Replacing Remedial Mathematics with Corequisites in General Education Mathematics Courses

Alana Unfried (California State University, Monterey Bay)

Alana Unfried completed her Ph.D. in Statistics at North Carolina State University in 2016. Her research interests focus on statistics education, including statistical service learning, co-requisite courses, and the development and validation of instruments assessing attitudes towards statistics. She also enjoys consulting work and collaborating with STEM and education faculty on improving student attitudes toward STEM.

1 Introduction

Every year, millions of students in the United States begin their college education. Most of these students will be required to complete a college-level mathematics course in order to graduate. However, consider what happens to students pursuing a college degree who are underprepared for college-level mathematics. Sometimes with hard work, these students find success at college-level mathematics; however, there are three other common scenarios: 1) They are simply not be admitted at certain universities; 2) They attempt a college-level mathematics course, but can not pass the course; and 3) They are required to take an Elementary Algebra or Mathematics Remediation course before being able to take a general education (GE) mathematics course. In fact, across the nation, more than one million students begin in Mathematics Remediation each year [7].

With so many students needing mathematics remediation, one would hope that remediation works. However, at four-year colleges, only 36 percent of students who begin in remedial mathematics successfully complete a GE mathematics course after completing remediation. At two-year colleges, only 20 percent of students are successful [7].

With the failure of remedial mathematics programs becoming more evident, several states are beginning to offer corequisite support courses in place of traditional remediation. In a corequisite model, students can enter directly into a college-level mathematics course instead of requiring remediation first. Since they might still need additional support to successfully complete the course, they can enroll in a corequisite support course alongside the college-level mathematics course to give them extra practice. This can improve time-to-graduation since students need to complete less units overall.

Research also shows that students in a corequisite model have improved pass rates compared to a corequisite model. A randomized experiment showed that students assigned directly to a college-level statistics course with a corequisite had a 16% higher pass rate than students placed in remedial algebra, and they earned college credit at the same time [13]. Burns Childers et al. [1] also found that many students get lost in the "pipeline towards earning college mathematics credit" when placed in a remedial mathematics structure, and recommend placing as many students as possible into a corequisite course rather than a remedial course. Results from the Tennessee community college system in 2015 showed that 51 percent of students enrolled in a corequisite mathematics course successfully passed the college-level course, whereas only 12.3 percent of students who began in mathematics remediation and attempted a college-level course were able to pass the college-level course [15]. Due to findings such as these, many states are moving to widespread implementation of corequisite models. This includes Georgia, West Virginia, Tennessee, Indiana, Colorado, and Texas [7, 9, 15].

Switching to a corequisite model, however, can be challenging. Daugherty et al. [9] identify issues such as scheduling and advising, buy-in from stakeholders such as students and the institution, and the cost of professional development for faculty to implement the new instructional model.

This paper discusses the switch from a mathematics remediation model to a corequisite support model at one mid-sized university in California. Section 2 gives university context and the motivation for the change. Section 3 describes the structure of the corequisite courses that were developed, and Section 4 similarly describes how GE mathematics courses were adapted to support this change. Section 5 provides results from the first year of implementation, and Section 6 gives recommendations for readers interested in moving to a corequisite model.

2 Context

As of 2017, California was added to the list of states practicing widespread implementation of corequisite models. In August of 2017, the Chancellor's Office of the California State University (CSU; 23 campuses serving 428,000 undergraduate students as of Fall 2018 [2]) issued Executive Order 1110, mandating the end of both mathematics and written communication remediation by Fall of 2018 across all CSU campuses [19]. In place of remediation, each campus may require only one unit of non-college-credit-bearing developmental math, either in the form of a corequisite course or a stretch course. Also in 2017, the California government passed AB705, a bill which requires community colleges to "maximize the probability that the students will enter and complete transfer-level coursework in English and Mathematics within a one-year time frame" [18]. This bill aims to substantially reduce the number of students placed into remedial courses, which in effect is increasing the use of corequisite courses in community colleges across California.

The university that is the subject of this article, California State University Monterey Bay (CSUMB), is a part of the CSU system and therefore subject to Executive Order 1110. CSUMB is classified as a Hispanic-Serving Institution, with 42% of students identifying as Latino in Fall 2018. Fall 2018 enrollment was just over 7,500 students, with 63% female, 95% coming from California, and 72% of students age 24 or younger [4]. In Fall 2018, CSUMB complied with the Executive Order by ending mathematics remediation and moving fully to a corequisite model across all GE mathematics courses, of which there are four (Quantitative Literacy, Finite Mathematics, Precalculus, and Introductory Statistics). The choice of GE mathematics course is determined by major; Precalculus is required by STEM majors, Finite Mathematics serves Business majors, Quantitative Reasoning serves Liberal Studies students, and Introductory Statistics is required for most other majors such as Psychology, Kinesiology, and Collaborative Health and Human Services.

