Learning Outcomes Data for the Senate Committee on Instructional Program Priorities

Program: **BA in Mathematics and Applied Computing**
Department: **Mathematics and Statistics**
Number of students enrolled in the program in Fall, 2011: **13**
Faculty member completing template: **John Ingram**  Date: **February 3, 2012**

*Period of reference in the template: 2006-07 to present*

1. Please describe your program’s learning-outcomes trajectory since 2006-07: Has there been a transformation of organizational culture regarding the establishment of learning outcomes and the capacity to assess progress toward their achievement? If so, during which academic year would you say the transformation became noticeable? What lies ahead; what is the next likely step in developing a learning-outcomes organizational culture within the program?

   [Please limit your response to 200 words or less]

   A few years ago, the department developed learning objectives and assessment plans for the department’s main program, the Mathematics BA. Since that time, attention has been focused on making that assessment plan work well. The fundamental issue has been the relationship between the learning objectives for the program and those for the core courses in the program, and the balance between depth and breadth and how that should be assessed. It seems to be the nature of our discipline that core courses determine the depth and quality of the program. Hence, the recent focus on learning objectives for core courses.

   With knowledge and experience gained from the above process, the department has moved forward with learning objectives for its other programs. Recently, we developed learning objectives for the Mathematics and Applied Computing BA. Students in this program complete all but 6 – 9 units (depending on their choice of electives) of the requirements for the Mathematics BA. The main difference is that the students in the former program are not required to take the B parts of the upper-division core sequences. As such, the learning outcomes for the Mathematics and Applied Computing BA are similar to those for the Mathematics BA with the addition of some statements addressing the computing focus of the program.

2. Please list in prioritized order (or indicate no prioritization regarding) up to four desired learning outcomes (“takeaways” concerning such elements of curriculum as perspectives, specific content knowledge, skill sets, confidence levels) for students completing the program. For each stated outcome, please provide the reason that it was designated as desired by the faculty associated with the program.

   [Please limit your response per outcome to 300 words or less]

   No prioritization:
a) The Mathematics and Applied Computing Major at CSUS is expected to become proficient at mathematical reasoning, to understand the central role that logical rigor plays in all mathematics and science, and to apply this knowledge specifically to computing.

For a degree in mathematics, a focus on mathematical reasoning is critical. Professional mathematicians regard mathematical proof as the intrinsic essence of mathematics, and it is expected that all undergraduate mathematics majors will arrive at an appreciation for the role of proof in mathematical discourse, as well as a grasp of the methods of proof that permeate all mathematical exposition and provide the theoretical foundations of computing.

Students should be able to identify various methods of proof, and apply these methods to their work in upper division courses. Application of these fundamental mathematical methods leads to a deeper insight into the nature of mathematics and computing, and promotes stronger programming techniques. It is important that students understand how mathematical training and reasoning provides rigor in applied areas like numerical analysis, probability and statistics, or programming so they can see how these applied areas connect with the core of mathematics.

b) The Mathematics and Applied Computing Major at CSUS is expected to develop a fundamental understanding of the main areas of mathematics and their applications to computing. The main areas of mathematical focus are geometry, algebra, and analysis while the main areas of computing focus are computing theory, programming concepts and methodology, and algorithm development and analysis.

The study of geometry is important from a historical perspective, as well as for introducing nascent mathematicians to the concept of proof in mathematics. For computing, it is particularly important in computer graphics, computer networks, and game programming. It is generally recognized that advanced study in mathematics also requires a solid background in the areas of analysis and modern algebra. These two strands represent a classical approach to mathematics that is still essential learning for any modern student of the subject. In computing, modern algebra provides a useful background for data structures, computing theory, and databases while analysis supports modeling and algorithm development and analysis.

Students are expected to complete a semester of modern algebra and a semester of either real or complex analysis, and are expected to demonstrate the ability to prove and explain some of the fundamental results from these areas. They also complete coursework in computer science that provides a background for applications. The three essential branches of mathematics along with the computer science courses provide the foundation required for graduate studies in mathematics or computing so that someone completing the BA in Mathematics and Applied Computing is well prepared to undertake graduate level work if desired.

This program produces graduates who can apply mathematical sophistication to areas of computer science, raising the ceiling on their careers so that they can do much more than just
computer programming. This requires that in addition to programming, they be knowledgeable in the theory of computation and in the mathematical analysis of algorithms.

c) The Mathematics and Applied Computing Major at CSUS is expected to have an appreciation of the variety of areas of mathematical and computing study and their applications.

