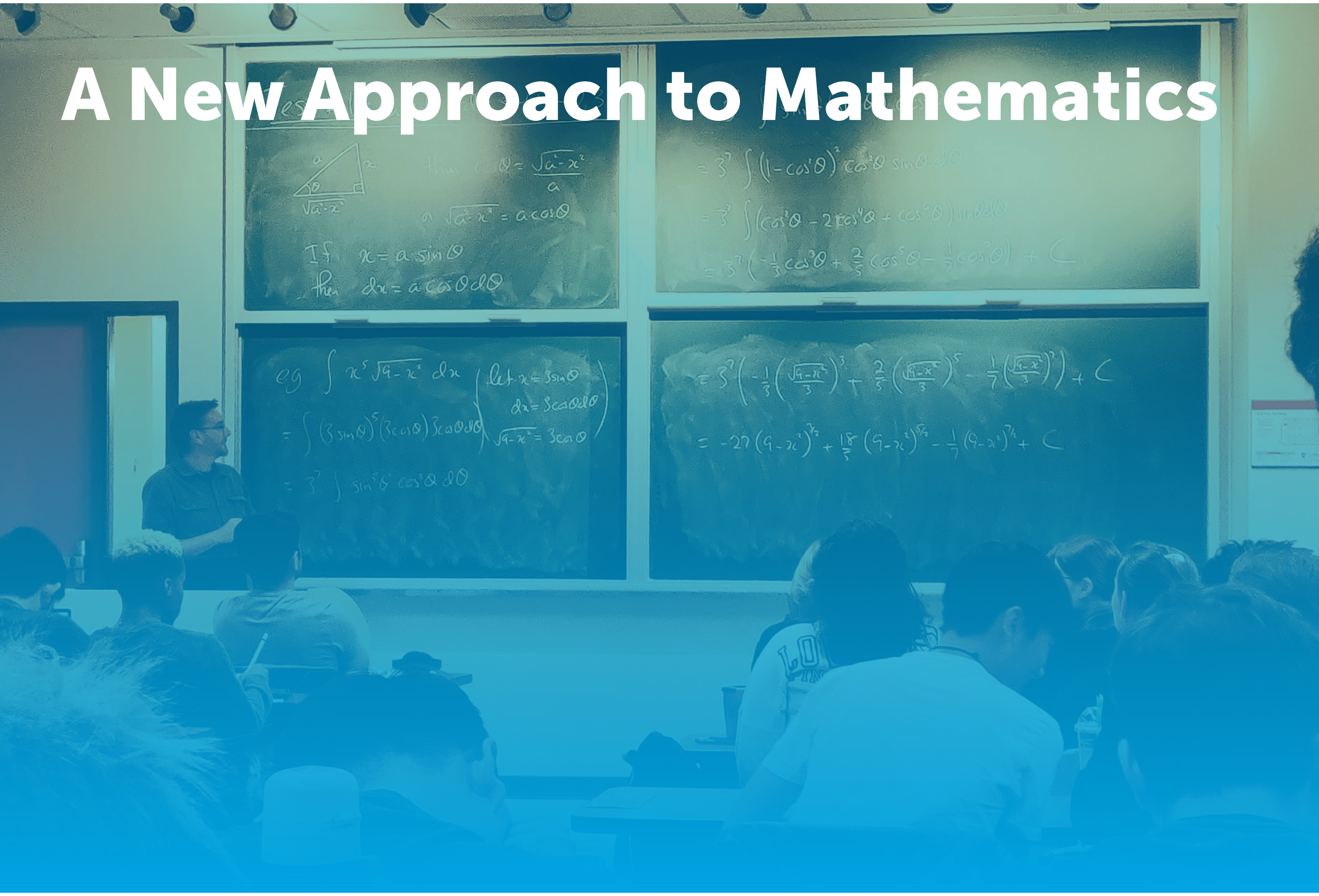
STRONG START TO FINISH

Building momentum for postsecondary success

EDUCATION COMMISSION OF THE STATES

Your education policy team.

A New Approach to Mathematics



Increased Success Rates for ALL Students at the University of Cincinnati

Ricardo Moena, *University of Cincinnati*

Alycia Marshall, *Anne Arundel Community College*

STEPS TO SUCCESS from STRONG START TO FINISH

About the Author

Dr. Ricardo Moena, Professor/Assistant Department Head of Mathematical Sciences, University of Cincinnati

Dr. Alycia Marshall, Associate Vice President of Learning and Academic Affairs, Anne Arundel Community College

Preferred Citation: Moena, R. & Marshall, A. (2020, April). A new approach to mathematics: Increased success rates for ALL students at the University of Cincinnati (Steps to Success series). Denver, CO: Strong Start to Finish, Education Commission of the States.

