meet with the dean and the dean's budget analyst on a quarterly basis to discuss the expenses.

Since the opening of Science III in 2008, grants and corporate donations have been used to upgrade several of the CS computer labs, as noted in Table 16, and to purchase a new teaching server. A mix of campus funding and donor funding was used to upgrade Sci. III 311 in the summer of 2018, as it was previously using ten-year old computers purchased when Science III opened.

Major and minor capital improvement projects are submitted by the department to the dean's office. These projects are prioritized at the school and university level on an annual basis. Replacements and upgrades are prioritized by the department as part of the major and minor capital improvement requests. These requests may also be funded through other means such as donations, lottery funds, and grants.

The department has currently prioritized upgrading the computers in Sci. III 324, as these computers are over a decade old, and the computers in the ECE lab Sci. III 313, which were purchased on a grant in 2010/11. The next level priority is Sci. III 315, as those computers have experienced a disproportionate number of warranty repairs from Dell and they will fall out of warranty at the end of Spring 2019.

F. Summary Reflections:
1. Alignment of Curriculum, Practices, Processes, and Resources with the Goals of the Program
The curriculum, practices, and processes are well-aligned to the goals of the CS program, as stated in Table 1: Program Educational Objectives for Computer Science. Under the semester-system, our faculty are active in research in several high-demand CS fields and our program aligns with cutting-edge curricular standards. The resources allocated to the CS side of the department have suffered during this program review period, with more resources allocated to launch the engineering programs. Now that the engineering programs are established and have successfully received ABET accreditation, we are focusing our attention on the CS side of the department. We are hiring more CS faculty to meet increased demand and growth, with one new full-time CS lecturer starting in Fall 2018 and two CS tenure-track searches being conducted in 2018/19.

2. Alignment of Program Goals with the Goals of the Constituents that the Program Serves
The program educational objectives (PEOs) were developed in consultation with the department faculty and industry representatives. The PEOs are related to the university mission statement and to NSME's mission statement, as shown in Table 2.

3. Alignment of Program Quality with Acceptable Level of Program Quality
As previously noted, the CS program is aligned with international curricular standards for computing programs and incorporates high-demand areas in its elective courses. Our program was the first CS program within the CSU to incorporate the curricular recommendations from the ACM/IEEE CS 2013 Body of Knowledge, which is now required for programs seeking ABET accreditation in CS. We are also aligned to the California transfer model curriculum for CS, providing a 60-unit pathway to graduation for students who transfer with a CS ADT.

4. Achievement of Program Goals
Student placement tracking shows that our alumni are going on to productive careers in industry and academia, although this placement differs by concentration. Students in the calculus-based CS-Traditional concentration go on to graduate school or to industry careers, primarily in software engineering. Students in the pre-calculus-based CS-Computer Information System concentration more frequently go on to careers in a

variety of programming jobs or as analysts, administrators, or technicians. The Information Security concentration is too new to have employment trends.

5. Achievement of Student Learning Outcomes

As shown in Figure 2, CS students are meeting expectations for course-level assessment. There is a slight lag in achievement for the Computer Information System concentration, particularly in mathematics, as shown in Table 11. This is expected since the CIS students only take pre-calculus level mathematics. There is a limit to the support faculty members can provide to bring up mathematics skills if the students have only completed pre-calculus courses.

Course-level assessment is currently being redesigned, as ABET had released new student learning outcomes for CS and engineering programs in October 2017. The department has been developing new course-level assessment plans for the CS, CE, and EE degrees since that announcement. This new assessment schedule will be implemented in Spring 2019, although it may require further fine-tuning as we gain more familiarity with the new SLOs.

Program-level assessment from the nationally normed Major Field Test in Computer Science, as illustrated in Figure 3 and Figure 4, show that our program is strongest in the Systems area of CS, which includes databases, operating systems, networking, computer architecture, and parallel and distributed computation. The Programming area is near the national average, which meets the department expectations. There has been a slight decrease in Programming over the past four years, which the faculty members have discussed and have developed a plan to address. There was also a historical deficiency in the Theory area, which we have addressed by adding the Theory of Computation course to the calculus-based concentrations under semesters.

