COREQUISITE MATHEMATICS EDUCATION AT MISSOURI COMMUNITY COLLEGES

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By

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The undersigned, appointed by the dean of the Graduate School, have examined the Dissertation entitled

COREQUISITE MATHEMATICS EDUCATION AT MISSOURI COMMUNITY COLLEGES

presented by Trisha White,

a candidate for the degree of Doctorate of Educational Leadership and Policy Analysis,

and hereby certify that, in their opinion, it is worthy of acceptance.

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DEDICATION

This dissertation is dedicated to my precious family, friends, and colleagues who have encouraged and supported me throughout my doctoral work. If I have learned anything, it is that we truly need each other.

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ABSTRACT

In an effort to raise graduation rates, the Missouri Department of Higher Education and Workforce Development directed public institutions to establish policies and create corequisite support structures to allow some underprepared students to take entry-level mathematics courses without first completing non-credit remedial courses. The present study explored the variety and effectiveness of corequisite structures implemented at 12 independent public community colleges in Missouri. Using a pragmatic parallel mixed method research design, this study used highly structured interviews and data from the Enhanced Missouri Student Achievement Study to address the research question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? This study described the unique structures and policies implemented at the colleges and using a chi-square test for homogeneity, compared the statewide and college persistence rates and completion rates of entry-level mathematics courses for students beginning in Fall 2014 and Fall 2018. The findings indicated that the statewide persistence rates increased but the increase was neither widespread nor consistent amongst the 12 individual colleges in the study; however, the increase in completion rates of entry-level mathematics courses was widespread and consistent with 11 of the 12 colleges seeing statistically significant increases. The study identified four conceptualizations of corequisite supports and noted that colleges allowing underprepared students greater access to non-STEM pathway courses with corequisite support saw the highest completion rates of entry-level mathematics courses.

Keywords: community colleges, mathematics pathways, corequisite remediation

SECTION ONE: INTRODUCTION TO THE DISSERTATION

In the United States, nearly 10 million students every year attend community colleges seeking the education necessary to attain better opportunities (Bailey, Jaggers & Jenkins, 2015). Community colleges are committed to maintaining access to education; there, many institutions permit allow anyone to attend regardless of educational preparation. Community colleges provide critical access to populations not served by traditional universities, that is more than half of African American and Hispanic students who attend college after high school enroll in community colleges (Bragg, 2001). In addition, community college students are more likely than four-year students to be first generation, non-White, and low income (Berkner & Choy, 2008; Fong et al., 2017).

Background of the Study

Community colleges are successful in promoting enrollment, but they struggle to retain their students and confer degrees. Nationwide, less than four in ten students who enter a community college have earned a credential or degree after six years (Bailey, et al., 2015). Using data from the National Education Longitudinal Study (NELS), Attewell, Lavin, Domina, and Levey (2006) ascertained that 58% of community college students were deemed unready for college-level work in at least one subject, and Monaghan and Attewell (2015) found that students attending community colleges were 19.2% more likely to be assigned to mathematics remedial courses than their academic equivalent peers attending universities. In addition, researchers have found that African American students, Hispanics students, and students with a low-income background are more likely to enroll in developmental education than White students with the same academic preparation (Attewell, et al., 2006; Chen & Simone, 2016).

Graduation rates for underprepared students placed in remedial education courses were significantly lower than students placed directly into college-level courses (Adelman, 1992; Complete College America 2012). Complete College America (2012) contended that nearly 4 in 10 students placed into developmental education never complete the remedial sequence, and only 9.5% of students beginning in a developmental course graduate within three years. In addition, several recent studies have concluded that traditional developmental sequences are ineffective and even harm rather than benefit students placed into them (Calcagno & Long, 2008; Martorell & McFarlin, 2011).

Statement of the Problem

In a corequisite system, underprepared students are registered for college-level mathematics courses and concurrently enrolled in additional credit hours that provide support for their academic deficiencies (Center for Community College Student Engagement, 2016). In response to statewide initiatives, nearly all Missouri public community colleges have established corequisite remediation structures for at least one mathematics entry-level course (MDHE, 2019a), but each public institution implemented corequisite courses in a variety of ways with different policies and procedures governing student placement and progression. A review of the existing literature shows these various corequisite structures have not been compared or evaluated for effectiveness. The ubiquitous nature of corequisite remediation makes the evaluation of effectiveness and the identification of good practices of urgent concern.

Although it has been shown that some underprepared students earn more college-level credit faster in a corequisite system and some graduate at a higher rate (Logue, Watanabe-Rose, & Douglas, 2016; Logue, Douglas, Watanabe-Rose, 2019), it has not been determined if this holds for students of all skill levels. Boatman and Long (2018) suggested that remedial sequences affect students of various skill levels differently; it has yet to be shown if students requiring the greatest amount of skill remediation benefit from corequisite courses. In addition, Logue, et al. (2016) determined that underprepared students completed college-level statistics courses at a higher rate than those placed in non-credit developmental algebra courses, but this study did not consider corequisite supported college algebra (precalculus algebra) or mathematical reasoning and modeling courses. The difference in the scope and nature of prerequisite knowledge required for successful completion of college-level statistics, college-level mathematical reasoning and modeling, and college-level algebra courses must be considered.

In 2014, only 19.7% of Missouri students who entered two-year colleges in 2011 graduated within three years (MDHE, 2014). In order to raise graduation rates, public institutions in Missouri must effectively support students arriving underprepared for college-level mathematics courses (Bettinger & Long, 2009; Merisotis & Phipps, 2000). The corequisite model for remedial mathematics has been proposed and implemented as a strategy for better supporting college completion; its effectiveness is mostly unknown.

Purpose

Using a pragmatic parallel mixed method design (Mertens, 2019), the purpose of this study was to explore the variety and effectiveness of the many structures and policies governing corequisite supports at Missouri two-year institutions. This mixed method design had expansion intent and increased “the scope of inquiry by selecting the methods most appropriate for multiple inquiry components.” (Greene, Caracelli, & Graham, 1989, p. 259). A key assumption of this design was that the quantitative and qualitative data provided different kinds of information (Creswell, 2014). Both quantitative and qualitative data were collected simultaneously, analyzed, and integrated to answer the study's research question (Mertens, 2019).

This study included interviews of mathematics faculty at public community colleges in Missouri to determine how community colleges structure their remedial, corequisite, and entry-level mathematics courses. Policies governing placement, grading, progression, and content delivery were gathered for analysis. Concurrently, this study analyzed student-level data provided by the Missouri Department of Higher Education and Workforce Development (MDHEWD). Student completion of mathematics entry-level courses and persistence rates were calculated. Data from the 2014-2015 academic year (before the widespread implementation of corequisite courses) was compared to data from the 2018-2019 academic year. Statewide and college completion and persistence rates were calculated and compared.