Acknowledgements

The authors would like to thank Strong Start to Finish (SSTF) who provided funding statewide to support Ohio's efforts to scale last mile work in implementing reform throughout the state which supports students in completing their credit math and English courses within their first year of college. The authors would also like to acknowledge the administration of the University of Cincinnati (UC) who thoroughly supported the course redesign efforts to include funding for the Math and Sciences Support Center (MASS), the Charles A. Dana Center who provided technical assistance and professional development, and the Ohio Department of Higher Education (ODHE) for providing professional development for faculty.

About Strong Start to Finish

Right now, a first-year student sits in a college classroom being ill-served by remedial math.

And if we fail them, they mostly likely will not earn their degree. There is a persistent trend among students placed in remedial or developmental courses – particularly math and English. They are not completing the courses and, in most cases, should not be taking them in the first place. This should not be their path.

We are a network of like-minded individuals and organizations from the policy, research, and practice spaces who've come together for one reason – to help all students, not just the select few, find success in postsecondary education.

Strong Start to Finish was created to better the chances of low-income students, students of color and returning adult students, to create a fundamental shift in the outcome of their college journey. We have networked higher education leaders, policy entrepreneurs, institutions and technical assistance providers to drive towards an outcome where all students pass their first credit-bearing English and math courses during the first year of study.

Abstract

Primary Audience:

The primary, though not sole, audience for this publication is a department chair or faculty member within an institution.

Problem Statement:

Like many institutions nationwide, the state of Ohio and more specifically, the University of Cincinnati (UC) increasingly became aware of alarming patterns which included increasing numbers of students placing in developmental courses (particularly those of underserved student populations) and low course success rates in several of their credit mathematics courses across all student demographics. This seemingly had a negative impact on student success and completion.

Action:

The University of Cincinnati eliminated developmental math courses in AY2016, placing all students directly into credit math courses while simultaneously implementing a corequisite model in five mathematics courses (College Algebra, Precalculus, Calculus, Calculus II, Applied Calculus) and revising a quantitative reasoning course which would now integrate corequisite course content (Foundations of Quantitative Reasoning). For successful students, this new corequisite model also shortens the time it takes for students to enroll in and complete credit math, likely leading to increased overall student success and completion.

Context:

Two pieces of legislation passed by the Ohio Senate (2012 and 2013) combined with a review of data provided by the Ohio Department of Higher Education (ODHE) on the state of Ohio's educational attainment during that time period resulted in a growing urgency for the state to reform, update, and develop new educational strategies. This led to a charge by the Chancellor of ODHE for the 36 public institutions in the state to increase success for students in the study of mathematics, increase the percentage of students completing degree programs, and improve the ability for credits to transfer from one institution to another.

Process:

A steering committee of stakeholders including faculty, administrators, and ODHE staff began working on addressing these charges across the state while UC responded as an institution by reforming their internal math pathways and curriculum to include corequisite instruction. UC mathematics faculty (with support from administration) eliminated a developmental course which prepared students for College Algebra or Precalculus and created corequisite/companion courses for College Algebra, Precalculus, Calculus, Calculus II, and Applied Calculus while adding corequisite content to Foundations of Quantitative Reasoning.

Outcomes:

Across the board and various racial categories, UC students enrolled in the corequisite course in addition to the credit level course for College Algebra, Precalculus, Calculus, Calculus II, and Applied Calculus had higher success rates across four semesters (Fall 17, Spring 18, Fall 18, Spring 19) for the credit course when compared to students enrolled in the same credit course without a corequisite. The new Foundations of Quantitative Reasoning Course with integrated corequisite content also showed higher success rates when compared to students enrolled in a stand-alone College Algebra course, which would previously have been the typical pathway for this student population.

Sources of Support:

The UC math department's implementation of the new corequisite pathways was supported by the college administration through the monetary support of faculty release time, the creation of the Math and Sciences Support Center (MASS) and their overall support of ideas and infrastructure which was instrumental in the success of this project. In addition, as a Strong Start state institution, UC was able to benefit from the funding provided to the state of Ohio through Strong Start which included financial support, technical assistance, and professional development provided by the Charles A. Dana Center which contributed to the university's ability to reform and implement with success.

Introduction

Mathematics, particularly in higher education, has often been depicted as a "gatekeeper" discipline and is seen by many as a significant barrier to student success and college completion, limiting access to STEM careers and overall success beyond college (Bailey, Jeong & Cho, 2010; Chen, 2016; Bressoud, 2018; Bryk & Treisman, 2010; Saxe & Braddy, 2015). This is compounded by long traditional developmental math course sequences which have been shown to negatively impact student progress while seemingly decreasing their ability to succeed as the number of required math courses increases (Bailey et.al., 2010; Chen, 2016). Adding insult to injury, this problem can have long-reaching equity implications as students of color and low-income students tend to be placed in developmental courses disproportionately (Attewell et al., 2006; Bailey et, al., 2010; Chen 2016; EdSource, 2012). In order to address this issue, many institutions, states, and systems have joined a nationwide movement to implement alternative math pathways for students including corequisite models which place students directly into credit math and minimize the number of courses required and time to completion (DCMP, 2019). These efforts seek to replace long developmental course sequences with accelerated and corequisite learning options that better align mathematical content with programs of study while integrating research-based knowledge into mathematics curriculum design and pedagogy (Marshall & Leahy, 2019).