Historically, close to 40 percent of students at CSUMB have begun in mathematics remediation. These students were required to complete either a one- or two-course remediation sequence of four-unit non-credit-bearing courses; the majority required two-course remediation. Our remediation program was recognized with a $3 million grant due to its success moving students through remediation efficiently; 90 percent of students completed mathematics remediation in their first attempt, when national rates hovered around 50 percent [3]. However, similar to national trends, successful completion of mathematics remediation did not guarantee successful completion of the subsequent GE mathematics course. Table 1 shows pass rates for GE mathematics courses in Fall 2016. Pass rates for students who never required remediation ranged from about 72 to 90 percent, whereas students who had successfully completed remediation generally had much lower pass rates, even though they were considered fully remediated. The equity gap for Quantitative Literacy is notably lower than for the other courses; this is likely due to smaller class sizes and being the GE mathematics course that requires the lowest level of mathematical skills.

Table 1: General Education Pass Rates in Fall 2016 as a function of Remediation. Parentheses display the total number of students in each category.

Course	No Remediation	2-Course Remediation	Equity Gap
Introductory Statistics	79.9% (189)	48.2% (112)	31.7%
Quantitative Literacy	90.5% (42)	88.7% (30)	1.8%
Finite Math	78.0% (82)	29.4% (17)	48.6%
Precalculus	72.1% (287)	39.0% (41)	33.1%

Although CSUMB was considered successful at mathematics remediation, it did not naturally follow that students were successful in their general education courses. Therefore, the 90% remediation completion rate should not be indicative that CSUMB is somehow different from other universities in terms of GE mathematics success. The demographics of our university are very similar to those of other California State Universities and public universities more generally. The high remediation completion rate is, however, evidence that CSUMB faculty strive to be innovative and effective educators. The efforts that faculty put into the remedial mathematics program were transferred to the development of the corequisite model instead.

Upon abandoning the mathematics remediation model, CSUMB faculty chose to create a one-unit corequisite course tied to each GE mathematics course to offer additional support to underprepared students. At the same time, faculty recognized that this change would result in a new mix of student preparedness in our GE mathematics courses, requiring careful consideration of pedagogy in those course courses as well. The following two sections detail the structures of the corequisite and GE courses, respectively.

3 Corequisite Support Course

On campus, we often refer to the corequisite course as a “support course” in order to remove any negative stigma from the course; it is not meant to be a punishment, but rather a resource for students. Therefore the phrases “corequisite course” and “support course” will be used interchangeably.

3.1 Who Enrolls in a Corequisite?

Under the mathematics remediation model, math placement exam scores were used to determine which students were placed into mathematics remediation. Under Executive Order 1110, however, the CSU implemented a Multiple Measures placement in which factors such as high school GPA, high school mathematics courses and grades, and ACT/SAT score, are used to determine if students are required, recommended, not recommended to enroll in a corequisite course.

Instead, CSUMB piloted Directed Self-Placement (DSP) in which students complete a short online reflective experience prior to enrolling in their courses. Directed self-placement is commonly used for placement in writing courses [16]. Some questions require mathematical reasoning, but other questions ask about a student's attitude toward mathematics and their previous experiences with mathematics. The DSP module offers them a recommendation to either enroll in the corequisite course or not, but students are given agency to decide for themselves if they will enroll. Our investigation of the validity of our DSP instrument is ongoing. In total, 21.6 percent of GE math students chose to enroll in a corresponding support course during the 2018-19 academic year.

3.2 Corequisite Structure

The corequisite course is offered as a one-unit, two-hour activity period. The corequisite course is comprised of students from any section of the corresponding GE mathematics course. Corequisites are capped at 25 students, and an embedded peer mentor from the university tutoring center assists in each class period so that students can receive more individualized attention and learn strategies from their peers. The corequisite course is always taught by an instructor who is also teaching a section of the GE course so that the instructor is up-to-date on current materials and challenges in the GE course.

3.3 Corequisite Class Components

The corequisite class has three components: 1) support for corequisite mathematics knowledge, 2) support for GE course content, and 3) study skill development.

3.3.1 Corequisite Mathematics Knowledge

Corequisite mathematics knowledge is developed through the use of an online adaptive learning system, EdReady. Each instructor creates a skill set of mathematical knowledge needed in a GE course prior to each exam, for a total of about three skill sets per semester. Each student completes a diagnostic quiz online to assess what mathematical skills need work, and then EdReady creates a custom study path for each student. Students can then learn and self-assess through the online platform, and work towards 90% proficiency on the skill set (Figure 1).

