DRAFT

Analysis of Math 2 Stretch within the Context of UCSC Mathematics Courses Below Calculus

Prepared by
Holly Gritsch de Cordova
Charis Herzon

The goal of this short report is to successfully explain Math 2 Stretch to faculty and advisers who work with students who need mathematical understanding in order to achieve their educational objectives and career aspirations. Math 2 Stretch, a two quarter option for students who enter UCSC lacking the ability to demonstrate an understanding of college algebra concepts, is designed to assist students to develop a strong foundation of algebraic understanding that will enable them to continue to pursue more advanced math courses and, thus, access courses and/or majors in the PBSci Division, School of Engineering, Economics Department, Psychology Department, and math-related General Education requirements.

Issues of Students' Mathematical Preparation and Self Perceptions

Having been admitted to UCSC, it is not surprising that most students are shocked and dismayed when they are required to place into university-level math classes and, based on the Mathematics Placement Examination score are told that they must enroll in Math 2, College Algebra or Math 3, Precalculus. Many UCSC students enter Math 2 and Math 3 with misguided perceptions of their mathematical abilities. Some overestimate their knowledge and skills and don't take the classes seriously, others are petrified by the apparent disconnect between their high school achievements and university expectations, and most are unfamiliar with the large lecture instructional delivery structure of Math 2, College Algebra, and Math 3, Precalculus. In order to assist students with academic goals dependent on mathematical expertise, Learning Support Services and the Mathematics Department formed a partnership ten years ago and have been working together to improve the effectiveness of UCSC mathematics instruction and academic support services in courses below calculus. Based on our ten-year partnership, the remainder of this brief report includes data and observations that should be of interest to academic advisors and faculty members teaching in disciplines that require students to demonstrate some mathematical understanding through the College Algebra and Precalculus levels in order to succeed in major-specific courses.

General Overview of the Math Courses Below Calculus and the Academic Support Programs Integrated into Each Course.

Analysis of Student Academic Achievement Trends in Math 2 Stretch, Math 2, and Math 3

The Mathematics Department and Learning Support Services have worked together to integrate academic support into the pedagogy and structure of Math 2, College Algebra, Math 2 Stretch, a two-quarter College Algebra course option (offered in fall, 2010) and

Math 3, Precalculus. Together the Mathematics Department and Learning Support Services have developed academic support programs and strategies that are integrated into the course content so as to address the teaching/learning needs of students at various levels of mathematical preparation within the same large lecture course. In the case of Math 2, based on their Mathematics Placement Exam (MPE) score and their Algebra Readiness Test score (given on the first day of class) students are advised to enroll into a mandatory small 12-15 student twice-a-week or once a week course section. They are also encouraged to attend Modified Supplemental Instruction (MSI) sessions and may also work with a math tutor. All students in Math 2 Stretch are enrolled in small, twice-a-week mandatory sections and encouraged to work with a tutor. They also have two quarters to master the content of Math 2, earning 7 units. Students in Math 3 are recommended to select small, twice-a-week sections based on their MPE scores or their course grade in Math 2. Again, students are encouraged to use MSI and to request tutoring. The following data will illustrate the relationships among the students' apparent academic preparedness for their math classes, their section choices, and their course performance as measured by course grades/demonstrated academic achievement.

Learning Support Services and the Mathematics Department prepared a longitudinal study of student achievement data in the spring of 2010 that clearly illustrated several trends and resulted in the creation of Math 2 Stretch. (To peruse this study, go to the LSS web site.)

- Although the primary purpose of Math 2 is to prepare students for Math 3, students who completed Math 2 were most likely to earn one grade lower in Math 3. Therefore, many students who earned a C in Math 2 were not passing Math 3.
- Students with MPE scores below the mid-point of the placement range for Math 2 and Math 3 were more likely to struggle in the class if they did not choose to enroll in twice per week sections.
- On average, students who used MSI did better in the classes than students who did not attend MSI sessions.
- Math 2 students who scored in the low end of the acceptable range on the MPE and the Algebra Readiness test were at high risk of not passing Math 2.
- Students who repeated Math 2 and Math 3 were likely not to pass the classes during these repeated attempts.

