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# Corequisite Developmental Mathematics Instruction: A Review of the Efficacy Research

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## Abstract

A recent trend in developmental education involves implementing instructional models for accelerating the academic skills development of underprepared college students. Corequisite mathematics instruction is now a primary part of this trend. Some argue that it is the sole best method for providing developmental education. Given this, a modest amount of efficacy research on this practice has emerged. As the corequisite model of mathematics proliferates, it is warranted that the field and professionals therein reflect on this work in the context of identifying the extent to which it improves practice. This literature review and discussion offers insight from a recent collection of recent research articles, working papers, and reports on corequisite mathematics instruction. Upon reviewing the literature, particular points regarding corequisite models, instructional issues, and course efficacy were identified and discussed.

## Corequisite Developmental Mathematics Instruction: A Literature Review of Recent Efficacy Research

In recent years, mathematics instruction for academically underprepared college students has undergone much change. In particular, the field has been charged to eliminate stand-alone developmental mathematics courses in favor of accelerated methods of college-level skills development, often designed for completion in one semester or less (Complete College America, [CCA], 2012). A popular instructional intervention

purported to do this is corequisite mathematics. This involves an underprepared student placement into college-level mathematics, along with a requirement to engage in some form of concurrent academic support. Vandal (2014) defined corequisite remediation as the "delivery of academic support to underprepared students while they are learning gateway course content in the same subject" (p. 3).

Though the corequisite course model was not new at the time, its broad application in developmental education was likely ushered in around 2012, when a few higher education advocacy groups labeled developmental education as ineffective and harmful to students. Along with this, the "solution" of corequisite instruction was declared as best for all underprepared students (CCA, 2012). At that time, there was only one corequisite model identified as efficacious with underprepared students. This was the Accelerated Learning Program (ALP); however, it was a corequisite design for the instruction of English/writing. It was not being applied at that juncture for the instruction of mathematics. Furthermore, it was not designed for, nor was it pitched by its founders as a solution for all underprepared students. It was developed quite carefully for those who were slightly underprepared in English/writing and motivated to participate in a more challenging and time-consuming class. The model was successful due to the application of best practices such as small class sizes, opportunities for individualized instruction, noncognitive support services, and faculty training (ALP, 2024). However, in spite of its lack of proven success with all underprepared students in both English/writing and mathematics, 46 states and U.S. territories have recently been reported to belong to an advocacy group alliance involved in the rollout of corequisite courses. These entities have mandated the application of corequisite courses broadly, with some requiring it as a complete replacement for traditional developmental education courses (Saxon, Martirosyan, & Sides, 2020).

Given the enormity of this trend and the length of time that it has been in place, there are studies now available that may inform decisions and actions regarding the continued application of corequisite developmental mathematics. The purpose of this work was to provide a review of research articles, working papers, and reports on corequisite mathematics. Upon reviewing this literature, particular points regarding corequisite model implementation, math content applications, and findings regarding corequisite course efficacy were identified and discussed. This review may be a useful resource for anyone involved with this academic intervention.

## Study Selection Process

An attempt was made to collect recent literature that described the efficacy of corequisite developmental mathematics. The literature search began with consultation of a reference list entitled *Resources on Corequisites* (Community College Data, 2020). Additional searches were conducted using a university library search engine. Search terms included "corequisite mathematics," "corequisite developmental education," and "corequisite model." The search results were limited to studies published in 2010 to 2024. Efforts were also made to primarily review studies that offered some description of the research methods applied. Appropriate articles addressing the effectiveness of corequisite mathematics were retrieved in full text.

## Review of the Research

### Corequisite Models and Components

Daugherty et al. (2018) identified five types of corequisite models including paired courses, extended instructional time, ALP, academic support services, and technology-mediated support. The predominant model specified in the literature for corequisite mathematics was that of paired courses (e.g., Fair, 2017; George & Milman, 2019; Kashyap & Mathew, 2017; Logue et al., 2016; Matz & Tunstall, 2019; Moening, 2016; Procknow et al., 2018; Royer & Baker, 2018; Sapp, 2018; Wilson, 2018). Some model dimensions were described in these reports, but this information was quite limited. Reported class sizes for corequisite sections ranged from 12 (Sapp, 2018) to 30 students (Buckles et al., 2019). Support courses were typically described as constituting one to three-credit hours, which equates to adding about 50 minutes to nearly three hours of instructional time per week. Ran and Lin (2019) noted that corequisite model dimensions varied across colleges in their study, however, these differences were not considered in their work. Online corequisite models were also mentioned once in the literature examined here as a part of the Ran and Lin (2019); however, no details about the model or unique analysis of these courses were provided.