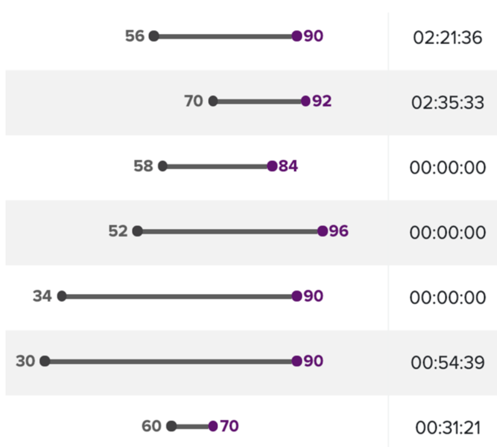


Figure 1: An example of starting and ending scores for students in EdReady, along with the amount of time they worked on learning additional skills. (A time of zero indicates students improved their scores on the assessment without needing to complete additional learning modules.)

Students can spend as much time as they would like working toward proficiency, rather than having a limited number of attempts. Some time is given in class for EdReady practice, but students are mostly expected to complete EdReady outside of the activity period.

3.3.2 Support for Course Content

Each support course is geared towards active learning, with the use of group activities and worksheets that give extra practice on concepts learned in the GE mathematics course (see Figure 2 for an example). Instructors also give mini-lectures on particularly difficult concepts for students, and sometimes open work time is provided for students to work on homework assignments, exam preparation, or projects. Some support courses also devote time to working on test corrections after exams. Mathematical knowledge development is also integrated into practice of GE course materials. For example, prior to practicing how to interpret regression coefficients, students begin by practicing plotting a line from a basic equation and interpreting the meaning of the slope and intercept (Figure 3).

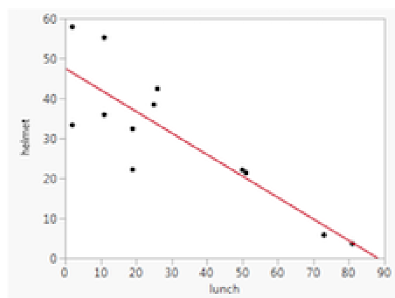
Use the following to answer questions 8 through 26.

The scatterplot shows the relationship between socioeconomic status measured as the percentage of children in a neighborhood receiving reduced-fee lunches at school (lunch) and the percentage of bike riders in the neighborhood wearing helmets (helmet). The average percentage of children receiving reduced-fee lunches is 30.8% with a standard deviation of 26.7% and the average percentage of bike riders wearing helmets is 38.8% with a standard deviation of 16.9%. The JMP output below shows correlation and regression results for this data.

8. Which variable (lunch or helmet) has more variability? How do you know?

9. In this scenario, which is the response variable and which is the explanatory variable?

10. What is a case in this dataset?



Linear Fit

helmet = 47.490446 - 0.5386091*lunch

Summary of Fit

RSquare	0.721253
RSquare Adj	0.693378
Root Mean Square Error	9.384827
Mean of Response	30.88333
Observations (or Sum Wgts)	12

Lack Of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2278.9268	2278.93	25.8748
Error	10	880.7499	88.07	Prob > F
C. Total	11	3159.6767		0.0005*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	47.490446	4.242456	11.19	<.0001*
lunch	-0.538609	0.105885	-5.09	0.0005*

Bivariate Normal Ellipse P=0.950

Variable	Mean	Std Dev	Correlation	Signif. Prob	Number
lunch	30.83333	26.72361	-0.84927	0.0005*	12
helmet	30.88333	16.94825			

Figure 2: An example of a worksheet assigned during the Introductory Statistics corequisite for regression practice.

3.3.3 Study Skills Development

Most students enrolled in the corequisite course are new to college, so time is spent developing general skills that will help them in the GE mathematics course and beyond. Our Center for Student Success provides a time management workshop, and our counseling center provides a workshop on anxiety. Time is also dedicated to discussing test anxiety and test-taking strategies. Additionally, CSUMB mathematics faculty continue to develop this component of the course by referencing strategies from [14].

Use the following equation to answer questions 1 through 6. $y = 3x - 2$

1. Fill out the following chart to calculate y for given values of x.

x	y
-1.0	
0.0	
1.0	
1.5	
2.0	

2. On the graph to the right, plot the equation $y = 3x - 2$. Use the chart form question 10 to help you.

3. On the graph, label which axis is the y axis and which is the x axis.

4. Using the equation and the graph to guide you, interpret the meaning of slope.

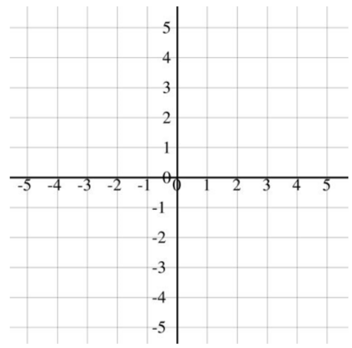


Figure 3: An example of a problem assigned during the Introductory Statistics corequisite prior to completing the regression exercise in Figure 2.