Among those who have joined the movement, many states and systems such as Tennessee have shown great success with the use of corequisites, particularly among students of color (Denley, 2016). Like their colleagues, UC faculty discovered the pathways movement as an opportunity to address this issue head on. In response, the main campus of the University of Cincinnati has implemented a corequisite instruction model across five mathematics courses (College Algebra, Precalculus, Calculus, Calculus II and Applied Calculus) and integrated corequisite material into a revised course (Foundations of Quantitative Reasoning) to improve student success and shorten the pathway towards completion. These courses were identified as part of a corequisite reform initiative since they were either STEM pathway courses or in the case of Foundations of Quantitative Reasoning, a gateway course closely aligned with a student's program of study. This Steps to Success Paper will discuss how this change was implemented at the University of Cincinnati in an effort to serve as a resource to other institutions, states, and systems interested in joining the math pathways movement.

Context

Location & Student Population

The University of Cincinnati is a four-year public research institution enrolling over 44,000 students (graduate and undergraduate). Its largest and main campus (among three) enrolling over 27,000 students, is located in the city of Cincinnati, Ohio. UC is one of 36 public colleges and universities which comprise Ohio's public institutions serving over 600,000 students in total. Fifty-one percent of UC students are male and forty-nine percent are female. Twenty-one percent of beginning undergraduate students receive a Pell Grant. Seven percent of UC students are Black/African American, 4% are Asian, 3% are Hispanic, 74% are White, 4% are more than one race, and less than 1% are Alaskan Native/American Indian.

[For more information see Appendix A]

Policy Factors

Two pieces of legislation were passed by the Ohio Senate in 2012/2013 and both helped support UC's developmental reforms. First, the Remediation Free Guarantee[1] (Ohio Revised Code 3345.061 bill) guarantees students' placement in a college credit bearing course in mathematics if the students' placement scores are at or above determined cut-off values. To increase access and decrease the number of students placed in developmental math, groups of faculty from two- and four-year colleges determined these cut-off scores for the widely used placement instruments available such as ACT and SAT among others. Secondly, Performance Funding[2]

2.0 changed the formula used to allocate State funds to public institutions. Beginning FY2013, course and degree completion drove 80 percent of State General funding to universities' main campuses, thus changing the old Performance Funding[3] 1.00 that allocated between 1% and 5% to outcome metrics in addition to established funding based on headcount. This factor motivated all public institutions in the state to take a long hard look at degree completion, including credit math completion[4].

Enabling Conditions

State-wide faculty support was a crucial factor in enabling the changes mandated by the legislation. Both pieces of legislation had significant faculty support[5], which emphasized to administration the need to revise placement practices, update course delivery, and strengthen support structures to drive student success, retention and graduation[6].

Another enabling factor was the involvement of the Ohio Department of Higher Education (ODHE) and the establishment of a steering committee. In response to requests from institutions to determine a statewide consistent and coherent approach to higher education in mathematics and acknowledging the vital importance of STEM disciplines in the economic future of the state, a comprehensive revision of the policies and transferability requirements for mathematics courses started in 2013. The ODHE convened a steering committee[7] formed of faculty, administrators, Department of Education[8] staff, and other stakeholders. The Chancellor of the ODHE gave the Steering Committee the following charge:

"To develop expectations and processes that result in each of Ohio's 36 public colleges and universities offering pathways in mathematics that yield: (a) increased success for students in the study of mathematics, (b) a higher percentage of students completing degree programs, and (c) effective transferability of credits for students moving from one Ohio public institution to another."

After careful analysis of the expectations described in the charge, the steering committee proposed the creation of five groups of mathematics faculty representing the 36 two- and four-year public institutions of higher education with five clearly defined tasks identified below. These tasks define an ongoing effort of these groups. The collective work of these groups is what we refer to as the Ohio Mathematics Initiative (OMI)[9].