As part of an efficacy study by Campbell and Cintron (2018), a follow-up survey was administered to identify effective program components. Those identified and recommended included having the same instructor teach both the corequisite and gateway courses, requiring attendance in both courses, mandating participation in advising, and requiring an orientation for the corequisite program.

### Efficacy Studies

#### *Mathematics corequisite pass rates.*

Logue et al. (2016) conducted a randomized control trial to compare pass rates in developmental Elementary Algebra (EA) courses with credit-bearing Statistics courses. The study involved tracking 717 randomly placed students at three CUNY community colleges. In Fall 2013, 244 students were placed in prerequisite developmental EA; 227 students were placed in an EA course with weekly workshops (EA-WS); and 246 students were placed in college-level Statistics with weekly workshops (Stat-WS). The courses with weekly workshops were considered corequisite interventions. All participants were first-time freshmen intending to major in programs that did not require College Algebra (CA). The pass rates were 39.3% for EA, 44.9% for EA-WS, and 55.7% for Stat-WS. When pass rates for Stat-WS only included participants just below the college-level placement threshold (a definition of this was not offered), they were similar to those who placed directly into college-level Statistics, 67.6% and 69%, respectively. The authors concluded that corequisite models have the potential to increase student success.

Logue et al. (2019) conducted a quasi-experimental analysis to compare the pass rates of students in corequisite Quantitative Reasoning (QR) or Statistics courses to those of propensity score matched students who completed remedial EA. Data were collected from four CUNY community colleges for all corequisite mathematics courses from Fall 2013 to Fall 2015 and for matched students in EA during 2013. Analyses showed that corequisite groups had a pass rate advantage that ranged from 22% to 53%. It was concluded that "corequisite mathematics is effective at

increasing students' success over time and in different contexts" (Logue et al., 2019, p. 307), when students do not need CA for their major.

Moening (2016) analyzed the relationship between a corequisite delivery model and student success as determined by course pass rates in a state community college system. Archival data were collected between Fall 2011 and Fall 2015 for 69,264 students enrolled in gateway mathematics, and between Fall 2013 and Fall 2015 for 9,296 students enrolled in corequisite liberal arts mathematics. In Fall 2013, 60% of gateway mathematics students passed the course compared to 52% of corequisite students. In Fall 2015, 65% of gateway mathematics students passed compared to 71% of corequisite students. Students that were older, female, White/Asian, and non-Pell achieved the highest pass rates in each subgroup. A regression discontinuity analysis showed that students who scored within five points below the Accuplacer cut score (100-point scale) passed the corequisite course at higher rates than students in the gateway course with a similar cut score.

Kashyap and Mathew (2017) conducted a mixed-methods study examining student performance and satisfaction in QR courses. They found that corequisite students had significantly higher average course grades than those in the prerequisite model. Eighty percent of students earned a C- or higher in the corequisite model compared to 50% in the prerequisite model. The authors attributed the gains to the supplemental instruction support offered and recommended that the corequisite support and content courses be taught by the same instructor. Limited information was offered on the structure of the prerequisite model. Responses from an end-of-course student survey indicated that the prerequisite model did not facilitate improved student motivation, confidence, or satisfaction.

Fair (2017) conducted a quantitative quasi-experimental study to determine the effectiveness of corequisite mathematics at a public, regional Southern university. In Fall 2016, 89 students in a college-level Liberal Arts Mathematics class were compared to 68 students in a corequisite Liberal Arts Mathematics class with remedial algebra content. Students who had an ACT Math subscore of 18 or less were placed in the corequisite section. There were four sections of each type of course. The corequisite course included three additional contact hours per week that focused on algebraic content. Four instructors taught one section of each format. The study compared course grades while controlling for gender, race, income, first-generation status, high school GPA, and math ACT subscore. No significant difference was reported in adjusted mean course grades across the standard and corequisite sections. Significant correlations were found for high school GPA and math ACT subscores with course grades. No correlations were identified among grades and demographic variables.

George and Milman (2019) compared pass rates among students in a developmental QL course and students in a developmental EA course at the Borough of Manhattan Community College. They also examined pass rates with subsequent course enrollment. The QL course applied Quantway resources and included a faculty development component. The EA course used a common textbook with an online homework platform. Propensity score matching was applied in order to compare 418 students enrolled across each type of course in Spring 2013. No significant differences regarding demographics or prior performance were determined across the two sample groups. The pass rate for the QL

course was 53% compared to 29% for the EA course. By Fall 2013, 110 of the 159 QL students who enrolled in the next sequential mathematics course passed compared to 44 of the 87 EA students. In Fall 2017, the QL course was combined with a college level QR course to create a 6-hour, 3-credit corequisite course. Of the 120 students who enrolled over three semesters, 59% of students passed the course. The researchers advised that a quantitative pathway should be offered for students in non-STEM programs.