Research Questions

This mixed method study examined the research question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? In order to answer this question, two subquestions were examined with each question requiring a different kind of data. The subquestions were:

(1) What corequisite mathematics course structures and policies are in place at community colleges in Missouri? (Qualitative Strand)

(2) What is the impact of those structures and policies on persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? (Quantitative Strand)

The study gathered qualitative data in order to answer the first subquestion. Concurrently, quantitative data was analyzed in order to answer the second subquestion. The findings of both subquestions were integrated to answer the research question.

Theoretical Framework

Using data from the National Education Longitudinal Study, Adelman (1999, 2006) observed that students who enroll in college soon after high school, maintain continuous enrollment, and earn more credit in their first year were more likely to graduate. He termed this factor *academic momentum*. Adelman (2006) determined that students who lost academic momentum and failed to complete at least 20 hours of college credit in the first year were one-third less likely to graduate from college.

In a further investigation of these observations, Driscoll (2007) found high correlations between first term intensity and enrolling for the next semester as well as transfer and degree earning rates. Interested in these findings, Doyle (2011) sought to determine if the observed relationship between more credit earned by community college students and transfer rates was merely a result of selection bias. Doyle (2011) concluded that there was "substantial evidence that increasing the number of credit hours taken in the first year is likely to increase transfer rates… [T]his result does not appear to be due solely to selection bias" (p. 199).

Later, Attewell, Heil, and Reisel (2012) attempted to delineate a theory of academic momentum contending that students' progress towards a degree in their initial semesters, or early momentum, influences the likelihood of graduation. Students beginning college part-time were less likely to graduate, and initial progress towards a degree was related to graduation regardless of a student's sociodemographic background or academic preparation. Grounded in Tinto's (1993) theory of college student retention, Attewell, et al. (2012) posited that greater academic intensity increased the integration of students into the academic community through increased time with peers and faculty thus increasing persistence. In a later study, Attewell and Monaghan (2016) found that students who enroll in 15 credit hours in their first semester graduate at a significantly higher rate than academically and socially similar students who enrolled in fewer hours; in addition, students who increased their course load to 15 credit hours in their second semester were also more likely to graduate than their peers who took less, but this increased likelihood of graduation did not hold for students working more than 30 hours a week. Attewell and Monaghan (2016) noted differences based on credit-load, observing "undergraduates who take more credits in their first semester are younger, whiter, more affluent and more likely to have college educated parents…less likely to have dependents or to work full-time" (p. 687). Belfield, Jenkins, and Lahr (2019) conducted a study on full-time students in Tennessee. They found that only 28% of community college students took 15 or more credit hours in their first semester, but the researchers could not control for occupational or financial status.

In response to previous studies, Davidson and Blankenship (2017) argued that *earned college-level* credit hours rather than *attempted* credit hours established beneficial academic momentum. Considering all first-time, full-time freshman enrolled at public institutions in Kentucky, Davidson and Blankenship (2017) found that only 4% of students enrolled in two-year institutions earned 30 college-level credit hours by the end of the first year, and 77% of these students persisted to their second year as compared to only 48.7% of students who earned less than 30 credit hours in their first year. Davidson and Blankenship (2017) considered noncredit developmental education courses a "detriment" to establishing beneficial academic momentum (p. 479).

Design of the Study

This study utilized a pragmatic parallel mixed method design (Mertens, 2019). Creswell (2014) stated that mixed method approaches involve "collecting both quantitative and qualitative data" and "integrating the two forms of data" (p. 4). He continued, "The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem" (p. 4). Greene, Caracelli, and Graham (1989) delineated five purposes of mixed method research through an analysis of 57 empirical evaluation mixed method designs. Using their criteria, this study could be described as having "expansion intent" that is "a study that aims for scope and breadth by including multiple components" (p. 260).

Setting

This study took place in community colleges governed by the Missouri Department of Higher Education and Workforce Development (MDHEWD) and the Coordinating Board of Higher Education (CBHE). In 2019, Missouri Governor Mike Parson signed an executive order merging the Missouri Department of Higher Education (MDHE), the Division of Workforce Development, and the Missouri Economic Research and Information Center and creating the Missouri Department of Higher Education and

Workforce Development (MDHEWD, n.d.a). MDHEWD gathers data from each of the 14 public community colleges in Missouri.

In 2011, Governor Jay Nixon and Missouri Department of Higher Education announced "Missouri's Big Goal for Higher Education" seeking 60% of working age adults to have a postsecondary credential by 2025 (MDHE, n.d.). In the same year, 64% of students entering a public two-year college in Missouri took at least one developmental course (Radford, Pearson, Ho, Chambers & Ferlazzo, 2012). In 2012, Missouri signed HB 1042 into law requiring public institutions to replicate best practices in developmental education as identified by the Coordinating Board of Higher Education (MO HB 1042, 2012). CBHE's *Best Practices in Remedial Education* identified mathematics pathways (aligning different mathematics courses to areas of study) and corequisite remediation as best practices (CBHE, 2013).

In 2016, Missouri joined Complete College America's Corequisite at Scale cohort and began encouraging public colleges and universities to offer mathematics courses using the corequisite model alongside or in place of the prerequisite model (CBHE, 2015). In the spring of 2017, nearly all Missouri public institutions signed a memorandum of understanding that stated the institution would create, "a system of academic support for underprepared students that includes…support for the vast majority of underprepared students while students are enrolled in the gateway course or learning gateway content, as a corequisite" (E. Anderson, personal communication, April 8, 2017). By the fall of 2018, most public institutions in Missouri offered at least two of the mathematics pathways courses (Precalculus Algebra/Precalculus, Mathematical Reasoning and Modeling, and Statistical Reasoning) and corequisite supports for at least one of those pathways. All Missouri public institutions have experienced significant change in their mathematics course structures and content in the last three years (MDHE, 2019a).

In 2018, Missouri graduated 68,424 students from secondary education, and in that year, every Missouri graduate (100%) took the ACT test at least once with an average composite score of 20.0 slightly lower than the national average of 20.8 (ACT, 2018). The average math score among Missouri graduates was 19.7, and 33% of Missouri graduates met the ACT Math College Readiness Benchmark (ACT, 2018). These numbers are down from 2014 when only 76% of high school students took the ACT and scored an average math score of 21.1 (ACT, 2018). The number of Missouri public high school graduates enrolling in mathematics remediation in Missouri has decreased for five consecutive years from 26.2% in fall 2014 to 17.5% in fall 2018 (MDHEWD, 2019).

Participants

Qualitative strand. Highly structured interviews (See Appendix A) were conducted with mathematics faculty at twelve public community colleges in Missouri (Merriam & Tisdell, 2016). This study included all colleges represented by the Missouri Association of Community Colleges (MCCA). Two institutions, despite being public two-year colleges, are not represented by MCCA and were not included in this study, i.e., State Technical College and Missouri State University, West Plains. Full-time mathematics faculty from each college participated in the study. The interviewees were identified through college websites and the researcher's professional connections.

Quantitative strand. Student-level data collected by the Missouri Department of Higher Education and Workforce Development was requested and analyzed. Data from the entire population of Missouri community colleges (excluding State Tech and Missouri State University, West Plains) was collected. Data for first-time, full-time students, i.e., students enrolled in at least 12 credit or noncredit hours, entering a community college in the fall 2014 and in the fall 2018 was included in the study.