The Change Process

MILESTONE EVENT 1

The Ohio Mathematics Initiative (OMI)

OMI is currently composed of 5 subgroups working on the essential components defined by the steering committee:

Subgroup 1: New and Alternative Pathways (16 members)

Subgroup 2: Revision of the Ohio Transfer Module (OTM) Criteria (25 members)

Subgroup 3: Communication, Outreach, and Engagement (13 members)

Subgroup 4: Data Collection, Analysis, and Sharing (14 members)

Subgroup 5: Alignment Between Secondary and Postsecondary Content and Instruction (25 members

As a result of their work and with assistance from the Charles A. Dana Center at the University of Texas at Austin, today, the 36 state public institutions are in the process of developing or have already developed, high-quality entry-level courses and pathways aligning mathematics to academic programs. Now with assistance from Strong Start to Finish, all 36 institutions are in the process of establishing corequisite strategies to support underprepared students and significantly increase completion rates of first year mathematics and English requirements for all students.

In addition to revamping the math curriculum, OMI subgroups have developed transfer policies and processes that foster effective transfer of course credits while encouraging course innovation. This was achieved by redesigning the OTM[10] (Ohio Transfer Module) course acceptance criteria, allowing institutional flexibility in determining prerequisite courses and credit hours, and by defining what "college-level" means in the State of Ohio.

In order to improve communication among faculty involved in collaborative work across the state, the ODHE facilitated the creation of the "chairs network." Chairs and Department Heads of the mathematics and statistics departments of the 36 Ohio public institutions of higher education meet twice a year with faculty working on statewide OMI projects. These meetings are held at Ohio State University, the flagship institution. The "chairs network" provides an effective means of communication between institutions, faculty, and stakeholders. In addition, a large amount of work is currently being done by OMI subgroups and the Ohio Department of Education (ODE) to strengthen communication between K-12 and higher education.

Due in large measure to these efforts, the last few years have shown a significant increase in the overall rate of educational attainment in the State of Ohio, from 36.5% in 2012 to 44.6% in 2017[11]. There is still much work to be done to meet the goal of 65% by the year 2025 as challenged in 2016 by the ODHE Chancellor.

MILESTONE EVENT 2

Ohio's Response to the Recommendations

After transitioning from the quarter system to semesters in the AY 2012, in order to reduce alarming drop, withdrawal and failure (DWF) rates in the STEM entry-level sequences, the mathematics department at UC embraced two charges: 1) to strengthen the coordination of entry-level courses and 2) to create a single developmental alternative. Highly enrolled courses of interest included College Algebra, Precalculus, and Calculus. For each one of these entry-level courses, all sections are now coordinated with common assessments throughout the semester which assess learning outcomes that follow the agreements with OTM for transferability, clearly define depth of coverage, and ensure consistency across all sections. Faculty Coordinators now obtain release time from teaching to perform this task and to ensure success along the pathway through collaboration with teams including coordinators of the next course in the sequence.

Beginning fall of 2012, the mathematics department at UC began offering a one-semester developmental course, MATH 0039, Algebra for College Mathematics. The course was designed to prepare students interested in STEM disciplines with placement scores below the required remediation guarantee limits. The delivery of the course was online using Assessment and Learning in Knowledge Spaces (ALEKS). ALEKS is a web-based assessment and learning system that uses adaptive questioning to quickly and accurately assess a student's content knowledge and knowledge gaps. After successful completion of this developmental course, students could enroll directly into College Algebra or Precalculus. Data collected during those years showed that, as of 2015, very few students who completed the developmental course continued on to the college-level course requirement of College Algebra or Precalculus. For those that did, the failure rate was approximately 70% in the first attempt and very few of these students remained in college after two semesters. These results are consistent with national data trends which show low enrollment and course success rates for students in credit level math courses when placed directly in a developmental math course as a prerequisite. As a result, the mathematics department at UC decided to eliminate the developmental option from the curriculum and began looking for alternatives.

MILESTONE EVENT 3

Replacing MATH 0039 with "Just in Time" Remediation

UC discontinued MATH 0039 at the end of AY 2016. During AY 2015, only students with pending work in the course from previous semesters could enroll. In the fall of 2015, mathematics faculty, with support and funding provided by administration, began the implementation of a new corequisite model for all gateway courses in the STEM pathway (College Algebra, Precalculus, Calculus, Calculus II, and Applied Calculus). Students placing near the cut-off scores or slightly below were strongly advised during their entry-to-college interview with advisors to enroll in a Supplementary Recitation Session (SRS).

The SRS is a one-credit, two contact hour additional class meeting that is a corequisite for the college level class. The sessions are designed by faculty teaching the course and delivered by upperclassmen. These upperclassmen facilitators undergo extensive training on how to deliver course content while maintaining an active learning environment in the session. The SRS class sizes are kept to a maximum of 20-25 students. The intent of the SRS sessions is to deliver just-in-time relevant background information and to reinforce course material presented in class. Students attending SRS sections are not in separate sections of the college level course; they are integrated in the same sections with students who are not enrolled in a SRS.

