Academic Program Review
MS Computer Science

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APRC Recommendation to Faculty Senate
MS Computer Science

The Academic Program Review Committee (APRC) affirms that the Department of Computer Science has completed program review as per policy, including self-study, external review, internal review, and action plan submission for the MS Computer Science. APRC recommends that the next program review be scheduled for six years from Faculty Senate approval; or, should the College of Engineering and Computer Science decide to schedule a college-wide program review, the next program review will occur at that time.

APRC Chair:

Computer Science (CSc)

Master of Science Degree Program

Self Study

Fall 2022

Sacramento State University Program

Review 2022-23

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Element One: Mission and Context

A. University, college, and academic unit missions

University mission: As California's capital university, we transform lives by preparing students for leadership, service, and success. Sacramento State will be a recognized leader in education, innovation, and engagement.

ECS College mission: Through contemporary curricula, engaging pedagogy, scholarship and applied research, we produce career-ready graduates prepared for a lifetime of professional achievement and intellectual growth.

The mission of the Computer Science Department is to:

1. Be a department of choice for high-quality and innovative undergraduate and graduate degree programs in computer science, software engineering, and computer engineering.
2. Educate a diverse student population.
3. Foster research and professional development activities that enable faculty to maintain currency in their fields, and engage students in research.
4. Provide technological leadership to the University community and the Sacramento region.
5. Provide experiences that reflect state-of-the-art/state-of-the-practice by incorporating new areas and technologies into its academic programs.
6. Strive to serve regional educational needs for professional development and interdisciplinary programs.
7. Participate in the development of new technologies that drive local, regional, and national economies through interaction with industry.

B. Degrees offered, with link to the University Catalog

B.S. in Computer Science

https://catalog.csus.edu/colleges/engineering-computer-science/computer-science/bs-in-computer-science/

M.S. in Computer Science

https://catalog.csus.edu/colleges/engineering-computer-science/computer-science/ms-in-computer-science/

M.S. in Software Engineering

https://catalog.csus.edu/colleges/engineering-computer-science/computer-science/ms-in-software-engineering/

C. Minors offered, with link to the University Catalog

None

D. Service to or from other departments, degree programs, and/or general education

Computer Engineering program: This degree is offered through a joint program sponsored by the Computer Science Department and the Electrical & Electronic Engineering Department. This arrangement has the advantage of support from two strong departments.

E. External educational partnerships

We partner up with local community colleges to transfer students to the department; reach out to local high schools for attracting high school students; collaborate with the computer science department at UC Davis through various research projects; team with San Francisco State, San Jose State, and Sonoma State for the "CSForAll" initiative, which builds a consortium of Northern California CSUs to support the professional development of local K-12 computer science teachers; and train local high school teachers in the areas of Cybersecurity as a certificate granting institution within the National Cybersecurity Teaching Academy (NCTA).

F. Major structural changes in academic unit since last review (new, moved, or discontinued degrees,

concentrations, minors, etc.)

None

Element Two: Learning Outcomes and Assessment

A. List program learning outcomes.

Computer science graduate program PLOs:

1. Master, integrate, and apply advanced knowledge and skills to solve complex computer science problems. (Disciplinary Knowledge)
2. Communicate research findings, original work, technical and non-technical support materials in writing and via oral presentation to a variety of audiences. (Communication)
3. Demonstrate the ability to be creative and analytical, and to contribute to the field of computer science. (Critical Thinking/ Analysis)
4. Demonstrate the ability to obtain, assess, and analyze developments and advancements in computer science. (Information Literacy)
5. Adhere to ethical standards of the profession when conducting academic and professional activities. (Professionalism)
6. Apply intercultural and/or global perspectives to solve problems, inform research, and make contributions to the field. (Intercultural/ Global Perspectives)

B. Summary of data for each learning outcome.

The department assesses the program learning outcomes on a yearly basis. We have taken two different approaches to the assessment. Earlier, we chose to assess individual courses or events such as CSC 295, Graduate Symposium whose assessment results and analysis can be found in the previous annual assessment reports. While each of these courses or events meets some of the learning outcomes, there are several drawbacks in this approach:

1. None of the assessed subjects meet all the learning outcomes.
2. The assessment doesn't close the loop. While the assessment data indicated the assessed PLOs were achieved, the quality discrepancy among culminating experiences and the consequent graduation delay remained significant.

To ensure the program learning outcomes and student success, the department changed to assess culminating experiences (MS projects and theses) by following a closed-loop approach. Starting from Fall 2021, the department has adopted a new process for culminating experience assessment that aims for both assessment of the program and quality control of MS projects/theses. Compared to the previous approach, it has the following advantages:

1. Culminating experiences meet all the learning outcomes.
2. Mapped into the learning outcomes, a rubric is created for the assessment of MS projects and theses respectively.

The rubrics are used to fill the gap between assessment and quality control of culminating experiences. Firstly, the rubric sets the requirements for the MS projects/theses to meet—students and their supervisors use the rubric to gauge the quality and substantiality of their projects/theses; Secondly, the assessment results provide timely feedback to address issues and improve quality for both current and

future projects/theses, which increases the chance for the timely completion of MS projects/theses. Table 1 shows the mapping from the MS project rubric criteria to the program learning outcomes while Table 2 shows the mapping from the MS thesis rubric criteria to the program learning outcomes.

Table 1. The Mapping from MS Project Rubric Criteria to Learning Outcomes

Outcomes **Criteria**	**PLO 1**	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**
1. Problem Definition: Clearly identified the problem and provided a coherent and compelling justification of the problem of study.	X	X	X			
2. Literature and/or Related Work: Demonstrated sound knowledge of literature in the area, and of prior work related to the problem of study.		X		X		
3. Impact: Provided a viable solution to the problem of study. Clearly identified the technical contribution of the study.			X			X
4. Design and Implement: Realized an original solution that meets the scope and requirements of the project; Demonstrated a sufficient amount of system design and coding.	X		X			
5. Analysis: Analyzed the work results through mathematical modeling, simulation, performance measurement, or other empirical or analytic methods.			X			
6. Overall Quality of The project:	X	X	X	X	X	X

Table 2. The Mapping from MS Thesis Rubric Criteria to Learning Outcomes

Outcomes **Criteria**	**PLO 1**	**PLO 2**	**PLO 3**	**PLO 4**	**PLO 5**	**PLO 6**
1. Problem Definition: Clearly identified the problem and provided a coherent and compelling justification of the problem of study.	X	X	X			
2. Literature and/or Related Work: Demonstrated sound knowledge of literature in the area, and of prior work related to the problem of study.		X		X		
3. Impact: Demonstrated the value of research to advancing knowledge within the area of study.			X			X
4. Design and Implement (if applicable): Realized an original solution that meets the scope and requirements of a thesis; Demonstrated a sufficient amount of system design and coding.	X		X			
5. Analysis: Analyzed the research results through mathematical modeling, simulation, performance measurement, or other empirical or analytic methods.			X			
6. Overall Quality of The Thesis:	X	X	X	X	X	X

Table 3 reports the numbers of completed and postponed MS projects/theses in AY 2021-22. A faculty supervisor postpones completion of an MS project/thesis to the next semester if they believe the project/thesis needs more work to meet the requirements set by the rubric.

Table 3. The Numbers of Completed and postponed MS projects/theses in AY 2022-23

	Completed	Delayed
Fall 2021	35	2
Spring 2022	20	2

Each completed MS project/thesis was assessed by a Culminating Experience Committee using the rubric. The data reported in the following is based on 100 evaluations collected. Figure 1 illustrates the assessment results for PLO 1 in AY 2022-23. Among the 55 completed projects, 96% meet or exceed target on Criterion 1, Problem Definition while 93% on Criterion 4, Design and Implementation. On average, 94 % meet or exceed target on PLO 1.

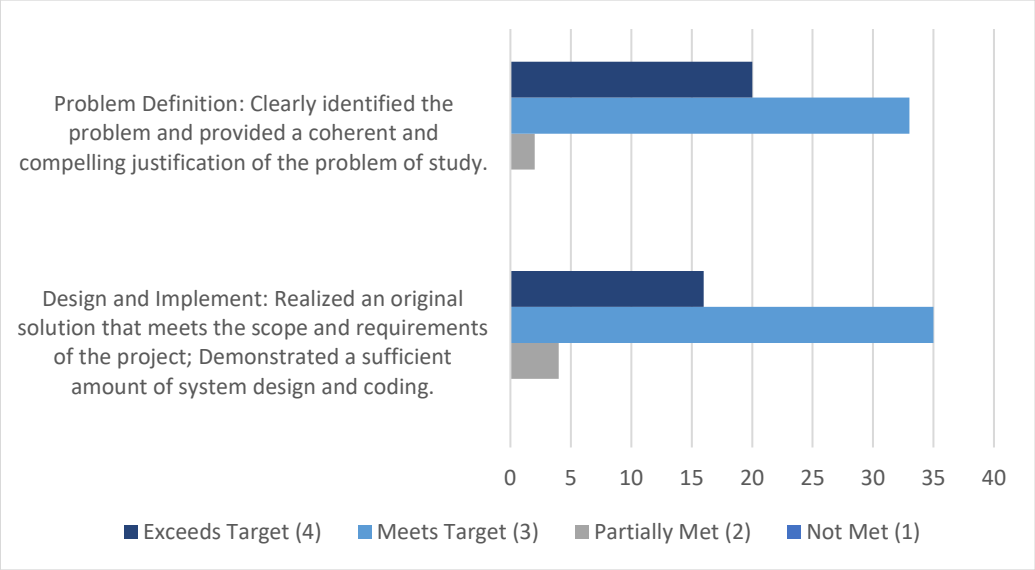


Figure 1. Assessment Data for PLO 1

Figure 2 summarizes the assessment results for PLO 2 in AY 2022-23. 96% of the completed projects meet or exceed target on Criterion 1, Problem Definition while 98% on Criterion 2, Literature and/or Related Work. On average, 97 % meet or exceed target on PLO 2.

