

Proposed title for Disciplinary Communication Grant (DCG)

Math 193: Pedagogy and Teaching Disciplinary Communication (DC) Course for the Mathematics Education Track Majors to Support the Hybrid Teaching Model of Precalculus (Math 3)

Department/Program:

Mathematics

Amount requested: \$28,618.08

- Two-course buyout * for Nandini Bhattacharya for creating the six-unit upper division pedagogy course taught over two quarters geared towards Math Education track majors and developing the Hybrid Math 3 curriculum.
- Technology-related expenses for creating the 10-15 minute lecture videos.

Number of students affected: Approximately 25-30 (mostly Education Track Mathematics majors) every academic year and approximately 2000 undergraduate students per academic year enrolled in Math 3.

Overview of the program's DC requirement:

Currently, Mathematics majors satisfy the DC requirement by taking Math 100 and either Math 194 (senior seminar) or Math 195 (senior thesis). The proposed senior pedagogy and teaching DC course Math 193 will satisfy the equivalent of Math 194 or Math 195 and it will be especially geared towards the Mathematics Education track majors. The purpose for developing this course is twofold: to offer a practical pedagogy course in teaching to the Education track Mathematics majors; and to improve the learning experience of the large lecture course Math 3.

What is proposed?

The primary objective of the proposal is to develop an upper division Pedagogy and Teaching DC course especially geared for the Education track Mathematics majors, which they can take instead of Math 194 or 195. In the current offering of courses, there are very few courses designed for the Education track Mathematics majors. Although the proposed course will be available to all Math majors, enrollment preference will be given to the Education track Mathematics majors. Currently, the Education track students have to seek out teaching experience in local schools

through programs like CalTeach, which can be sometimes difficult for them given time constraints and logistics. Since the proposed course will be required for all Education track Mathematics majors, it will give them a hands-on learning/teaching experience contained within their course work as they get ready to graduate. This will be especially timely and beneficial for the matriculating seniors who are interested in teaching as a way to evaluate if a teaching career is the right option for their future career.

The six-unit course taught over two quarters will have a theoretical and a practical component. We will discuss teaching pedagogy and effective teaching methods in a weekly seminar-style class. Students will be able to apply that knowledge in the Math 3 discussion sections like a practicum in collaboration with the graduate student TAs. The DC requirement will be satisfied through this upper division course because STEM majors will learn and then practice effective communication techniques in teaching mathematics as they satisfy the equivalent of the senior seminar requirement. Hopefully some of these students will decide to become future K-12 teachers after being exposed to teaching for two quarters in such a nurturing setting. Moreover, Math 3 curriculum covers one of the most crucial concepts in foundational math. The heart of precalculus is the concept of a function – a rule assigning a mathematical object to each member of some collection of mathematical objects. In Precalculus, the objects in question are real numbers. Therefore, the benefit of a solid understanding of the Math 3 course gained by teaching others will strengthen graduating students' knowledge of this core concept, which in turn will help them with their foundational knowledge in the subject area that they may choose to teach in the future. The Mathematics department plans to submit the course approval forms and a detailed syllabus for Math 193 to CEP in October of 2015 in order to review the documents and incorporate the course into the curriculum plan and catalog copy on time. I plan to develop then a detailed syllabus outline along with the specific assignments and course objectives for the proposed course. The development of the pedagogy course will take place in the winter quarter of 2016. Please see the letter of support from the Mathematics chair Jie Qing. The course Math 193 will be first offered in the winter –spring of 2017.

The secondary objective of the proposal is the development of a Hybrid Precalculus lecture course supported in part, by undergraduate students enrolled in the pedagogy course, as well as graduate student TAs. Hybrid instruction offers an effective pedagogically sound solution to the challenge of teaching Precalculus to an extraordinarily large and diverse cohort of students. We will break down the curriculum into concept modules. For example, after we introduce the techniques of graphing by using transformation, we will introduce the students to different families

of functions (e.g. logarithmic, exponential, trigonometric) studied in Precalculus, and show them how the concepts related to transformation of graphs are common to all of these families. The same idea will be pertinent to solving equations, applying them to real world problems etc. By following this approach, rather than closely following the structure of a standard textbook, we will enhance students' learning by emphasizing mastery of concepts over memorization of property after property.

