Learning Outcomes Data for the Senate Committee on Instructional Program Priorities

Template

Program: Mathematics BA  
Department: Mathematics and Statistics  
Number of students enrolled in the program in Fall, 2011: 242  
Faculty member completing template: Ed Shea  
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]

Prior to 2009 the department developed its learning objectives for the BA in Mathematics.

In 2009, the Department of Mathematics and Statistics prepared its Self Study, and in Fall 2009, an external consultant prepared a report. This report was generally positive, and noted that the department's assessment plan resolved the difficulties associated with assessment at least as well, and in several ways better, than other math departments' plans with which the consultant was familiar. The report recommended rewording some of the learning objectives so someone from outside the department could understand the basis of the assessment plan. The Core Curriculum Committee of the department revised the learning objectives for the BA in Mathematics, and these revisions were approved by the department in April 2010.

In the 2009-10 academic year, the Department’s Core Curriculum Committee went about the task of clarifying learning objectives for the two upper division core sequences required for math majors. These two sequences, Math 110A/B (Modern Algebra) and Math 130A/B (Functions of a Real Variable), are classical subjects that form the basis of all modern mathematics study. These learning objectives for the upper division core sequences were discussed and approved by the department in May 2010.

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

Professional mathematicians regard mathematical proof as the intrinsic essence of mathematics, and it is expected that undergraduates 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.

Students should be able to identify various methods of proof, and apply these methods to their work in their upper division courses. Application of these fundamental mathematical methods leads to a deeper insight into the nature of the subject.

b) The mathematics major at CSUS is expected to develop a fundamental understanding of the main areas of mathematics: geometry, algebra, and analysis.

Geometry is a branch of mathematics dealing with questions of shapes, lengths, areas, and volumes. The ancient Greeks put it into an axiomatic form and developed techniques for calculating areas and volumes that were a precursor of calculus that was developed centuries later. The study of geometry is important both from an historical perspective, as well as introducing nascent mathematicians to the concept of proof in mathematics.

It is generally recognized that advanced study in mathematics requires a solid background in the areas of real analysis and modern algebra. These two strands represent a classical approach to the subject that is still essential learning for any modern study of the subject.

Students are expected to complete a full year of study of both real analysis and modern algebra, and are expected to demonstrate the ability to prove and explain some of the fundamental results from these areas. These two branches of mathematics also provide the foundation required for graduate studies in mathematics so that someone completing the BA in Mathematics is well prepared to undertake graduate level work if desired.

c) The mathematics major at CSUS is expected to have an appreciation of the variety of areas of mathematics study and of mathematical applications.

The study of mathematics has been an integral part of mankind’s intellectual history for over two thousand years, and in many ways approaches the pinnacle of mankind’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 include 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.

Students should be able to recognize the various branches of mathematics, and according to their interests, should be able to describe and understand the basic methods of study in their chosen option. Students at CSUS will choose between the pure mathematics option, the applied mathematics and statistics option, and the teacher preparation option. Depending on the option chosen, students are exposed to many of the variety of areas of mathematical study and applications including probability, statistics, linear algebra, differential equations, complex analysis, numerical analysis, linear programming, combinatorics, number theory, logic, and the history of mathematics.

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

The ability to communicate mathematical ideas should be expected of all students graduating with a degree in mathematics. This ability goes to the heart of the mathematical process 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 presentations of mathematical results, such as in the capstone course, or in other courses where student presentations are required; responding to questions both in formal class settings and in group settings; explaining mathematics as part of duties associated with the Math Lab, Math 9 instruction, Learning Skills instruction, tutoring, AMP co-ordination and tutoring, as well as other tutorial duties associated with the mathematics department.

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 learning outcomes described in item 2 all involve 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 by majors in Mathematics. Mathematical reasoning mentioned in goal 1 is essential to inquiry and analysis, as well as critical and creative thinking mentioned in the Sacramento State Baccalaureate Learning Goals. Using reasoning skills to construct logical arguments can be applied in science, social science, humanities, history, and the arts. Understanding geometry, algebra, and analysis stated in goal 2 gives knowledge of the natural world through study of mathematics. The third goal in item 2, to appreciate the variety of areas of mathematical study
and mathematical applications raises the quantitative literacy of the math graduate. Goal 4, to effectively communicate mathematical thought, aligns with the Baccalaureate learning goal of obtaining intellectual and practical skills including written communication.