6. Challenges to Program Quality

Development of the semester curriculum was a balancing act between the California regulations on units after transfer, the overall 120 semester unit limit, the units remaining to the major after general education and cognate courses were taken into consideration, and the international curricular standards. CS faculty members carefully considered which upper-division courses needed to be 4-unit courses due to high levels of required content and which courses could be 3-unit courses. This allowed us to design each of the three CS concentrations to meet all of the unit constraints while still aligning with the appropriate standards for that concentration.

Another challenge to program quality is having a mix of calculus-based and pre-calculus-based students in certain mathematically intensive CMPS courses, such as algorithms, artificial intelligence, networking, and databases. Instructors must compromise between showing the mathematical foundations of a concept and showing how to apply the concept. If they go too deeply into the mathematical foundations, the students who have only taken pre-calculus will struggle. But if they focus on applications and ignore the mathematical foundations, the calculus-based students will not be as well-versed in the concepts as students from other institutions. This approach was necessary in the past, as student enrollments did not justify having a calculus-based course versus an algebra-based course. Enrollments have now grown to the point where there would be sufficient demand to justify such a split. This is discussed further below in the Program Plan.

II. Program Plan

A. Program Goals for the Next Seven Years

1. Address Faculty Levels and Unmet Student Demand for Courses

An immediate goal for the CS program is to have a successful search for the two open tenure-track positions in software engineering and in systems. Most of the other CSUs are also searching for CS faculty in 2018/19, so we have moved up our recruitment timeline to start on-campus interviews in February 2019, instead of the March/April timeline of prior years. These two positions will be critically important to meet the current growth of the CS program by adding more sections of upper-division CMPS courses, to fill in gaps in our current specialty/research areas, and to support our other goals for the next seven years.

2. Master of Science in Computer Science

The department is also authorized to start a M.S. degree in Computer Science on CSUB's Academic Master Plan, with a drop-dead implementation date of Fall 2022. We realize that launching such a program will be both a challenge and an opportunity for the department. The challenges presented by this program relate to staffing and space. This degree will be offered through the Extended Education division as a self-support program, which provides additional flexibility given our current faculty levels. Faculty members will have the option to either voluntarily overload by up to 3 WTU per term or to buy out their stateside time to support the graduate program.

The program will also be self-supporting in another fashion: growing our own local lecturer pool. The primary reason we have issues addressing the demand for upper-division courses is a lack of qualified lecturers in the greater Bakersfield area. Most of our upper-division courses require graduate-level knowledge to teach effectively, but there are very few people in Bakersfield with MS degrees in CS or Software Engineering. Once the MS in CS program is established, alumni of the program who remain in the area will be sufficiently trained in the subject area to help us meet the undergraduate student demand. The graduate students can also assist while in the program by being teaching assistants for the laboratory sections.

Space issues in the short-term will be addressed by utilizing the EEGO classroom as much as is feasible and by sharing our existing teaching and research rooms between both undergraduates and graduate students. In the long-term, when the Energy and Engineering Innovation Center (EEIC) is built, space on the third floor of Science III currently occupied by the engineering programs will likely be moved to the new building, freeing up additional space to be used by the CS program. The department will work with the NSME dean's office on both short-term and long-term space planning.

Besides "growing our own" pool of future lecturers, the Master's program will provide the CS faculty with the opportunity to supervise and conduct a higher level of research, which will enable them to seek additional research funding. While our undergraduate students are very involved in research, it is rare to get an undergraduate student, like Mr. Alex Rinaldi, who produces research at a graduate level. Funding is highly competitive within CS and the lack of a graduate program puts us at a disadvantage for many funding opportunities. The lack of a graduate program also hampers our efforts at recruiting new tenure-track CS faculty members, since they know it will be more difficult to conduct CS research and obtain external funding at an undergraduate-only institution.