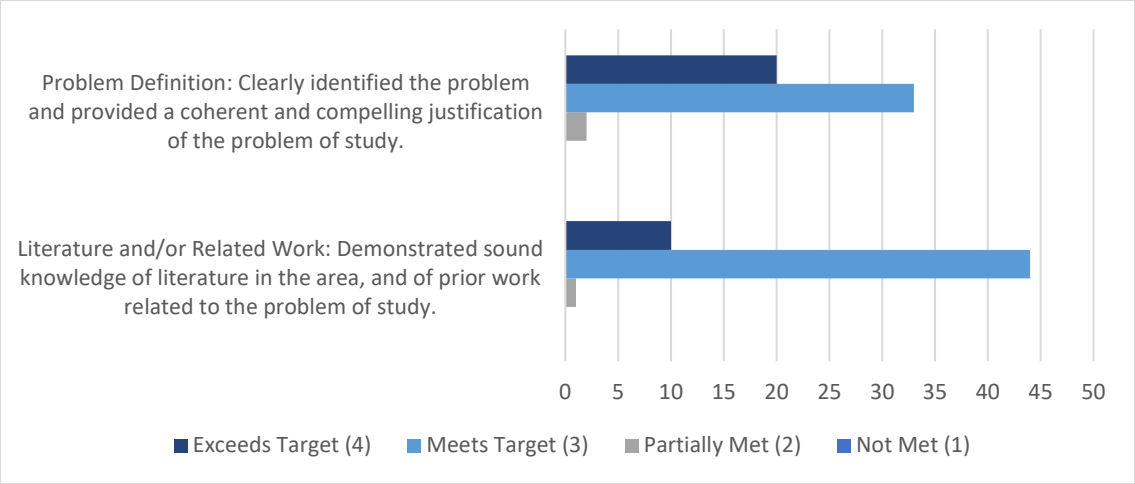


Figure 2. Assessment Data for PLO 2

Figure 3 shows the assessment results for PLO 3 in AY 2022-23. 96% of the completed projects meet or exceed target on Criterion 1, Problem Definition; 96% on Criterion 3, Impact; 93% on Criterion 4, Design and Implementation; and 94% on Criterion 5, Analysis. On average, 95% of the assessed projects meet or exceed target on PLO 3.

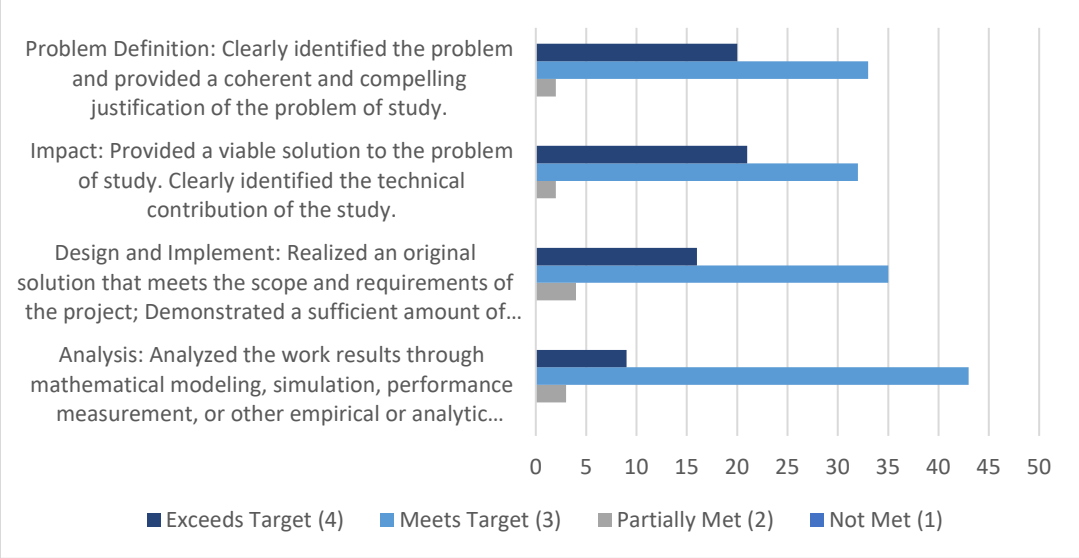


Figure 3. Assessment Data for PLO 3

Figure 4 presents the assessment results for PLO 4 in AY 2022-23. 98% of the completed projects meet or exceed target on Criterion 2, Literature and/or Related Work that is mapped to PLO 4.

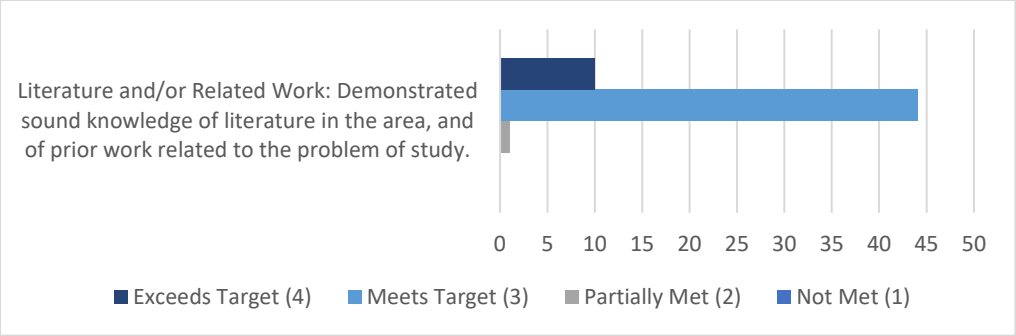


Figure 4. Assessment Data for PLO 4

PLO 5, professionalism is assessed in criterion 6, overall quality of the project/thesis. As shown in Figure 5, 98% of the completed projects meet or exceed on target on PLO 5—adhere to ethical standards of the profession when conducting academic and professional activities.

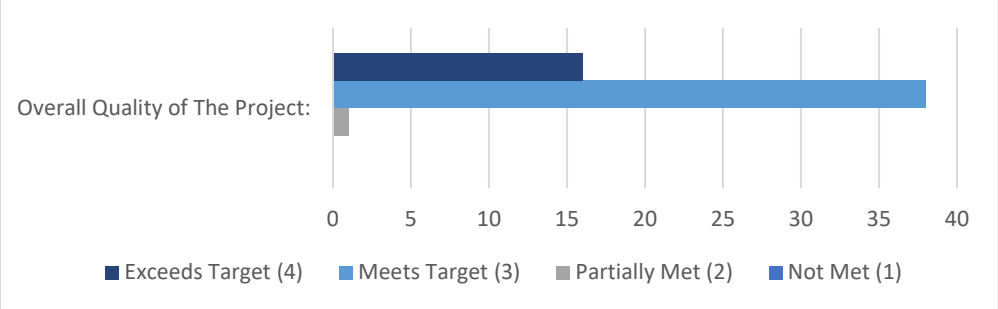


Figure 5. Assessment Data for PLO 5

Figure 6 shows the assessment results for PLO 6 in AY 2022-23. 96% of the completed projects meet or exceed on target on PLO 6—apply intercultural and/or global perspectives to solve problems, inform research, and make contributions to the field.

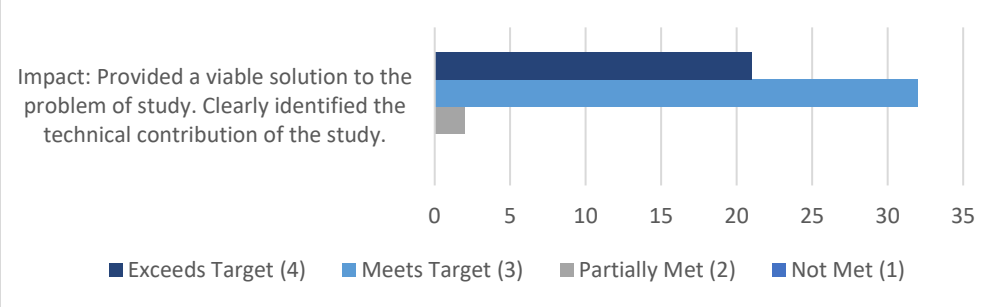


Figure 6. Assessment Data for PLO 6

In summary, the data indicates the effectiveness of the assessment. Not only does it assess each learning outcome, but also it closes the loop and enables project/thesis committees to proactively help students improve the quality and meet the requirements of MS projects/theses. As shown Figure 7, 91% of the projects in AY 2021-22 met the requirements, 7% delayed, and 2% failed. As illustrated in Figure 8, each learning outcome is met at a satisfactory level.