So, in the fall of 2010, Math and LSS offered Math 2 Stretch for the first time, a two-quarter, seven-unit option through which students can complete Math 2 and, we hope, become better prepared for Math 3. The following brief data analysis examines the Math 2, Math 2 Stretch, and Math 3 student achievement data during the 2010-2011 academic year.

Please See Appendix 1 (at the end of this report) for an in-depth explanation of the educational expectations and instructional format of Math 2 Stretch.

Math 2 Data for Fall and Winter, 2010-2011

Now that Math 2 Stretch is available to students, LSS and the Math Department are interested in collecting evidence to establish clear guidelines regarding which students are best served by Math 2 Stretch and which are best served by Math 2. Obviously, we only want to recommend that students who need a two-quarter exposure to college algebra so as to master the material such that they can succeed in more difficult Math, AMS, major-related, and General Education requirements complete Math 2 Stretch. Therefore, we looked at four groups of Math 2 students, those who scored in the low ranges of the MPE (below 17) and the low ranges of the Algebra Readiness test (below 18), the low-low group, those who scored in the high range of the MPE, (17 or above) and the high range of the Algebra Readiness test (18 and above), the high-high group, those who scored low on the MPE but high on the Algebra Readiness test, the low-high group, and those who scored high on the MPE but low on the algebra Readiness test, the high-low group. Table 1 shows a comparison of the academic achievement of students in these four groups.

Table 1 Pass Rates of Students with the Four Combinations of Algebra Readiness Scores (Alg) and Math Placement Score (MPE) (AY 2010/2011) and Their Utilization on Once a Week or Twice a Week Sections

	Low MPE , Low Alg		High MPE, Low Alg		Low MPE, High Alg		High MPE, High Alg	
	Number of students	Pass Rate	Number of students	Pass Rate	Number of students	Pass Rate	Number of students	Pass Rate
Once a week sections	22	45%	14	86%	86	78%	104	86%
Twice a week sections	56	59%	25	76%	20	80%	12	92%

Low MPE: 12-16, High MPE 17 and above, Low Alg: 0-17, High Alg 18 and above

It is clear those students who score in the low range on both the MPE and the Algebra Readiness test benefit from twice a week sections if they enroll in Math 2. However what is also clear is that they are likely candidates for Math 2 Stretch. Even with twice-a-week sections they had only a little more than a 50% chance of passing Math 2. The Algebra Readiness test also seems to be a better predictor of students' academic achievement in Math 2 than the MPE. Additionally, twice-a-week sections may not be needed for students who score in the high ranges of the Algebra Readiness test.

Table 1 reflects the academic performance of all of the Math 2 students for fall and winter quarters. Table 2 identifies the course pass rate by quarters. It is evident that the students who enrolled in Math 2 in the fall were a stronger group than those who enrolled in the winter.

Table 2 Math 2 Pass Fall 2010 and Winter 2011

	Total Number of Students	Pass rate
Math 2 Fall 2010	193	79%
Math 2 Winter 2011	182	70%

Perhaps it can also be argued that the overall pass rates for the Math 2 classes are problematic when one considers that these UC eligible students who do not pass Math 2 cannot pursue any major requiring math skills and may not be able to fulfill at least two of the current General Education requirements, Mathematical and Formal Reasoning and Statistical Reasoning.

Table 3 illustrates the positive effects of Modified Supplemental Instruction (MSI) on students' academic performance in Math 2.

Table 3 Math 2 Pass Rates based on MSI Participation combining Fall 2010 and Winter 2011

	Number of Students	Pass rate
MSI participation	220	80%
Non-MSI Participation	147	69%

Students who chose to attend MSI were from all four groups of Math 2 students described in Table 1 and attended both once and twice-a-week sections. Therefore, it appears that these small, peer-led, interactive learning groups assisted students to master the material presented in lecture, further explained in the textbook, drilled in the mastery-learning, on-line homework program, and discussed and practiced in the sections. Math 2 students seem to need time on task with the support of a peer group and a knowledgeable Learning Assistant trained to ask probing questions and not to lecture or provide answers. This is what MSI provides when it works according to LSS guidelines.