3.4 Corequisite Grading Structure

The course is non-college-credit bearing, but students receive a letter grade to help them assess their progress during the semester (this grade does not affect their college GPA). The corequisite grade and GE grade are independent from one another; it is possible to pass both courses, fail both courses, or pass one but fail the other. Students who fail their GE mathematics course are required to take the corequisite course when they retake the GE course (although this is difficult to enforce). The ultimate goal is for students to pass their GE course. Therefore, if a student passes the GE course but fails the corequisite course there are no negative consequences since the corequisite course does not count for college credit or affect GPA. The corequisite course grade is comprised of points for completing EdReady assignments and participation/attendance points.

3.5 Corequisite Student Experiences

At the end of the Fall 2018 and Spring 2019 semesters, students enrolled in the corequisite courses for any of the four GE mathematics courses (Quantitative Literacy, Finite Mathematics, Precalculus, and Introductory Statistics) were asked to complete a survey describing their experiences in the support course. The response rate for students who consented to participate in the research study and answered the survey was 33 percent (107 students). Results are displayed in Figure 4.

Experiences in the support course are highly positive. Only two items show more mixed reviews. Regarding learning better study habits, we expect this experience to increase as more activities are integrated from [14]. Regarding EdReady, we find that students have mixed opinions about the online mathematical skills development. Focus groups revealed that some students found the EdReady content did not seem to align well with what they needed to know in their GE mathemat-

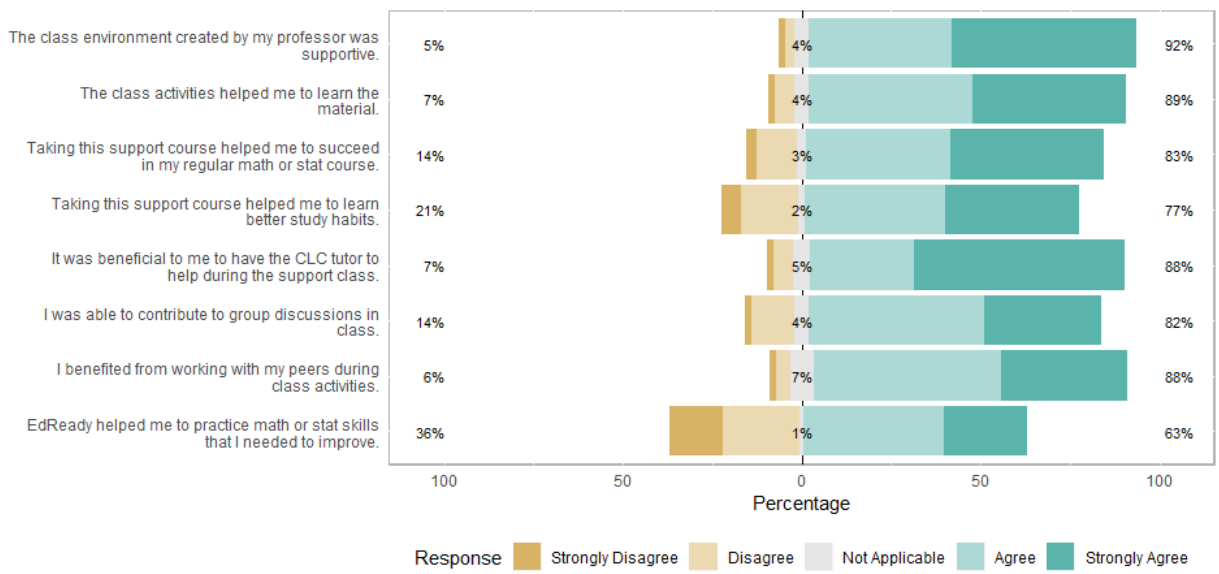


Figure 4: Student experiences in a corequisite course during the 2018-19 academic year.

ics course. Finite Mathematics and Precalculus students found EdReady most useful (80 percent and 72 percent respectively), where only 57 percent of Introductory Statistics and 62 percent of Quantitative Literacy students found the platform useful. In addition to the experiences displayed in Figure 4, 98 percent of corequisite students who responded to the survey said they would recommend the support course to a friend. Based on these results, we conclude that students are generally having positive experiences in the corequisite courses.

Note that GE course pass rates were found to differ between students who completed the corequisite experiences survey and who did not complete the survey. About 90 percent of students who completed the corequisite experiences survey passed their GE mathematics course, where only about 63 percent of students who did not complete the survey passed their GE mathematics course. This difference is not surprising since the survey was administered during class at the end of the semester, and many students had stopped attending the corequisite course. The pass rate difference might suggest that reported experiences are biased in the positive direction since responses were from students more likely to be satisfied with their grade in the GE course.

4 General Education Math Course

The general education mathematics course structure at CSUMB is considered co-mingled, in corequisite language [8]. This means that college-ready and underprepared students are mixed together in the GE course, and the underprepared students enroll in their corequisite course separately. The alternative is "cohorting," in which sections of the GE course are reserved for underprepared students.