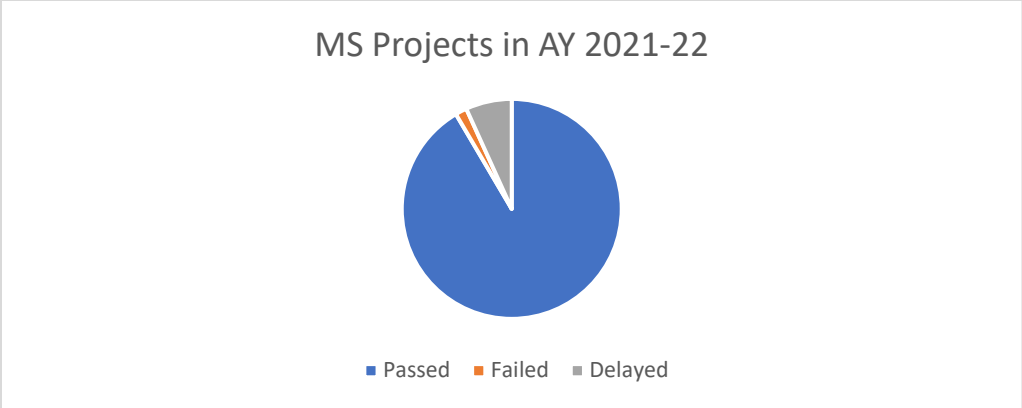


Figure 7. MS Projects in AY 2021-22

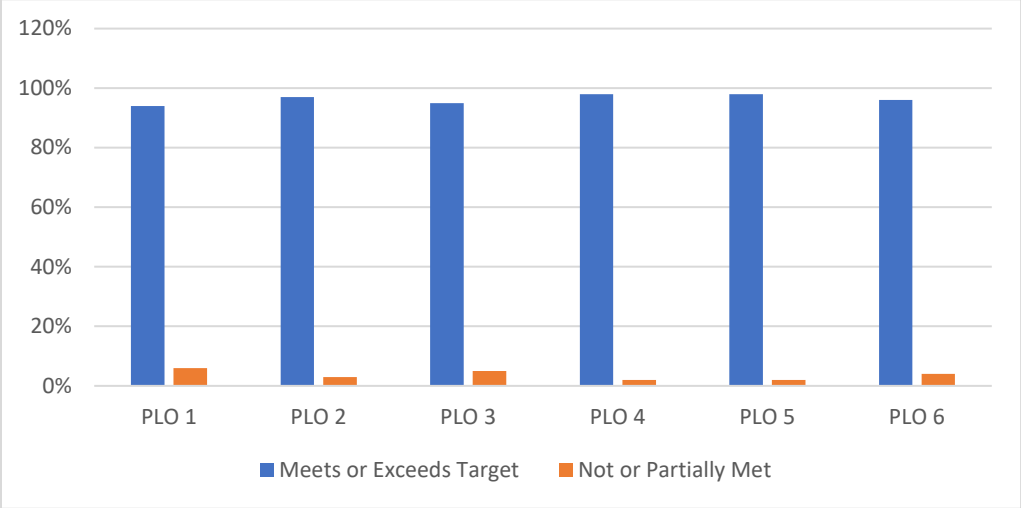


Figure 8. Passing Rate for Each Learning Outcome

C. Analysis for each learning outcome, including how to maintain success and improve learning

- Learning Outcome 1: Master, integrate, and apply advanced knowledge and skills to solve complex computer science problems (Disciplinary Knowledge). It includes the following indicators:
    - Apply advanced knowledge of mathematics, algorithmic principles, computing theory, and principles of computing systems in the modeling and design of computer-based systems
    - Apply hardware design or software development process that includes requirements, design, development, verification and validation.
    - Apply current technology and best practices in the development of computer-based systems of varying complexity.

  This PLO may be assessed using the required and/or elective courses, corresponding to the seven areas of specialization in our graduate degree program. Students are required to select at least three areas within the program.

As explained in Section B, we assessed this PLO using CSC 500/502, Master's Thesis/Project in AY 2022-23. In each of recent years, the completed MS projects/theses cover six out of the seven areas in the graduate program: *Database Management Systems, Information Assurance and Security, Intelligent Systems, Networks and Communications, Software Engineering, and System Software.* The only uncovered area is *Computer Architecture/Computer Engineering* which is hardware-related and computer science students don't normally undertake in their culminating experiences. In addition, MS projects/theses require the fundamentals covered by the required courses. Logically, the assessment of this PLO using CSC 500/502 also provides a meaningful indicator for at least one elective course in each of the six areas as well as the required courses.

As described in Section B, 94 % of the completed MS projects meet or exceed target on this PLO. The reason for the high passing rate, we believe, is largely accredited to a well-designed rubric that fills the gap between assessment and quality control of MS projects/theses. Firstly, the rubric sets the requirements for the MS projects/theses to meet—students and their supervisors use the rubric to gauge the quality and substantiality of their projects/theses—the projects failing to meet the requirements are typically delayed until the requirements are satisfied; Secondly, the rubric-based evaluation results provide timely feedback to address issues and improve quality for both current and future projects/theses, which increases the chance for the timely completion of MS projects/theses. For example, if a project fails to meet the target on any of the criteria related to this PLO, the student is provided with specific suggestions for improvement—the project, if/after properly addressing the issues, can be approved—and the project evaluation is updated accordingly using the same rubric.

- Learning Outcome 2: Communicate research findings, original work, technical and non-technical support materials in writing and via oral presentation to a variety of audiences (Communication). It includes the following indicators:
    - Use proper structure, syntax, and organization.
    - Communicate effectively technical content.
    - Deliver oral presentations effectively.

  This PLO may be assessed in the culminating experience (CSc500 and Csc502) and/or the required core courses (CSc200 and CSs 209)

  CSC 200 is a newly created GWI course and has not been used for the assessment purpose. Compared to CSC 209, CSC 500/502 is a much better tool to assess this PLO because the requirements of communication are much higher and comprehensive. Using the MS project/thesis rubric, we assess both oral and written communications. As presented in Section B, 97 % of the completed MS projects meet or exceed target on this PLO. Due to the same reason described in Learning Outcome 1, we observe an even higher passing rate for this PLO. Another probable reason for the high passing rate is that faculty members pay attention to not only technical aspects of the projects/theses but also communication.

- Learning Outcome 3: Demonstrate the ability to be creative and analytical, and to contribute to the field of computer science (Critical Thinking/Analysis). It includes the following indicator:
    - Create novel ideas, algorithms, and/or theoretical solutions; or develop new techniques and/or innovative implementations for a new or existing problem.

  This PLO may be assessed using the required and/or elective courses, corresponding to the seven areas of specialization in our graduate degree program. Students are required to select at least three areas within the program.

  As learning outcome 1, we assessed this PLO using CSC 500/502, Master's Thesis/Project in AY 2022-23. Among the completed MS projects, 95% of them meet or exceed target on this PLO. While the passing rate remains high, a closer look at the different criteria related to this PLO reveals that the most technical components of an MS project/thesis, i.e., design and implementation, and analysis are most challenging to the students.

- Learning Outcome 4: Demonstrate the ability to obtain, assess, and analyze developments and advancements in computer science (Information Literacy). It includes the following indicators:
    - Perform a thorough study and evaluation of related work.
    - Evaluate the current methodologies and state of the art technologies.

  This PLO may be assessed using the required and/or elective courses, corresponding to the seven areas of specialization in our graduate degree program. Students are required to select at least three areas within the program.

  Compared to other courses, CSC 500/502, Master's Thesis/Project is clearly the best to assess this PLO. As shown in Section B, students perform very well in the criterion—98% of the completed projects meet or exceed target on this PLO.

- Learning Outcome 5: Adhere to ethical standards of the profession when conducting academic and professional activities (Professionalism). It includes the following indicator:
    - Understand, and abide by, ethical standards when conducting academic and professional activities.

  This PLO may be assessed in the culminating experience (CSc500 and Csc502) and/or the required core courses (CSc200 and CSs 209).

  CSC 200 is a newly created GWI course and has not been used for the assessment purpose. Compared to CSC 209, CSC 500/502 is a much better tool to assess this PLO because the faculty supervisor's reputation and professionalism are at stake should an MS project/thesis not adhere to ethical standards. It is in the best interest of a supervisor to make sure their students to abide by ethical standards in each aspect and throughout the entire course of the culminating experience. As a result, 98 % of the completed MS projects meet or exceed target on this PLO.

- Learning Outcome 6: Apply intercultural and/or global perspectives to solve problems, inform research, and make contributions to the field (Intercultural/Global Perspectives). It includes the following indicator:
    - Understand the implication of his/her professional activities.

  This PLO is assessed in the culminating experience (CSc500 and Csc502).

  Students are advised that any technological solutions in the world of the Internet and mobile Internet should be worldwide. For example, a technology developed in the US must interact with different technologies from other parts of the world; A user interface should comply with accessible, usable, and universal design. Research and development in computer science and the resulting technologies may impose both positive and unintended negative impacts on society, such as AI research and social networks.

  In the MS project/thesis rubric, there is a specific criterion mapped into this PLO. As shown in Section B, 96% of the completed projects meet or exceed on target—a vast majority of the students have a global perspective when designing and implementing a technical solution—and they understand the potential impacts their work may impose on the communities.

  In summary, moving forward, we believe that the key to maintain success and improve learning is to continue to fine-tune the rubric while enforcing it when supervising and assessing MS projects/theses.

D. Other relevant data (student surveys, alumni, licensure passage rates, grad school acceptance, internships, etc.) and how the data is used to maintain success and improve learning.

Other relevant data involve the assessment processes using a variety of the following tools:

- Supervisor surveys from industry internships (CSC295)
- Student and alumni surveys reflecting on program learning outcomes.
- Independent assessment by Department's Industry Advisory Board.
- Independent assessment by College's Industry Advisory Board.
- Site visits to local industry.

E. Comprehensive assessment plan

Our PLOs are assessed in two ways: Course Level Assessment and Program Level Assessment.

As part of our current improvement efforts to maximize the student success/outcomes, starting from Fall 2011, all the students are required to complete an oral defense to defend their culminating experience (thesis/project) work. The defense committee will assess the student's individual performance using the newly developed criteria/rubrics to collectively determine the overall grade of the thesis/project. The evaluation data will be collected to assess our PLOs.