Student Achievement Data from the First Offering of Math 2 Stretch

Math 2 Stretch was offered for the first time in fall, 2010. Students who complete Math 2 Stretch must be prepared to spend two quarters mastering the content of Math 2 as the program description indicates. Therefore, Math 2 Stretch is only available to students once each year and always begins in the fall quarter. Last fall we had 26 students begin Math 2 Stretch. Table 4 compares Math 2 Stretch students with Math 2 students. (It is noteworthy that not all of the students who chose to enroll in Math 2 Stretch were members of the low MPE-low Algebra Readiness group described in Table 1. LSS and Math did not yet have data to identify the students best suited to Math 2 Stretch.)

Table 4 Overall Pass Rate for Math 2 Fall 2010, Winter 2011 and Each Quarter of the Math 2 Stretch Program

	Total Number of Students	Pass rate
Math 2 Fall 2010	193	79%
Math 2 Winter 2011	182	70%
Math 2S Fall 1st quarter (2-unit)	26	85%

Math 2S students: Winter 2011 (Math 2 5-unit)	19	79%

The data comparing the pass rates of students in Math 2 and students in Math 2 Stretch clearly indicates that the students in Math 2 Stretch passed the class at a higher rate. However, as is also evident, the group of students who chose to enroll in Math 2 Stretch was small. The Algebra Readiness test was given on the first day of Math 2 in the fall, and all students who scored below 18 on this test were encouraged verbally by the instructor and via an email from Learning Support Services to enroll in Math 2 Stretch rather than Math 2. Twenty-six students did make the choice to enroll in Math 2 Stretch, but not all of them were from the group scoring low on the Algebra Readiness test and low on the MPE, the group that Table 1 clearly indicates are most likely to fail the one-quarter Math 2 class.

Relationship of Students' Academic Achievement in Math 2S and Math 2 to Their Demonstrated Academic Achievement in Math 3

Before Math 2 Stretch can be considered as an effective instructional delivery format for students who enter UCSC without mathematical preparation to enable them to succeed in traditionally formatted UCSC Math classes, we need to investigate the academic achievement patterns of successful Math 2 Stretch students as they take Math 3. Table 5 presents data comparing the academic achievement of Math 2 and Math 2 Stretch students enrolled in Math/AMS 3 in spring 2011.

Table 5 Math/AMS 3 Outcomes for Winter 2011 Math 2 versus Students Who Completed Math 2 via the Math 2S 2-Quarter Option

	Total Number Went Into Math/AMS 3 Spring 2011	Total Number that Passed Math/AMS 3
Math 2	112	77 (69%)
Math 2S	15	13 (87%)

Because the Math 2 Stretch group is so small, these comparisons may only represent possible future trends. Yet, it does appear that the Math 2 Stretch option does offer students with underdeveloped algebra skills and, perhaps, a lack of confidence regarding their ability to learn math an effective learning environment. Their higher pass rate in Math 3 than their peers who took the traditional Math 2 class seems to hint that the Math 2 Stretch students retained more of the college algebra skills that they learned than did their Math 2 peers.

Based on data from the first year of Math 2 Stretch, we have the following recommendations:

- Advisors should urge all students who score below 17 on the MPE to enroll in Math 2 Stretch in fall quarter.
- Continue to give the Algebra Readiness test during the first Math 2 class.
- Urge and (eventually ask the Math Department to require) all students who score below 17 on the MPE and below 18 on the Algebra Readiness test to enroll in

Math 2 Stretch. (Based on 2010-11 data, we anticipate this to be approximately 45 to 50 students each fall.)

- Continue to offer Math 2 Stretch using the current instructional model including extensive evaluation, data collection and data analysis.
- Review the effectiveness of the program each year. The program review should continue to follow students through their pathways to majors, comparing the success of students who take Math 2 and Math 2 Stretch in major prerequisites in the Mathematics, Applied Mathematics and Statistics, and, perhaps, Chemistry, Economics, and Psychology Departments.
- Collect feed back regarding Math 2 and Math 2 Stretch from College, Academic Department, EOP, DRC, and STARS advisors.

Analysis of Student Achievement Patterns in Math 3

Since the main purpose for Math 2 is to prepare students for more advanced Math and AMS classes, particularly Math 3, Precalculus, we will end this report with a brief discussion of students; academic achievement trends in Math 3 during the 2010-11 academic year.

