External Review of Mathematics & Statistics Department
CSU Long Beach

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This memo is our report as the external reviewers for the Mathematics Department at CSU Long Beach. This report is based on our visit to CSU Long Beach on 23{24 March 2017 and our reading of the Mathematics Department self-study and related documents. During our visit, we met with the following people and groups of people at CSU Long Beach (in the order listed, removing repetitions):

Chair of Mathematics Department
Provost & Senior Vice President, Academic A airs
Vice Provost for Academic A airs & Dean of Graduate Studies
Dean of the College of Natural Sciences and Mathematics
Director, Program Review & Assessment
Tenured and tenure-track faculty in Mathematics
Mathematics tutoring centers supervisors
Students in Math 361A (entire class, with instructor not in room)
Lecturers in Mathematics
Mathematics credential advisors
Mathematics undergraduate associate chair and advisors
Two Engineering students taking Math 364A (instructor not in room)
Students in Stat 410/510 (entire class, with instructor not in room)
Mathematics graduate advisors
Mathematics education faculty
Pure mathematics faculty
Chairs of ve CSULB departments that make heavy use of mathematics
Statistics faculty
Applied math faculty
Mathematics sta and lecturers
Mathematics TAs and GTAs
Mathematics junior faculty

Before getting to the formal part of the review, we want to express our thanks to everyone involved in our visit to Long Beach. We are grateful to all the people who helped arrange our visit and all the people who took time to talk with us, with special thanks to Tangan Gao for organizing our visit and providing superb logistical support.

Student Success and Student Learning

Developmental (Pre-baccalaureate) and General Education Instruction

General Education courses are central to the department's undergraduate teaching mission. About 60-70% of the undergraduate FTES comes from GE courses. The department is striving to provide students in lower level courses with consistent learning experiences and assessments. Most of the department's service courses have a course coordinator. Instructors are encouraged to make use of the provided homework, quizzes, exams, and syllabi. Given the common practice in math departments of assigning new Lecturers and Graduate Teaching Assistants to developmental courses, this coordinated instruction provides important assistance to new instructors, helping them to better serve at-risk students.

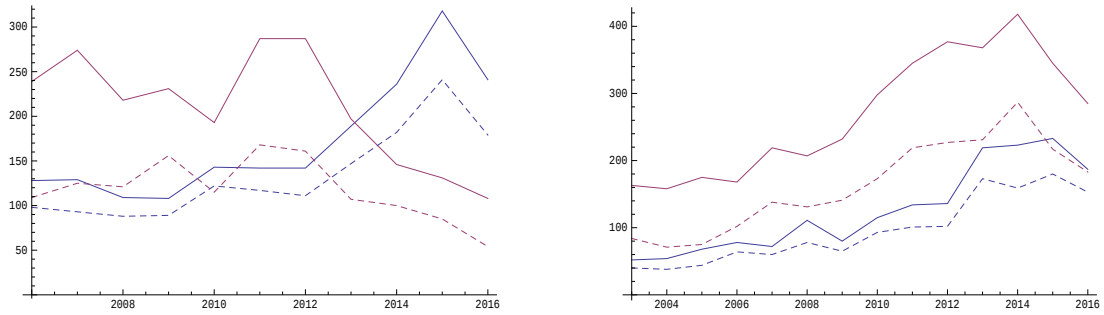
In recent years, the department has taken several important steps in improving the support of students who need to complete pre-baccalaureate coursework in math before advancing to college-level courses. While the long-term academic success, particularly in STEM courses and majors, of students requiring substantial developmental coursework is still limited, the department's outcomes are improving.

The expansion of the TA training program is an excellent investment. Some graduate students with whom we spoke had prior instructional experience. They seemed consistently pleased with their experiences teaching general education and pre-baccalaureate classes|their TA training seemed su cient to support a smooth transition from K{12 teaching or tutoring at CSULB to being the instructor of a CSULB course. New TAs take MTED 590, *Introduction to College Mathematics Teaching*, in the fall. Graduate students with little or no hands on teaching experience reported feeling stressed during their rst term as a TA; some noted that students in developmental courses can be unforgiving of fumbles by novice instructors. Graduate students with limited teaching experience might bene t from a term of less demanding instructional experience, in addition to the TA training, before being put in charge of a developmental course.

There appears to be some tension between a few senior faculty in Mathematics & Statistics and some faculty of departments requiring substantial mathematical training for their majors. Inclusion of modern applications, e.g., data science and graphics, could update key courses and increase their relevance to STEM programs. Increased active learning in service courses could improve the learning experience for all students; in-class experiments and explorations provide excellent opportunities for students to develop intuitive understanding of abstract concepts and learn to recognize mathematics in situ. This could better align some courses with the needs of outside programs while allowing retention of texts and syllabi well-suited for math majors.

Calculus Preparation and Instruction

In the past two years, the primary STEM calculus sequence MATH 122 and 123,



(a) MATH 122 (b) MATH 123

Figure 1: Enrollment and pass rates in MATH 122 and 123,*Calculus I* and *II*. Blue: rst time frosh, red: other students; solid: enrolled, dashed: passed.