MILESTONE EVENT 4

Creation of the Math and Sciences Support Center (MASS)[12]

Scheduling and staffing many sections of corequisite SRS and providing training to large numbers of upperclassmen facilitators is not within the expertise of a service and research mathematics department. The administration, again in conjunction with mathematics faculty, decided that a specialized group of educators would be better suited for this job. In 2015, the decision was made to centralize academic support and move tutorial services from the Mathematics Department to Learning Commons. This effort resulted in the creation of MASS (Math & Science Support Center); an office independent of the mathematics department that works in close collaboration with faculty from the department. MASS is staffed by professionals with backgrounds in education. These professionals train peer tutors for one-on-one tutorial sessions, schedule staff, and supervise the delivery of the SRS sections. They keep in close contact and communicate with the faculty that are developing and updating materials for the SRS meetings.

MILESTONE EVENT 5

Redesigning Foundations of Quantitative Reasoning (FQR)

During AY2015, the Mathematics Department at UC redesigned the course Foundations of Quantitative Reasoning (FQR). The redesign was necessary to comply with State agreements for transferability. Faculty added to the learning objectives just in time necessary background material and agreed to use research-based pedagogy across the sections. This course was originally developed at UC in 2005 as a collaborative effort of faculty from the mathematics department and several liberal arts programs in the College of Arts and Sciences as an alternative to College Algebra for liberal arts students. Despite this, the practice of enrolling students from the liberal arts in College Algebra continued for some years. Now, with the new emphasis on aligning pathways with programs of study and additional support from advisors, the number of students enrolled in this class has increased significantly. Further, the set of learning outcomes can be achieved with meaningful applications to many different disciplines. The math department has invited participation of faculty from the liberal arts to provide direction and collaborate in the design of the projects that students complete during the semester and also to provide relevant example problem situations that arise in the different liberal arts fields. As a result, there are now dedicated sections of FQR for students in the department of Psychology and starting Fall 2020, dedicated sections will be offered for the Early Childhood and Middle School programs in the College of Education. The nature of the FQR course requires constant professional development for faculty. The ODHE has made opportunities available for faculty training[13] and the means to share ideas with the Knowledge Base Server, a virtual place, where faculty can post materials and review materials posted by peer faculty from different institutions across the state teaching Quantitative Reasoning courses.

Outcomes from Change in Practice

Overall Changes

Across four semesters (Fall 17, Spring 18, Fall 18, and Spring 19) and five courses linked to a corequisite SRS (College Algebra, Precalculus, Calculus, Calculus II, and Applied Calculus), students enrolled in a corequisite course outperformed their counterparts enrolled in the same standalone course when looking at course success rates collectively defined as the percentage of students earning a grade of C or above (see Table 1). All differences were statistically significant at a level of .05. For example, students enrolled in College Algebra succeeded at a rate of about 86% with a corequisite when compared to 79% of those in the standalone version. Similar results were seen for Precalculus students (73% versus 58%), Calculus (69% versus 64%), Calculus II (74% versus 64%), and Applied Calculus (79% versus 71%).

These results were consistent with observed differences in the course success rates of students enrolled in Foundations of Quantitative Reasoning with integrated corequisite content and standalone College Algebra. The overall FQR success rate of approximately 85% was much higher than the success rate for students enrolled in the standalone College Algebra course, which was approximately 79% as stated above (see Table 2). Students enrolled in the FQR course would most likely have enrolled in a standalone College Algebra course prior to the design and implementation of this revised course as this was previously the typical pathway. It should be noted however, that although these results are encouraging, this difference in success rates was not determined to be statistically significant since comparisons were between two different courses.

Table 1: Overall Student Success in All Co-Requisite Courses by Treatment and Race/Ethnicity