Procknow et al. (2018) described the corequisite approach at the University of Texas in Austin. It was developed in 2017 in response to state legislation requiring corequisite developmental education. The developmental support course enrolled a maximum of 15 students that met for 90 minutes once a week. The credit-bearing content courses allowed for 100-200 students per section. All developmental education students were placed in the same section of the credit bearing course. Each support course was taught by a separate "success" instructor that worked with those teaching the credit bearing courses. In the support courses, students were exposed to upcoming topics and involved in application-based learning experiences. Data for 2016-17 and 2017-18 indicated that all 42 developmental education students passed their college-level courses and 38 of them earned a C- or better.

Strother and Klipple (2019) studied the first-year implementation of Quantway and Statway corequisite courses. Results from courses that involved 15 faculty, 21 sections, and 410 students were collected from six institutions. About 65% of the students earned a C or better in corequisite courses. The mean pass rates were 79% for the Quantway course and 54% for the Statway course. Design elements such as contact hours, credit hours, and placement varied by institution. However, all institutions used a cohort model whereby the same faculty member taught both the content and support courses.

***Course completion.***

Ivy Tech Community College established three mathematics pathways including Technical Mathematics, QR, and STEM. This was done to address low completion rates in gateway mathematics courses (Royer & Baker, 2018). The QR pathway included a corequisite remediation component. Royer and Baker (2018) presented completion rates for this intervention over a five-semester period from Spring 2014 to Spring 2016. Of the 9,029 students who enrolled in the corequisite model, about 59% completed it. The researchers noted that this was a favorable completion rate to that of those previously taking remedial mathematics courses, which was 29%. The report offered no mention of the corequisite design or model dimensions.

***Other efficacy measures.***

Ran and Lin (2019) reported that no significant effects were found for corequisite participation on enrollment persistence. The mean total credit accumulation advantage for Stat-WS (with a corequisite component) participants increased from 2.38 to 4 credits over EA (no corequisite component) participants during the Logue et al. (2016) study. With regard to credentialing, by Fall 2016, 17.2% of 297 EA students had earned an associate degree compared to 25.3% of the Stat-WS students. Logistic regression indicated that the Stat-WS group had an 8.1% higher probability of graduating than the EA group, and about a 4.8% higher probability of graduating or transferring to a

bachelor's degree program (Logue et al., 2016).

***College Algebra corequisite efficacy.***

Five studies (Buckles et al., 2019; Matz & Tunstall, 2019; Sapp, 2018; Smith, 2019; The Charles A. Dana Center, 2018) covered corequisite instruction specifically for CA. Sapp (2018) conducted a causal-comparative quantitative study to determine student factors associated with performance and retention in corequisite CA compared to non-corequisite CA at a public 2-year college in the Midwest. Variables including gender, age, high school GPA, ACT scores, attendance, and course performance were analyzed for 532 students over five semesters during Fall 2015 to Spring 2017. Of those students, 270 were in corequisite sections and 261 were in non-corequisite sections. The 26 corequisite sections were taught by nine instructors. There was a common textbook, content, and grading scale across all sections. However, there were nine different grade-weighting structures, instructor-created assessments, and varying supports across instructional locations. Corequisite sections enrolled 12 students. Students passed the corequisite component if they met six of eight competencies. Based on correlational analyses, attendance in CA and ACT composite score were predictors of success for both the corequisite and the non-corequisite students. There was no significant difference in student performance or retention across the corequisite and the non-corequisite sections.

Buckles et al. (2019) studied the impact of a corequisite CA redesign at Dillard University. Students who had an ACT or SAT score just below the required cut score to place into CA were enrolled in the corequisite course. The course was four credits with students attending for 75 minutes, three days per week. In addition, students used a commercial online mathematics instructional platform for assignments and were required to attend a tutoring lab. All 25 students in the Summer 2018 pilot study passed the corequisite course with a C or better. Of those, 10 enrolled in Precalculus the following semester and eight of those students passed. The corequisite course was fully implemented in Fall 2018. Of the 140 students in five corequisite sections, 78% completed the course and 80% of those passed with a C or better. The researchers surmised that corequisite CA courses have the potential to minimize the time and cost of developmental mathematics course sequences.