- Course Level Assessment (Direct Measurement)

There are six Core courses that are mandatory for all incoming CS graduate students:

- CSC 200 Professional Writing in Computer Science
- CSC 201 Programming Language Principles
- CSC 204 Data Models for Database Management Systems 1
- CSC 205 Computer Systems Structure 1
- CSC 206 Algorithms and Paradigms
- CSC 209 Research Methodology

In addition, since computer science has different fields of specialization, students are required to choose one course from three of the following areas:

- COMPUTER ARCHITECTURE/COMPUTER ENGINEERING
    - CSC 237 Microprocessor Systems Architecture
    - CSC 242 Computer-Aided Systems Design and Verification
    - CSC/EEE 273 Hierarchical Digital Design Methodology
    - CSC/EEE 280 Advanced Computer Architecture

- DATABASE MANAGEMENT SYSTEMS
    - CSC 212 Bioinformatics: Data Integration and Algorithms
    - CSC 244 Database System Design

- INFORMATION ASSURANCE AND SECURITY
    - CSC 250 Computer Security
    - CSC 252 Cryptography Theory and Practice
    - CSC 253 Computer Forensics
    - CSC 254 Network Security

- INTELLIGENT SYSTEMS
    - CSC 214 Knowledge-Based Systems
    - CSC 215 Artificial Intelligence
    - CSC 219 Machine Learning

- NETWORKS AND COMMUNICATIONS
    - CSC 255 Computer Networks
    - CSC 258 Distributed Systems
    - CSC 275 Advanced Data Communication Systems

- SOFTWARE ENGINEERING
    - CSC 230 Software System Engineering
    - CSC 231 Software Engineering Metrics
    - CSC 232 Software Requirements Analysis and Design

- CSC 233 Advanced Software Engineering Project Management
- CSC 234 Software Verification and Validation
- CSC 235 Software Architecture
- CSC 236 Formal Methods in Secure Software Engineering
- CSC 238 Human-Computer Interface Design

- SYSTEM SOFTWARE
  - CSC 239 Advanced Operating Systems Principles and Design
  - CSC 245 Performance Modeling and Evaluation
  - CSC 250 Computer Security
  - CSC 251 Principles of Compiler Design

Table 1 below maps the PLOs to the Core and Elective courses in the CS Graduate Program:

Outcomes / Courses	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
CSC 200		X	X	X	X	
CSC 201	X		X	X		
CSC 204	X		x	X		
CSC 205	X		X	X		
CSC 206	X		X	X		
CSC 209		X	X	X	X	
CSC 212	X		X	X		
CSC 214	X		X	X		
CSC 215	X		X	X		
CSC 219	X		X	X		
CSC 230	X		X	X		
CSC 231	X		X	X		
CSC 232	X		X	X		

CSC 233	X		X	X		
CSC 234	X		X	X		
CSC 235	X		X	X		
CSC 236	X		X	X		
CSC 237	X		X	X		
CSC 238	X		X	X		
CSC 239	X		X	X		
CSC 242	X		X	X		
CSC 244	X		X	X		
CSC 245	X		X	X		
CSC 250	X		X	X	X	
CSC 251	X		X	X		
CSC 252	X		X	X		
CSC 253	X		X	X	X	
CSC 254	X		X	X		
CSC 255	X		X	X		
CSC 258	X		X	X		
CSC 273	X		X	X		
CSC 275	X		X	X		
CSC 280	X		X	X		
CSC 288	X		X	X		
CSC 295	X	X	X	X	X	X

CSC 296R	X		X	X		
CSC 299	X	X	X	X	X	X
CSC 500	X	X	X	X	X	X
CSC 500C	X	X	X	X	X	X
CSC 502	X	X	X	X	X	X
CSC 502C	X	X	X	X	X	X

Table 1: Mapping of Program Learning Outcomes with Program Courses

- Program Level Assessment (Indirect Measurement)

Outcomes assessment at the program level is carried out by using a variety of assessment tools below:

- Supervisor evaluations and surveys from industry internships
- Student and alumni surveys reflecting on program learning outcomes.
- Independent assessment by Department's Industry Advisory Board.
- Independent assessment by College's Industry Advisory Board.
- Site visits to local industry.

Element Three: Student Success

All data presented in this section was obtained from the CSUS ORIEP office

https://www.csus.edu/president/institutional-research-effectiveness-planning/

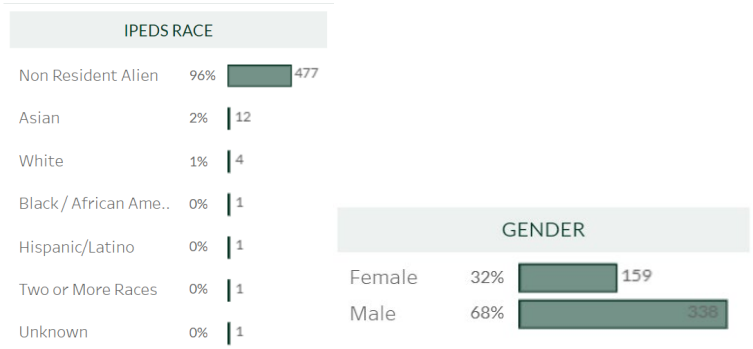
A. Admission data disaggregated by gender and ethnicity for each degree.

- 2016-2021 Admission data for CS M.S. program

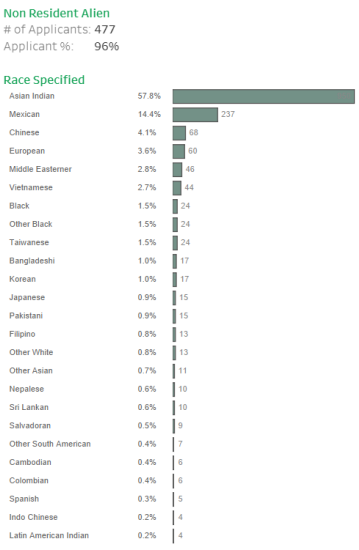
Year	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021
Students admitted	210	296	153	308	566	497

- A typical view of ethnicity and gender distribution is shown below for Fall 2021 CS M.S. admissions:

https://www.csus.edu/president/institutional-research-effectiveness-planning/dashboards/admissions.html



As seen above, a majority of our applicants (96%) are international, and the ethnicity distribution within international applicants is shown below:



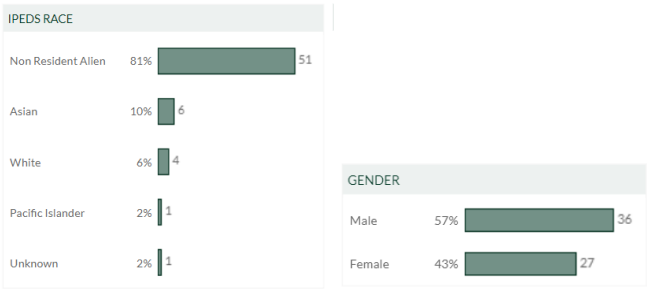
B. Retention data disaggregated by gender and ethnicity for each degree.

- 2016-2021 Enrollment data for CS M.S. program

Year	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021
Students enrolled	55	69	76	103	95	63

- A typical view of ethnicity and gender distribution is shown below for Fall 2021 CS M.S. enrollment:

https://www.csus.edu/president/institutional-research-effectiveness-planning/dashboards/enrollment.html



As seen above, a majority of our enrolled students (81%) are international.

C. 4-year and 6-year graduation data disaggregated by gender and ethnicity for each degree.

- 2016-2021 Graduation data

Year	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Students graduated	44	35	39	49	40

- A typical view of ethnicity and gender distribution is shown below for 2020-2021 CS M.S. graduation data:

https://www.csus.edu/president/institutional-research-effectiveness-planning/dashboards/enrollment.html

D. Analysis on admission, retention, and graduation data, including how to maintain success and improve time to degree, and consider concentrations as needed.

The department has been working diligently on safeguarding the quality of the culminating experience to ensure student success and maximizing the program learning outcomes. The following improvements have been implemented recently.

- Redefine our program PLOs to closely align with the institution-level PLOs.
- Redesign the evaluation of the master culminating experience (CSc 500/502). (1) Reform the evaluation mechanism of the master theses/projects. Starting from Fall 2021, a new oral defense has been required for each master thesis/project. (2) Develop the evaluation rubrics for the new oral defense to evaluate the effectiveness of the culminating experience to gauge the success of our master program and identify potential deficiencies for continuous improvement. (3) Create the student guidelines for master theses/projects on data science, machine learning, and artificial intelligence areas.
- The following courses have been proposed since last review: CSC200, CSC296R,
- The following courses have been significantly refactored since last review: CSC215, CSC244, CSC275,

The following are the improvement tasks that we plan to implement over the next five years to shorten the time to graduation, improve the effectiveness of the program, and increase both the overall number of majors and the diversity of the body of majors.

- Restructuring/refactoring our curriculum to **shorten the graduation time** to attract more local U.S. students to increase both the overall number of majors and the **diversity of the body of majors**. Currently, our students have to spend at least 5-6 semesters to graduate, which makes it difficult for us to compete with other local master programs to attract local students. As a result, more than 96% of our applicants are international students. The department has been working on reforming the graduate curriculum by enabling students to work on their master theses/projects earlier. One major program change we will make is to split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This program innovation will enable students to have the flexibility to start to work on their master theses/projects as early as they become fully classified, which will **accelerate their degree** significantly and allow them to obtain their degrees as fast as within 2 or 3 semesters. This program improvement will pave the way for the potential **bachelor's/master's five-year (4+1) pathways** we plan to offer.

- Refining the admission criteria. We will continue our effort in refining the **admission ranking criteria** to further improve the diversity and inclusion of our admission for matriculating more local and minority students.

- Refining the **evaluation rubrics** for both the program assessment and quality control of the culminating experience (CSc 500/502). Those rubrics will also be evaluated for aligning better with the institution-level PLOs.

- Developing a new course CSC290 (Preparation for Culminating Experience) for accelerated degrees by shortening the time to graduation. Continue the effort on the **new course creation on emerging topics** in Computer Science (such as data science, artificial intelligence, cybersecurity, game development, and software engineering) and the **refactoring of existing course** to ensure student success, maximize the program learning outcomes, and attract more local applicants to increase both the overall number of majors and the diversity of the body of majors.