4.1 Why Change the GE Course?

Due to the co-mingled nature of the GE courses, students in each section are largely varied in terms of their mathematical preparation for the course. But, our goal is to help all students succeed, not just some. A common concern with moving to a corequisite model is that the "rigor" of the college-level course will be lost when under-prepared students are included. Therefore, CSUMB faculty were careful to utilize pedagogy that caters to the success of all students without losing the strength of the content or creating bimodal outcomes. This pedagogy is described in Section 4.3.

4.2 GE Course Structure

General education mathematics courses at CSUMB are capped at 36 students. Each course is highly coordinated by a tenured or tenure-track faculty member overseeing all sections. This ensures that all sections implement common pedagogical practices, lesson plans, an exams for a consistent student experience. This coordination was also crucial due to the co-mingled structure, in which each corequisite contains students from many different sections of the GE course, so that each student was receiving the same course content each week and was ready for common material in the corequisite. Each GE course also uses open educational resources to keep costs at a minimum for our students. For example, Precalculus instructors designed their own course activity pack that serves that the textbook and class materials. Statistics instructors use *Introductory Statistics with Randomization and Simulation* [10], which costs less than 10 dollars per copy and is available for free online.

4.3 GE Course Pedagogy

The goal with our chosen pedagogy was to develop each student's sense of belonging in the course, no matter their mathematical background, and also to empower our students to be successful learners. In a traditional lecture-based learning environment, students engage with mathematics solely through the instructor, rather than directly themselves (Figure 5). There is much evidence showing that active learning, in which students interact directly with course content, benefits all students and closes equity gaps [11]. In an environment geared towards equitable student learning (Figure 6), the teacher develops systems for students to interact directly with mathematical content, and serves to manage the interaction so that it is fruitful [12, p.17].

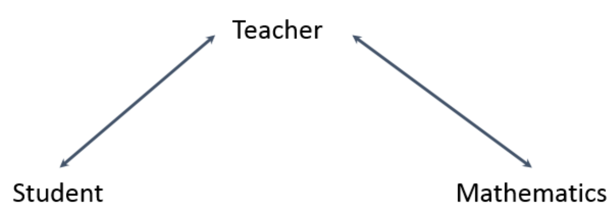


Figure 5: Instructional Triangle in a Lecture-Based Model.

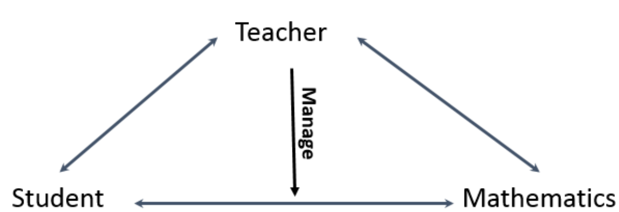


Figure 6: Instructional Triangle in an Active-Learning Environment (Horn, 2012).

The questions remain, though, of how to create productive student interactions with the content, and how to manage the interactions effectively. These issues are addressed through the use of *complex instruction* and *reading apprenticeship* frameworks.

4.3.1 Complex Instruction

Complex instruction, first developed by [5], is "a combination of pedagogical strategies used to create a classroom 'social system' that directly attends to problems of social inequality, which undermine academic access and achievement if left unexamined" [Lisa Jilk, personal communication, 2018]. Generally speaking, in a complex instruction classroom, students work in groups to complete tasks and learn mathematical content directly. However, specific structures are put into place in order to make this an equitable learning environment (Figure 7).

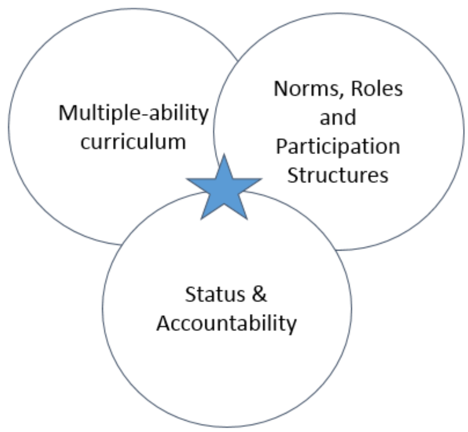


Figure 7: Components of Complex Instruction [Lisa Jilk, Personal Communication, 2018].

The groupworthy tasks that students complete in groups are open-ended and require multiple abilities to solve; that way each student has an entry point into the problem even if each student does not possess the same skill. Students must rely on one another to solve the problem (*multiple-ability curriculum*).

In order for these groups to function well, *norms, roles and participation structures* are introduced. Groups of three to four students are assigned randomly, and re-randomized every two to three weeks. Norms describe how students learn together (see Table 2). Each student in a group is given a role (Facilitator, Resource Manager, Recorder/Reporter, or Team Captain) in order for group members to hold each other accountable to learning [12, p. 50].

Table 2: Norms for group learning. Posters with these norms are posted in mathematics classrooms at CSUMB.