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

a) Sample final exams from Math 110A/B (Modern Algebra) and Math 130 A/B (Functions of a Real Variable) are collected from all sections of these courses taught each semester. There are usually one or two sections of each course taught each semester, and 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 understands mathematical reasoning. Each question on the exam will be rated as to whether or not it checks this accomplishment.

Learning outcome: The mathematics major at CSUS is expected to develop a fundamental understanding of the main areas of mathematics: geometry, algebra, and analysis.

a) The sample exams are evaluated as described above, only now questions are rated as to whether they show an understanding of the main areas of geometry, algebra, and analysis. In addition, the instructor of Math 193 (Capstone Course for the Teaching Credential Candidate) submits an assessment of the strengths and weaknesses of the students enrolled in the class.

b) Math 193 is currently taught once a year during the spring semester. The class has five upper division prerequisites, so students enrolled in Math 193 are typically within one semester of graduation. All students completing the Teacher Preparation option are required to take this course, while those in the Pure Math or Applied Math and Statistics options may enroll in the course, but it is not required.

c) See Appendices A and B.

d) In Math 193, students give presentations to the class, usually in groups of two or three. The instructor looks for a fundamental understanding of the main areas of mathematics.

Learning outcome: The mathematics major at CSUS is expected to have an appreciation of the variety of areas of mathematics study and of mathematical applications.

a) The sample exams are evaluated as described above, only now questions are rated as to whether they show the variety of areas of mathematical study and of mathematical applications. The instructor of Math 193 will also look for the presentations showing the same.

b) As noted previously, exams are collected each semester, with evaluations taking place annually. Math 193 runs each spring semester.

c) See Appendices A and B.

d) Exams are evaluated to see that they ask questions that will test a variety of applications. The Math 193 instructor looks for a variety of areas of mathematical study and applications.

Learning outcome: The mathematics major at CSUS is expected to demonstrate an ability to effectively communicate mathematical thought.
a) The final exams are now evaluated as to whether the questions give students the opportunity to effectively communicate mathematical thought in written form. In Math 193, the instructor looks for effective oral communication in the student presentations.

b) As noted previously, exams are collected each semester, with evaluations taking place annually. Math 193 runs each spring semester.

c) See Appendices A and B.

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. In Math 193, the instructor looks for effective oral communication in the student presentations.

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]

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

b) Findings from the learning outcomes process have strengthened the resolve of the Department of Mathematics and Statistics to maintain its requirement of the two yearlong sequences for all options in the Mathematics BA program. Many universities have single semester courses in Modern Algebra and Real Analysis required for their majors, whereas the requirement at CSUS is for a two-semester sequence in each if these subjects. It is also evident from the assessment process that aspects of geometry permeate many different courses in the program.

c) A variety of areas of mathematical study and mathematical applications were evident from the submission of the instructor of Math 193 (Capstone Course). Students showed an understanding of group theory. Real analysis was used less significantly in the Capstone Course. Students did make use of convergence of sequences, although mostly at a calculus level, but the class' understanding was fine. The students were very familiar with basic number theory, and
were enthusiastic about seeing applications of number theory. Geometry was also a popular topic for presentations in the class as well. The instructor was impressed by the willingness of students to dive into problems. Students were comfortable with the prospect of working geometry problems that require a sequence of steps to complete.

d) The learning goals dealing with effective communication of mathematical thought was assessed by both the examination of exams and by the Capstone Course assessment. On the Math 110A/B exams, 80% of the questions dealt with effectively communicating mathematical thought, while in Math 130A/B, 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. The Capstone Course report also commented on the students' skills in mathematical communication. Unlike in Math 110 and Math 130 where the information obtained is largely through written responses of students, in the Capstone Course, students give several oral presentations. The quality varies, and students are not always comfortable in this role, and they may not always be smooth in their deliveries, but they were consistently enthusiastic and interested in improving. Over the course of the semester in which students each gave three presentations, there was significant improvement by every student. Students have been asked to work extremely hard in their core courses to solve very challenging problems and they have learned that discussing mathematics with each other is a crucial strategy. This is certainly a desirable outcome.

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]

A survey of Mathematics alumni is periodically conducted by the Office of Institutional Research. 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 it was felt that it would
be important to try to offer more electives to try to meet these needs, but this was at the same time when budget constraints forced a reduction in the number of elective offerings.

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 program does not pursue learning outcomes identified by an accrediting or other professional discipline related organization.

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.