Calculus I and *II*, has been redesigned. These courses are required for math majors and

247 Linear Algebra and MATH 370A Applied Mathematics). It is time to rethink their contents and redesign the courses to better serve our students.

We strongly support this plan.

Some faculty, particularly the junior faculty, are implementing active learning in their courses. We applaud this practice and encourage the department to support the development of new instructional materials and strategies in all courses, not just the lower division courses. Traditional lecturing for 75 minutes of can tax the stamina of both the students and the instructor past the point of diminishing returns. In the two classes we visited, lecturing seemed to be the standard instructional protocol; in fact, some of the students seemed unaware that other approaches to math instruction exist.

Professor Chang's ipped version of Math 247,*Linear Algebra*, is an excellent example of an active-learning course. This course uses a mix of instructional videos|many

faculty, rewarding successful innovations, recognizing the value of pedagogic experiments (even if they are not fully successful), and gently coaxing experienced faculty to try a few new tricks. We hope that over time more faculty will adopt materials and instructional strategies that have been shown to be e ective in CSULB courses and elsewhere.

Undergraduate Major Programs

The department currently o ers four options for its robust BS in Mathematics:

The General option is a traditional pure mathematics program, with an emphasis on analysis.

The Applied option has two suboptions:

- Suboption I, *Application in Science and Engineering*, is a traditional applied math program, emphasizing di erential equations and physics, with optional coursework from EE, CE, or MAE.
- Suboption II, *Application in Economics and Management*, combines coursework in analysis and economics, adding some statistics and probability.

Both suboptions include an introductory programming course.

The Math Education option is designed to prepare students to enter a single subject credential program. The department has recently modi ed some course content so as to better prepare students teach to Common Core standards.

The Statistics option includes coursework in analysis and probability in addition to a solid foundation in statistics.

Four-year Graduation Targets

The goal of graduation in four years is not aligned with the academic priorities and non-academic constraints of most CSULB math students. While we are well aware of the present emphasis on four year graduation rates, we are concerned that increased pressure to complete the undergraduate program in four years could deter many students from entering or completing the program.

Only a handful of the students we spoke with were enrolled for the fteen units that would be needed in an average term to meet the four year completion target. Most students who are working halftime or more cannot maintain the academic workload required to complete the degree program in four years (or two years for junior transfer students); these students are a vital part of the CSU community and should not be made to feel that their progress is substandard.

As described above, in recent years the department has implemented many changes

A few suggestions:

Familiarize students with some key terminology and proof-relevant constructs in MATH 247, *Introduction to Linear Algebra*. (The course description states \Emphasis on computational methods.") If adequately motivated, this need not alienate students from other disciplines; elementary linear algebra possesses a wealth of simple examples that convincingly illustrate the importance of hypotheses.

Increase the instruction in formal proof given in MATH 323, and strongly encourage students pursuing the Applied and Statistics options to take MATH 323 before MATH 361A, scheduling both courses so as to facilitate that enrollment pattern. An introductory numerical analysis course, even one that does not emphasize rigorous proof, easily supports discussion of the analysis constructs (e.g., quanti ers). Error analysis is a crucial application of `epsilon{delta' estimates; numerical di erentiation and integration are excellent introductions to rigorous treatments of limits as applied in calculus.

Dedicate substantial in-class time to group work, including collaborative theorem and proof construction, and critiquing of other groups' constructs. Almost-immediate feedback can help students to improve their understanding of challenging concepts by means of low stakes experimentation. For example, if students are known to have di culty with quanti ers, develop short in-class exercises involving correct interpretation and use of quanti ers.

Programming Courses

All four options for the Mathematics BS provide students with at least one course focused on e ective use of computers in mathematics, statistics, or education. The tCitiqcali73420Theinkng tn tt-1(h)e-312(tDigtati73420TInormals.)]T6420TAage-TJ/F15 10.9091 Tf 1.02 0 0 1

Proposed Computational Mathematics BS

The department is currently considering adding a new degree program, a BS in Computational Mathematics. We fully support the department's plans to o er computation-focused courses that will provide students with highly marketable skills in data analytics and related elds, but recognize the risk that introduction of a new BS degree program could cannibalize the existing Applied Mathematics suboptions of the Mathematics BS program, potentially redirecting students who would otherwise choose the Applied option, rather than attracting additional students and resources. At present, there does not appear to be consensus among departmental faculty and administrators regarding the best approach to providing thorough training in computational science at the undergraduate level.

The current courses MATH 323, *Introduction to Numerical Analysis*; 472, *Fourier Analysis*; 473, *Scienti c Computing*; and 479, *Mathematical Modeling* appear to emphasize traditional ODE and PDE modeling of systems arising in the natural sciences, but much of the content of these courses is also central to graphics and data analysis, which do not rely on traditional ODE/PDE modeling. MATH 485, *Mathematical Optimization*, doesn't have an upper division ODE prerequisite, but does require MATH 233, *Fundamental Concepts for Advanced Mathematics*, for students in the Math major, while Math 233 is not required for the Applied and Statistics options in the Math BS. We encourage the department to carefully consider which courses and prerequisite requirements could be adjusted to optimize use of courses in multiple degree programs and options.