The proposed hybrid course is tailored to accommodate diverse learning styles and to allow students to learn at their optimal pace, determined by their own learning need. This approach will also enhance the human component of learning from one another and make students responsible for staying on schedule within the fast pace of a quarter system. The on-line instruction modules will give students ample time to become familiar with and process the complex concepts presented in each module at their own pace. This will allow them to come to class prepared to participate and allow instructors to use the class time more efficiently. We intend to present most of the definitions, theorems, and basic examples in on-line 10-15 minute modules in the form of lecture videos, allowing more time in class to develop the material in greater depth via discussion, examples, and questions students answer with a clicker system after they view the modules.

The preliminary work plan for the development of the Hybrid course will begin in summer quarter 2015, and course materials will be piloted, evaluated, and revised during fall quarter 2015. Development will be supported by UCSC instructional designer Aaron Zachmeier and Faculty Instructional Technology Center staff. Tablet-based lectures will be recorded in the Faculty Instructional Technology Center.

The following is a preliminary list of development tasks:

- Develop senior pedagogy and teaching DC course Math 193
- Develop course site in learning management system (Canvas or eCommons)
- Record and edit short tablet-based lectures
- Develop quizzes for learning management system and classroom clicker system.

Before each module, we will list the objectives of the module and give the students a list of question we expect them to answer after viewing and before attending the lecture. The undergraduate students enrolled in the pedagogy course will be also attending lectures and helping facilitate the proposed active-learning set-up during the lecture.

In once-a-week discussion sections, students will work in small collaborative learning groups led by graduate student TAs alongside undergraduate students enrolled in the senior pedagogy and teaching course. We will develop worksheets for the discussion sections in the senior pedagogy and teaching course, where carefully chosen problems will be designed to walk students through both computational and open-ended questions with a range of easier to challenging conceptual mathematical problems, promoting dialogue/discussion and mathematical inquiry. In sections, students will learn how to better use resources such as textbooks, online e-books and class notes to distill important concepts and apply them effectively to solve problems.

The students in the senior pedagogy and teaching course Math 193 will be mentored and instructed in weekly seminars where much of the time will be dedicated to discussions on topics such as questioning techniques, learning theory, cooperative learning, student epistemologies, argumentation, etc. Worksheets to be solved in the Precalculus (Math 3) discussion sections will be developed and used as examples to analyze the critical thinking posed by the pedagogy curriculum. This course will be developed with the help of the available teaching material of the Learning Assistant (LA) Program offered by University of Colorado, Boulder. The teaching resources from the Boulder LA program are quite extensive and the LA Alliance will mentor me in developing a pedagogy course that is appropriate for our campus and exactly satisfies the vision of my proposed course. I will also consult with Mathematics Education professors from UCSC's Department of Education as I develop the syllabus for Math 193. Also, I have received Postgraduate Certification in Education in June 1988 and Professional Clear Single Subject (Math) Teaching Credential for High School, 1988-present from UCSC. Given my background in education and a long history of teaching Precalculus to students (including ACE) for the past 28 years, I feel confident to take on the development of the pedagogy course.

What problem will this proposal solve?

First and foremost, the senior pedagogy and teaching course will give the Education track Mathematics majors a hands-on practical course in their field of interest. The UCSC Mathematics undergraduate curriculum is by and large geared towards students who are interested in pure or computational mathematics research. This will be the first course purely customized for Education track Mathematics majors. Although, the number of Education track Math majors consists of approximately one third of the total number of Math majors, there is only one course in the current offerings (Euclidean and Non-Euclidean Geometry) that is suitable for their interest

of math teaching. Therefore, the proposed course will be a great addition to the Education track students' learning experience.

Second, it will transform the educational experience of the large lecture course Math 3. This will create an environment (both during the lecture and discussion section) in which students will interact with each other, engage in collaborative problem solving, and articulate and defend their ideas. To accomplish this, a good portion of the large lecture time will be devoted to solving (with I-clickers and/or other similar electronic devices) multi-step thought-provoking examples connecting the concepts across the discipline, relevant to the course. Instead of a lecture-style algorithmic approach to solving problems, we will be able to model how to think through problems requiring multiple approaches and learning styles. Instead of always forcing students to come to the right answer, this approach will engage students in thinking about math and exploring the subject with more creative thinking processes.

Rather than answering on-line homework questions, students will work on specially designed worksheets in small groups where a graduate student TA and senior undergraduate students will work side-by-side asking guiding questions to enhance learning experience. In this setting, Math 3 students will dialogue/defend their ideas while working collaboratively and thinking through the core concepts relevant to the course. The long-term benefit of using the best practices of teaching currently cannot be availed due to the large lecture size and lack of infrastructure. This class will ensure better prepared students and a higher pass rate. A sense of community, which is much-needed for the success of first-year students, will be developed in these discussion sections. As a result, it will help with retaining those students who may never succeed at UCSC due to lack of attention and hands-on learning experience

How does the DC fit within your program's learning outcome goals?