Treatment Group & Course	% of ALL Students Who Passed Course	% of White Students Who Passed Course	% Latinx Students Who Passed Course	% Asian Students Who Passed Course	% Black Students Who Passed Course	% Multi-race Students Who Passed Course	% Unknown Students Who Passed Course	% Alaskan Native or American Indian
College Algebra with Co-requisite (N=139)	85.61%	87.27% (N=110)	80% (N=5)	75% (N=4)	84.62% (N=13)	66.67% (N=6)	100% (N=6)	N/A (N=0)
College Algebra Standalone (N=1991)	78.91%	81.79% (N=1549)	75.64% (N=78)	83.87% (N=62)	59.18% (N=147)	60.87% (N=92)	91.91% (N=11)	44.44% (N=9)
Precalculus with Co-requisite (N=131)	75.52%	70.75% (N=106)	88.9% (N=9)	60% (N=5)	100% (N=5)	75% (N=4)	100% (N=1)	0% (N=1)
Precalculus Standalone (N=556)	57.55%	57% (N=407)	54.84% (N=31)	50% (N=24)	59.52& (N=42)	56.52% (N=23)	100% (N=1)	N/A (N=0)
Calculus with Co-requisite (N=416)	69.23%	68.73% (N=355)	75% (N=8)	72.73% (N=22)	57.14% (N=14)	72.73% (N=11)	100% (N=3)	N/A (N=0)
Calculus Standalone (N=2276)	64.28%	64% (N=1697)	65.06% (N=83)	60.33% (N=121)	49.11% (N=112)	71.67% (N=85)	66.67% (N=30)	50% (N=2)
Calculus II with Co-requisite (N=245)	74.29%	73.81% (N=210)	100% (N=7)	66.67% (N=9)	50% (N=2)	75% (N=4)	75% (N=4)	N/A (N=0)
Calculus II Standalone (N=1821)	64.03%	64.11% (N=1382)	67.74% (N=62)	63.27% (N=98)	57.89% (N=57)	51.25% (N=80)	70.83% (N=24)	100% (N=1)
Applied Calculus with Co-requisite (N=251)	79.28%	82.67% (N=202)	100% (N=4)	77.78% (N=9)	25% (N=16)	86.67% (N=15)	50% (N=2)	N/A (N=0)
Applied Calculus Standalone (N=2099)	70.67%	72.17% (N=2343)	66.67% (N=93)	74.85% (N=167)	53.72% (N=242)	69.47% (N=32)	62.5% (N=32)	100% (N=3)

**The difference in passing rates for ALL students between the treatment and comparison group is statistically significant (p<.05).*

Equity-Focused Change

When disaggregating the data by race, sample sizes were small preventing the authors from concluding that the differences between the treatment and control groups were statistically significant. However, when looking at the impact of the corequisite model among students of color, encouraging results emerged. For Black/African American students taking College Algebra, Precalculus, and Calculus with corequisites, course success rates were higher than their counterparts in the control group (see Table 1). For all five courses, Hispanic/Latinx students in the corequisite structure seemingly outperformed standalone Hispanic/Latinx students (see Table 1). Asian/Pacific Islander students in corequisite courses also outperformed their counterparts in standalone versions for all courses except College Algebra (75% versus 84%). Similar to the results for the Hispanic/Latinx students, all students that identified as two or more races in the corequisite courses outperformed their standalone counterparts in all five corequisite classes (see Table 1). Although sample sizes were extremely small, unknown race students in the corequisite courses also outperformed their counterparts in the standalone courses across all courses except Applied Calculus (50% versus 63%) and Precalculus where all students passed the course they were enrolled in regardless of treatment. The sample of Alaskan Native/American Indian students was too small to compare across treatments as there were no students enrolled in either the treatment or control group for each course (see Table 1). Lastly, student success across all five courses with the corequisite model was mirrored among White students who comprised the majority of all course enrollments consistent with UC's student population: College Algebra (87% versus 82%), Precalculus (71% versus 57%), Calculus (69% versus 64%), Calculus II (74% versus 64%), and Applied Calculus (83% versus 72%). Collectively, although the results could not be determined to be statistically significant when disaggregating the data by race, all students of color seemingly had greater success using the corequisite model than when taking a standalone class with only a few exceptions mentioned above.

Although direct comparison and statistical significance cannot be proven when comparing across multiple courses and content, some promising results emerged for the FQR course along equity lines as well. For the FQR course, Hispanic/Latinx students' course success rate was higher than the success rate for all students as indicated in Table 2 and was also higher than the success rate of their counterparts in the standalone College Algebra course which would have been their typical pathway. Similarly, multi-race students enrolled in FQR outperformed their counterparts enrolled in a standalone College Algebra class (about 74% to 61%) as did Black/African American students (about 65% to 59%) and White students (about 88% to 82%). Although course success rates differed in favor of the corequisite course structures, it should be noted that sample sizes were too small by race to determine the statistical significance of the differences. Collectively however, these results show significant potential gains in student success across multiple racial and ethnic demographics (particularly for Hispanic/Latinx, multi-race, and White students) and multiple courses for corequisite implementation at UC.

Table 2: Overall Student Success in Foundations of Quantitative Reasoning (FQR) and College Algebra

Treatment Group & Course	% of ALL Students Who Passed Course	% of White Students Who Passed Course	% Latinx Students Who Passed Course	% Asian Students Who Passed Course	% Black Students Who Passed Course	% Multi-race Students Who Passed Course	% Unknown Students Who Passed Course	% Alaskan Native or American Indian
Foundations of Quantitative Reasoning (N=974)	85.54%	88.28% (N=751)	87.5% (N=32)	77.78% (N=18)	64.71% (N=85)	74.42% (N=43)	81.82% (N=22)	100% (N=1)
College Algebra Standalone (N=1991)	78.91%	81.79% (N=1549)	75.64% (N=78)	83.87% (N=62)	59.18% (N=147)	60.87% (N=92)	91.91% (N=11)	44.44% (N=9)