Role of the Researcher

In the qualitative portion of a mixed-method study, the researcher is "the primary instrument for data collection and analysis" (Merriam & Tisdell, 2016, p. 16). The researcher's perceptions of students at community colleges have been shaped by experience. The researcher has served for nine years as a full-time instructor at a Missouri community college and has witnessed many changes in structure and delivery of remediation during that time. She has participated in statewide reform efforts and has served on statewide groups tasked with implementing change. Her background in developmental education, developmental education reform, and her experience with the creation and implementation of corequisite courses impacted the interpretation of the results, but she asserted that her experience also grounded the research in a deeper understanding of the history and sequence of reform in Missouri.

Data Collection Tools

The qualitative and quantitative data in this study were collected concurrently (Creswell, 2014). Creswell (2014) emphasized that data collection in mixed methods studies must involve multiple sources of information.

Qualitative strand. Qualitative data was collected by conducting interviews and mining each college's course catalogs for the 2014-2015 and the 2018-2019 academic year.

Interviews. Highly structured interviews—that is, interviews with predetermined questions and order—were conducted with public community colleges full-time mathematics faculty (Merriam & Tisdell, 2016). An interview protocol (See Appendix A) was used to conduct thirteen interviews each lasting about one hour. Twelve interviews were conducted remotely via Zoom, and one interviewee chose to submit written responses by email. With the permission of the participant, all interviews were recorded using Zoom. All video files were kept in the personal vault section of the researcher's OneDrive cloud storage account. Files were thus password protected and protected by an additional pin number.

The interview identified several key decisions made by each college in the implementation of corequisites including: (1) the relationship between the corequisite and the pathway (i.e., Is the corequisite embedded in the college-level pathway or a separate course?); (2) the scheduling of instructors (i.e., Does the same instructor or different instructors teach the pathway and corequisite?); (3) the placement of students into the corequisite (including measures and policies); and (4) the grading procedures (i.e., Are the courses separate grades? What if one is passed and the other is failed? How is it determined if the student received credit for the college-level course?).

In addition, the interview examined decisions on policy and structure of corequisite courses. The interview limitedly investigated the challenges colleges faced in the implementation of corequisite courses. Questions were carefully worded to avoid leading questions and to allow participants to determine what was important (Seidman, 2013). Each participant was sent via email the informed consent document (See Appendix B) before participating in an interview.

Documents. Before each interview, the online course catalog for each college from the 2014-2015 and 2018-2019 academic year was analyzed. The researcher recorded the titles, numbers, credit hours, and prerequisite relationships of all developmental and entry-level mathematics courses. The researcher created a summary of information for each college using the document analysis guide (see Appendix C). The summary was modified and corrected during the subsequent interview.

Quantitative strand. Each public community college provided student-level data to the Missouri Department of Higher Education and Workforce Development. Completion and enrollment data from the 2014-2015 academic year (before implementation) and data from 2018-2019 academic year was requested. In order to calculate persistence rates, enrollment data from Fall 2015 and Fall 2019 was also obtained. Data was reidentified by MDHEWD before it was provided to the researcher to ensure the identities of the students were protected. All identifying data including gender, race, and ethnicity were deleted from the data before it was provided to the researcher.

Data Analysis

This study placed equal emphasis on the qualitative and quantitative data collected (Creswell, 2014). The qualitative data was used to answer the question: how do community colleges in Missouri structure and implement corequisite mathematics courses? The quantitative data answered the question: what is the impact of those structures on the completion rates of entry-level mathematics courses and persistence rates at community colleges in Missouri? Finally, the data from both strands was integrated to answer the primary research question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri?

Qualitative strand. Using data collected from interviews and documents, a holistic description of the policies and structures of remedial, corequisite, and pathway mathematics courses was developed for each community college.

Interviews. The data analysis of the interview began as soon as the first interview was completed. Both Merriam and Tisdell (2016) and Creswell (2014) contended that data collection and analyzation should happen simultaneously. All interviews were transcribed, and all responses were coded and compared. Data pertinent to the research question was identified and categorized.

Documents. A document analysis guide (See Appendix C) was used to evaluate the course catalog for each college emphasizing the structure of developmental, gateway, and corequisite courses. The guide facilitated the side-by-side comparison of the course rationale and structures of each gateway course and its corresponding corequisite course. The researcher conducted a side-by-side comparison of all corequisite courses identified for each Missouri mathematics pathway; that is the researcher compared corequisite courses paired with mathematics pathway courses identified by the same MOTR number as fulfilling the mathematics general education requirement by CORE 42. All documents and transcripts were stored the researcher's password protected OneDrive cloud storage account. The researcher enabled the second level authentication for additional security.

Validation strategies. The researcher confirmed the study's findings by "member checking" (Creswell, 2014, p. 201). The initial summaries of each college's policies, procedures, and structures were shared with all participants; any comments or corrections made by the participants were integrated into the summaries.

Quantitative data. Using data provided by MDHEWD, completion and persistence rates were calculated for each institution and the entire state. Data from this strand was used to answer the second subquestion.

Persistence rates. Student persistence rates were calculated (i.e., did a student enroll in the next semester of courses?). The number of students persisting to consecutive fall semesters (Fall 2014/2015 or Fall 2018/2019) was calculated for the 2014 and 2018 cohorts for each institution and statewide. A chi-square test for homogeneity was conducted using the following hypotheses:

> H_0: The number of students not persisting to the next semester is independent of remedial structures.
>
> H_1: The number of students not persisting to the next semester is dependent on remedial structure.

The *Yate's Continuity Correction* was not used despite the 2 by 2 contingency table created as Field (2018, p. 626) argued it is "best ignored." Instead the *Pearson Chi-Square* statistic was reported.

Completion rates. Completion was defined as earned college-level credit in an entry-level mathematics course (not including Intermediate Algebra). Completion rates of entry-level math courses were compared in the 2014 cohort of first-time, full-time students and in the 2018 cohort. The number of students at each institution and statewide having completed a college-level mathematics credit in the first academic year (i.e., the summer, fall, intersession, or spring semesters) was calculated for the 2014 and 2018 cohorts. A chi-square test for homogeneity (Triola, 2018) was conducted using the following hypotheses:

H_0: The number of students completing an entry-level math requirement is independent of remedial structures.

H_1: The number of students completing an entry-level math requirement is dependent on remedial structures.

As with the persistence rates, the *Pearson Chi-Square* statistic was reported (Field, 2016).

Integration of the Qualitative and Quantitative Data

Qualitative and quantitative data from each college was analyzed independently—consistent with the parallel mixed method approach (Creswell, 2014). Both subquestions were fully addressed for each institution, and an analysis was conducted determining the impact of structural changes on completion and persistence rates at each institution.