Matz and Tunstall (2019) examined course pass rates and demographic data for students in three gateway mathematics courses at Michigan State University. Courses with embedded remediation were labelled as *enhanced* and were considered corequisite courses. In Fall 2017 and Spring 2018, 268 students in QL1, 151 students in QL2, and 587 students in CA were divided into four categories based on placement score, developmental mathematics requirement, and the type of course. The non-enhanced QL sections met two times per week for 80 minutes. The first meeting each week was a lecture with the instructor and the second meeting was review with a teaching assistant. The enhanced QL sections included an additional 50-minute meeting between the lecture and the review session. The non-enhanced CA sections met for two 50-minute lectures and one 50-minute review each week. The enhanced CA section included two additional 50-minute meetings per week.

Listwise regression analysis showed that, in enhanced QL courses, final grades were lower for students with developmental mathematics preparation than for those who

waived developmental mathematics for the gateway course. In CA, student grades in the enhanced sections were lower than those for students in the non-enhanced sections, however, the difference was not statistically significant. Prior math GPA, race, ACT math subscore, and financial need were reported to be predictors of success in gateway mathematics courses. The authors noted the importance of the design and implementation of enhanced sections, and the importance of keeping students progressing through, rather than allowing time lapses between, taking mathematics courses.

Smith (2019) studied the relationship between corequisite support and success in gateway CA at a public college in the University System of Georgia. The research compared 158 first-time, full-time degree seeking CA students in Fall 2017 with 55 similar students in Fall 2018 who received corequisite support with their CA course. Neither group included students with prior mathematics credit, a high school GPA greater than 3.4, an ACT Math score greater than 19, or an Accuplacer EA score greater than 78. By comparison, the 2017 group had a higher percentage of females and White students, as well as higher mean high school GPA and ACT composite scores. The 2018 group had a higher percentage of males, Black students, and Hispanic students. Smith reported a statistically significant relationship between corequisite support and course success in gateway CA. Students in the corequisite course passed CA with C grade or higher at a rate of 72.7%, compared to 56.3% for those in a CA course without corequisite support.

In collaboration with the Charles A. Dana Center (2018), the University of Central Arkansas piloted corequisite QL courses in 2014 which resulted in a 100% pass rate in the credit-bearing course. Both the content and support courses were taught by the same instructor. This initiative was later expanded to include corequisite CA courses in which students attained an 82% pass rate. The Foundations of College Algebra (formerly prerequisite developmental education) course was paired with credit-bearing CA. College-ready and underprepared students were comingled in the CA sections. One of the four sections had the same instructor in the support and content courses. Similar success results, regardless of student ACT score, for both QL and CA were observed through 2017. Student and faculty feedback indicated a preference for placing all underprepared students together with the same instructor for both courses.

### *Uncommon comparisons*

Florida legislators mandated an uncommon model of reform whereby colleges were ordered to accelerate developmental education applying varying options (including corequisite), while simultaneously rendering it optional to students. In seeking to consider the impact of Florida Senate Bill 1720, Park et al. (2018) examined the choices first time in college (FTIC) students made regarding mathematics courses and the success of students who took Intermediate Algebra in their first semester. Data from the Florida Education Data Warehouse were examined. The sample consisted of 20,591 FTIC students who entered the Florida College System in Fall 2014. It only included students who were exempt from developmental education based on Senate Bill 1720. Students were divided into four groups based on their enrollment choice of: (1) no mathematics course, (2) developmental mathematics, (3) Intermediate Algebra (the gateway course), and (4) both developmental mathematics and Intermediate Algebra in the same

semester in either a corequisite or a compressed format. High school academic preparation was the primary indicator of preparedness. Only 3.4% of those in the sample chose to take both developmental mathematics and Intermediate Algebra in the same semester. The most severely underprepared FTIC students were the least likely to choose this pathway. However, the underprepared students who chose corequisite or compressed developmental education support had higher probabilities for passing Intermediate Algebra than those who did not. The predicted probabilities for passing with corequisite were 48.2%, 53% with the compressed modality, and 40.8% with the non-developmental support modality. The authors stated that there was no evidence to support that either the corequisite or the compressed model worked better than the other. Although these support modalities were beneficial for students, only a small percentage of students chose to enroll in them.

### *Precalculus corequisite efficacy*

Wilson (2018) compared mathematics course success rates and credential completion among students in Precalculus with no academic support and Precalculus with a corequisite study skills component. Variables from 2013-2016 including high school GPA, credits earned, credentials earned, retention, and transfer, were analyzed for 946 students at a large urban community college in North Carolina. The 222 students in the corequisite course had high school GPAs between 2.6 and 2.99. The one-credit study skills course met for two contact hours per week. The college-level course content was reviewed through mini-lectures and cooperative group activities. Analyses indicated that students in the study skills course were more likely to be White, male, and FTIC. Chi-square analyses were applied to six outcomes including credits attempted, credits completed, credits A-C, math credits attempted, math credits completed, and math credits A-C. No significant differences were identified in success or retention across the two groups.