Over the past year, we have formed a subcommittee to develop the MS program. The subcommittee has met at least twice per month during Fall 2018. The program envisioned by the subcommittee will be a face-to-face program with a cohort of 15-20 students admitted each year that offers both a thesis and a project option. The target populations will be local CS alumni, local workers seeking to change careers into computer and data science, and international students. The core of the program will be a traditional MS in CS program, similar to other CSUs and to UCs, with the elective areas focusing in the high-demand areas of cybersecurity, artificial intelligence and data science, and distributed and parallel computation.

We have been in discussions with EEGO about the degree formation process for several years, including conducting a market survey in Spring 2016 that affirms there is a growing market for the topic areas the subcommittee has chosen. We just submitted a Development Grant proposal for $65k to the CSU Commission on the Extended University to provide additional funding to support the development of the program. If we successfully receive that funding, we plan to develop the degree proposal over the summer to submit for the approval process by the beginning of Fall 2019. The timeline may be delayed if the funding for development stipends is not awarded.

3. Elevate CIS Concentration to B.A. Degree

A longer-term goal for the CS program is to address the calculus vs pre-calculus concentration issues by elevating the pre-calculus-based Computer Information Systems (CIS) concentration to its own B.A. degree. This split was recommended by the external evaluator for the previous CS program review, as noted in Appendix E, but was not pursued during the current program review period due to budgetary concerns and a focus on launching the engineering programs.

There will be several benefits to this: delineate the calculus-based vs pre-calculus based programs for our constituents, address the pedagogy concerns of teaching mathematically-intensive CMPS courses to students with a mixed level of mathematical maturity, provide additional articulation options for California community college students, enable the calculus-based program to apply for ABET accreditation, and align with similar splits of programs at other universities.

Currently, local employers must ask the student about which concentration they follow, or review the mathematics courses on their transcripts, to know if a CS student is in a calculus-based vs pre-calculus-based concentration. Several employers have contacted the department asking that targeted recruitment for a position only go out to students with a calculus background, particularly for data analytic jobs for the local energy companies. Other employers are recruiting for system/network/database administrator or web/mobile developer positions that would be better suited for the CIS concentration. Additionally, employers from outside of the region may not realize that the CIS concentration is pre-calculus-based since they are not familiar with our program. Elevating CIS to its own degree would clearly delineate the programs in the minds of our constituents.

As noted in the Self Study, there has also been a long-standing pedagogy concern about teaching mathematically-intensive CMPS courses to students with calculus-based and pre-calculus-based backgrounds. The CIS students as a whole struggle with the mathematical content of these courses. On the other hand, if a faculty member teaches the course purely as an applied course with only a focus on real-world applications, our calculus-based students do not receive the same level of knowledge as they would have received at other institutions that are purely calculus-based. In the past, when an upper-division CMPS course would only have half of the seats taken, it would have been too resource-intensive to split these courses into a calculus-based course for the Traditional and Information Security students and an applied course for the CIS students. Now that these courses are waitlisting in the first or second week of registration, there is sufficient student demand to justify splitting the courses. This would cause sufficient differences in the set of core courses to also justify splitting the degree programs.

This would also enable us to offer new articulation options for California community college students. We do not currently allow the C-ID.net ITIS course descriptors to transfer for CMPS course credit because they are primarily non-calculus-based. Some of the ITIS course descriptors would be better suited for an MIS program (Business-focused) rather than a CIS program, but there are some which could be considered for lower-division elective credit within a CIS degree program.