Next, the researcher conducted a "side-by-side comparison" of the qualitative and quantitative data from each college (Creswell, 2014, p. 222). Data was compared for the different pathways—Precalculus Algebra, Statistical Reasoning, and Mathematical Reasoning and Modeling—and different methods of remediation. The researcher noted commonalities and differences in structure and compared completion and persistence rates amongst the timeframes and colleges. Finally, the researcher sought to uncover patterns that suggested better structures of corequisite remediation.

Limitations

Several limitations impacted the results of this research study. First, only students who persisted at the same institution were counted as persisting. Transferring students could not be followed to their new institution if the college was outside the study. Second, the development and implementation of three major reforms—mathematics pathways, multiple measure placement, and corequisite remediation—coincided in Missouri. The timing of the reforms confounded to some extent this study's determination of the cause of any changes in completion and persistence rates.

Definitions of Key Terminology

Academic Momentum

Attewell, Heil and Reisel (2012) described academic momentum as the "speed with which undergraduates initially progress in college" (p. 27); that is, academic momentum describes the number of credits earned each semester. Many authors (Adelman, 2006; Attewell, et al., 2012; Attewell & Monaghan, 2012) make no distinction in type of credit taken; thus students completing developmental (non-credit) courses are treated similarly to students taking all college-level courses. Other authors (Davidson & Blankenship, 2017) insist that academic momentum is influenced by courses in which successful completion counts toward a post-secondary credential or degree. Since both groups of authors use the term academic momentum, this study will differentiate the two ideas by using the following terms:

Developmental Curriculum

Developmental Education (or *Remedial Education*). Developmental or remedial education refers to content or courses aimed at addressing skill deficits negatively affecting student success in entry-level college courses; no college credit is awarded for such content since it is considered below college-level. Developmental education is frequently used interchangeably with remedial education.

Developmental Course Sequence (or *Remedial Course Sequence*). A developmental or remedial course sequence is a sequence of courses leading up to a college-level degree requirement which requires successful completion of one in order to progress to another. This sequence seeks to address perceived skill deficits of incoming students.

Curricular Design

Corequisite Instruction. This is an instructional design which places underprepared students directly in college-level courses with additional instructional support (Richardson & Dorsey, 2019).

College-level Course. This is a course in which upon successful completion a student earns college credit toward a post-secondary credential.

Gateway Course (or *Entry-level Course*). The gateway or entry-level course is the first course deemed college-level in a particular academic area. Gateway course and entry-level course are used interchangeably.

Mathematics Pathway. A mathematics pathway refers to a mathematics course or sequence of courses specifically aligned to a student's program of study (Richardson & Dorsey, 2019).

Remedial Structures (or Developmental Structures). This refers to the structure in which remedial content is delivered to students. The most common structures include a developmental sequence of courses or corequisite instruction.

Research Terminology

Completed (or *Completion Rate*). For the purposes of this study, a student was considered to have completed their entry-level mathematics requirement when they earned at least a D and received college-level mathematics credit toward a post-secondary credential. The completion rate was determined to be the number of students in a cohort having completed their college-level mathematics requirement divided by the number of students initially enrolled in the cohort.

Persisted (or Persistence Rate). For the purposes of this study, a student is considered to have persisted when they enrolled and attended courses in two consecutive fall semesters at colleges in the study. The persistence rate was determined to be the number of students in a cohort having persisted divided by the number of students initially enrolled in the cohort.

Significance of the Study

Community colleges receive billions of dollars in tax money each year, and Strong American Schools (2008) estimated the cost of college remediation in the 2004 - 2005 academic year to be over two billion dollars. It is an important matter of public policy to investigate why so many students enrolled at public two-year colleges fail to earn a postsecondary credential (Rosen, 2011).

With a statewide push for schools to adopt a corequisite model of remediation and limit or eliminate a prerequisite model of remediation, it is critical that these structures be studied, and their effectiveness determined. It is of particular importance for marginalized populations who are more frequently placed into these structures (Attewell, et al., 2006; Chen & Simone, 2016). In addition, with so many institutions adopting corequisites structures and implementing them in a diverse manner, it provides an opportunity to compare the effectiveness of various policies and practices, and perhaps, determine a list of promising practices that will inform the creation of mathematically rigorous corequisite courses that provide all students the best opportunity for successful completion of an entry-level mathematics course.

Summary

Mathematics education in Missouri is changing and all public institutions are being asked to implement new models of corequisite remediation for the numerous students that arrive underprepared for college-level content. If these students are to find opportunity, colleges must examine their policies and practices and build structures that support underprepared students and help them to rise to the challenge of college-level mathematics.

This study utilized a pragmatic parallel mixed method study design to analyze the various structures community colleges termed corequisite education. It sought to determine the impact these models on completion of entry-level mathematics courses and persistence rates and to identify precisely which structures and policies most benefit underprepared students.

SECTION TWO: PRACTITIONER SETTING OF STUDY

The setting for this study is community colleges across the state of Missouri. This section will consider the wider context in which educational practitioners in the state of Missouri operate and make decisions. First, this section will consider the local contexts of Missouri community college and the history of policies and initiatives impacting them. Next, it will describe the structure and organization of higher education in Missouri and leadership of state-level agencies. Finally, it will briefly discuss implications of research in the practitioner setting.

Community Colleges in Missouri

The 12 community colleges included in this study are separate and independent open enrollment institutions established in local elections (MCCA, 2017). Each college confers associate degrees and a variety of certificates serving the local needs of its own region (MCCA, 2017). In fall of 2018, 82,293 students attended these 12 community colleges representing approximately 36% of all students attending public higher education institutions in Missouri (MDHE, 2018b). Nearly 98% of community college students are residents of Missouri and 93% stay in Missouri after graduation (MCCA, 2017).

Local Context of Community Colleges in Missouri

Understanding the local context of each community college is essential to understanding the structures and policies put in place while implementing corequisite remediation; thus, a brief description of each community college is provided below.

Crowder College. Crowder College serves a nine-county region in southwest Missouri. Established in 1963, Crowder's main campus is positioned in Neosho, a city of about 12,000 people (U.S. Census Bureau, 2019). Additional locations exist in Cassville, McDonald County (Pineville), Nevada, Webb City, and Joplin (Crowder College, 2017a). In the fall of 2018, 4,521 students attended Crowder at its various locations (MDHEWD, n.d.b). Crowder College employs 118 full-time and 356 part-time faculty members (MDHE, 2019b) including 7 full-time mathematics instructors (Crowder College, 2017b).

East Central College. East Central College, located in Union, MO, is approximately 50 miles east of St. Louis in Franklin county. Union's population exceeds 11,000 people (U.S. Census Bureau, 2019). East Central College was established in 1968 and moved to its permanent campus in 1972 (MDHE, 2019b). In the fall of 2018, 2,629 students attended classes at its locations in Union, Rolla, and Washington (MDHE, 2019b; MDHEWD, n.d.b). East Central College employs 66 full-time and 138 part-time faculty members (MDHE, 2019b) including 5 full-time mathematics instructors (ECC, n.d.).