When disaggregating the data by age (see Tables 3 and 4), it is the younger students (under 25) who consistently outperformed older students (25 and older) across all six courses. It should be noted, however, that sample sizes for older students were small with 94 being the largest sample size of older students in the Applied Calculus class so results cannot be determined to be statistically significant. These sample sizes, however, are consistent with the overall student population at UC's main campus which is only 12% twenty-five and older (according to IPEDS data from Fall 2018). Since sample sizes for the comparable older student group were so small and the majority of the students were under 25, many of the success rates for the younger students were equivalent to or extremely close to the success rates for the overall student population enrolled in the course. Therefore, the results of the corequisite implementation are difficult to interpret in terms of whether or not it is as successful for older students. Additional data collection is recommended. Due to extremely small sample sizes and low numbers of UC students identifying as low income (as indicated by Pell status), an analysis of student performance based on income status was not conducted.

Table 3: Overall Student Success in All Co-Requisite Courses by Treatment and Age

Treatment Group & Course	% of ALL Students Who Passed Course	% of Students 25 and Older Who Passed Course	% of Students Under 25 Who Passed Course
College Algebra with Co-Requisite (N=139)	85.61%	N/A (N=0)	85.61% (N=139)
College Algebra Standalone (N=1991)	78.91%	75.76% (N=33)	78.96% (N=1958)
Precalculus with Co-Requisite (N=131)	75.52%	50% (N=2)	72.87% (N=129)
Precalculus Standalone (N=556)	57.55%	50% (N=6)	57.64% (N=550)
Calculus with Co-Requisite (N=416)	69.23%	66.67% (N=3)	69.25% (N=413)
Calculus Standalone (N=2276)	64.28%	45.78% (N=83)	64.98% (N=2193)
Calculus II with Co-Requisite (N=245)	74.29%	66.67% (N=3)	74.38% (N=242)
Calculus II Standalone (N=1821)	64.03%	55.81% (N=43)	64.23% (N=1778)
Applied Calculus with Co-Requisite (N=251)	79.28%	0% (N=5)	80.89% (N=246)
Applied Calculus Standalone (N=2099)	70.67%	48.31% (N=89)	71.33% (N=3010)

**The difference in passing rates between the treatment and comparison group is statistically significant (p<.05).*

Table 4: Overall Student Success in Foundations of Quantitative Reasoning (FQR) and College Algebra by Age

Treatment Group & Course	% of ALL Students Who Passed Course	% of Students 25 and Older Who Passed Course	% of Students Under 25 Who Passed Course
Foundations of Quantitative Reasoning (N=974)	85.42%	66.67% (N=9)	85.6% (N=965)
College Algebra Standalone (N=1991)	78.91%	75.76% (N=33)	78.96% (N=1958)

Sources of Support

Technical Assistance Support

Although this was primarily an internal project led by UC mathematics faculty and supported by campus administration, the Charles A. Dana Center did provide technical assistance in the form of professional development. In addition, ODHE provided faculty training.

Reallocation of Resources

The Learning Commons (LC), an established component of the University of Cincinnati, already had in place the infrastructure to accommodate the change to incorporate corequisite SRS sections. LC hires many peer-tutors for one-on-one sessions with students from many disciplines in the University Tutorial Center. The addition of the Math and Sciences Support Center in 2014 was an effort by the University, aware of the necessity to increase success and graduation rates, to provide focused assistance to students in STEM disciplines. With the Center already established, the additional task of managing corequisite SRS in 2015 did not increase significantly the expenses of the Center.

Other Resources

To date, the University of Cincinnati has allocated $1,450,000 in resources to hire Educator Faculty in the mathematics department to support the department's intentional focus on pedagogy and increasing course success rates. These are full-time renewable positions whose primary mission is to teach. The mathematics department has an enrollment of 7000+ students per semester. Approximately 70% of these students are enrolled in entry-level courses. Educator Faculty now teach most of the entry-level courses. They participate in course development and conduct pedagogical research. The rationale behind this change was to have stability and continuity in these pedagogical efforts. The Provost has funded 18 of these positions to date. Educator Faculty also oversee the coordination of multi-section entry-level courses.

Moving Forward

Lessons Learned

FQR is a Viable Alternative to College Algebra. One of the lessons we learned from this work, which also mirrors a national conversation, is that students may be more successful in alternative math courses than in College Algebra, which has historically been seen as the required math course for all students regardless of program of study. At UC, students who most likely would have typically been placed in College Algebra but were instead enrolled in Foundations of Quantitative Reasoning (FQR), were extremely successful at a higher rate than those students in the standalone College Algebra course. In particular, the results shown regarding Hispanic/Latinx students and multi-race students in this course were also promising. Collectively, these results are encouraging and contribute to the current literature challenging the notion that College Algebra is the best math course for "all" students and that students may benefit from alternative math courses which are more closely aligned to their programs of study. Moving forward, UC and the mathematics department expects the use of the FQR course as a general education requirement will extend to most of the liberal arts programs. The effect of this change can already be detected by decreased enrollment in the College Algebra sections and increased student success.