Elevating the CIS concentration to its own degree program will also be necessary to eventually pursue ABET accreditation for the CS program. All pathways to an ABET-accredited CS program must be calculus-based, so we do not meet the ABET curriculum requirements currently. If CIS is elevated to its own B.A. degree, we would need to graduate all remaining CIS concentration students within the CS program or have them switch to the B.A. in CIS before pursuing ABET accreditation. This means we would have to wait several years after the creation of the B.A. degree before becoming eligible for ABET accreditation, which will likely take us to the next program review cycle before that point is reached.

Within the CSU, there are also several campuses that have separated CIS to their own programs: Chico, Los Angeles, and San Bernardino (combined with their Information Technology degree). At Chico, the CIS program is a stand-alone degree in the CS Department with a lower level of mathematics required. Chico's CIS program uses several CS courses and also has several courses for the CIS program, similar to our envisioned design. At Los Angeles and San Bernardino, the CIS programs are within the Business area instead of the CS area, so they are not similar to our programs.

The budgetary implications of elevating the CIS concentration to its own B.A. program primarily relate to the need to offer two course pathways for multiple upper-division courses: a calculus-based sequence (CMPS prefix) and an applied, algebra-based, sequence (likely under a CIS prefix). When the CS program was smaller, we only offered one section of these courses every year, so this was a severe budgetary constraint. However, in the past two academic years, we have explored offering multiple sections and/or large lectures with multiple lab sections. This was done for all upper-division core CMPS courses except the two courses added under the semester catalog (CMPS 3140 and 3640). To meet the current upper-division student demand, we would need to offer three sections of each course in the next academic year. About one-third of the CS students currently have the CIS concentration declared and 43% of our degrees awarded since the last program review were for CIS students. So, CIS demand would be equivalent to about one section of each of the courses. If we are already planning to offer three sections, splitting one of those sections off into an applied course for just the CIS students would not have severe budgetary implications.

4. NSA/DHS Center of Academic Excellence in Cyber Defense for Information Security Concentration

The development of the Information Security concentration was funded by an NSF capacity-building grant for the NSA/DHS Centers of Academic Excellence (CAE) in cybersecurity, currently called the CAE in Cyber Defense (CAE-CD). There are several benefits to receiving the CAE-CD designation. While the CAE-CD program is co-sponsored by the NSA and DHS, it is nationally recognized and supported by multiple federal agencies. Universities that receive the CAE-CD designation are eligible for additional funding sources ranging from K-12 outreach ("GenCyber" program co-funded by NSA and NSF) to scholarships for undergraduate and graduate students ("Scholarship for Service" program funded by NSF). Research funding related to cybersecurity can also be easier to obtain when a university has been recognized as a CAE.

Currently, the following CSU campuses have received the CAE-CD designation for four-year programs: Cal Poly Pomona, Sacramento, San Bernardino, and San Jose. There are also three California community colleges with the two-year designation, Coastline Community College, Cypress College, and Long Beach City College, which could provide additional articulation partners beyond the Kern County region. At the graduate level, UC Davis and UC Irvine carry the research designation for graduate programs.

Receiving designation as a CAE-CD requires a curriculum in compliance with the Knowledge Units, as outlined in Appendix F, Section C. The university must also demonstrate outreach, collaboration and multi-disciplinary faculty, and campus support for the designation. CSUB faculty have offered cybersecurity-related REVS-UP summer outreach sessions and the Information Security concentration is interdisciplinary through its Global Intelligence and National Security cognate courses. The department has also been in preliminary discussions with ITS about the implications of such a designation, which included attending the annual colloquium for CAE-CD two years ago so Faust Gorham and selected ITS staff members could learn more about the program.

Since one of the focus areas of the Master's program will be in cybersecurity, waiting to seek CAE-CD designation until after the Master's program is established would make sense. The NSF Scholarship for Service grant would be a high-priority funding source to pursue after receiving the CAE-CD designation, as it would provide scholarships for both undergraduate and graduate students in our programs. The GenCyber program would also provide funding to supplement existing K-12 outreach, such as hosting teacher workshops to train them as teacher mentors for the CyberPatriot cybersecurity competition for middle school and high school students.