The study of mathematics has been an integral part of humankind’s intellectual history for over two thousand years, and in many ways approaches the pinnacle of humankind’s intellectual accomplishments. During the past two thousand years, the nature of mathematical inquiry has expanded to include a wide range of topics, from the classical studies of geometry and number theory to more modern subjects of interest such as topology, chaos theory and game theory. Current mathematical studies range over a wide variety of courses and often include interdisciplinary exchanges.

In contrast to mathematics, computing has been a very recent development in the history of humankind, having its beginnings in the code-breaking efforts of World War II only about seventy years ago. From those modest beginnings, it has grown rapidly to permeate almost all of humankind’s activities. The tremendous growth of computing power and reach of the internet and cell phone has transformed our lives. Nowadays, almost every job or business enterprise makes extensive use of computers and the internet. This program helps to make mathematics more relevant to our modern world.

Students should be able to recognize the various branches of mathematics and computing applications. Students in this program can choose either no concentration or a specialized concentration in one of three computing application areas: games, databases and data mining, or intelligent computing. Depending on the option and electives chosen, students are exposed to many of the variety of areas of mathematical study and computing applications including probability, statistics, linear algebra, differential equations, complex analysis, numerical analysis, linear programming, combinatorics, number theory, logic, modeling, data structures, algorithm development and analysis, computing theory, databases, computer graphics, artificial intelligence, and data mining.

d) The Mathematics and Applied Computing Major at CSUS is expected to demonstrate an ability to effectively communicate mathematical and computing thought processes.

The ability to communicate mathematical ideas is expected of all students graduating with a degree in mathematics. This ability goes to the heart of the mathematical process and the development and use of computing applications, and centers on the need for clear, logical presentation and exposition.

Students are expected to demonstrate effective communication in mathematics in a variety of ways: in written class assignments where they present mathematical and computing results, in
writing computer programs in both mathematics and computer science courses, in oral presentations before a class, in cooperative work with peers, in tutoring, and occasionally in disseminating undergraduate research results.

3. *For undergraduate programs only*, in what ways are the set of desired learning outcomes described above aligned with the University’s Baccalaureate Learning Goals? Please be as specific as possible.

[Please limit your response to 400 words or less]

The first learning outcome describes competence in the discipline of mathematics and quantitative literacy. Mathematical knowledge is applicable to most other disciplines as well. From Art to Zoology, most disciplines use quantitative reasoning skills that are acquired and enhanced by Mathematics Major. Mathematical reasoning mentioned in outcome 1 is essential to inquiry and analysis, as well as critical and creative thinking mentioned in the Sacramento State Baccalaureate Learning Goals. Mathematical reasoning is at the heart of genuine problem solving, which is the primary intellectual and practical skill that a student in this major would acquire.

Understanding geometry, algebra, analysis, and computing applications stated in outcome 2 and being able to reason mathematically stated in outcome 1 is what it means to have competence in this discipline.

The breadth of knowledge, skills, and experience described in the third learning outcome provides for the quantitative literacy of the graduate.

The fourth learning outcome, to communicate effectively mathematical and computing thought processes, aligns with the Baccalaureate Learning Goal of obtaining intellectual and practical skills including written communication.

The University’s Baccalaureate Learning Goals align with the methods by which the program is delivered, not just with the program’s learning goals. For example, the assignments within the program facilitate engagement with big questions, teamwork, progressively more challenging problems and projects, real-world challenges, and integrative learning. These tend to appear more clearly in the program in the specifics of the instruction rather than in the learning goals for the program.

4. *For each* desired outcome indicated in item 2 above, please:
   a) Describe the method(s) by which its ongoing pursuit is monitored and measured.
   b) Include a description of the sample of students (e.g., random sample of transfer students declaring the major; graduating seniors) from whom data were/will be collected and the frequency and schedule with which the data in question were/will be collected.
c) Describe and append a sample (or samples) of the “instrument” (e.g., survey or test), “artifact” (e.g., writing sample and evaluative protocol, performance review sheet), or other device used to assess the status of the learning outcomes desired by the program.

d) Explain how the program faculty analyzed and evaluated (will analyze and evaluate) the data to reach conclusions about each desired student learning outcome.

[Please limit your response to 200 words or less per learning outcome]

(If the requested data and/or analysis are not yet available for any of the learning outcomes, please explain why and describe the plan by which these will occur. Please limit your response to 500 words or less.)