### *The efficacy of unspecified content corequisite course models*

Four studies did not specify a mathematics content area in their descriptions (Anderson et al., 2020, Campbell & Cintron, 2018; Denley, 2017; Ran & Lin, 2019). Denley (2017) reported on Tennessee's full-scale implementation of the statewide corequisite model. In the traditional prerequisite model, only 12.3% of developmental mathematics students completed the gateway mathematics course. This was the basis for reassessing developmental education and mandating corequisite models in the state. When the corequisite model was applied in community colleges during the 2015 academic year, 55% of students passed gateway mathematics courses with 52% of them passing during the first semester. During the 2016 academic year, universities also applied a corequisite model that included a supplemental lab experience. At universities, 75% of students passed gateway mathematics courses, with 67% passing during the first semester.

Denley (2017) also reported on achievement gaps by minority status, age, and income status. At universities, 73% of minority students and 72% of low-income students passed the mathematics corequisite and gateway courses. At community colleges, ethnic minority student pass rates were 47.3%. Older returning student pass rates in mathematics rose from 11% prior, to 57.6% following corequisite implementation. Gains for racial minorities,

returning adults, and low-income students were strong. As specified, no outcomes data were offered for particular content courses, but it was noted that the majority of students in corequisite courses required Elementary Statistics or QR as their gateway mathematics course.

Ran and Lin (2019) studied the impact of Tennessee's system-wide corequisite reform. For the mathematics component, the researchers examined data from 13 community colleges to ascertain the comparative effects of corequisite models, prerequisite models, and direct placement into gateway math courses. They focused on students at the margins of college readiness who enrolled in these interventions from 2010 to 2016. Using regression discontinuity, they analyzed ACT scores, grade point average, credits attempted and earned, degree completion, and transfer data. The data were from the Tennessee Board of Regents and the National Student Clearinghouse, and outcomes were tracked through Spring 2018. The sample of 35,707 students was limited to those with ACT scores two points above and below the math subscore of 19 that determined placement into gateway mathematics. The average age of students in the study was 18, and 75% were within one year of having completed their high school diploma. Students who completed corequisite mathematics support were 15% more likely to pass the gateway mathematics course within one year of enrollment and 8% more likely to pass a subsequent college-level mathematics course when compared to the students enrolled in the prerequisite model. No significant effects were found on enrollment persistence, transfer to baccalaureate institutions, or degree completion up to three years following initial enrollment.

The Louisiana Board of Regents conducted pilot studies at eight community colleges from 2012 through 2015 with the intent of identifying best practices in accelerating developmental education. Campbell and Cintron (2018) reported outcomes from five of the community colleges involved in the mathematics pilots, which offered corequisite support designed after the ALP model. These colleges included three urban, one suburban, and one rural. The variables examined included gender, race, Pell eligibility, and full- or part-time status. Students were eligible for the pilot if they had an ACT Math subscore of 17 or 18. Successful completion was defined as a course grade of C or better.

Students in the pilot sample (group one) were compared to students who were eligible for the pilot but chose the traditional developmental mathematics sequence (group two), and to students who were not eligible for the pilot due to an ACT Math score less than 17. These students were placed in a traditional developmental mathematics sequence (group three). The researchers reported no statistically significant difference in college-level mathematics completion rates across the three groups. The success rates for all groups were similar, ranging from 66% to 68.3%. However, students in the corequisite pilot did have a significantly lower noncompletion rate (10.2%) than the other two groups (22.2% and 20.4%, respectively).

Anderson et al. (2020) examined the co-enrollment of students in developmental mathematics and college-level mathematics to determine the extent to which completion rates differed from those in a traditional developmental mathematics course. Students at nine community colleges in a Southeastern state were matched and compared based on socioeconomic status, first-generation status, race and ethnicity, age, sex, college location, and number of credit hours enrolled. Data for the 208 co-enrolled students were analyzed for

matching characteristics (and minimized variance) from approximately 7,000 students participating in developmental education. Passing was defined as a D grade or higher. The researchers reported that co-enrolled students were 3.6 times more likely to pass the developmental mathematics course when co-enrolled in college-level mathematics.