B. Changes to the Curriculum

1. Changes in Response to Assessment and Updated International Standards for Program

We do not anticipate any major curricular changes due to international standard changes. The quarter-to-semester conversion provided a timely opportunity to align the semester CS curriculum to the new CS 2013 Body of Knowledge and to support the California CS ADT for transfer students. We will continue to monitor the conversations about establishing ACM and ABET curricular standards for cybersecurity programs, which may require minor changes to the CS-Information Security concentration.

Most of the changes made to the CS side of the department for the 2018-20 catalog were due to the Chancellor's Executive Order that eliminated mathematics remediation. This changed the definition of "pre-calculus ready", which had previously been a prerequisite for CMPS 2010 Programming I. CMPS 2010 now requires co-enrollment in a pre-calculus or calculus course (or prior completion of such a course). We also added completion of a pre-calculus or calculus course as a prerequisite to CMPS 2020 and 2240, as these courses follow CMPS 2010. For the CIS concentration, the MATH 1209 or 2200 cognate was changed to just MATH 2200, as MATH 1209 was weakened to comply with the executive order while MATH 2200 is still at an appropriate level for our expectations.

With respects to assessment, the department has already implemented plans to address most of the assessment deficiencies discussed in the Self Study. We will continue to monitor the Major Field Test results to see if the Programming area ceases its decline and if the Theory area continues to improve after these changes. We will also be monitoring the new course-level assessment schedule, which is planned to be implemented in Spring 2019, and we will fine-tune the schedule as needed.

The assessment also showed a lag in mathematical maturity for Computer Information Systems students. As discussed in the last section, one program goal is to split the mathematically intensive courses into a calculus-based course for the Traditional and Information Security students and an algebra-based course for the Computer Information Systems students. This will allow faculty to focus on more mathematical theory and background for the calculus-based concentrations without disadvantaging the CIS students. The algebra-based courses will focus more on the application of the mathematical concepts to real-world problems and will not require as much mathematical maturity.

2. Changes Built on Program's Strengths

As noted in the Self Study, one of our program strengths is the systems area of computer science. We have added the course CMPS 3640 Distributed and Parallel Computation under semesters, which is a new systems core area in the CS 2013 Body of Knowledge. This course discusses the theoretical foundations of cloud computing and GPU computing, which are used extensively in research and industry.

Undergraduate research is also a strength of the CS program. Undergraduate research is a proven high-impact practice that builds skills and keeps students engaged in their degree programs. Undergraduate research students gain meaningful hands-on experience through research projects that prepares them for productive careers. We added the course CMPS 4800 Undergraduate Research under semesters as an elective option for CS-Traditional and CIS students.

3. Quarter-to-Semester Conversion

As previously discussed, extensive work was done during the Q2S process to ensure that the semester curriculum complied with all curricular constraints placed upon it. Similar care was taken with the Q2S transition plans for each student who started under the quarter-system. For example, CS-Traditional students were previously required to take ECE/CMPS 320, but this course was made more engineering-specific under semesters. Given this change, the department allowed CS-Traditional students to take one of ECE 3200, CMPS 3140, or CMPS 3640 under semesters to meet the ECE/CMPS 320 requirement.

Q2S transition plans, 2013-15 catalog checklists with both quarter-system and semester-system course numbers, and detailed notes on the individual course Q2S transitions were posted on the department website so students could access the information during the transition. This information was also shared with the staff advisors at the NSME Student Center so they could develop each student's individual academic plan (IAP) for the transition.

C. Changes to Department Usage of Resources

1. Current Program Offerings

Our recommendations for the CS programs were previously discussed in Section A. Program Goals for the Next Seven Years.