Learning outcome: The Mathematics and Applied Computing Major at CSUS is expected to become proficient at mathematical reasoning, to understand the central role that logical rigor plays in all mathematics and science, and to apply this knowledge specifically to computing.

a) Sample final exams from Math 110A (Modern Algebra) and Math 130A (Functions of a Real Variable) are collected from all sections of these courses taught each semester, usually one or two sections per course. The instructors submit three copies of the completed exams (with students' names removed), one showing exemplary achievement of the course objectives, one showing superior achievement, and one showing satisfactory achievement. The chair and a member of the Core Curriculum Committee review these exams as a means of assessing the proficiency of mathematical reasoning of students exiting these courses. The reviewers look for questions and answers showing proficiency in mathematical reasoning and showing an understanding of how to write proofs.

b) Exams are collected each semester, but the review of the exams takes place annually in May or June. The exams are selected to illustrate a range of achievement of the students.

c) See Appendix A for the Core Final Exam Assessment worksheet. Copies of final exams are on file in the Department of Mathematics and Statistics.

d) The chair and a member of the Core Curriculum Committee evaluate the exams checking for questions that test whether the student displays appropriate mathematical reasoning skills. Exams are assessed for a sufficiency of items that require problem solving and mathematical reasoning, rather than recall of facts.

Learning outcome: The Mathematics and Applied Computing Major at CSUS is expected to develop a fundamental understanding of the main areas of mathematics and their applications to computing. The main areas of mathematical focus are geometry, algebra, and analysis while the main areas of computing focus are computing theory and its mathematical foundations, programming concepts and methodology, and algorithm development and analysis.
a) The sample exams are evaluated as described above, and questions are rated as to whether they show an understanding of the main areas of algebra, and analysis.

b) Exams are collected each semester, but the review of the exams takes place annually in May or June. The exams are selected to illustrate a range of achievement of the students.

c) See Appendix A.

d) The chair and a member of the Core Curriculum Committee evaluate the exams to ensure that they delve sufficiently into the central areas of modern algebra and real analysis.

**Learning outcome:** The Mathematics and Applied Computing Major at CSUS is expected to have an appreciation of the variety of areas of mathematical and computing study and their applications.

a) Because this is a breadth outcome, it is not as amenable to assessment by exams as the other outcomes. Instead, the variety of available options determines the genuine breadth of the student experience.

b) All students in the program are required to meet the breadth requirement for graduation. The department chair along with departmental advisors would determine exceptions when they sign graduation petitions. Thus, the department has control over the enforcement of the breadth outcome.

c) N/A

d) Faculty are currently meeting to discuss the specific requirements for applied majors. Reacting to increases in enrollment and to changes in the fields, the appropriateness of the breadth requirement is under frequent consideration.

**Learning outcome:** The Mathematics and Applied Computing Major at CSUS is expected to demonstrate an ability to effectively communicate mathematical and computing thought processes.

a) The final exams are now evaluated as to whether the questions give students the opportunity to effectively communicate mathematical thought in written form.

b) As noted previously, exams are collected each semester, with evaluations taking place annually.

c) See Appendix A.
d) Exams are analyzed as to whether or not they give students the opportunity to effectively communicate mathematical thought. The reviewers look for questions that will ask for explanations, demonstrations, and proof as opposed to true/false, multiple choice, or fill in the blank type questions.

5. Regarding each outcome and method discussed in items 2 and 4 above, please provide examples of how findings from the learning outcomes process have been utilized to address decisions to revise or maintain elements of the curriculum (including decisions to alter the program’s desired outcomes). If such decision-making has not yet occurred, please describe the plan by which it will occur.

[Please limit your response to 200 words or less per item]

The assessment of learning outcomes for the Mathematics and Applied Computing BA leans heavily on the evaluation of student work on exams in the core courses that is a part of the Mathematics BA learning outcomes assessment. That work has gone on for several years. The analysis of that data for feeding back into the Mathematics and Applied Computing program will begin this year.

a) The role of mathematical reasoning is essential to the mathematics major and the findings from the evaluations of the final exams in Math 110 and Math 130 suggest that the goal is being met. In 2010-11, virtually all of the questions from Math 130 did a good job assessing this goal. In Math 110, approximately 86% of the questions assessed this outcome well. Students are capable of putting together a competent proof using a definition.

b) The evaluation of these examinations to date clearly indicates that the core courses are meeting the departmental expectations for a focus on the basic understandings of the disciplines. This aspect of the evaluation of the examinations is most pertinent to the assessment of the second learning goal for this program, so if this continues through the current year evaluations, it is unlikely to result in a revision to the program.

c) The number of waivers approved on graduation petitions will be considered. In addition, discussions underway in the department about the specific choices for electives, based on what is current in the field, might lead to some changes in the program.

d) The fourth learning goal, dealing with effective communication of mathematical thought, is assessed by the inspection of exams. On the Math 110 exams, 80% of the questions dealt with effectively communicating mathematical thought, while in Math 130, all questions dealt with this. Student responses ran the gamut from highly competent to marginally capable, but overall it was felt that students were competent in this area.