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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Appendix B

Assessment of the Undergraduate Major Program at CSUS by Examination of Student Performance in the Capstone Course Spring 2011

As the instructor for the Capstone Course, Math 193, during the Spring semester of 2011, I assessed the mathematics major program by consideration of how students performed in various areas at the end of their undergraduate careers. I made this analysis was made in five areas:
• Quality of general mathematical background (lower division)
• Understanding of Core Subjects
• Breadth of Understanding
• Facility with Technology
• Skills in Mathematical Communication

In the Capstone Course, students are required to give presentations on various mathematical topics, all related to secondary mathematics curriculum. These talks draw connections between the mathematics the students have learned in college and secondary mathematics curriculum. This course provides a unique perspective on the students, because in addition to seeing the students in their traditional roles, I am able to see them as presenters of mathematics.

**Quality of general mathematical background (lower division)**

In general, their grasp of lower division mathematics was solid. Many of the students had tutored lower division mathematics for years, so this was not surprising. Their understanding of the topics, especially precalculus material, was overly formulaic. They could solve the routine sorts of problems, but their understanding of the mathematics behind the solution was sometimes not solid. When they were shown a glimpse of the mathematical explanation, they moved very quickly to the fuller understanding that I want them to carry with them as graduates.

Geometry was a particular area of strength for these students. They are all future math teachers, and perhaps it is the love of geometry that brought them to their careers, but they were generally very current in their knowledge of basic plane geometry.

Students were generally familiar with the traditional proofs and explanations for the lower division mathematics we encountered. They were not generally familiar with more hands-on or visual ways of explaining and proving that mathematics. This is part of the point of the Capstone Course, to provide future teachers with more of these ways of approaching traditional mathematical topics.

Appendix B (cont.)

**Understanding of Core Subjects**

We did an extended exercise that required significant applications of group theory, and as a class, they were strong in this area. The particular coverage of the presentations in Math 193 this semester did not make use of ring theory, so I cannot assess their knowledge in that area. Use was made of field theory, and there were several students who were fluent in this area, although many students hadn’t yet taken the second semester of the abstract algebra course, so they were not familiar with fields.
This reinforces the department’s belief that the Capstone Course provides a good perspective from which to make an assessment such as this. As the instructor for this course, it was very clear to me which background material the students understood.

The other portion of the core, real analysis, was used less significantly in the Capstone Course. We did make use of convergence of sequences, although mostly at a calculus level, but the class’s understanding was fine.

The department has long believed that its first duty in the major program is to produce students with mathematical depth and sophistication. My conclusion, after working with students who are at the end of the program, is that we are largely successful in this goal.

**Breadth of Understanding**

Most of the students in the class had completed the courses that they take in order to achieve the breadth of understanding that we expect of future teachers, i.e., number theory, geometry, and history of mathematics. In the Capstone Course we made extensive use of their knowledge of these topics.

The students were very familiar with basic number theory and enthusiastic about seeing applications of number theory. Many students chose their presentation topics accordingly. Likewise, geometry was a popular topic for presentation.

Especially in these two areas, I was impressed by the willingness of the students to dive into problems. They certainly are comfortable with the prospect of working their way through a geometry problem that requires a sequence of steps.

**Facility with Technology**

Students used basic computer technology in their presentations, such as some MS PowerPoint, but the main use of technology was graphing calculators. They are clearly comfortable with this technology. I cannot report on their facility with computer programming.

Appendix B (cont.)

**Skills in Mathematical Communication**

The quality of the presentations given by the students in the course varied greatly. The students were not always comfortable in this role, and they were not always smooth in their deliveries, but they were consistently enthusiastic and interested in improving. Over the course of the semester, in which each student made three presentations, there was significant improvement for every student.

The students were apparently used to speaking with other students about mathematics. It appears to me that as they are asked to work extremely hard in their core classes to solve very challenging problems, they have learned that discussing mathematics with each other is a crucial strategy. In this way, they have learned to use mathematical vocabulary in talking with other students. While this might not be a part of the department’s plan in its core courses, it certainly is a desirable outcome.
I asked each student to provide a written lesson plan for each of their presentations as well as a written self-evaluation of each presentation after it was over. Their writing skills were good.

One last aspect of their communication of mathematics that was most striking was their inventiveness. They put a great deal of thought into their presentations and developed some very clever ways of looking at secondary mathematics. Sometimes this was a great example that they concocted and sometimes it was a manipulative that they built for a specific presentation. It was impossible not to be impressed by the creativity they showed in their presentations.

**Final Comments**
As in the past when I teach this course, I walk away impressed by the enthusiasm of the students for learning mathematics.