2. Course Scheduling and Capacities

With respects to course assignment, some courses are highly specialized and faculty members are assigned to teach those courses based on their primary and secondary specialty areas. Every faculty member submits a list of courses they are qualified to teach and a list of courses they are not qualified to teach to the department chair to facilitate course scheduling. Faculty members can also indicate courses that they would prefer to teach and courses that they would prefer not to teach, even if they are qualified to teach it. Every CMPS course has at least two faculty members who could teach that course, even if is not a course that they would prefer to teach.

Scheduling of courses depends upon student demand and on department budget. All lower-division core CMPS courses (CMPS 2010, 2020, 2120, and 2240) are offered in both Fall and Spring semesters. Multiple sections of CMPS 2010 and 2020 are offered each semester, based on anticipated demand for the courses. If the offered sections are waitlisted, additional sections may be added depending upon how much budget is available to hire a part-time lecturer to teach the section.

The department has offered least three sections of CMPS 2120 and 2240 each year since the semester conversion. We plan to reduce the number of sections of CMPS 2240 offered in the future, as that course is no longer a cognate course for the ECE students. Student demand for that course has dropped as more of the quarter-system ECE students complete their lower-division work.

All upper-division core CMPS courses are offered at least once per year in their "guaranteed" term on the two-year rotation of courses. Additional sections may be added in the "off-schedule" semester if the waitlists are high enough and faculty workload can be manipulated to free-up a faculty member to teach the new sections. In 2017/18, most core upper-division courses were taught as a large lecture with multiple labs in a single semester, which caused poor student outcomes in the courses due to the large-lecture format and if a student failed the course, they had to wait a full year to retake the course, which impacted time to graduation. In the 2018/19 academic year, most core CMPS courses are offered every semester and are still waitlisting within the first two weeks of registration.

Several faculty members plan to teach upper-division core CMPS classes in Summer 2019 to help address this unmet demand. The department is also planning to have two sections in the "guaranteed" term and one section in the "off-schedule" term for the courses with very large waitlists. This plan depends on the successful completion of the two tenure-track searches.

Core upper-division courses for a single concentration (CMPS 3140, 3390, 3480, 3640, and 3680) are only offered once a year. Most elective courses are offered on a two-year rotation. Some high-demand elective courses such as CMPS 2650 Linux Environment and Administration are offered on an annual basis. Electives may be cancelled if they do not have sufficient enrollments and if the students signed up for the elective can be given an alternative schedule that does not impact their time to graduation.

Course capacities for most CMPS courses are set at 35, as that is the number of computers in the department's three computer labs. The capacity for CMPS 1200, our service course, depends on the computer lab assigned to the course. The Senior Project sequence, CMPS 4910 and 4928, is capped at 25 students, with two sections offered for each course to meet student demand. This cap is due to the high level of faculty supervision needed for the projects. CS tenured and tenure-track faculty members rotate responsibility for teaching Senior Project.

3. Teaching Loads and Assigned/Release Time

Faculty members currently receive release time from new faculty release time, grant release time, service that comes with release time, campus release time programs (such as RCU), and NSME's release time policy for supervision of the undergraduate research course (CMPS 4800 and ECE 4800). NSME's release time policy for undergraduate research supervision gives the standard individual study rate of 1/3 WTU per student, up to a maximum of 3 WTU in an academic year. Under the NSME policy, faculty members are responsible for asking the chair for this release time during the Spring semester, when teaching schedules for the upcoming academic year are being developed.

4. External Funding and Faculty Professional Development

CS faculty members have received funding from a variety of national-level sources, primarily the U.S. Department of Education, National Science Foundation, and Department of Defense. Faculty members have also received grants from state-level sources, such as the Central Valley Grape Authority, and from the Chancellor's Office.

Department faculty members are encouraged to make use of the professional development funds available through the Provost's Office and Faculty Teaching and Learning Center to support their travel to conferences and presentations. The NSME Dean's Office has identified additional funding that can be used for faculty professional development for tenured and tenure-track faculty.