Currently the Department of Mathematics offers three courses (Math 100, Math 194 and Math 195) towards satisfying DC requirements. The proposed pedagogy course Math 193 will expand on the current offerings very nicely and will customize an educational experience geared towards Mathematics Education track majors right before they graduate. The senior students will have to analyze the topics learned in the pedagogy course and connect that to their practical experience in the collaborative Math 3 discussion sections. Education track Mathematics majors rarely have an opportunity to develop rigorous math curriculum and write lesson plans. The senior seminar class will give students opportunities to write lesson

plans with the Math 3 curriculum, develop worksheets for the discussion sections, and keep a weekly journal reflective of their learning and teaching practices. The weekly journal will help me assess their learning experience and use it to have students reflect and improve their teaching on a weekly basis as part of the discussions. I would also have students learn about effective oral communications in teaching mathematics. We will discuss how to organize concepts for best teaching practices. Students will teach 10-15 minutes of a concept during the discussion section on the lesson that they have developed in the seminar class. For example, the Precalculus course emphasizes the use of functions as models of relationships in mathematics. The survey of standard elementary functions (including linear, polynomial, rational, logarithmic/exponential, and trigonometric functions) includes modules specified with key features such as studying functional properties, graphing with transformational properties, solving and application to real word problems. I would have students in the pedagogy course choose one such module of a specific function and have them fully develop the concept. The students will learn how to communicate as they teach mathematics by developing a lesson plan, an oral presentation of the concept in Math 3 discussion section and a subject-specific curricular development of worksheets to be used in the collaborative learning style sections supported by the graduate TA. A weekly journal will help students reflect and process the pedagogy as they develop their skills as a math teacher. All of these assignments will be guided by the theory learned in the pedagogy course Math 193. At the end of each quarter students will be asked to submit a portfolio of writing (18-20 pages) consisting of their key reflections and learning out come from the weekly journal in the course, lesson plans and worksheets that they created for the Math 3 discussion sections. I believe all these different forms of communication will be invaluable learning for Education track Mathematics major in their discipline.

The DC also fits indirectly with the development of the Hybrid Math 3 course. The campus trend for the past few years has been that more and more students are placing into Math 3 (Precalculus). Precalculus is a pre-requisite course for many STEM courses. The outcome of my proposed hybrid model will teach 2000+ undergraduates every year how to communicate mathematics by using proper vocabulary and understanding of basic important mathematical concepts. The hybrid teaching model is based on active learning during lecture and collaborative learning during the discussion sections. In both settings, students have to clearly articulate their knowledge in order to participate in coming up with a solution. Promoting interactions with each other will help students to become comfortable in the language of mathematics. This training in how to study math will in turn help

them to process and communicate learning more easily in other STEM- related disciplines.

This innovative, multifaceted approach that incorporates on-line modules, and graduate and undergraduate upper classmen assistance to help students in a critical gateway math course like Precalculus is very much in alignment with the National Science Foundation's call to transform students' learning and educational experience in higher education. I intend to write a NSF proposal after we gather some initial data of the learning outcome of the Math 3 students with the hybrid model and eventually scale it to other disciplines at UCSC. Moreover, if this teaching model can be proven to be successful, the campus retention issue will be well addressed.

Detailed budget: (you may attach additional spreadsheet)

Two-course buyout for Nandini Bhattacharya

\$26,706.08*

Technology and Equipment

- Intuos Pro Large (Tablet): \$500
- Sennheiser ew 112-p G3 (Wireless Lavalier Microphone and Receiver): \$630
- MXL USB Mic Mate (USB Interface): \$40
- Acoustic insulation: \$150
- Camtasia (screen recording software): \$227
- SketchBook Pro (drawing software): \$65

Total: \$1612

Course Production

- Video captioning (accessibility): \$300 (roughly \$2.00 per minute)

Total: \$300

Grand Total: \$28,618.08

Assessment plan. How will the effectiveness of this change be measured?

I plan to conduct mid-quarter and end-of-quarter evaluations of the students enrolled in the senior pedagogy class to measure their rate of satisfaction with the course and how we can improve it further. I also would like to conduct an exit interview with students at the end of the spring quarter to evaluate their experience in the pedagogy course and to mentor them regarding their career plans, especially related to teaching, upon their graduation from UCSC.