Norms for Group Learning
No one is done until everyone in your group is done.
You have the right to ask anyone in your group for help.
You have the duty to assist anyone in your group who asks for help.
Helping peers means explaining your thinking, not giving answers or doing work for others in the group.
Provide justification (say why!) when you make a statement.
Only ask the instructor a question when it's a team question.
Think and work together. Don't divide up the work.
Work only within your group — no crosstalk with other groups.
No one is as smart as all of us together!

Lastly, the instructor is responsible for managing the status of students in the classroom and holding groups accountable for learning (*status and accountability*). Status characteristics refer to criteria that students use to deterine whether or not they are smart (past mathematical experiences, gender, speed of problem solving, race/ethnicity, reading comprehension, social class, etc.). It is the instructor's job to manage student status, or students will exhibit unequal participation. Much of this is accomplished by what has already been mentioned. One way to manage status is by randomizing groups to demonstrate that all students and groups are equally capable of solving a problem. Another way is by assigning roles so that students do not define roles based on expectations of competence; e.g. "You do the coding, you will be better at it than me." Creating problems that require multiple abilities to solve allows equitable access to a problem. Lastly, instructors should assign competence to their students; identify the various intellectual abilities and skills that students posess, and tell them out loud [6].

4.3.2 Reading Apprenticeship

With so much groupwork happening in class, it is difficult to move through content at the same pace that one would during lecture. Further, to be successful in mathematics courses, students need to develop the skills needed to read mathematical texts, which is very different from other types of reading. We therefore implement Reading Apprenticeship strategies in our GE mathematics courses, a framework in which instructors apprentice students into reading within the discipline [17]. Reading Apprenticeship centers on having metacognitive conversations with students about how we learn and process information. CSUMB faculty model their reading processes out loud in the classroom, showing students how they annotate text.

As for saving time in class, with little room for lecturing in the classroom, many of our GE mathematics courses assign daily reading assignments so that students are engaging with concepts outside of class prior to working on the topics in class, allowing groups to move directly into more complex tasks rather than starting with basic definitions and surface-level understanding. Most courses have students complete daily reading logs, which are incorporated into course grades (Figure 8).

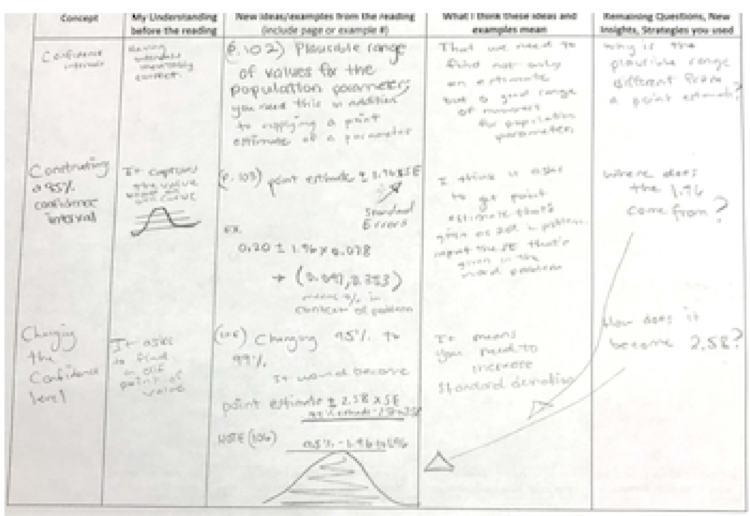


Figure 8: Reading log from an Introductory Statistics student.

4.4 GE Student Experiences

At the end of the Fall 2018 and Spring 2019 semesters, students enrolled in three out of four of our GE mathematics courses (Quantitative Literacy, Finite Mathematics, and Statistics) were asked to complete a survey describing their experiences in the GE mathematics course. The response rate for students who consented to participate in the research study and answered the survey was 44 percent (405 students). Results are displayed in Figure 9. These results demonstrate that the vast majority of students are finding reading apprenticeship and complex instruction to be valuable frameworks for their learning.