The department uses the department share of indirect funds from existing grants to support both student and faculty travel for research presentations. Student researchers traveling to present are also supported through new faculty start-up funds, grant funding, and campus travel funding for student researchers such as TSSR.

5. Advising and Support Services

Advising and support services for students is a collaboration between department faculty members and the staff advisors at the NSME Student Center. Currently, staff advisors handle freshman advising and intake advising for transfer students, as well as questions on general education, academic petitions, and campus programs. Faculty advisors handle major and career advising for all remaining students.

The department makes a strong effort to remain in communication with the staff advisors. As faculty identify weaknesses, changes are suggested to the staff advisors. For example, transfer students are having difficulty adjusting to CSUB when they just have intake advising with their staff advisor, as they may not have had previous exposure to the Linux operating system used by the department. The department has requested that transfer students be sent over to the department after their intake advising appointment so that they can be introduced to the Linux OS and they can work through the tutorials posted on the department website before classes begin.

Advising effectiveness is also affected by the student-faculty ratio. Only tenured and tenure-track faculty members advise students, based on recommendations from the prior program review. During the program review period, the number of faculty members advising CS students has varied greatly depending on the year. We had several unexpected retirements occur during this time frame. There was one year where only Dr. Danforth and Dr. Wang were available to advise over 200 CS students. As of the 2018/19 academic year, CS students are advised by Dr. Bianchi, Dr. Cruz, Dr. Danforth, and Dr. Lei. Since he is FERPing, Dr. Wang no longer advises students.

6. Allocation of Existing Resources

The department already makes very efficient use of its resources. As noted in the Self Study, the budget and full-time equivalent faculty numbers for the CS side of the department have barely grown during the program review period, despite the massive growth in the number of CS majors. This has caused some growing pains, primarily the waitlist issue for upper-division core CMPS courses and the student-faculty ratios for advising. However, the two tenure-track CS lines that we are searching for in 2018/19 will alleviate these issues. The new hires will also shore-up weak areas on the CS side of the department, which are primarily software engineering, operating systems, and networking.

The department has also created a space plan to maximize the efficient use of department space as part of the overall NSME space planning effort. To take pressure off the centralized classroom availability, the CS computer labs are used as much as possible for CMPS lectures and labs and are also used for lectures for some ECE courses. The department-controlled space has been able to meet the growing student demand during the program review period. However, CS computer labs are at nearly 100% utilization in 2018/19, so some courses have had to request campus classrooms for the lecture sections.

Our space plan also considers reallocating spaces to better reflect the needs of the department. For example, prior to 2018/19, Sci. III 328 was a low-utilized teaching lab. As a consequence of department space planning discussions, the lab was converted to a research lab shared by two CS faculty and one ECE faculty. Consolidating three faculty members into that one lab also freed up space in another shared lab for use by the ECE tenure-track hire that began in Fall 2018, Dr. Ehsan Reihani.

D. Request for Additional Resources

The two primary issues facing the CS side of the department over the next seven years are space and faculty numbers. Space, particularly teaching space, is the more immediate concern, as our ongoing faculty searches will meet the current student demand.

Teaching space is one of our immediate concerns. Several CMPS courses are also taught more effectively within a computer lab, so lectures can use the computers for interactive activities, such as coding along with the instructor. As noted on the Spring 2018 Classroom Task Force report, all three CS computer labs (Sci III 240, 311, and 315) were well-above the 55% utilization goal set by the Chancellor's Office (55% of 45 hours/week for lab space). According to the report, the average utilization rates from Fall 2016 to Spring 2018 were 105% for Sci III 315, 95% for Sci III 311, and 76% for Sci III 240. The department estimates the Fall 2018 utilization rates to be 98% for Sci III 315, 111% for Sci III 311, and 89% for Sci III 240. Each section of a CMPS course is about 10-11% utilization (4.5 to 5 hours per week for both lecture and lab), so Sci III 240 was only one section away from full utilization in Fall 2018.