Next Steps

The following are proposed next steps for UC as a result of their work, the findings of this corequisite implementation, and the movement in the field.

Consider increasing access to corequisites through revisiting current advising, scheduling, and placement practices. It is not known whether or not all students had equal knowledge of and access to the corequisite courses. Since the corequisite models at UC have demonstrated such high levels of success, faculty, staff, and administrators at UC may want to consider revisiting their advising and placement practices to allow greater access to the corequisite models for students. This may involve more aggressive or intrusive advising and a review of placement cutoffs to possibly include consideration of multiple measures. To allow for greater impact and increased success for larger numbers of students at UC, faculty and staff may want to examine their current scheduling practices to allow for more corequisite options for students. This may include increasing the number of corequisite sections as well as the availability of these sections to include adequate daytime and evening options for example. Special attention should be given to addressing the scheduling needs of older adult students since their numbers were much smaller in our samples and may possibly be due to the scheduling of available sections. UC has already begun this process by increasing the SRS sections from 25 in 2015 to 48 this year and plans to offer 54 SRS sections in the academic year 2021.

Follow students beyond the corequisite course into the next math course to track their progress. This could perhaps become a longitudinal study to assess whether or not students can continue to benefit from and be successful following a corequisite course as indicated by their course success rate in one or more subsequent math courses.

Share Information Statewide. Share information statewide regarding the success of the corequisite models at UC and assist other institutions with designing and implementing similar models to increase student success in mathematics and transferability statewide. The focus should be on UC collaborating with two-year institutions in developing and designing these models to increase the potential for transferability across institutions such as the regional campuses of Blue Ash and Clermont Colleges, and the Cincinnati State Community College.

References

Attewell, P. A, Lavin, D. E., Domina, T., & Levey, T. (2006). New evidence on college remediation. The Journal of Higher Education, 77(5), 886–924.

Bailey, T., Jeong, D. W., & Cho, S.W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. Economics of Education Review, 29, 255–270.

Bressoud, D. (2018). Why colleges must change how they teach calculus. The Conversation. Retrieved from https://theconversation.com/why-colleges-must-change-how-they-teach-calculus-90679

Bryk, T. & Treisman, U. (2010). Make Math a Gateway, Not a Gatekeeper. The Chronicle of Higher Education. Retrieved from https://www.chronicle.com/article/Make-Math-a-Gateway-Not-a/65056

The Charles A. Dana Center. (2019). The Case for Mathematics Pathways. Austin, TX: The Charles A. Dana Center at The University of Texas at Austin.

Chen, X. (2016). Remedial course taking at U.S. public 2- and 4-year institutions: Scope, experiences, and Outcomes (NCES 2016-405). U.S. Department of Education, Washington, DC: National Center for Education Statistics.

Denley, T. (2016) Corequisite remediation full implementation 2015-2016 (Brief No. 3). Tennessee Board of Regents.

EdSource. (2012, February). Passing when it counts. Retrieved from https://edsource.org/wp-content/publications/pub12-Math2012Final.pdf.

Marshall, A. A, & Leahy, F. F. (March, 2019). Math pathways and equity: Gateway Course Outcomes In Emerging Issues in Mathematics Pathways: Case Studies, Scans of the Field & Recommendations Monograph Austin, TX: Charles A. Dana Center.

Saxe, K., & Braddy, L. (2015). A common vision for undergraduate mathematical sciences programs in 2025. Retrieved from http://www.maa.org/sites/default/files/pdf/CommonVisionFinal.pdf.

Appendix A:

Site Context

What is the name of the institution(s), and if appropriate system, where the changes in practice took place?

University of Cincinnati (main campus location)

In which state(s) is/are your institution/system located?

Ohio

At which type of institution(s) did this change in practice take place?

4-year public

What is the total, undergraduate (headcount) enrollment for the institution where the change in practice took place?

27,762 (as of Fall 2018)

What percentage of full-time, beginning undergraduate students received a Pell Grant?

21%

What percentage of students are African American/ Black?

7%

What percentage of students are American Indian/ Alaskan Native?

Less than 1%

What percentage of students are Asian/Pacific Islander?

4%

What percentage of students are Hispanic or Latinx?

3%

What percentage of students are More than One Race?

4%

What percentage of students are White?

74%

What percentage of students are aged 24 or under?

88%

What percentage of students are aged 25 or older?

12%