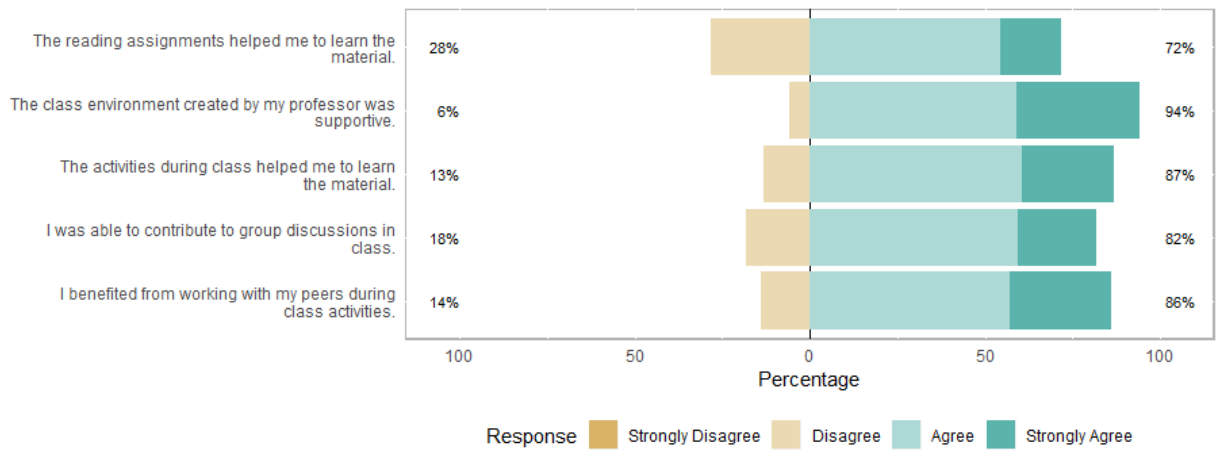


Figure 9: Student experiences in a corequisite course during the 2018-19 academic year. (Does not include Precalculus students.)

What about maintaining the "rigor" of the course? Although only one metric for the "rigor" of the course, 74 percent of students found their GE mathematics course somewhat or very challenging, which we consider a good thing. (Please note that this number does not include Precalculus students.)

Similar to the corequisite student experiences survey, some charactersticis were found to differ between students who completed the GE course survey and who did not complete the survey. About 88 percent of students who completed the corequisite experiences survey passed their GE mathematics course, where only about 72 percent of students who did not complete the survey passed their GE mathematics course. Additionally, 71 percent of survey-completers were female whereas only 57 percent of non-survey-completers were female. No other meaningful differences were found. The pass rate difference might suggest that reported experiences are biased in the positive direction since responses were from students more likely to be satisfied with their grade in the course.

5 Results

Recall that under a remedial model, large equity gaps existed in CSUMB GE course pass rates between students who had completed remediation and those who did not require remediation. Table 3 displays the corresponding data under the corequisite model.

Table 3: General Education pass rates in Fall 2018 as a function of corequisite enrollment. Parentheses display the total number of students in each category. A negative equity gap implies that the pass rate was higher among students who completed the corequisite course. The remediation equity gap refers to Fall 2016 data from Table 1.

Course	No Corequisite	Corequisite	Equity Gap	Remediation Equity Gap
Introductory Statistics	79.9% (204)	83.3% (78)	-3.4%	31.7%
Quantitative Literacy	90.7% (54)	93.8% (16)	-3.1%	1.8%
Finite Math	73.1% (93)	53.8% (13)	19.3%	48.6%
Precalculus	83.0% (336)	66.7% (99)	16.3%	33.1%

Compared to the remediation model Fall 2016 data in Table 1, the equity gaps between between corequisite students and those not enrolled in the corequisite have either shrunk substantially or actually reversed.

One point to consider is that the cohort of students who enrolled in a corequisite course is not analagous to the cohort of students who were required to complete remediation. Students self-selected into the corequisite course, and it was a smaller group. Therefore it might seem unfair to compare the pass rates for remediation versus corequsite students. However, it is important to note that since fewer students opted into the corequisite course, many students completed GE mathematics courses without additional support who in past years would have been required to complete remediation. One might expect that this would cause the pass rates for the "No Corequisite" group to drop significantly compared to previous years. However, it is evident from the data that this is not what happened. Among students who did not enroll in a support course, pass rates compared to Fall 2016 have either been maintained or even been surpassed (in the case of Introductory Statistics and Precalculus).

These results demonstrate that when looking at students in aggregate, moving to a corequisite model allowed just as many students, and in some cases more students, to successfully complete their GE mathematics course without requiring the burden of four to eight units of remedial mathematics. Further, under the new model, underprepared students have a much reduced equity gap compared to their peers, which we attribute to the pedagogical changes addressing classroom dynamics and student learning. Together, this evidence suggests that with a careful course design and well-structured corequisite courses, remedial mathematics courses are not necessary for student success in general education mathemaitics courses. This aligns with the literature discussed in Section 1 showing that corequisite models can lead to improved pass rates, in contrast to the failures of many remedial mathematics programs to push students through completion of GE mathematics courses.

6 Limitations and Future Directions

We made changes to our course structure and pedagogy all at the same time, so it is impossible to determine which individual components had the greatest impact on students. We know that students are succeeding in our GE mathematics courses without mathematics remediation, sometimes at even higher rates than during the remediation model. However, we cannot say definitively if these changes are due to the reduced class size, the implementation of complex instruction and reading apprenticeship frameworks, better course coordination, etc. It is the CSUMB mathematics and statistics faculty's belief that these changes are synergistic and together create the positive results that we are seeing. Further, the data presented here is only from one academic year of implementation. It remains to be seen how students perform in subsequent mathematics and statistics courses, such as a Research Methods course or Calculus.