- For ten years Learning Support Services and the Mathematics Department have been in a partnership offering academic support to students in Math 3. LSS offers small (12 to 15 student) twice-a-week sections for students entering Math 3 with MPE scores at the low end of the placement range, 20 to 24. Students who earn below a B in Math 2, Math 2 students who prefer more section style support and students who are repeating Math 3 are recommended to twice a week sections as well. The Math Department offers larger (25 student), TA-lead, once-a-week sections for students scoring 25 or above on the MPE.

Many students enter Math 3 directly after taking the Mathematics Placement Examination. Table 6 presents an overview of these students' academic achievement by MPE score and section type. As previously mentioned, students who score at the low end of the placement range (20-24) are recommended to enroll in twice a week sections. Students who score in the high range (25 and above) are encouraged to enroll in once a week sections. The pass rate in Math 3 for students in the low MPE range who followed the recommendation and enrolled in twice-a-week sections was 80% as compared with a 71% pass rate for students who did not follow the section placement recommendations. These students did benefit from the twice-a-week sections rather than the larger, once-a-week sections.

Table 6 Math 3 Pass Rates for Students Who Placed Into Math 3 via the Math Placements Exam Based on MPE Range and Type of Section Utilization (AY 2010/2011)

	Once a Week Section	Pass rate	Twice a Week Section	Pass rate
MPE 25 or above	490	87%	56	84%
MPE below 25	144	71%	211	80%

Table 7 illustrates the performance of Math 2 students who take Math 3. It appears that students who earn a B or above in Math 2 do not really need to be placed in twice-a-week sections in Math 3. A better choice for them might be to attend a once-a-week section and also attend MSI.

Table 7 Math 3 Pass Rates for Students Came from Math 2 Based on Math 2 Grade Ranges and Type of Section Utilization (AY 2010/2011)

	Once a week Math Section	Pass rate	Twice a Week Section	Pass rate
Came from Math 2 with a B or higher	74	89%	59	90%
Came from Math 2 with a lower than a B	46	59%	80	50%

Table 8 illustrates the pass rates for students who repeat Math 3 by section placement. It is evident that students who repeat Math 3 continue to struggle. That being said, they are more likely to pass the class when they repeat it if they enroll in twice-a-week sections.

Table 8 Math 3 Pass Rates for Students Repeating Math 3 and Type of Section Utilization (AY 2010/2011)

	Once a Week Section	Pass rate	LSS Twice a Week Section	Pass rate
Repeating Math 3	69	67%	86	73%

Unfortunately, year after year LSS student achievement data continues to show that students who take Math 2 and then take Math 3 tend to earn one grade lower in Math 3 than they earned in Math 2. Table 9 presents data from 2010-11 that again corroborates this trend.

Table 9 Average Math 3 Grade Based on Math 2 Grade and Section Utilization

	Once a Week Section	Twice a Week Section
Math 2 Grade: A	3.00	3.24
Math 2 Grade: B	2.06	2.03
Math 2 Grade: C	1.32	1.37

(Primarily whole grades are given in Math 2 thus pluses and minuses for Math 2 grades were lumped to closest whole grade)

Table 10 focuses on the grade trends for Math 2 Stretch students who enrolled in Math 3. Although the group is small, and we have only one year of data thus far, it appears that Math 2 Stretch students may carry more knowledge and skill with them to Math 3. Their academic performance in Math 3 did not, on average, fall as dramatically.

Table 10 Math/AMS 3 Average Grades Spring 2011, for Winter 2011 Math 2 versus Students Who Completed Math 2 via the Math 2S Route

	Average Math 2	Average Math 3 Grade*

	Grade*	
Math 2	2.82 (S.D. 0.74, N=111)	1.90 (S.D. 1.37, N=102)
Math 2S	3.16 (S.D. 0.58, N=15)	2.59 (S.D 1.06, N=14)

*The average grade is only for the students who went into Math 3 and requested a letter grade for the specified class

Math 2 Stretch students ended Math 3 with higher grades on average than Math 2 students.

Our recommendations regarding student placement in Math 3 are as follows:

- Strongly encourage students who enter Math 3 with an MPE score of 20 through 24 to enroll in a twice-a-week section.
- Do not encourage Math 2 students entering Math 3 with a B grade or above to enroll in a twice-a-week section, but do encourage them to attend an MSI session in addition to their once-a-week section.
- Strongly encourage, and if the data continues to illustrate the same patterns as shown in this report, eventually require all students who score below 17 on the MPE and below 18 on the Algebra Readiness test to enroll in Math 2 Stretch. These students are most likely to earn a C or not to pass Math 2. Students who leave Math 2 with a C grade are, on average, likely to fail Math 3. On the other hand, students from Math 2 Stretch did better in Math 3 than students from Math 2.
- During advising sessions, share data with students and help them make informed choices.