Jefferson College. Just south of St. Louis, Jefferson College has facilities in Hillsboro and Arnold. In 1963, Jefferson College became the second community college district to be approved by voters in Missouri (Jefferson College, 2019a). In the fall of 2018, 2,879 students attended Jefferson College (MDHEWD, n.d.b). Jefferson College employs 98 full-time and 171 part-time faculty members (MDHE, 2019b) including 6 full-time mathematics faculty (Jefferson College, 2019b).

Metropolitan Community College. Metropolitan Community College (MCC) is the oldest and second largest community college system in Missouri. In 1915, Kansas City Polytechnic Institute was established and became one of the first 2-year institutions in the U.S. to confer associate degrees (MCC, 2019). Today, MCC is comprised of five campuses scattered across the Kansas City, MO metropolitan area: Blue River

(Independence), Longview (Lee's Summit), Maple Woods, Penn Valley, and Business and Technology Campuses (MDHE, 2019b). In the fall of 2018, 16,351students enrolled at MCC campuses (MDHEWD, n.d.b), and MCC employs 240 full-time and 1,330 part-time faculty members (MDHE, 2019b).

Mineral Area College. Residents in St. Francois, Madison, Washington, and St. Genevieve counties in southeast Missouri voted to establish Mineral Area College (MAC) in 1965 (MAC, 2019). In fall of 2018, 2,885 students attended classes at MAC's main campus in Park Hills (population approximately 8,500) (MDHEWD, n.d.b; U.S. Census Bureau, 2019). The college has other sites in Perryville, Bonne Terre, Winona, and Fredericktown and employs 68 full-time and 176 part-time faculty members (MDHE, 2019b).

Moberly Area Community College. Moberly Area Community College (MACC) serves a large area in northeast Missouri. Established in 1927, MACC's main campus is positioned in Moberly (population approximately 13,600) with other locations in Columbia, Hannibal, Kirksville, Mexico, Edina and Macon (MDHE, 2019b; U.S. Census Bureau, 2019). In fall of 2018, 5,174 attended MACC (MDHEWD, n.d.b). MACC employs 69 full-time and 206 part-time faculty members (MDHE, 2019b).

North Central Missouri College. North Central Missouri College (NCMC) serves a 16-county region in northwest Missouri. The college was founded in 1925 and operated as part of the Trenton R-IX School District until becoming an independent institution in 1986 (NCMC, 2019). The college has three campuses—the Main Campus in Trenton, the Barton Farm Campus, and the Extended Campus in Andrew County—with additional locations in Cameron, Chillicothe, Brookfield, Bethany, Maryville and St.

Joseph (MDHE, 2019b; NCMC, 2019). In fall 2018, 1,855 were enrolled in NCMC (MDHEWD, n.d.b). NCMC employs 38 full-time and 41 part-time faculty members (MDHE, 2019b).

Ozarks Technical Community College. Established in 1990, Ozarks Technical Community College (OTC) is the youngest community college in Missouri, and its system serves a 12-county region in southwest Missouri (OTC, n.d.). It is comprised of three campuses—Springfield, Richwood Valley (Nixa), and Table Rock (Hollister)—and three educational centers in Waynesville, Lebanon, and Republic. OTC is currently the third largest community college in Missouri (Zwiegle, 2015). In fall of 2018, 12,217 students were enrolled at OTC locations (MDHEWD, n.d.b). OTC employs 217 full-time and 944 part-time faculty members (MDHE, 2019b).

St. Charles Community College. St. Charles Community College (SCC) was established in 1986 (SCC, 2019) and is located in Cottleville, a city in the extreme northwest St. Louis metropolitan area. In fall 2018, SCC had 6,269 students enrolled at its single location (MDHEWD, n.d.b). SCC employs 108 full-time and 261 part-time faculty members.

St. Louis Community College. St. Louis Community College (STLCC) is the largest community college system in Missouri. Established in 1962, STLCC has campuses and educational centers throughout the St. Louis metropolitan area including: the Florissant Valley Campus (Ferguson), Forest Park Campus, Meramec Campus, and Wildwood Campus (STLCC, 2019). In fall 2018, STLCC enrolled 18,157 students (MDHEWD, n.d.b). STLCC employs 390 full-time and 907 part-time faculty members (MDHE, 2019b).

State Fair Community College. Established in 1966, State Fair Community College (SFCC) serves a 14-county region in central Missouri. SFCC's main campus is in Sedalia with additional locations in Boonville, Clinton, Eldon, Lake of the Ozarks, Warsaw, and Whiteman AFB (SFCC, 2019). In fall 2018, 4,728 students attended classes at SFCC locations (MDHEWD, n.d.b). SFCC employs 79 full-time and 255 part-time faculty members (MDHE, 2019b).

Three River College. Positioned in southeast Missouri, Three Rivers College (TRC) has locations in Poplar Bluff, Dexter, Kennett, Piedmont, Sikeston, Van Buren, and Cape Girardeau (TRC, 2019). TRC was established in 1966 and employs 67 full-time and 130 part-time faculty members (MDHE, 2019b). In fall of 2018, TRC had 3,076 students enrolled at its various locations (MDHEWD, n.d.b).

Comparisons of Missouri Community Colleges

Enrollment. Overall enrollment at Missouri community colleges decreased from the fall 2014 to fall 2018 from 96,143 to 82,293 respectively. Only one of the twelve, North Central Missouri College, experienced an increase in enrollment during that time (MDHEWD, n.d.b). In fall 2018, nine of the twelve community colleges have an enrollment less than 6,500 students, and the remaining three community colleges have nearly double or more than that size (MDHEWD, n.d.b). Figure 1 depicts the enrollment of each community college in the study in fall 2014 and fall 2018.