## Results of the Efficacy Review

The efficacy results for corequisite mathematics as reported in the literature were mixed. Inclusive of all mathematics subject areas, eight studies compared the pass rates of the corequisite approach to the pass rates of the traditional prerequisite sequence. Of those, three reported positive results for student pass rates in corequisite courses (Anderson et al, 2020; Kashyap & Mathew, 2017; Royer & Baker, 2018). Another reported higher success for completing gateway courses, but no difference for students in longer term success measures (Ran & Lin, 2019). One study reported no difference across the two models (Campbell & Cintron, 2018). Two concluded that the corequisite model was effective, but the comparisons seemed misleading as it was across differing math content (Logue et al., 2016; Logue et al., 2019). Yet another study showed pass rate gains in corequisite, but similar gains were made concurrently in other accelerated models (Park et al., 2018).

Nine studies compared the pass rates of similar student groups in corequisite courses to the pass rates of the gateway course without supports. Of these, three reported gains for students in corequisite courses (Denley, 2017; Moening, 2016; Smith, 2019). One study (Park et al, 2018) showed gains for corequisite students, as well as similar gains for those choosing other accelerated models. Five studies reported no difference across the two groups (Campbell & Cintron, 2018; Fair, 2017; Matz & Tunstall, 2019; Sapp, 2018; Wilson, 2018).

Organizing these studies by mathematics content area, the following comparisons across models were reported. Nine studies specifically analyzed corequisite models associated with QR or liberal arts mathematics courses (Fair, 2017; George & Milman, 2019; Kashyap & Mathew, 2017; Matz & Tunstall, 2019; Moening, 2016; Procknow et al., 2018; Royer & Baker, 2018; Strother & Klipple, 2019; Charles A. Dana Center, 2018). Two of those studies showed that the corequisite approach increased the gateway course pass rates as compared to the pass rates of the traditional prerequisite course(s) and gateway course sequence (Kashyap & Mathew, 2017; Royer & Baker, 2018). One study indicated no change in pass rates (Fair, 2017) and one study indicated lower pass rates for corequisite compared to non-corequisite students (Matz & Tunstall, 2019). The remaining studies provided pass rates for the corequisite approach with no comparison to another course model.

Two studies analyzed corequisite models associated with statistics content (Logue et al., 2016; Procknow et al., 2018). Logue et al. (2016) determined that the corequisite approach increased pass rates for the college level statistics course (55.69%) as compared to the developmental algebra course (39.34%). Procknow et al. (2018) found that all 42 students who took corequisite courses passed the college level course.

As noted, five studies analyzed corequisite models specifically associated with CA and similar groups of students. Smith (2019) reported substantial gains in CA success in corequisite versus standalone courses (73% versus 56%). Conversely, Matz and Tunstall (2019) found no statistically significant difference among

students in corequisite CA courses and standalone algebra. Both models served students who were assessed as needing developmental education. They concluded that course type could not predict student success. Sapp (2018) indicated there was no significant difference in performance or retention among corequisite and non-corequisite students. Buckles et al. (2019) reported 62% of corequisite CA completers passed with a C grade or higher. They made no comparisons, but concluded that corequisite courses minimized the time and cost of developmental education for successful students. And finally, when a corequisite initiative administered by the Charles A. Dana Center was expanded to include CA, students attained an 82% pass rate.

Denley (2017) reported substantial gains in corequisite gateway math completion relative to the prerequisite model. Anderson (2020) explained that students were 3.6 times more likely to pass developmental math when they were concurrently enrolled in CA, rather than taking developmental math exclusively. In a study of corequisite versus standalone Precalculus courses, no differences in student success as measured by grades or retention were identified across the models (Wilson, 2018). In four studies of unspecified math content corequisite courses, the primary measure applied was success in the gateway course based on a passing grade. These studies compared the success rates of prerequisite developmental courses, corequisite courses, and standalone gateway courses. Each supported the efficacy of corequisite models (Anderson et al., 2020, Campbell & Cintron, 2018; Denley, 2017; Ran & Lin, 2019).

Park et al. (2018) showed that various accelerated developmental math modalities showed similar results. The probabilities of passing ranged from 48.2% to 53% for corequisite and compressed modalities, respectively. The models modestly outperformed prerequisite developmental math courses, however, developmental education was optional for students in these studies. Therefore, only a small percentage of students selected any developmental education modality, opting instead to directly enter college gateway courses.

## Discussion

### *How do we determine efficacy given what we have?*

There are multiple means and measures for determining efficacy among instructional models. These may consist of varying measures of student success (i.e., course grades, persistence, and retention) from short- to long-term, as well as relative performance of, and across, particular student subgroups. They may also relate to organizational and institutional objectives such as reform assessment, cost, efficiency, strategic priority, et cetera. Much of the work reviewed here offers only pass rates and, in some cases, corequisite course completion rates. As it seems that there were no studies offering broad scale benchmarks or standards for corequisite course completion and pass rates, perhaps success lies in the administrative beholder of a given corequisite program. There was also a notable absence of attention to, and discussion on student withdrawal from corequisite courses. Given that student attrition in prerequisite developmental education was revealed as problematic (Bailey et al. 2009) and later cited as a reason to adopt corequisite developmental education (CCA, 2012).