Future work will focus on additional comparisons of characterstics between those students required to complete remediation and those who enrolled in corequisite courses. Additionally, we will further examine other types of equity gaps based on demographic characteristics and use more advanced modeling methods to understand, aside from corequisite course enrollment, what covariates play a role in GE mathematics course success.

7 Recommendations

Readers of this article might be involved with many differing types of institutions. If you work at an institution which offers elementary algebra and/or mathematics remediation, consider checking the pass rates of remedial students in subsequent courses. Do they succeed at the same rates as their non-remedial peers? If not, consider switching to a corequisite model. Better yet, even if the equity gaps are minimal, try switching to a corequisite model to reduce the burden of extra units that these students must complete. If you work at an institution in which students must enter directly into college-level mathematics, consider if you might be excluding students from your university who might be able to succeed just as well as their peers if given the opportunity. Further, consider adding corequisites to other courses in which students may struggle, such as Calculus. Lastly, for all readers, I encourage you to believe that any student can succeed in mathematics, no matter how underprepared they may be at the start of college. Moving beyond belief, move into action by enacting equitable learning environments in your courses so that students themselves can develop the belief that they can succeed in mathematics.

8 Acknowledgments

I work with incredible colleagues who were all equally devoted to making the corequisite model a successful endeavor. Special thanks to Judith Canner, Peri Shereen, Jeffrey Wand, Jennifer Clinkenbeard, Alison Lynch, and Steven Kim, all of whom have contributed to this work. This research was approved by the Committee on the Protection of Human Subjects at CSUMB.

References

[1] Annie Burns Childers, Lianfang Lu, Joshua Hairston, and Timothy Squires. Impact and Effects of Co-Requisite Mathematics Remediation. *Primus*, 0(0):1–28, 2019.

[2] California State University. Total Enrollment by Sex and Student Level, Fall 2018, 2018.

[3] California State University Monterey Bay. CSUMB Awarded $8 Million Innovation Grants, 2015.

[4] California State University Monterey Bay. Institutional Assessment and Research: Enrollment Overview, 2018.

[5] Elizabeth G. Cohen and Rachel A. Lotan. *Working for Equity in Heterogeneous Classrooms: Sociological Theory in Practice*. Teachers College Press, 1997.

[6] Elizabeth G. Cohen and Rachel A. Lotan. *Designing Groupwork: Strategies for the Heterogeneous Classroom*. Teachers College Press, New York, 3rd edition, 2014.

[7] Complete College America. Corequisite Remediation: Spanning the Completion Divide. Technical report, Complete College America, 2016.

[8] Dana Center Mathematics Pathways. Co-requisite Courses: Narrowing the Gap betwee Instruction and Supports. Technical report, University of Texas at Austin Charles A. Dana Center, Austin, TX, 2017.

[9] Lindsay Daugherty, Celia J. Gomen, Diana Gehlhaus Carew, Alexandra Mendoza-Graf, and Trey Miller. Designing and implementing corequisite models of developmental education. *RAND Corporation*, 2018.

[10] David M. Diez, Christopher D. Barr, and Mine Çetinkaya-Rundel. *Introductory Statistics with Randomization and Simulation*. 1st edition, 2014.

[11] Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth. Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, 111(23):8410–8415, 2014.

[12] Ilana Seidel Horn. *Stength in Numbers: Collaborative Learning in Secondary Mathematics*. The National Council of Teachers of Mathematics, Inc., Reston, VA, 2012.

[13] A. W. Logue, Mari Watanabe-Rose, and Daniel Douglas. Should Students Assessed as Needing Remedial Mathematics Take College-Level Quantitative Courses Instead? A Randomized Controlled Trial. *Educational Evaluation and Policy Analysis*, 38(3):578–598, 2016.

[14] Lisa M. Nunn. *33 Simple Strategies for Faculty: A Week-By-Week Resource for Teaching First-Generation Students*. Rutgers University Press, New Brunswick, 2018.

[15] Office of the Vice Chancellor for Academic Affairs. Co-requisite Remediation Pilot Study - Fall 2014 and Spring 2015 and Full Implementation Fall 2015. Technical report, Tennessee Board of Regents, 2016.

[16] Anne Ruggles Gere, Laura Aull, Timothy Green, and Anne Porter. Assessing the validity of directed self-placement at a large university. *Assessing Writing*, 15(3):154–176, 2010.

[17] Ruth Schoenbach, Cynthia Greenleaf, and Lynn Murphy. *Reading for Understanding: How Reading Apprenticeship Improves Disciplinary Learning in Secondary and College Classrooms*. Jossey-Bass, San Francisco, second edition, 2012.

[18] State of California. Assembly Bill No. 705, 2017.

[19] Timothy P. White. Executive Order 1110: Assessment of Academic Preparation and Placement in First-Year General Education Written Communication and Mathematics/Quantitative Reasoning Courses, 2017.