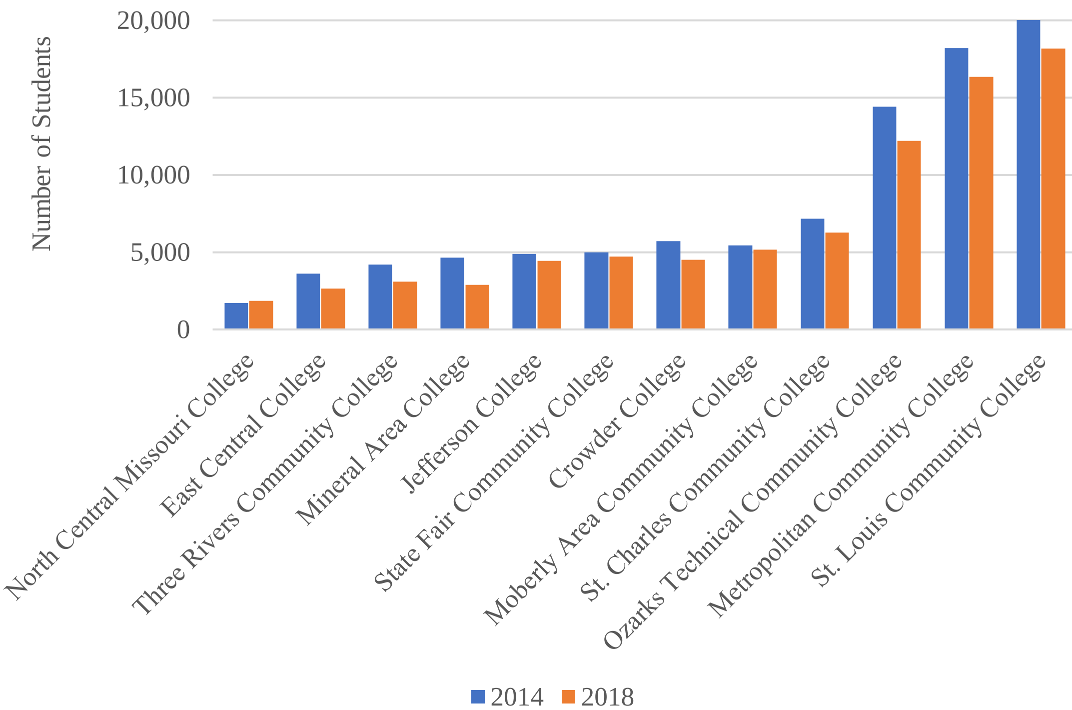


Figure 1. Number of students enrolled at the twelve community colleges included in the study in Fall 2014 and Fall 2018 (MDHEWD, n.d.b).

State Appropriations. Funding for community colleges comes from a variety of sources including: state appropriations, tuition, local property tax revenue, and federal and state grants (MCCA, n.d.). The level of local support, grant funding, and state appropriations varies for each college (See Figure 2).

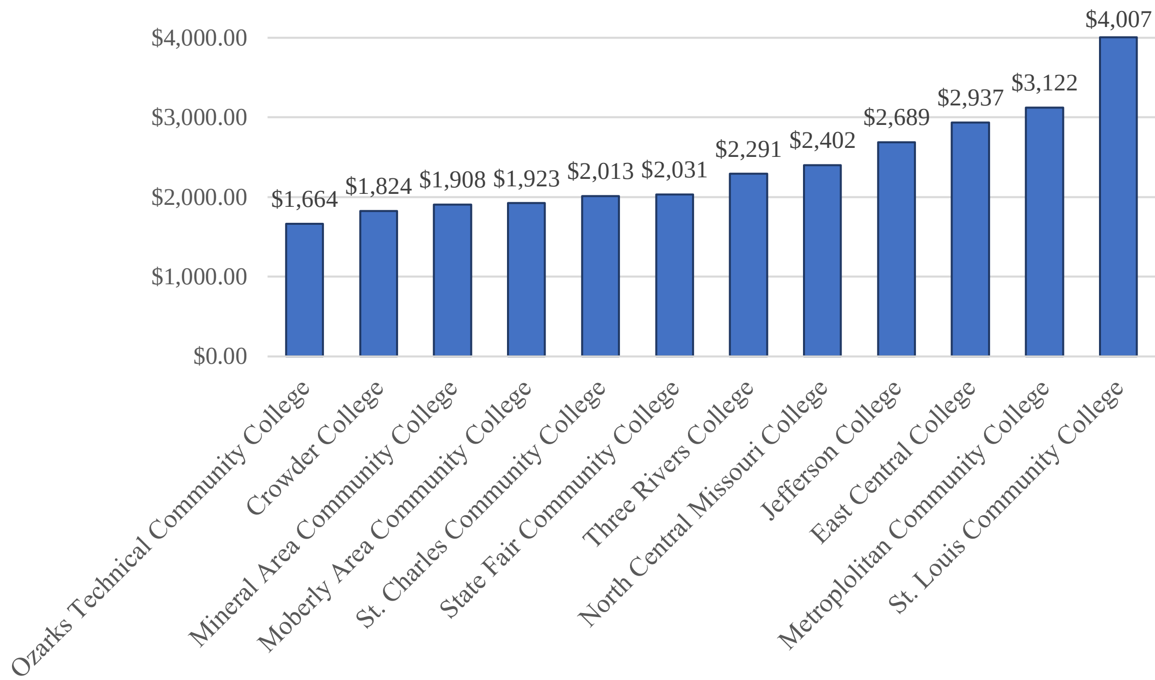


Figure 2. 2018 state appropriations per student full-time equivalent enrollment (MDHE, 2019b, p. 6).

History and Background of Policies Influencing Missouri Public Institutions

Between the years 2011 and 2018, legislation, policy changes and statewide initiatives impacted mathematics education at Missouri public institutions (See Figure 3). In 2011, Governor Jay Nixon announced “Missouri’s Big Goal for Higher Education” seeking 60% of working age adults to have a postsecondary credential by 2025 (MDHE, n.d.). In the same year, 64% of students entering a public two-year college in Missouri took at least one developmental course (Radford, Pearson, Ho, Chambers & Ferlazzo, 2012). In 2012, Missouri signed HB 1042 into law requiring public institutions to replicate best practices in developmental education as identified by the Coordinating Board of Higher Education (MO HB 1042, 2012). CBHE’s *Best Practices in Remedial*

Education identified mathematics pathways (aligning different mathematics courses to areas of study) and corequisite remediation as best practices (CBHE, 2013).

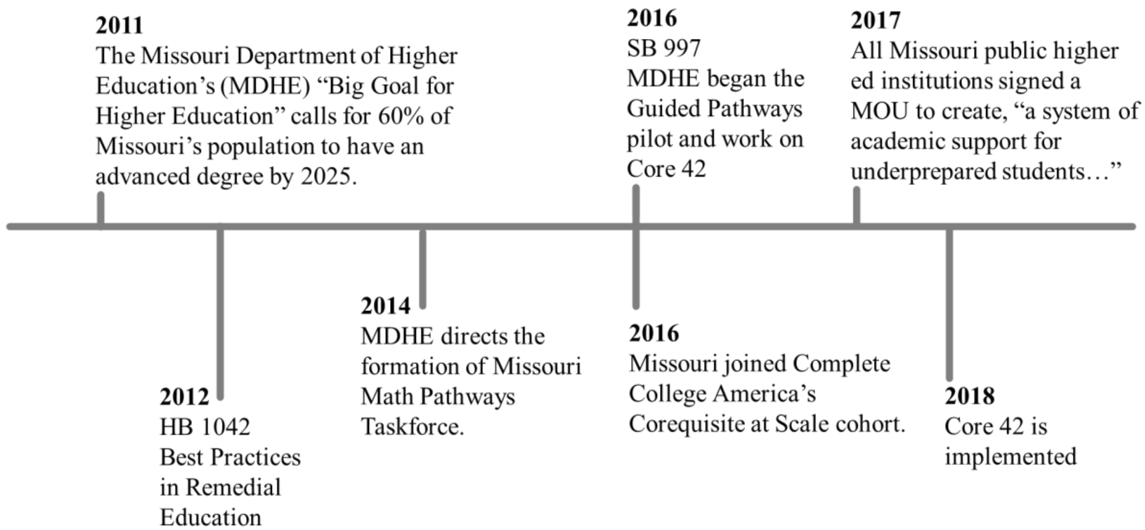


Figure 3. Statewide policies and initiatives affecting math education at Missouri public institutions.