There were a few analogous comparisons of corequisite with other types of developmental education models. Some

comparisons offered were across differing math content courses, which seems ambiguous or even deceptive if indeed the goal is to investigate the performance of a particular instructional model. When course content is changed from CA to Statistics, QL, or QR, perhaps a substantial amount of the variance in student performance could be explained by this rather than an instructional model change.

A case can be made that it would be helpful to developmental mathematics reform to examine the data from ALP (2024), as it seems that this model was initially considered the standard for corequisite instruction. Any comparisons made, however, should be done under the consideration that ALP is an English/writing content course model and that it adhered to strict model design dimensions (noted earlier). The ALP (2024) website offers this statement about student success: "Student completion rates in the College Composition course have doubled compared to the stand-alone sequential developmental model" (para. 5). The ALP students likely had higher skills assessment scores as they were students who placed in the highest level of developmental English/writing, and they were students who, upon being advised, chose to take the corequisite course. Cho et al. (2012) reported that it was likely that students opting into ALP had higher motivation and that this contributed to improved outcomes. They found that, across a matched sample, students taking ALP were 31.3% more likely to complete college-level English than their non-ALP counterparts. But to reiterate, it appears that ALP students and those placed in prerequisite developmental education were quite different in terms of skill and motivation. Perhaps this renders cross model comparisons moot, and it may suffice to say that students who are just below college skill level who are motivated to proceed at an accelerated pace, are likely to do so successfully in most instructional models. A classic study of traditional prerequisite developmental education infers a similar conclusion. Boylan and Bonham (1992) reported that of students passing the top level of developmental education, 91% of English/writing students and 77% of mathematics students went on to pass their first college level course in the same subject.

Another approach in assessing efficacy across studies is to examine the results across studies of similar corequisite course content. As mentioned in the review, five studies were particular to teaching corequisite CA. The results showed a mixed picture of effectiveness. Sapp (2018) showed no difference across EA when taught standalone or corequisite. Matz and Tunstall (2019) reported no difference in grades across standalone or corequisite CA. Smith (2019) showed significantly higher pass rates for similar groups of students taking corequisite CA. And in two studies offering only corequisite course pass rates, a case can be made that the 80% and 82% pass rates reported by Buckles et al. (2019) and The Charles A. Dana Center respectively were commendable.

### *Is corequisite a total replacement for prerequisite developmental education?*

It seems that some claims that were made to press for corequisite reform trend now seem daunting in light of the current state of the research. Corequisite developmental education was pitched as a long-term solution to replace the "bridge to nowhere" (CCA, 2012, p. 2) of prerequisite developmental education. More recently, the same organization was claiming that "Corequisite Support is doubling and tripling gateway college course success in half the time or better" (CCA, 2024, p. 1). However, no research methods, comparative

data across models, or detailed model specifications were offered to verify this claim. Practically, it appears that both models may have a role. A few anecdotal reports were offered to support this and are subsequently described.

A college vice president in Georgia offered success rates in corequisite QR and CA of 66.8% and 54.6% respectively for students placed there as a result of being assessed as just below the college-level threshold. The administrator went on to describe that the college still maintained prerequisite developmental education for students who assessed with larger skill gaps (CCA, 2024). To the extent that the reported pass rates were viewed as a success, this suggested that corequisite (or perhaps any accelerated intervention) works for students who are already close to being college ready. No data were offered to support that corequisite is generally more successful than prerequisite developmental education. Apparently, at this college, there was a belief that both types of interventions were of value.

Similarly, a former Colorado Community College System administrator described corequisite as successful with regard to pass rates for students that exhibited skill sets just below the college level. This system also maintained some prerequisite developmental education for lower skilled students. Further, content changes were made concurrently with corequisite adoption whereby math pathways were created for Career Math, QR, Statistics, and Algebra. So again, the corequisite intervention was touted as successful for slightly under-skilled students, and when redesigned concurrently with curricular and course content changes (CCA, 2024).