The Learning Assistant Alliance nationwide is launching a large data study on learning gains in the LA-assisted courses. As an active participant of the LA conference, I have been invited to join the Alliance. They will provide us with reports comparing UCSC students' learning gains to national normed data. On a local context, I will run a similar report for my Hybrid Undergraduate Assisted (UA) Math 3 course with the second Math 3 (in the fall) that is not Hybrid and LA assisted. Also, I have taught Math 3 for the past 23 quarters in a row. I would be able to assess the learning gain of students with the hybrid model and see any significant trends by comparing the outcome to that of the past 23 quarters. I can compare data both for the overall pass rate and the individual grades received by students.

Sustainability. How will this innovation be continued without DCG funding?


After the on-line learning modules are created and the pedagogy course is developed, teaching of the Hybrid Math 3 course will be very similar to running a five-unit Math course and a six-unit DC course spanning two quarters (Winter-Spring) for the campus. The expenses for the course will mostly be required in the first year as we develop the technology and teaching curriculum. Once the content and the technology are developed, we can share this with any member of the Math department who will teach Math 3 or the senior pedagogy and teaching class in the future.

I plan to put together a reader consisting of examples from the students' work (lesson plans and worksheets) along with the reading material of the pedagogy course on topics such as questioning techniques, learning theory, cooperative learning, student epistemologies, argumentation, etc. The topics will cover the curriculum taught in the Math 193 course with representative examples developed by the Math 193 students (from their portfolios) as they are integrated with the Math 3 curriculum.

I have been mentoring the undergraduates hired by Learning Support Services who assist with the teaching of Math 3 on a weekly basis since 2007. As a result, a lucid model of such activity like developing worksheets with best practices of teaching is already in place and I feel comfortable leading such discussions. The funding of this proposal will allow me to develop, implement, and put in place a senior seminar course on pedagogy and teaching for the Education track Mathematics majors, interwoven with development and implementation of large lecture style Math 3 as the practicum component of the senior seminar course, that will transform the learning experience of many undergraduates in their first year. If successful, this model then can be scaled to not only other courses in math, but also to other STEM courses such as General Chemistry, Introductory Physics, etc. The reader developed in this course then can be shared with other department in PBSci and the development of a course like Math 193 will open up the possibility to transform the learning experience of many introductory and traditionally difficult STEM courses for the campus.

* If less grant money is awarded, I will focus on development of the Math 193 course and not record and edit short tablet-based lecture modules for the Math 3 Hybrid course.

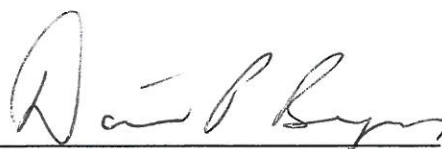
Recommended by (or attach dated email approval):



Dept. Chair or Program Director

Mar 18 2015

Date

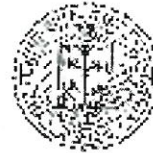


Dean

3/18/15

Date

Approved by CEP October 15, 2014



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March 18, 2015

Dear Disciplinary Communication Grant Committee (DCG)

This is a letter in support of Nandini' Bhattacharya's proposal to create a Disciplinary Communication (DC) course which will support a restructured hybrid course Math 3 Precalculus.

In recent years we have seen growing enrollments in our preparatory calculus courses. It becomes a huge challenge to deliver the curriculum when the class sizes are close to 500 for these preparatory courses. We are very grateful that Nandini has taken up the task to use innovative teaching tools to meet the challenge. We support the idea of creating a specialized DC course to provide professional training in pedagogy for students who are interested in teaching mathematics. This DC course will be integrated with the restructured teaching of Math 3 through the use of small interactive sections in Math 3. This approach not only enriches our program for education track students but also will contribute towards success in solving the issues on student graduation time and retention.

The DC course that Nandini is proposing is a 6-unit course. It will be offered in the form that the first half (3 units) goes with a Math 3 offering in Winter and the second half (3 units) goes with the Math 3 offered in Spring.

The Department of Mathematics is making the commitment to continue to offer this proposed packed course offering for an additional two years, should Nandini's proposal be funded. We also recognize that the work involved with teaching of the DC course should be assigned an instructional workload credit of 1.33 in addition to the teaching credits for the teaching of two Math 3's (3 courses @1.33 IWC).

It is a great deal of effort to create a DC writing course and integrate it into the restructuring of the teaching of pre-calculus. In order for Nandini to have adequate time and resources for this endeavor, she will require two course releases (buy-outs) to complete the work on her proposed project.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Jie Qing'.

Jie Qing
Chair, Mathematics Department

JQ:md