6. Has the program systematically sought data from alumni to measure the longer-term effects of accomplishment of the program’s learning outcomes? If so, please describe the approach to this
information-gathering and the ways in which the information will be applied to the program’s curriculum. If such activity has not yet occurred, please describe the plan by which it will occur.

[Please limit your response to 300 words or less]

The Office of Institutional Research periodically conducts a survey of Mathematics alumni. The last survey was conducted in July 2007. The purpose is to gather information about the mathematics program from those engaged in their professional careers with the aim of addressing future needs of our undergraduates. Information gathered from the last survey shows that the graduates are meeting the third learning goal of having an appreciation of the variety of areas of mathematical study and mathematical applications. The survey showed that 92.45% of the alumni felt that the mathematics curriculum provided them with a broad knowledge of theories and principles in the discipline either adequately or exceptionally well. Also 91.45% of alumni felt that the curriculum provided them with problem solving skills in a broad range of situations either adequately or exceptionally well.

An area of weakness that showed up in the survey was that 16.98% of the alumni either disagreed or strongly disagreed with the statement that the mathematics program was flexible enough to meet the needs of individual students. With this information, the department felt that it would be important to offer more electives to meet these needs, but unfortunately, this was at a time when budget constraints forced a reduction in the number of elective offerings.

We now have a list of the recent graduates in this program. We hope to utilize the services of the Office of Institutional Research to disaggregate the students in the Mathematics and Applied Computing BA in order to obtain data that is more specific to this program.

7. Does the program pursue learning outcomes identified by an accrediting or other professional discipline-related organization as important? Does the set of outcomes pursued by your program exceed those identified as important by your accrediting or other professional discipline-related organization?

[Please limit your response to 300 words or less]

The mathematics portion of the program does not pursue learning outcomes identified by an accrediting or other professional discipline related organization. However, a major in this program is only 26 units short of a BS in Computer Science, completing all of the lower-division requirements and about half of the upper-division ones. The BS in Computer Science is accredited by the Computing Accreditation Commission of ABET, Inc.

8. Finally, what additional information would you like to share with the Senate Committee on Instructional Program Priorities regarding the program’s desired learning outcomes and assessment of their accomplishment?

[Please limit your response to 200 words or less]
Beginning in the Fall of 2011, the Department began conducting a short written survey each semester to be completed by students who were graduating that semester. The survey asked about plans for the upcoming year, including work plans, plans to enter a credential program, a graduate program, or a professional program. In the three semesters for which data is available, 26 surveys were completed from the 45 graduating seniors. Of the 26 completed surveys, 13 were planning on entering a credential program (of these, six were currently in the Math Blended Program at CSUS at the time of graduation), seven were planning on attending graduate school in Mathematics or Statistics, one was planning on attending a professional school, and five planned to seek a job.

Responses from graduates in the Mathematics and Applied Computing BA will be analyzed separately in the future.

Appendix A

Core Final Exam Assessment Worksheet

Learning Goals:

1. The mathematics major at CSUS is expected to become proficient at mathematical reasoning, and to understand the central role that logical rigor plays in all mathematics.

2. The mathematics major at CSUS is expected to develop a fundamental understanding of the main areas of mathematics: geometry, algebra, and analysis.
3. The mathematics major at CSUS is expected to have an appreciation of the variety of areas of mathematics study and of mathematical applications.

4. The mathematics major at CSUS is expected to demonstrate an ability to effectively communicate mathematical thought.

5. The mathematics major at CSUS is expected to demonstrate a basic understanding of current technology in mathematics and to demonstrate skills with that technology.

Generally speaking the core courses are devoted primarily to goals 1, 2, and 4. Each core course contributes to the achievement of goal 3 as a student progresses through the program. Final exams may (and usually do) contain some assessment of goal 4. Goal 5 is met by other program requirements but may be incorporated into a core course.

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