In the fall of 2014, MDHE formed the Missouri Mathematics Pathways Task Force (MMPT) and directed it to explore options and make recommendations for increasing student success rates in entry-level mathematics courses (MMPT, 2015). The initiative was funded in part by Complete College America in collaboration with the Charles A. Dana Center at the University of Texas at Austin. The taskforce was made up of mathematics faculty from 26 different public colleges and universities across the state and staff members of MDHE (MMPT, 2015).

In 2016, Missouri was selected by Complete College America to participate in its Corequisite at Scale Initiative and formed the Missouri Corequisite at Scale Taskforce (MCST) (MDHE, 2016). States participating in CCA's initiative committed to scaling corequisite remedial education—that is, 75% of students needing remediation receive it in a corequisite model—by the spring of 2018 (MDHE, 2016).

In June 2016, Missouri Governor Jay Nixon signed a bill including the “Guided Pathways to Success Act” (Section 173.2515 RSMo); the bill called for Missouri higher education institutions to develop “clear degree maps” and “proactive advising” (MO SB 997, 2016). In addition, the same bill included the “Higher Education Core Curriculum Transfer Act” (Sections 178.785-178.789 RSMo) which directed the creation of a 42-hour common course curriculum for general education at Missouri public institutions (MO SB 997, 2016). Courses accepted into the CORE 42 framework must transfer as the corresponding general education requirement to all Missouri public institutions and to participating private institutions (MDHEWD, n.d.c). Courses accepted to CORE 42 receive a common MOTR number indicating which general education requirement it fulfills.

In the spring of 2017, all Missouri public institutions signed a memorandum of understanding that stated the institution would create, “a system of academic support for underprepared students that includes…support for the vast majority of underprepared students while students are enrolled in the gateway course or learning gateway content, as a corequisite” (E. Anderson, personal communication, April 8, 2017); thus, many public institutions in Missouri offer support for many mathematics pathway courses as a corequisite. As of fall 2018, all public community colleges in Missouri offer at least two of the mathematics pathway courses (Precalculus Algebra/Precalculus, Mathematical Reasoning and Modeling, and Statistical Reasoning) and half of all community colleges offer corequisite remediation (MDHE, 2019a).

Organizational Analysis

Education organizations are complex and ambiguous entities made up of diverse individuals with different priorities and values. Manning (2013) described education institutions as "paradoxical: familiar yet hard to describe, unpredictable though at times oddly rational" (p.11), and noted "No one person regardless of power or position, fully understands the many realities and perceptions present in the organization" (p.14).

Bolman and Deal (2013) proposed four frames or viewpoints from which leaders may attempt to understand situations: the structural, human resource, political, and symbolic frame. These frames may assist leaders as they struggle to shift their perspective and see previously hidden aspects of a situation. In analyzing the context of this study, the structure and political frame seem to suit its purpose in particular.

The Structural Frame

The structural frame seeks to understand how an institution organizes, divides and integrates labor (Bolman & Deal, 2013). Many organizations possess a vertical, highly centralized structure (Taylor, 2005) and seek to standardize processes and increase efficiency (Mitzberg, 1979/2005). These types of hierarchical structures functioned best in stable and predictable environments (Bolman & Deal, 2013).

Structure of higher education governance in Missouri. This study will take place in public community colleges governed by the Missouri Department of Higher Education and Workforce Development (MDHEWD) and Coordinating Board of Higher Education (CBHE). It is necessary for this study to understand how these entities oversee the practice and funding of public colleges and institutions in Missouri.

The Coordinating Board of Higher Education was established in 1972 and is made up of nine members—one representing each of the eight congressional districts and one member at-large. Members are appointed by the governor and confirmed by the Missouri Senate. The board may be comprised of no more than five members of the same political party, and each member services a six-year term. The board governs the Missouri Department of Education and Workforce Development (Ashcroft, 2019).

In 2019, Missouri Governor Mike Parson signed an executive order merging the Missouri Department of Higher Education (MDHE), the Division of Workforce Development, and the Missouri Economic Research and Information Center and creating the Missouri Department of Higher Education and Workforce Development (MDHEWD, n.d.a). MDHEWD oversees statewide planning, evaluation of institutional performance, identification of needs, review of institutional missions, approval of new degree programs, and submission of a unified budget request to the governor (Ashcroft, 2019).

Loosely coupled systems. Each community college is governed by their own local board of trustees; no direct statewide governance exists (MCCA, n.d.). MDHEWD influences but does not mandate or direct changes in structure, policy, or procedure at community colleges. Each community college is independent of the others though administration and faculty may collaborate at times. Weick (1976) argued organizations may exists as a series of loosely coupled systems. These systems are "somewhat attached" but retain their own "identity and separateness" (Weick, 1976, p. 3). The coupling mechanisms that create strong attachments, the technical core and the authority of office, are difficult if not impossible to identify when observing the network of public community colleges and MDHEWD (Weick, 1976).

Loosely coupled systems enjoy many advantages. Weick (1976) asserted that loosely coupled systems resist standardization and allow for significant "self-determination" increasing a sense of efficacy and allowing for "localized adaptations" and "novel solutions" (p.7). The loose coupling of MDHEWD and community colleges allows for each community college to develop a unique structure of corequisites and respond to its own challenges. The loose coupling also allows for one college's implementation of corequisites to be successful while another college's implementation may fail. Resistance to influence can be both a benefit and a hinderance in this type of system; neither good nor bad ideas are easily passed to other systems (Weick, 1976).

The Political Frame

Bolman and Deal's (2013) political frame considers the disbursement of resources among groups of varying interests, priorities, and levels of influence. The political frame implies that in the context of scarcity—a context in which higher education constantly operates—political activity will become more intense and divisive (Bolman & Deal, 2013).

Power of the state agencies. MDHEWD influences policy at each of the colleges through political and financial incentives. CBHE and MDHEWD approve the funding models that govern the distribution of state funding to all public universities and colleges (CBHE, 2017) and compliance to state initiatives and policies may be a condition of funding. Increases to funding in higher education are distributed based on performance measures that can be "organized around the categories of student success and progress, efficiency and affordability, and graduate outcomes" (MDHE, 2018a, p. 3). Success is defined as improvement over the previous year or sustained excellence based on an established benchmark.

MDHEWD's utilizes reward and coercive power to influence community colleges (French & Raven, 1959/2005). French and Raven (1959/2005) described *reward power* as based on the entity's "ability to administer positive valences" (p. 313), and similarly, *coercive power* as stemming from the expectation of punishment if the institution "fails to conform to the influence attempt" (p. 314). MDHEWD's control of the community college funding model potentially supplies the agency with significant reward and coercive power. *Legitimate power*, or the acceptance that one organization has an obligation to accept the influence of another, is certainly in play (French & Raven, 1959/2005), but as MDHWED has no explicit authority, the potency of its legitimate power may vary among colleges.