Lending further support for the student placement nuance, Logue et al. (2016) reported modest gains in EA student success for their corequisite College Statistics model. These corequisites offered 56% pass rates, however, the researchers reported that if pass rate calculations only included students just below the college-level placement threshold, the average pass rate of 68% would be similar to students with a placement in standalone College Statistics. It seems Moening (2016) would also concur. In this study, corequisite pass rate results were mixed, with some corequisite cohorts faring better and some worse. The researcher, however, noted that students just under the skills assessment cut score for college-level course placement fared better in corequisite courses than did the broader underprepared student population.

Given these observations, it seems that any proposed application of corequisite courses in lieu of prerequisite developmental education may be more informative if it includes an acknowledgment that the intervention is best designed to serve a targeted group of underprepared students—rather than as an intervention designed for the total replacement of prerequisite developmental education. This targeted group includes students that are just below college-level placement, and that have the time and volition to engage in a rigorous academic intervention that accelerates the pace at which they will need to learn college mathematics skills.

### *Changing the subject*

It should be considered that along with corequisite instructional redesign, some colleges also incorporated content requirement changes for students (often across disciplines or majors). These changes were often referred to as *pathways*. For example, Royer and Baker reported an increase in course completion rates (from 29% to 59%) when remedial math courses

were redesigned to pathways that included technical math, QR, and STEM. In this study, the only corequisite course option was QR. Therefore, it may be considered that this work offered more insight about pathways than for corequisite redesign. Further, Logue et al. (2019) showed that the course content change from an algebra requirement to QR weighed substantially on student outcomes. They reported that students in corequisite QR courses showed a pass rate advantage of 53% to 23% over those in remedial EA courses.

Ran and Lin (2019) reported that there was no difference in short term persistence outcomes for students in corequisite Statistics relative to those in EA with no corequisite component. Though the content for these classes was quite different, they reported higher degree completion rates for corequisite students in a different math content course. Findings in these types of cross-content comparison studies should be interpreted carefully. Attributing outcomes gains to corequisite instruction seems misleading when the course content is also changed. It should be generally considered that success for underprepared students is likely facilitated by some combination of a quality instructional model, content contextualization, and integrated academic support (Boylan, 2002). Simply offering a gateway course with support may not, in and of itself, have been responsible for gains in student outcomes.

## Conclusions and Recommendations

The corequisite mathematics research that examined efficacy offered a mixed and perhaps, scattered view of its impact on student success. In some cases, little more than single measures such as pass rates and course completion rates were offered with no comparisons to other instructional models. There were several studies that were driven by curricular and content changes, as well as the design and delivery of developmental education instruction. Furthermore, very little comparative research was offered on similar student groups participating in pre- and corequisite courses. Given this, it cannot be ascertained that any particular model examined in these studies prevails as the sole path forward for developmental education.

There is, however, evidence to suggest that the corequisite model may work well with particular student groups—primarily those who place just below the level of college readiness. Not a lot of guidance, however, was given as to exactly what those levels are. Given the heterogeneity of courses, curricula, placement policy, and practice across institutions, it seems to fall on individual program administration to determine the appropriate student developmental education placement.

With regard to corequisite mathematics, no particular design or model has been identified as particularly efficacious (Homan et al., 2022). More broadly, when the work of Parks et al. (2018) is considered, it seems various types of accelerated developmental education models other than corequisite may work just as well.

In summary, it seems that the following can be concluded and should warrant further consideration for investigation and practice:

- Various models of accelerated mathematics developmental education are likely to work (Cho et al., 2012).
- Prerequisite developmental education seems to be a mainstay, especially for students who assess at a substantially lower skill level than college

ready in mathematics (CCA, 2024).

- It should not be ruled out that students successfully completing the highest level of prerequisite developmental education can also fare quite well in college-level courses (Boylan & Bonham, 1992). Therefore, developmental education is not a "bridge to nowhere" (CCA, 2012, para. 1).
- It is likely that course content changes, variance in model characteristics, and student skill levels will impact the effectiveness of the instructional model.

Furthermore, other changes should be considered when engaging in reform. As noted, curricular and content changes will have an impact, particularly when more challenging content such as college algebra is replaced with some types of contextualized mathematics content. Mangan (2019) noted a similar sentiment, expressing that although there were studies showing corequisite success, there is no evidence that the model works for all students, particularly the least prepared.

Students and faculty must weigh in as well. Mangan (2019) noted that faculty are skeptical of one-size-fits-all approaches and that this impacts their buy-in to instructional reform mandates. The work described here, supports the need for flexibility with regard to the administration of developmental education. We know that some students can effectively learn mathematics at an accelerated pace. They are motivated and able to invest substantially more time (in some cases double the credit hours) to complete gateway mathematics requirements in a single semester. Conversely, some are not. One of our primary tasks is to identify and sort out the best fit of instruction and support for each developmental mathematics student.

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