E. If the program is impacted, summarize data and future impaction plan.

NA

F. Summarize current partnerships in success efforts (Advising, Writing Center, Library Student Success Center, internship sites, etc.) and consider ways to better work together to maintain success and improve time to degree.

We have been collaborating with the ECS college advising center, the university writing center, the library student success center, and a number of internship sites and employers.

Element Four: Developing Resources to Ensure Sustainability

A. List key strategic initiatives for the academic unit, and append any strategic plan. These can be structural, such as new or discontinuations of degrees, concentrations, minors; tied to university strategic initiatives, such as Anchor University; or operational, such as ways to be more inclusive in the academic unit's planning.

Here we outline the specific strategies that we plan on over the next five years to shorten the time to graduation, improve the effectiveness of the program, and increase both the overall number of majors and the diversity of the body of majors.

- Restructuring/refactoring our curriculum to **shorten the graduation time** to attract more local U.S. students to increase both the overall number of majors and the **diversity of the body of majors**. Currently, our students have to spend at least 5-6 semesters to graduate, which makes it difficult for us to compete with other local master programs to attract local students. As a result, more than 96% of our applicants are international students. The department has been working on reforming the graduate curriculum by enabling students to work on their master theses/projects earlier. One major program change we will make is to split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This program innovation will enable students to have the flexibility to start to work on their master theses/projects as early as they become fully classified, which will **accelerate their degree** significantly and allow them to obtain their degrees as fast as within 2 or 3 semesters. This program improvement will pave the way for the potential **bachelor's/master's five-year (4+1) pathways** we plan to offer.

- Refining the admission criteria. We will continue our effort in refining the **admission ranking criteria** to further improve the diversity and inclusion of our admission for matriculating more local and minority students.

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- Developing a new course CSC290 (Preparation for Culminating Experience) for accelerated degrees by shortening the time to graduation. Continue the effort on the **new course creation on emerging topics** in Computer Science (such as data science, artificial intelligence, cybersecurity, game development, and software engineering) and the **refactoring of existing course** to ensure student success, maximize the program learning outcomes, and attract more local applicants to increase both the overall number of majors and the diversity of the body of majors.

B. Summarize hiring needs for the academic unit, and append the multi-year faculty and staff hiring plan.

We are the largest department in the College of Engineering and Computer Science. The department currently has around 1600 undergraduate students and more than 100 graduate students. There is a severe shortage of faculty and part-time instructors at the department. We have essentially lost three tenure/tenure-track faculty members; two FERPed faculty finished their terms; three faculty members retired and started FERPing. With only 13 full-time faculty members including the Chair, Computer Engineering Program Coordinator, and 3 PERPing faculty, it has become extremely challenging to maintain a curriculum to accommodate the ever-increasing number of students. In addition, we are short staffed too. While the department has one ASC and 2 ASA positions, only the ASC position is filled.

To address the issue, we plan to hire three tenure-track faculty members in AY 2022-23 and continue to do so in next few years till we have at least twenty tenure/tenure-track faculty members. We also plan to fill the two ASA positions—we are currently interviewing candidates for the first ASA position.

C. Summarize other major budget concerns (facilities, equipment, student assistants, etc.).

To maintain a quality curriculum for a large student population, the department needs more funding support for student assistants working as graders or teaching assistants. To engage graduate students in quality research, the department also needs funding support for research assistantships.

D. Summarize revenue opportunities (grants, gifts, partnerships, etc.).

Faculty members at the department actively seek research grants both internally and externally. Currently we have three NSF grants, an Intel-funded research project, and a few internal grants. We also partner up with industry for joined research, gifts, or equipment donation.

Element Five: Planning to Maintain Success and Engage in Continuous Improvement

A. Summary of Areas of Concern and Means of Improving

The following are the improvement tasks that we plan to implement over the next five years to shorten the time to graduation, improve the effectiveness of the program, and increase both the overall number of majors and the diversity of the body of majors.

- Restructuring/refactoring our curriculum to **shorten the graduation time** to attract more local U.S. students to increase both the overall number of majors and the **diversity of the body of majors**. Currently, our students have to spend at least 5-6 semesters to graduate, which makes it difficult for us to compete with other local master programs to attract local students. As a result, more than 96% of our applicants are international students. The department has been working on reforming the graduate curriculum by enabling students to work on their master theses/projects earlier. One major program change we will make is to split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This program innovation will enable students to have the flexibility to start to work on their master theses/projects as early as they become fully classified, which will **accelerate their degree** significantly and allow them to obtain their degrees as fast as within 2 or 3 semesters. This program improvement will pave the way for the potential **bachelor's/master's five-year (4+1) pathways** we plan to offer.

- Refining the admission criteria. We will continue our effort in refining the **admission ranking criteria** to further improve the diversity and inclusion of our admission for matriculating more local and minority students.

- Refining the **evaluation rubrics** for both the program assessment and quality control of the culminating experience (CSc 500/502). Those rubrics will also be evaluated for aligning better with the institution-level PLOs.

- Developing a new course CSC290 (Preparation for Culminating Experience) for accelerated degrees by shortening the time to graduation. Continue the effort on the **new course creation on emerging topics** in Computer Science (such as data science, artificial intelligence, cybersecurity, game development, and software engineering) and the **refactoring of existing course** to ensure student success, maximize the program learning outcomes, and attract more local applicants to increase both the overall number of majors and the diversity of the body of majors.

Appendix A: Computer Science Department Strategic Plan

Computer Science MS
Program Strategic Plan

Fall, 2022

The Computer Science Department at California State University, Sacramento commits itself to an ambitious program: sustaining the qualities that have served us and our students so well, while adapting to current challenges and taking on new opportunities. This plan outlines our path.

MISSION STATEMENT

The mission of the Computer Science Department is to:

1. Be a department of choice for high-quality and innovative undergraduate and graduate degree programs in computer science, software engineering, and computer engineering.
2. Educate a diverse student population.
3. Foster research and professional development activities that enable faculty to maintain currency in their fields, and engage students in research.
4. Provide technological leadership to the University community and the Sacramento region.
5. Provide experiences that reflect state-of-the-art/state-of-the-practice by incorporating new areas and technologies into its academic programs.
6. Strive to serve regional educational needs for professional development and interdisciplinary programs.
7. Participate in the development of new technologies that drive local, regional, and national economies through interaction with industry.

Undergraduate Program
Educational Objectives

Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program educational objectives are based on the needs of the program's constituencies. Three to five years after graduation, a graduate of the B.S. in computer science should have:

- Made contributions to the development, maintenance, and support of real-world computing systems.
- Taken initiative and assumed responsibilities as an effective member of project teams.

- Worked independently and functioned effectively in an environment with incomplete information.
- Progressed in the computing field, engaged in professional development, and/or pursued an advanced degree.
- Produced quality technical and non-technical documents and presentations for a variety of audiences.
- Adhered to the ethical standards of the profession and understood the implications of his/her professional activities.

Undergraduate Student Outcomes

Student outcomes describe what students are expected to know and be able to do at the time of graduation. These relate to the knowledge, skills, and behaviors that students acquire as they progress through the program.

At graduation, a B.S. in computer science graduate should be able to:

- Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.
- Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
- Communicate effectively in speech in a variety of professional contexts.
- Communicate effectively in writing in a variety of professional contexts.
- Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
- Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
- Apply computer science theory and software development fundamentals to produce computing-based solutions.

Computer Science Graduate Program PLOs

At graduation, a M.S. in computer science graduate should be able to:

- Master, integrate, and apply advanced knowledge and skills to solve complex computer science problems. (Disciplinary Knowledge)
- Communicate research findings, original work, technical and non-technical support materials in writing and via oral presentation to a variety of audiences. (Communication)
- Demonstrate the ability to be creative and analytical, and to contribute to the field of computer science. (Critical Thinking/ Analysis)
- Demonstrate the ability to obtain, assess, and analyze developments and advancements in computer science. (Information Literacy)
- Adhere to ethical standards of the profession when conducting academic and professional activities. (Professionalism)

- Apply intercultural and/or global perspectives to solve problems, inform research, and make contributions to the field. (Intercultural/ Global Perspectives)

Graduate Program Strategies

Here we outline the specific strategies that we plan on using over the next five years to shorten the time to graduation, improve the effectiveness of the program, and increase both the overall number of majors and the diversity of the body of majors.

- Restructuring/refactoring our curriculum to **shorten the graduation time** to attract more local U.S. students to increase both the overall number of majors and the **diversity of the body of majors**. Currently, our students have to spend at least 5-6 semesters to graduate, which makes it difficult for us to compete with other local master programs to attract local students. As a result, more than 96% of our applicants are international students. The department has been working on reforming the graduate curriculum by enabling students to work on their master theses/projects earlier. One major program change we will make is to split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This program innovation will enable students to have the flexibility to start to work on their master theses/projects as early as they become fully classified, which will **accelerate their degree** significantly and allow them to obtain their degrees as fast as within 2 or 3 semesters. This program improvement will pave the way for the potential **bachelor's/master's five-year (4+1) pathways** we plan to offer.

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- Refining the **evaluation rubrics** for both the program assessment and quality control of the culminating experience (CSc 500/502). Those rubrics will also be evaluated for aligning better with the institution-level PLOs.

- Developing a new course CSC290 (Preparation for Culminating Experience) for accelerated degrees by shortening the time to graduation. Continue the effort on the **new course creation on emerging topics** in Computer Science (such as data science, artificial intelligence, cybersecurity, game development, and software engineering) and the **refactoring of existing course** to ensure student success, maximize the program learning outcomes, and attract more local applicants to increase both the overall number of majors and the diversity of the body of majors.

