Assessing Student Learning Experiences in a Corequisite Calculus Course

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The corequisite model of academic support has been touted as an efficient way of supporting student learning while decreasing the time to degree completion for students needing academic support. With the learning losses that have occurred globally as a result of the global coronavirus pandemic, the Department of Mathematics at California State University, Fullerton piloted a corequisite course to support one section of Calculus I, a course historically riddled with high DFW rates. In this paper we share preliminary results of our department's implementation of the corequisite model. While corequisite students from the first iteration of the course earned higher GPAs than their non-corequisite peers, more data (including longitudinal data) is needed to determine the lasting impact from the Calculus I corequisite experience.

Keywords: Corequisite mathematics, academic support, curriculum development

Background

Introductory mathematics courses have historically been a roadblock for students intending to major in the Science, Technology, Engineering, and Mathematics (STEM) fields. For most STEM majors, students must complete a sequence of calculus courses before commencing their major coursework. Historically Calculus I and Calculus II have been identified as bottleneck courses at California State University, Fullerton (CSUF). From 2012-2022, the Calculus I course was ranked eighth highest in terms of DFW (grades of D, Fail, or Withdraw) with a rate of 33%, while Calculus II ranked sixth highest with a 38% DFW rate. Given this institutional data, the authors developed an academic support course to try to combat this systemic issue through the creation of a Calculus I corequisite, and piloted the course with first-time-freshmen beginning their academic journey at CSUF with a declared Mathematics major.

The primary goal of the Calculus corequisite course at CSUF was to reinforce student conceptual understanding of prerequisite mathematical content knowledge, provide students with additional opportunities to engage with course content, and to help students develop the required skills to perform and succeed in college. Research (e.g., Hancock et al., 2021; Kashyap & Matthew, 2017; Logue, 2014; Richardson, 2021; Stone-Johnstone, 2023) on corequisite courses like the one created here at CSUF, have demonstrated benefits to student learning, as well as supported the placement of students directly into gateway courses (with academic support) as opposed to a long sequence of prerequisite courses.

The primary goal of this work is to increase access to Calculus I and Calculus II. We do this by creating a course with the aim of helping students better communicate mathematically (in writing and in speech), supporting students in problem solving, and developing their skills in using technology when doing mathematics. We hypothesize, based on previously research, that this corequisite course will help decrease the time to graduation at CSUF by providing students with targeted academic support. The driving research questions in this study are:

1. What effect does a Calculus I corequisite course have on student success in Calculus II?
2. What effect does a Calculus I corequisite have on students intending on majoring in mathematics?

Methods

This study employs a convergent mixed methods approach (Creswell, 2012) where quantitative and qualitative data were collected to assess the efficacy of the Calculus corequisite. Quantitative data in the form of Calculus I course outcomes of all course sections from the Fall 2021 semester and the Calculus II course outcomes from a special section of Calculus II composed primarily of mathematics majors in the Spring 2022 semester were collected and analyzed. Comparisons were made between the subgroups (corequisite and non-corequisite students) by performing a series of one and two-sample independent t-tests.

Qualitative data in the form of student focus groups and classroom observations of the corequisite course during the Fall 2021 semester were collected and subsequently analyzed. Fifteen corequisite students were interviewed during the data collection period, and from interview data, structural codes (Saldaña, 2021) based on the focused research questions were used to categorize and interpret their narratives around their experiences in mathematics during and after participating the Calculus corequisite course.

Preliminary Findings

The Calculus corequisite course was piloted during the Fall 2021 semester with only mathematics majors. Incoming students who intended to major in mathematics were advised to take the course in conjunction with their regular Calculus I course. Certain students who would have normally been placed into Pre-Calculus were also invited to take Calculus I with a corequisite support course during their first semester at CSUF. In this section we report both preliminary quantitative and qualitative results from the first iteration of the corequisite course at CSUF.

Quantitative Results

In Fall 2021, 38 math majors were enrolled in the corequisite course. Preliminary results from the quantitative analysis of the Calculus 1 course data shows that students who participated in the corequisite (versus all other students in other sections of Calculus 1) had higher overall course GPAs (grade point averages) and lower DFW rates. In addition, when only considering those students who received a non-DFW grade, the corequisite students outperformed the non-corequisite students (see Table 1). This latter category is infrequently reported, but at CSUF we have noticed that students who pass with lower grades in Calculus I tended to struggle more in their subsequent calculus and upper-division STEM courses. Out of the 38 corequisite students, 23 enrolled in the special section of Calculus II that was composed of only mathematics majors in the semester that followed. Nine of the other students did not pass Calculus I with a C or better (a requirement for STEM majors at CSUF), and the six others changed to a major that did not require any additional mathematics coursework.

Table 1. Calculus I Course Data from Fall 2021 across all sections

	Corequisite Students	Non-Corequisite Students
n	38	410
GPA	2.66*	1.88
DFW	24%**	41.8%
GPA (excluding DFW)	3.36*	2.93

*Significant at the .001 level
** Significant at the .007 level

Course data from the Spring 2022 Calculus II special course shows that students who were enrolled in the corequisite during the previous semester had slightly higher course GPAs and lower DFW rates in that course than those students who did not take Calculus I with a corequisite support course. When comparing all students that did not receive a DFW in Calculus II, the corequisite students earned higher GPAs relative to their non-corequisite classmates (see Table 2). It is important to note, of the 21 non-corequisite students, only two were first-time-freshmen and the rest were either upper-classmen or students repeating the course for credit.