Since we are already heavily utilizing our current teaching space, this limits how many CMPS sections we can add to meet the student demand within our space. Our two options are to start utilizing campus lecture rooms more frequently or to find additional space for another department-controlled computer lab. As mentioned above, some lectures need to be in a computer lab for effective pedagogy, so not all lectures can be moved to campus lecture rooms. On the other hand, if we had another department-controlled computer lab, we could meet existing demand and have some breathing room for future demand.

We would prefer to receive another department-controlled computer lab, such as converting a low-utilized space. Our current scheduling reflects approximately 130 hours per week of classes in the three computer labs. If that schedule was spread out over four computer labs, each room would still have approximately a 72% utilization rate. That would enable us to add approximately 12 more sections of classes before we saturated the utilization of the rooms.

In the short-term, existing research and office space can be creatively utilized. We have sufficient department-controlled offices to house the two tenure-track hires that we are searching for in 2018/19, although this will require all part-time lecturers to share one office, instead of the three offices available to them in 2018/19. If additional faculty are hired in future years, two full-time lecturers will have to share an office to house that new hire within our existing office space. With respects to research space, most CS research is computational, with equipment primarily being compute servers in the department server room or high-end workstations in a research lab. CS tenure-track faculty can share the two existing research labs in the short-term, as long as there are enough computers available for their research students to use.

In the long-term, when the Energy and Engineering Innovation Center (EEIC) is built, we will need the office space in Science III that will be vacated by Physics & Engineering to support both the CS and ECE programs. We will also need space in EEIC to support teaching and research for the ECE side of the department, as noted in last year's ECE Program Review. Some of the current ECE spaces on the third floor of Science III are also good candidates for moving to EEIC. For example, Sci III 309 is a 546 square foot room that can only hold 20 students per lab section. It might be better to move that teaching lab over to a larger space in EEIC and convert Sci III 309 to a research lab.

We also support the funding model proposed in the Classroom Task Force Report to provide a more consistent source of base funding for refreshing highly utilized computer labs on a five-year rotation. With the exception of Sci III 311, which was upgraded through a mix of campus and donor funding, all of the department computer labs have been upgraded through a mix of external grants and corporate donations. NSME and the department have been highly successful in these efforts, but this is not a consistent source of funding for upgrades. With the model proposed in the Classroom Task Force Report, we would only have to fundraise the difference between what the campus provides and what would be needed to meet our computational demands, rather than fundraise for the entire lab upgrade. As noted in the Self Study, this is particularly pressing on the CS side for Sci III 315, as the warranty expires at the end of Spring 2019 and the computers have had a high rate of warranty repair with Dell.

With respects to faculty numbers, while our ongoing searches are sufficient to meet the current student demand and to start the Master's program, there is potential need for more CS faculty in the future to respond to future growth and to address the tenure-track density on the CS side of the department. As shown in Figure 14: Historic Headcount of Computer Science Majors and Projected Future Headcount, the projected number of future majors is highly variable, depending on whether we stabilize at around 300 CS majors or if we continue to grow as we have in the past decade. Our current hiring is just now catching up with the sudden jump in enrollments we experienced three years ago, when we went from 183 majors to 247 majors in one year. If growth continues, we will need to either hire more faculty members or consider impaction status.

As shown in Figure 19: CEE/CS Department Tenure-Track Density by Primary Area of Responsibility for Faculty Members, our tenure-track numbers have also not fully recovered from the retirements we have experienced during the program review period. The two new hires will bring us to 6.5 T/TT CS faculty in 2019/20, when we had 5 T/TT faculty at the time of the last program review. We realize that this is an issue across the campus in a multitude of departments, but the negative implications of teaching twice the number of students with hardly any increase in T/TT faculty members bears repeating. High advising and teaching loads hamper research productivity, impose higher service demands on a small pool of faculty members, and make it difficult to provide students with the level of advising and mentoring that they should receive.