External Review Report

Academic Unit Name: Department of Computer Science

Degrees: M.S. Computer Science and M.S. Software Engineering

Site Visit Dates: Mon Feb 6, 2023 - Tue Feb 7, 2023

Abbreviations

[MSSE] = comment pertaining to M.S. Software Engineering

[MSCS] = comment pertaining to M.S. Computer Science

[BOTH] = comment pertaining to both programs

Otherwise-unmarked comments can be considered general and pertinent to both programs.

STAGE	DESCRIPTION
Initial	The program is at a preliminary stage in this practice. The program shows the need for additional policies, resources, or practices in order for it to provide the education program to which it is committed or aspires. Insufficient data is available to make determinations.
Emerging	The program partially satisfies the criterion. Some data is available documenting this dimension. The program has many, but not all, of the policies, practices, and resources it needs to provide the educational program to which it is committed or aspires.
Developed	The program satisfies this criterion, with developed policies and practices. The program has the availability of sufficient resources to accomplish its program goals on this dimension. Data demonstrates accomplishment of this criterion.
Highly Developed	The program fully satisfies this criterion. The program may serve as a model and reference for others on campus. The program's practices, policies, and/or its resources contribute to program excellence on this dimension.

ELEMENT ONE: ACADEMIC UNIT'S MISSION AND INSTITUTIONAL CONTEXT	
INQUIRY	**STAGE**
Does the academic unit have a mission statement or statement of program goals that is appropriate?	HD
Are the academic unit's mission and its programs aligned with CSUS and college missions and strategic priorities?	HD
Is the academic unit supportive of the CSUS general education program and/or general graduate learning outcomes?	D
Does the academic unit engage key constituencies and campus partners in academic and strategic planning, including faculty, professional colleagues, current and prospective students, and the community?	I

Does the program have policies and procedures that facilitate articulation with community colleges and/or other external educational partners?	N/A

Comments:

Department has well-developed mission statement and PLOs, aligned with University/College.

Recommendations:

Poll constituencies and campus partners in the form of surveys for IAB, alumni, and graduating seniors.

ELEMENT TWO: LEARNING OUTCOMES AND ASSESSMENT TO MAINTAIN SUCCESS AND ENGAGE IN CONTINUOUS IMPROVEMENT

INQUIRY	STAGE
Does each degree program have appropriate and measurable learning outcomes that reflect current standards in the discipline?	D
Does each course have appropriate and measurable learning outcomes that allow students to achieve program learning outcomes?	D
Are the curriculum and graduation requirements for each degree reflective of current standards in the discipline?	D
Are each degree's curriculum and graduation requirements appropriate for the degree level and do they reflect high expectations of students?	D
Is the assessment loop regularly being closed for each of the degree's program learning outcomes?	D
Is the learning assessment data being used to, per the Element Two heading, maintain success and engage in continuous improvement?	D
Do students feel connected to academic support services (writing, math, tutoring, library, etc.)?	D

Comments:

Both programs help to prepare students to be career ready by training them with hands-on projects, in connection with industry, and teamwork with faculty.

Recommendations:

Consider allowing students to specialize in one subdomain (depth) vs choosing 3 separate courses (breadth).

Consider enriching the Data Science/Machine Learning curriculum to address student and industry demand for this skillset.

ELEMENT THREE: STUDENT SUCCESS AND ASSESSMENT TO MAINTAIN SUCCESS AND ENGAGE IN CONTINUOUS IMPROVEMENT

INQUIRY	STAGE
Does each degree program use aggregated and disaggregated data to understand admission trends and to manage enrollment with an eye to diversity and impaction, or to address program-specific concerns?	D

Does each degree program use aggregated and disaggregated data to consider ways to improve retention?	N/A
Does each degree program use aggregated and disaggregated data to consider ways to improve time to degree or to close graduation gaps?	D
Does the program provide appropriate opportunities for students to participate in curricular-related activities, such as research and creative opportunities, service learning experiences, performances, and internships?	HD
Does the program provide or partner with other entities to provide appropriate co-curricular activities for its students, such as clubs, field trips, lectures, and professional experiences?	N/A
Does the program provide adequate student advising?	E
Do students feel connected to student success support services?	D

Comments:

Student retention does not seem to be an issue at this time, but time-to-degree has been identified as a challenge.

Students are not sure about which breadth courses to take to prepare them for a specific field/domain or project. (Example: which set of courses best prepares students for data science, or for a career in cybersecurity?)

Both programs have a very healthy female student population (> 30%).

Reports identified the imbalance issue of international vs. domestic graduate applicants.

Recommendations:

Develop sample sets of breadth courses which are appropriate for specific subdomains of the discipline.

Coordinate with the Office of Graduate Studies to increase outreach to potential domestic applicants.

ELEMENT FOUR: DEVELOPING RESOURCES TO ENSURE SUSTAINABILITY

INQUIRY	STAGE
Does the program have faculty in sufficient numbers and with appropriate rank, qualification, and diversity to allow students to meet the program learning outcomes and deliver the curriculum for each degree program?	E
Does the program employ professional staff and/or appropriately partner with campus partners (e.g., graduate studies or College of Continuing Education) to support each degree program?	E
Are the program's facilities, including offices, labs, and practice and performance spaces, adequate to support the program?	D
Does the program have access to information resources, technology, and expertise sufficient to deliver its academic offerings and advance the scholarship of its faculty?	E
Does the program seek and receive extramural support at the appropriate level, including grants, gifts, contracts, and alumni funding?	D
Has the program identified other concerns that impact budget and resource planning?	No

Comments:

Several faculty have FERP'd or retired during pandemic, **[MSSE]** including those with Software Engineering expertise.

Recommendations: Hire new faculty in specializations of Data Science/Machine Learning to address student and industry demand for this skillset. **[MSSE]** Hire new full-time or part-time faculty in specialization of Software Engineering to replace faculty lost in past half-decade.

ELEMENT FIVE: PLANNING TO MAINTAIN SUCCESS AND ENGAGE IN CONTINUOUS IMPROVEMENT	
INQUIRY	**STAGE**
Does the academic unit engage in planning activities which identify its academic priorities and their alignment with those of the college and the university?	D
If appropriate, does the program have an advisory board or other links to community members and professionals? Does the program use community professional input for program improvement? Does the program maintain a relationship with its alumni?	E
Does the academic unit have a strategic plan, and other long term plans (5-year hiring, facilities, etc.)?	D
Does the academic unit have regular processes to revise plans and timelines?	E
Do plans include engagement with needed campus partnership and external entities to accomplish goals?	D
Comments: The Department and Dean work with Office of Graduate Studies to perform capacity planning.	
Recommendations: Gather measurable input from industry partners and alumni, and then make use of this in continuous improvement process.	

Commendations

- **[BOTH]** The department has developed a more rigorous rubric with which to score project/thesis defenses vs prior project presentation format. This cumulative experience meets all PLOs of programs.
- **[BOTH]** The department is running both graduate programs with limited resources (faculty/staff).
- **[BOTH]** Both programs help to prepare students to be career ready by training them with hands-on projects, in connection with industry, and teamwork with faculty.
- **[BOTH]** Both programs have a very healthy female student population (> 30%).
- **[BOTH]** University/College IT administrators provide good amount of support for both faculty and student needs.
- **[BOTH]** The department is actively recruiting new faculty to replace faculty lost during past half-decade and to accommodate increased admissions/enrollment in M.S. Computer Science.
- **[MSCS]** Computer Science enrollment capacity is tracked by Dean in coordination with Office of

Graduate Studies.

- **[MSCS]** CSC 209 advertises faculty research areas and methodology.
- **[MSSE]** The department is flexible in helping students graduate on time in the MSSE program with relatively low enrollment.
- **[BOTH]** Several issues have been identified in the self-study report (e.g., international vs. domestic applications) and plans were proposed to address these issues.

Recommendations

Recommendations and Specific Considerations to Improve Learning and Student Success For Each Degree

- **[BOTH]** The department can identify opportunities to strengthen graduate student sense of community, including student engagement activities and events. In the student/alumni interview session, students pointed out that they felt somewhat disconnected, particularly during the pandemic.
- **[BOTH]** The department can shorten Time-to-Degree to attract domestic students. This can be done by creating a blended undergraduate/graduate program (aka 4+1, aka "Accelerated"), which the department has begun exploring. This can also be accomplished by splitting the culminating experience into two separate courses, which will allow students to begin work on their thesis or project as soon as they become fully classified. The department has already begun developing this curriculum proposal.
- **[BOTH]** The department can clearly define and advertise the thesis and project options. Interviewed students have the impression that thesis is only for students seeking PhD degrees and is less practical and more theoretical. These students perceive that thesis may take longer time. Faculty have also supervised project options with productive publications.
- **[MSCS]** The department can pre-identify a set of breadth courses that are suggested for specific project domains
    - Students would find a strict course sequence beneficial…would be able to orient their studies better to align with goals.
- **[BOTH]** The department can advertise faculty expertise on a central web resource for students to help select project/thesis advisor. Students do not presently know the research areas of the department faculty until taking CSC 209. Additional resource page could be added to the department website providing general guidance on how to contact faculty advisors for their thesis/project requests.

Recommendations and Specific Considerations to Develop Resources to Ensure Sustainability:

- **[BOTH]** The department can work with the Office of Graduate Studies to increase outreach to potential domestic applicants. This is anticipated to create a balance in the application pool.
- **[MSSE]** The department can explore resources to revitalize the MS Software Engineering program. Toward this endeavor, the department may consider the use of part-time faculty with industry project management experience to teach some graduate SWE courses. The department may also consider additional pay for remote CSU faculty to teach online sections. Many Software Engineering course sections can be pivoted to hybrid/online modality to attract more working professionals. The department may reshape the PLOs of this program to better distinguish from MSCS program.