Table 2. Calculus II Special Course Data from Spring 2022

	Corequisite Students	Non-Corequisite Students
n	23	21
GPA	2.178	1.952
DFW	26%	33%
GPA (excluding DFW)	2.88	2.786

*Significant at the .001 level
** Significant at the .007 level

Qualitative Results

There were two dominant themes that arose from the qualitative analysis: *Students valued the course structure of the corequisite course*, and *Students valued opportunities for community-building*. During the Fall 2021 semester, the corequisite students received more than six hours per week of course contact with their course instructor and peers. They were scheduled to attend their Calculus I course in person on Mondays and Wednesdays for 1 hour and 50 minutes each, and their corequisite course virtually on Tuesdays and Thursdays for 1 hour and 15 minutes each. During the corequisite sessions, students spent their time actively engaging in either Calculus I review or Pre-Calculus and Trigonometry activities that prepared them for the new Calculus content they would cover during the following day. In contrast, the instructor focused Calculus I class time on presenting new course material through a mixture of traditional lecture and active learning methods.

The first theme, *Students valued the course structure of the corequisite course*, arose as students were describing the nature of the corequisite course. One student shared that,

> [the corequisite course] helps us refresh and review … like with radicals and radical numbers and rationalizing numbers and stuff like that, so I feel like that was really helpful … I feel like it's pretty helpful and backing up like you're just reviewing - to help support what you're learning in calculus …"

Students recognized that the purpose of the corequisite course was for review and developing a deep conceptual understanding of their Calculus material. This course was a low-stakes support course where students could seek and receive help from their instructor, teaching assistants, and peers. Another student elaborated,

> So [the corequisite course] kinda introduced to us what we're going to do the next day. So it's not as hard the next day we're kind of like we know what we're about to do, like we have a taste of it. And it was really nice seeing all my classmates, all my groupmates day in, day out and seeing [my instructor] four days a week. And yeah … it wasn't that hard - it's like I wouldn't go stressing … like I have this class, like, I look forward to it. Because the problems aren't that hard and they're a good introduction to the next day and yeah it was fun.

The second theme, *Students valued opportunities for community-building*, showed up in all the interview data. For instance, when asked what they have gotten out of the corequisite course, one student shared,

> I mean, uh, I mean as cheesy as it might sound … like a community. I feel comfortable talking in front of those people, there's like 30 of them. I asked the teacher questions. In a class last year I wouldn't be doing that because I wouldn't be comfortable. We would be on ourselves most of the time. Now, we're like actually like you have people that you know and that you trust and that are actually helping you and want to help you too. If you're actually struggling and you wanna help them if they're struggling, it's more like personable I guess. You know everyone I guess too. Like even if I haven't talked to someone, I feel comfortable talking to them, which is odd because I've never really done that before, but yeah this class has definitely helped that.

Another student added,

> We engaged a lot, as a group ... We sat in groups of four and we engaged a lot … and I feel like that also helped us understand the material more because it's just you're figuring it out not by yourself, this time, but with, with the group, and I feel like, figuring it out together also helps us understand the material.

The corequisite students engaged in active learning and discovery within both their Calculus I and corequisite course four days per week. The early and consistent engagement among the students helped foster relationships that spanned past the Fall 2021 semester and into their Calculus II course during the following semester. When asked again, during the Spring 2022, to reflect on their corequisite course, several students reiterated the benefits of the collaborative learning experience. From their experience in the corequisite, students developed friendships and study groups that have helped them navigate Calculus II.

Discussion

The first driving research question for this work was, what effect does a calculus corequisite course have on student success in Calculus II? The preliminary data demonstrates that the corequisite course has the potential to support student learning in their Calculus I course as well as equip them with the tools for success in Calculus II. The Fall 2021 corequisite students attributed their success to the greater mathematical foundation they obtained from their

corequisite course as well as the community they were able to build to help support them in their studies in Calculus II.

The second driving question was, what effect does a calculus corequisite have on students intending on majoring in Mathematics? While some students who intended to major in Mathematics ended up switching majors by the end of the semester, many others persisted into Calculus II. However, one student that ended up switching majors shared,

> I was struggling, I think more than I needed to. Or, more than like most of my peers. And, when I did my major advising, I was telling her that I was struggling and she was like "It's only going to get harder" and I was like "Hmm" and I was like "I don't know how much more of this I can take" so I did change my major.

This student was discouraged by an academic adviser to continue her mathematics pursuit based on her present academic struggles in Calculus I. It is unknown whether this student could have passed the course should they have stayed the course and sought extra help outside of what was offered in the corequisite course and the instructor's office hours.

While 23 of the original 38 students persisted to Calculus II, it is too early to firmly measure the effect a Calculus I corequisite will have on student persistence in STEM in general. A full assessment of the benefits of the corequisite requires a longitudinal study, where we can track student progress throughout the tenure of their college experience. Based on the prior research and the preliminary findings reported here, we hypothesize that a Calculus I corequisite course has the potential to increase student success in Calculus I and Calculus II. The findings from this study will be used to optimize future iterations of the corequisite course to support student learning and achievement. As we collect more data, we will better understand the potential of the corequisite model in supporting our student learning and academic success in STEM.

1. What kinds of data would convince you that a corequisite course is doing its intended job, of academically supporting students and helping them to persist in mathematics?
2. Does it make sense for an institution to adopt a corequisite model when they also have a Supplemental Instruction program?

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