Conclusion

It is the goal of the Mathematics Department and Learning Support Services to continue to increase our understanding of UCSC students' needs regarding their mathematical skill development. Math 2 Stretch may offer a viable pathway for mathematically underprepared UCSC eligible students to gain access to and eventual success in majors requiring some level of mathematical expertise. We need to first encourage and soon require more students to select this option and continue to collect data regarding their academic achievement trends. College and Department advisors can be particularly helpful in guiding students toward the most appropriate pathways for them within Math 2 Stretch, Math 2, and Math 3. Data indicates that students in the low placement range of the MPE for Math 2 (below 17) should initially enroll in Math 2 Stretch, and students in the low placement range for Math 3 (20-24) should select a small, twice-a-week section when enrolling in Math 3. Participating in Modified Supplemental Instruction is also helpful in both classes. Advisors can assist students to make these choices.

Appendix 1

Explanation of Math 2 Stretch

Purpose and Goals

This course is designed to address two problems validated by an extensive study of student achievement patterns in Math 2 and Math 3 at UCSC.

1. Although the purpose of Math 2, College Algebra, is to prepare students for Math 3, Precalculus, students are most likely to receive one grade lower in Math 3 than they received in Math 2. Thus, many students who receive a C in Math 2 do not pass Math 3. For example the student from 2007-2009 that received a C in Math 2 passed Math 3 at a rate of 44%. Furthermore, the C grade has consistently been the most common grade given in Math 2.
2. Students who score below 18 on the Algebra Readiness Diagnostic Test given on the first day of Math 2, on average, fail Math 2 at a rate of 66%.

The goal of Math 2 Stretch is to provide a supportive educational environment wherein students entering UCSC needing to master algebraic conceptual and computational skills may spread this learning over two quarters.

Course Description

Math 2 Stretch contains the same content as Math 2 but allows students two quarters to master the material. In the first quarter, students enroll in Math 2 Stretch and earn two units if they demonstrate mastery of half of the material taught in Math 2. During the second quarter, students enroll in Math 2 and will earn five units of credit if they demonstrate mastery of the second half of all of the material covered in Math 2. Students who score below 17 on the Mathematics Placement Examination should be advised to enroll in Math 2 Stretch. If they score below 18 on the Algebra Readiness Test given in the first Math 2 class meeting, they will be advised to remain in Math 2 Stretch.

- Students who enroll in Math 2 Stretch will be placed in small, twice-a-week sections and given a tutor/coach.
- Students in Math 2 Stretch will no longer attend lectures after the first mid-term but will continue to attend twice-a-week sections, attend concept discussions and computation practice sessions with the Math 2S Graduate Student Teaching Assistant, work with a tutor/coach, and continue working with the on-line, mastery-learning algebra program (ALEKS).
- A student who passes the first mid-term will consult with the instructor and might be assisted to enroll in Math 2 rather than remaining in Math 2S.
- When students in Math 2S have demonstrated mastery of material on the first mid-term through weekly quizzes and a similar mid-term exam, they will move into new material such that they master the first half of Math 2 by the end of fall quarter.
- Students in Math 2S who have made satisfactory progress will receive two units of credit at the end of the first quarter.
- Students in Math 2 Stretch will enroll in Math 2 in the winter quarter.

- Prior to the first mid-term, they will not attend class, but will continue to learn the material covered in the second half of Math 2 in TA–lead discussions/problem solving sessions, twice-a-week sections, tutor/coaching, and the on-line, mastery learning, ALEKS program.
- After the first mid-term in Math 2, the Math 2 Stretch students will join the Math 2 class and continue to learn the material. They will continue to attend twice-a-week sections, tutoring, and consult with the Teaching Assistant. (Tutoring, sections, and ALEKS will continue.)
- Students in Math 2S will take the second mid-term and the final exam, and will earn five units of credit for the class if they pass these exams and have acceptable attendance, homework, and participation credits.

Below is a visual representation of the Math 2 Stretch, two-quarter course.