- **[MSCS]** The department can recruit faculty in Data Science / Machine Learning. This field is currently in hot demand in the computer industry, and interviewed students expressed a desire to see more such course offerings in the curriculum.

Recommendations and Specific Considerations to Improve Academic Unit Planning:

- **[BOTH]** The department can poll constituencies and campus partners in the form of surveys for IAB, alumni, and graduating seniors. This input should contain quantitative and/or measurable input, including but not limited to Likert agreement questions. The department can then make use of this data in their continuous improvement process.

External Reviewer One Name: Fang Tang Affiliation: Cal Poly Pomona
Signature: _____

External Reviewer Two Name: Adam Kaplan Affiliation: California State University Northridge
Signature: _____

Internal Review Report

Internal Review Report:	Computer Science
College:	College of Engineering & Computer Science
Degree Programs:	**MS in Computer Science**
Internal Reviewers:	Ben Amata, Library Pooria Assadi, College of Business
Date Submitted:	April 4, 2023

I. Context:

The Department of Computer Science submitted a 28-page self-study in fall 2022 that conformed structurally to the self-study requirements in the *Academic Program Review Guide* (referred to as the Guide). It was timely and complete. Overall, it demonstrated sufficient reflection, which sometimes was excellent. However, reflection and analysis were not always distinct making it difficult to articulate commendations and recommendations for each degree and the potential ways forward for one degree that has enrollment and awarding degrees annually. The Department repeated most of the Self-Study information for both degrees, the MS in Computer Science and Software Engineering.

The External Reviewers wrote one report with most of their commendations/recommendations applying to both degrees. In a few instances, they were degree specific. The Internal Reviewers (IRs) will address them in later sections of this report.

The External Reviewers (ERs) are computer science department chairs at their respective universities, Professor Fang Tang at California State Polytechnic University, Pomona and Professor Adam Kaplan at CSU Northridge. Their report was useful and made some valuable commendations/recommendations. The IRs did not know the extent of their knowledge of assessment and found they didn't extensively comment on it. Overall, the IRs found that their report's bullet point approach lacks an adequate and nuanced discussion of programmatic issues.

The scheduled visit using Zoom was on February 6-7, 2023, conformed to the Guide's requirements.

II. Recommendations:

A. To Maintain Success

IRs found it useful for the Department to provide the University, their College, and their Departmental mission statements as context for their goals to maintain programmatic success. There was no reason to mention in the Self-Study for a master's degree their BS program unless it impacted their graduate degree (e.g. provided enrollment for it) or that they don't offer minors. The Self-Study stated that the Department contributed to the Computer Engineering program, a joint program sponsored by the Computer Science and the Electrical & Electronic Engineering Departments. It noted (Self-Study p 4)

"...this arrangement has the advantage of support from two strong departments." In the future, the IRs suggest that the Department explain how this joint program relates specifically to the success of the master's programs.

The Department has several established partnerships with the local community colleges for transfer students, with local high schools, with the UC Davis computer science department on various research projects, and with other CSUs for the "CSForAll." The IRs applaud these Departmental outreach efforts and understands how they relate to the overall success of the Department's mission. For the master's degree Self-Study however, it should include only those partnerships that relate to the specific degree. We would think that collaborating with UC Davis on research projects would be relevant. This would be an activity for the Self-Study to provide a more in-depth explanation.

The ERs recommended that the Department "Poll constituencies and campus partners in the form of surveys for IAB, alumni, and graduating seniors." The Department already stated in its Self-Study (p 18) that it utilized indirect measures for programmatic PLO evaluation. The IRs concluded that the Department doesn't reflect, discuss, or provide conclusions on this data. The Department didn't identify in its Self-Study that graduate students lacked a sense of community, particularly during the pandemic even though it stated it reviewed indirect measure data. Therefore, the IRs encourage the Department to more seriously gather, analyze, and share the data with all of its faculty.

Recommendation R.A.1: The IRs recommend that the Department analyze indirect measures to inform it on the success of its specific degrees and programs, utilize when appropriate to improve programs, and share the results with all the faculty.

Recommendation R.A.2: The IRs recommend that the Department consider when appropriate how out-reach efforts contribute to student learning and success.

B. To Improve Student Learning (consider university/college goals on learning, research/scholarship, diversity)

In their Self-Study, the Department listed five programmatic learning goals (PLOs). They clearly defined them, and they are congruent with the University's master's PLOs. In 2021, the Department changed from assessing individual courses and events (e.g., Graduate Symposium) for their PLOs to using their master's theses/projects. It concluded that the previous methodology didn't completely assess all the goals and didn't close the loop. The IRs view this change as a valuable reflection and one that improves its assessment. The Department mapped its PLOs to the theses/projects and to their rubrics. It used charts/graphs to illustrate their analysis of the PLOs and reflection on their assessment. They concluded that student's theses/projects to a high degree successfully meet their PLO.s. Additionally, they used courses to assess learning outcomes, maintaining success, and improving student learning (SS Element 2 C p 11). The IRs would like to have learned about the types of work, assignments, etc. that it assessed at the course level and who conducts the assessment? Do all the graduate teaching faculty evaluate or is there an assessment team? A robust evaluation program would have a team evaluating elective course work rather than just the instructor of record. While the Department states that it has a comprehensive assessment plan that addressed assessing PLOs through course level and program assessment, the IRs suggest that the Department would benefit from describing it in more detail in their Self-Study. Finally,

the Department listed various indirect measures that it utilized but failed to analyze and/or describe how they used this valuable data to inform it and provide potential improvements.

The ERs rated the *Guide's* seven prompts as developed. Except for a single commendation, they offered no direct or relevant recommendations for student learning. Instead, they commented that the program prepared the students for working in the industry (ER Report Element 2 p 2). They didn't offer any rationale for their two recommendations. (ER Report Element 2 p 2). "Consider allowing students to specialize in one subdomain (depth) vs choosing 3 separate courses (breadth)." "Consider enriching the Data Science/Machine Learning curriculum to address student and industry demand for this skillset."

The IRs commend the Department developing a more rigorous rubric with which to score project/theses defenses vs prior project presentation format and that they've included an oral communication goal with the theses/projects.

The ERs didn't mention that while the Department examined valuable indirect measures (Self–Study Element 2 D p 14), they failed to report, reflect, or discuss their findings that could possibly result in program and learning improvements. This may be another example of the ERs lack of experience with assessment.

Neither the Self-Study nor the ERs described who exactly conducts PLO assessment. Is it done by a committee, all graduate faculty, a graduate coordinator, or the advisor and readers? The IRs believe the Department would benefit from explaining who conducts PLO assessment.

Commendation C.B.1: The IRs commend the Department for its overall assessment of PLOs.

Recommendation R.B.1: The IRs recommend that the Department examine/consider/discuss indirect measures results as they relate to student learning outcomes and compare them with relevant direct measures. Combining the two types creates a robust assessment of student learning.

Recommendation R.B.2: The IRs recommend that the Department describe in a comprehensive assessment plan and annual assessment reports the types of student course work it evaluates, who performs the evaluation, and sharing the results in-order to better close the loop.

Recommendation R.B.3: The IRs recommend that the Department describe in a comprehensive assessment plan and annual assessment reports who performs the assessment of master's theses/projects and sharing the results in-order to better close the loop.

C. To Improve Student Success (consider university/college goals on recruitment, retention, graduation, diversity, engagement)

The Department answered all the *Guide's* six prompts. It reflected and offered a series of strategies to improve student success. For the quality of the culminating experience, they redefined program PLOs to greater align with the University's PLOs, redesigned the evaluation of the master's culminating experience implemented a new oral defense for each master thesis/project, developed rubrics for the new oral defense, and created new guidelines for master's theses/projects for several areas. The IGs suggest that they can demonstrate their success for these changes in annual assessment reports. They listed several strategies to shorten the time to graduation, improve the effectiveness of the program,

and increase both the overall number of majors and the diversity of the body of majors over the next 5 years. They will restructure/refactor their curriculum to shorten the graduation time to attract more local U.S. students to increase both the overall majors and the diversity of majors. Since their students spend at least 5-6 semesters to graduate, they state it is difficult to compete with other local master's programs to attract local students. They have been working on reforming the curriculum by enabling students to work on their master theses/projects earlier. By splitting the culminating experience into two separate courses, they claim students will have the flexibility to start to work on their master's theses/projects earlier which will accelerate their degree significantly and allow them to obtain their degrees as fast as within 2 or 3 semesters. This improvement will potentially create a potential bachelor's/master's five-year (4+1) pathway. The IGs propose that the dean or their designee monitor the faculty's efforts to reduce time to degree to ideally achieve this goal before the next program review. Additionally, they will develop a new course, Preparation for Culminating Experience, to accelerate degrees by shortening the time to graduation. They will continue new course creation on emerging topics in computer science to ideally (such as data science, artificial intelligence, cybersecurity, game development, and software engineering) improve student success, maximize the program learning outcomes, and attract more local applicants to increase both the overall number of majors and the diversity of the body of majors. The IRs concluded that the Department has seriously reflected on these issues and developed reasonable solutions.

The ERs made various recommendations about balancing foreign with domestic enrollment, blended undergraduate/graduate programs, developing sample sets of breadth courses, clearly defining and advertising the thesis and project options, and advertising faculty expertise at a central web resource for students to help select advisors. The IRs disagree with the ERs recommendation that the Office of Graduate Studies has the expertise to increase outreach to potential domestic applicants. The IRs suggest that reviewing disciplinary literature and surveying similar programs potentially offer more fruitful strategies as this probably isn't a unique challenge to the Department.