If there are insu cient resources to support and enrollments to justify both these courses and analogous courses with a more `modern' emphasis, the department might want to consider introducing a Computational Mathematics option in the Mathematics BS and revising some of the existing courses|including the prerequisites|so that most of the courses could do double duty for both the Applied and Computational options. We encourage the department to consult with outside departments, particularly engineering programs, to identify common course needs.

Graduate Program

Graduate Students

The most recent data shows that the Department of Mathematics & Statistics has 182 graduate students enrolled in its masters programs. This makes the department's graduate program one of the largest masters degree programs in mathematics/statistics in the country (and only a few American universities with doctoral programs have more graduate students in mathematics/statistics).

We had two opportunities for good discussions with large groups of graduate students. One of these opportunities was with the approximately 45 students we met who are

enrolled in STAT 410/510; a big majority of these students are graduate students. We met them at their usual class time in the usual classroom, but with the instructor absent. Our second opportunity to meet with graduate students was a discussion with about a dozen graduate teaching assistants and graduate assistants, again with no faculty present.

Overall, we found the graduate students to be very satis ed with their experience at CSU Long Beach. The graduate students consider the departmental faculty, in general, to be ne teachers who care deeply about helping their students to learn. The graduate students reported that faculty, in general, welcomed students to their o ce hours and provided appropriate assistance to help students succeed. Several graduate students contrasted this welcoming attitude with their undergraduate experiences at southern California campuses of the University of California, where some CSU Long Beach students reported that it had been di cult to have a conversation with a faculty member outside of class time. A nontrivial percentage of the graduate students with whom we talked had also been undergraduates at CSU Long Beach. That these students decided to stay at CSU Long Beach for their graduate education rather than go elsewhere is good evidence that they had an excellent experience as undergraduates at CSU Long Beach.

About 76% (three year average) of students admitted to a graduate program in the Department of Mathematics & Statistics at CSU Long Beach actually enroll in the program. This high success rate in attracting graduate students is a strong indication of the good reputation of the program.

The data in the self-study about years-to-graduation with the masters degree shows a healthy program. Speci cally, the average time to degree in the masters program in the Department of Mathematics & Statistics in under three years, in contrast to the other departments in the College of Natural Sciences and Mathematics (all with averages over three years).

Course Times

The only serious complaint that we heard from the graduate students involves class times. Only a small percentage of the graduate students are supported by teaching assistant or graduate assistant positions in the department. Thus most of the graduate students work, many of them with full-time jobs. These students very strongly requested a larger selection of classes that meet in the late afternoon (many students can arrange to get o work a bit early to attend class) or the evening. Similarly, faculty o ce hours in the morning or early afternoon do not help these students.

We note that in the current semester, no MATH/MTED/STAT courses start after 5:30 pm. As a sample contrast, we note that the Electrical Engineering Department at CSU Long Beach o ers ve graduate classes this semester that start at 7 pm (our guess is that many of the Electrical Engineering graduate students also have full-time jobs).

The Mathematics & Statistics Department is aware of this problem, as the self-study states:

mathematics, applied statistics, mathematics education, pure mathematics. Students who choose the comprehensive exam option must pass two exams in one of these four areas.

We looked over the written comprehensive exams from recent years. These exams seem to be at the appropriate graduate level.

Students who choose the comprehensive exam option must take both their comprehensive exams during the same semester. We were told that the dates on which the two exams are given are often separated by only a week.

A few students mentioned to us that they would appreciate being able to take the two exams in di erent semesters. We do not have strong feelings about this issue, but it

the corresponding courses. In contrast, writing a masters thesis will be a new kind of experience for most graduate students. This new experience can be useful for students whether they are going on to a doctoral degree or whether they intend to work in industry (where soft skills, such as writing ability, often help determine career success).

The current culture in the department is that only the best students should write theses. We recommend that this culture be changed|graduate students at all levels of mathematical pro ciency can bene t from writing a masters thesis. To encourage more students to write masters theses, it should be clear that expectations for a masters thesis di er drastically from expectations for a doctoral thesis. The results of a masters thesis need not be publishable original research. A masters thesis should include some work by the student that is more than a literature summary (for example, the student might work out a special case of a known theorem), but the discovery and proof of a new theorem should not be expected.

An increase in theses in the department will require a serious increase in the amount of faculty time spent supervising theses. Indeed, the requirement of faculty time to supervise theses may be one of the causes of the departmental culture that steers most students away from theses. To deal with this situation, we recommend that teaching credit, perhaps $\frac{1}{3}$ unit, be given for each completed thesis written under a faculty member's supervision; this would be in addition to the $\frac{2}{3}$

the lack of equipment requirements all point in the direction of outstanding future hires

Weaknesses

Students reported to us that the predominant teaching style in the

services. We recommend that the Statistical Consulting Group start charging fees for its services. Faculty with grants may have funds allocated in their grants for statistical consulting. Faculty without appropriate grant funds can be given a discount (perhaps even a 100% discount). O -campus organizations should not have a problem paying for statistical consulting. The funds generated by a fee structure could be used, for example, to provide professional travel funds to