The Department noted, its enrollment and majors are 81% international and therefore reflects considerable ethnic diversity. Female enrollment is 34%, 4% above the national average of 30% for women graduating with PhDs in computer and information science for 2020 the latest data available from the *Statistical Abstract of the United States*. The IRs commend that the Department celebrate its successful female enrollment. The Department recognized in its Self-Study that it should increase the number of U.S. residents as majors. The IRs recommend continued efforts to increase both U.S. and female enrollment.

It states that it collaborated with the ECS college advising center, the University Writing Center, the Library Student Success Center, and internship sites and employers. There is no Library Student Success Center; the Department probably meant that their students utilize the Library's services and Tabzeera Dosu, the engineering librarian's expertise in supporting its program. If the Department has any data (quantitative or qualitative) data about how these collaborations contribute to student success, they should include them in future Self-Studies.

Commendation C.C.1: The IRs commend the Department's ability to attract women students into its MS program.

Recommendation R.C.1: The IRs recommend that the Department continue to explore increasing U.S. resident enrollment and women as URMs by reviewing the literature and surveying other programs for possible strategies.

Recommendation R.C.2: The IRs recommend that the dean or their designee monitor the faculty's efforts to reduce time to degree.

D. To Build Partnerships and Resource Development to Enhance the Student Experience (consider university/college goals on university as place, university experience, community engagement)

The Department repeated the various measures already presented previously which were not necessary for this section: shortening time to graduation, refining admission criteria, refining the evaluation rubric criteria, and developing a new course for accelerated degrees to shorten time to graduation.

The Department stated they are the largest department in their College. They currently have approximately 1,600 undergraduate and more than 100 graduate students. They have a severe shortage of faculty and part-time instructors. They lost three tenure/tenure-track faculty members. With only 13 full-time faculty (including the Chair), the Computer Engineering Program Coordinator, and 3 FERP faculty, it has been extremely challenging to maintain a curriculum to accommodate the ever-increasing demand. Additionally, while they have 1 ASC and 2 ASA positions, they've only filled the ASC position. They plan to hire 3 tenure-track faculty members in AY 2022-23 and continue to do so in next few years until they reach twenty tenure/tenure-track faculty. As well, they plan on filling all the staff positions. The ERs provided only 1 recommendation: "Hire new faculty in specializations of Data Science/Machine Learning to address student and industry demand for this skillset."

The University never has sufficient resources to completely address all resource problems for any department. The strategic plan should prioritize its requests based on the current and future needs for faculty and the curriculum. The ER's recommendations were not particularly useful in this regard as they simply repeated the Department's request for more faculty with certain specializations and have software engineering expertise.

The Department requests more funding for student assistants as graders or teaching assistants. To engage graduate students in quality research, it needs funding for research assistantships. The IRs suggest that they need to include these requests in its strategic plan and the rationales/successful improvements that can result from additional funding. Analysis of faculty and curricular needs should drive future hires according to the IRs.

The Self-Study notes that faculty seek internal and external research grants. They have 3 NSF grants, an Intel-funded research project, and a few other grants. Also, they have been successful in obtaining industry joined research, gifts, and equipment donation. The IGs recommend that the Department provide more detailed explanations of these activities and how they benefit the degree program.

Recommendation R. D.1: The IR recommends the Department prioritize faculty requests based on current and future needs and curriculum needs to include in its strategic plan.

Recommendation R.D.2: The IR recommends that Department prioritize its requests for graders/teaching assistants and the rationales for how they will improve programmatic success in the strategic plan.

Recommendation R.D.3: The IR recommends that Department explain in greater detail how grants, contracts, funded research, etc. contribute to the educational goals and economic benefit of the degree program.

E. To Improve Strategic and Budget Planning and Operational Effectiveness and to Ensure Sustainability (consider university/college goals on innovative teaching, scholarship, research, university as place, university experience)

The Self-Study element has a single prompt: Summarize areas of concern and means of improving. The Department repeated in this section the various measures it already presented previously: shortening time to graduation, refining admission criteria, refining the evaluation rubric criteria, and developing a new course for accelerated degrees to shorten time to graduation. In its Self-Study's Appendix, it furnished its Departmental strategic plan which included: mission, undergraduate educational goals, undergraduate student outcomes, software engineering MS program PLOs, and graduate program strategies.

It lacked any mention of faculty and teaching assistants/graders needs. Additionally, they should provide operational needs such as laboratories and software/hardware. They should also address any internal/external grants, industry funded/joint research, gifts, and equipment donations, especially as it pertains to the graduate degree.

The ERs provided only two unique recommendations pertaining to Computer Science master's degree under this element. "The department can pre-identify a set of breadth courses that are suggested for specific project domains. Students would find a strict course sequence beneficial…would be able to orient their studies better to align with goals." Additionally, "the department can recruit faculty in Data Science / Machine Learning. This field is currently in hot demand in the computer industry, and interviewed students expressed a desire to see more such course offerings in the curriculum. The IRs don't have the expertise to comment on the first. As noted in previous Element D, the IRs recommended that the Department include staffing requests in it strategic plan.

Recommendation R.E.1: The IRs recommend that Department develop a holistic strategic plan that includes operational expenditure and other supplemental needs that impact the degree program.

MOU/Action Plan

Program: Computer Science (CSc) Master of Science

College: ECS

Date: 6/26/2023

Program Review Finding	**2 YR**	**4 YR**	**6 YR**
Cite self-study, external review, internal review, and/or accreditation documentation	List goal, success indicator, responsible parties, and resource implications.	List goal, success indicator, responsible parties, and resource implications.	List goal, success indicator, responsible parties, and resource implications.
To Maintain Success			
Hire new faculty in specializations of Data Science/Machine Learning to address student and industry demand for this skillset.	Plan to hire 2 more faculty members in Machine Learning/AI areas	Maintain a desirable number of faculty members in Machine Learning/AI areas based on student enrollment	Maintain a desirable number of faculty members in Machine Learning/AI areas based on student enrollment

Shorten Time-to-Degree to attract domestic students.	Split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This will enable students to start their master theses/projects as early as they become fully classified	Explore the option of providing bachelor's/master's five-year (4+1) pathway	Explore the option of providing bachelor's/master's five-year (4+1) pathway
To Improve Student Learning (consider university/college goals on learning, research/scholarship, diversity)			
Consider enriching the Data Science/Machine Learning curriculum to address student and industry demand for this skillset.	Keep refactoring CSC215/219/296R to reflect the latest advancement and development in the Data Science/Machine Learning areas	Keep our Data Science/Machine Learning curriculum up to date	Keep our Data Science/Machine Learning curriculum up to date
Clearly define and advertise the thesis and project options	Better advise students on the existing thesis/project guidelines. Refine the related advising resources and webpages.	Better advise students on the existing thesis/project guidelines. Refine the related advising resources and webpages.	Better advise students on the existing thesis/project guidelines. Refine the related advising resources and webpages.

To Improve Student Success (consider university/college goals on recruitment, retention, graduation, diversity, engagement)			
The imbalance issue of international vs. domestic graduate applicants.	Split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This will enable students to start their master theses/projects as early as they become fully classified to shorten the time to graduation.	Explore the option of providing bachelor's/master's five-year (4+1) pathway to increase both the overall number of majors and the diversity of the body of majors	Explore the option of providing bachelor's/master's five-year (4+1) pathway to increase both the overall number of majors and the diversity of the body of majors
The department can advertise faculty expertise on a central web resource for students to help select project/thesis advisor. Additional resource page could be added to the department website providing general guidance on how to contact faculty advisors for their thesis/project requests.	Keep the dept website up to date to reflect faculty members' current research. Refine the related advising resources and webpages.	Keep the dept website up to date to reflect faculty members' current research. Refine the related advising resources and webpages.	Keep the dept website up to date to reflect faculty members' current research. Refine the related advising resources and webpages.

To Build Partnerships and Resource Development to Enhance the Student Experience (consider university/college goals on university as place, university experience, community engagement)			
Poll constituencies and campus partners in the form of surveys for IAB, alumni, and graduating seniors to gather, analyze, and share the data with all faculty for continuous improvement	Collaborate with IAB closely for project, internship, and job opportunities. Consult with IAB and alumni for updating curriculum to reflect best industrial practices.	Collaborate with IAB closely for project, internship, and job opportunities. Consult with IAB and alumni for updating curriculum to reflect best industrial practices.	Collaborate with IAB closely for project, internship, and job opportunities. Consult with IAB and alumni for updating curriculum to reflect best industrial practices.
To Improve Strategic & Budget and Operational Effectiveness and to Insure Sustainability (consider university/college goals on innovative teaching, scholarship, research, university as place, university experience)			
Work with the Office of Graduate Studies to increase outreach to potential domestic applicants. This is anticipated to create a balance in the application pool.	Split the culminating experience (CSC 500/502) into two separate courses (CSC 290 and CSC 500/502). This will enable students to start their master theses/projects as early as they become fully classified	Explore the option of providing bachelor's/master's five-year (4+1) pathway to increase both the overall number of majors and the diversity of the body of majors	Explore the option of providing bachelor's/master's five-year (4+1) pathway to increase both the overall number of majors and the diversity of the body of majors

	to shorten the time to graduation to attract domestic students.		
The department can recruit faculty in Data Science / Machine Learning. This field is currently in hot demand in the computer industry	Plan to hire 2 more faculty members in Machine Learning/AI areas	Maintain a desirable number of faculty members in Machine Learning/AI areas based on student enrollment	Maintain a desirable number of faculty members in Machine Learning/AI areas based on student enrollment
More funding for student assistants as graders or teaching assistants	Prioritize dept spending to provide sufficient support for student assistants	Prioritize dept spending to provide sufficient support for student assistants	Prioritize dept spending to provide sufficient support for student assistants

Department Chair Name/Signature Jinsong Ouyang 6/27/2023

College Dean Name/Signature K<evan Shafizadeh 8/4/2023