Missouri Community College Association. The Missouri Community College Association represents all twelve community colleges in the Missouri legislature (MCCA, n.d.). Through effective lobbying, MCCA works to protect its interests in the Missouri legislature and exert influence over MDHEWD. The association informs and connects the leadership, faculty, and staff of all twelve community colleges.

Complete College America. Complete College America is a powerful and well-funded organization that seeks to influence higher education policy at the state level (Mangan, 2013). Complete College America has created an alliance of 38 states and the District of Columbia that have committed to some or all of CCA's key initiatives (CCA, n.d.c). Founded in 2009, Complete College America describes itself as an advocate "for dramatically increasing college completion rates and closing equity gaps by working with states, systems, institutions, and partners to scale highly effective structural reforms and promote policies that improve student success" (CCA, n.d.a, para. 1). Funded in part by the Gates and Lumina Foundations, CCA has urged states to overhaul remedial education and has strongly advocated for corequisite education (CCA, 2012; CCA, n.d.b; Mangan, 2013). CCA strongly advocates and facilitates the move of state higher education policy to performance-based funding. "Funding should shift from simply rewarding enrollment to valuing outcomes, such as credentials awarded or classes successfully completed. Funding is a powerful incentive, and rewarding performance allows states to align their fiscal policies with statewide goals for workforce development and economic prosperity" (CCA as quoted in Walters, 2012, p. 34). Walters (2012) argued that these policies could be more accurately characterized as "pressure-punitive funding" and used to compel institutions to implement change (p. 34).

By engaging legislators and state officials before higher education administrators or educators, CCA can effect change at many institutions at the same time and avoid local resistance to change. CCA (2019) stated its goal is to "serve as a credible advisor and thought partner to local, state, and national policymakers" (p. 2). Then with the authority of the legislature or state agency behind them, CCA works with administrators and educators to guide them in the implementation of the mandated change, that is a change in which the institution's funding is now contingent upon.

Charles A. Dana Center. The University of Texas at Austin's Charles A. Dana Center works to influence policy surrounding gateway mathematics courses at two-year and four-your colleges and universities (Dana Center, 2020a). The Dana Center Mathematics Pathways Initiative seeks to improve the success of students in mathematics by working with policymakers at the institution and state levels. The Dana Center advocates for change in several areas including implementation of mathematics pathways—that is, college algebra should not be the only or the default mathematics requirement for all programs—and the use of corequisite structures instead of developmental sequences when students arrive to college underprepared (Dana Center, 2020b). The Dana Center (2020b, para. 3) acknowledged its "top down/bottom up approach" to change saying that mathematics pathways must be supported by policymakers, faculty, and administrators.

Leadership Analysis

The leadership style displayed by CBHE and MDHEWD frequently can be described as transactional. Northouse (2016) described transactional leadership as a strategy that provides followers with rewards contingent on meeting specified expectations; in addition, leaders will only intervene when corrective action must be taken. Northouse (2016) asserted that transactional leaders are "influential because it is in the best interest of followers" to comply with the leaders' requests (p. 171).

MDHEWD has a significant but inexplicit influence over the leadership of the community colleges in Missouri. In its effort to fundamentally reshape entry-level mathematics by creating mathematics pathways and instituting corequisite remediation at all public institutions, the agency chose to create two taskforces—the Missouri Mathematics Pathways Taskforce (MMPT) and the Missouri Corequisite at Scale Taskforce (MCST). Both involved mathematics faculty from nearly every public college and university. Northouse (2016) noted that teams of individuals make better, more innovative decisions, and Levi (2017) suggested that teams are preferable to traditional organizational structures and leadership when tasks are complex or change is necessary. This decision added legitimacy to the recommendations handed down to the colleges and created a local expert regarding the initiative at every public institution.

It is essential that leadership teams be provided with a clear purpose (Levi, 2017; Northouse, 2016). MDHEWD charged MMPT “to explore options and make recommendations that will significantly increase the percentage of students completing degree programs and student success rates in mathematics gateway courses without compromising the integrity of mathematics instruction” (MMPT, 2015, p. 2). Discussions of both taskforces frequently were guided by documents provided by Dana Center Mathematics Pathways or Complete College America, and MDHEWD staff and taskforce leadership participated in regular “check-in calls for tracking implementation of state work plan” with both groups (MDHE, 2016 , p.2).

With regards to the widespread policy changes in Missouri, MDHEWD chose to lead change by involving a diverse group of individuals. This decision allowed them to effect change in entry-level mathematics courses at every public institution in Missouri.

Implications for Research in the Practitioner Setting

Missouri community colleges have experienced rapid and widespread changes in their entry-level mathematics courses in the past several years. Although there is research supporting the use of corequisite remediation strategies (Logue, Watanabe-Rose, & Douglas, 2016), it is essential that colleges and faculty review the changes and continue to improve their structures and policy.

The loosely coupled structure of Missouri community colleges and state agencies allow for various structures, policies, and solutions of corequisite remediation to exist.

This study will delineate the key aspects of those structures and policies and assess effectiveness. This will provide valuable information to administrators and instructors seeking to improve completion at their institution.

The theory of academic momentum contends that early progress and success affects the likelihood that students will continue to pursue a postsecondary degree and graduate. For many students, the entry-level mathematics requirement presents an early and difficult hurdle in their journey to graduation (Logue, Douglas, & Watanabe-Rose, 2019). Effective corequisite remediation structures are a critical component of success if Missouri is to achieve its "Big Goal" (MDHE, n.d.).

Summary

The statewide policies and structures examined in this study have the potential to impact thousands of students across Missouri. Missouri community colleges operate in a variety of diverse local contexts throughout the state. Each had the opportunity to develop a unique mathematics curriculum while complying with the state's initiatives. By considering each college's structures or policy, this study provided options and recommendations for colleges seeking to solve problems and improve completion.

SECTION THREE: SCHOLARLY REVIEW FOR THE STUDY

Every year, nearly 10 million students in the United States attend community colleges to gain the education necessary to better their lives (Bailey, Jaggers & Jenkins, 2015). The community colleges' commitment to accessibility allows many students who face significant social, economic, and academic challenges to attend college—individuals who would not otherwise attempt a post-secondary credential (Bragg, 2001; Rouse, 1995).

Using data from the National Education Longitudinal Study (NELS), Attewell, Lavin, Domina, and Levey (2006) determined that 58% of students attending two-year colleges were deemed unprepared for college-level work in at least one subject and placed into developmental (or remedial) education. Graduation rates for students beginning in developmental education are much lower than other students placed directly into college-level courses (Adelman, 1992; Complete College America 2012).

Traditional developmental sequences have been largely judged to be ineffective in the last few decades (Calcagno & Long, 2008; Martorell & McFarlin, 2011). Corequisite remediation has been highly touted and recommended to replace traditional remedial sequences (Vandal, 2014). In Missouri, statewide higher education policy has changed to encourage all public institutions to implement alternative forms of remedial education (Coordinating Board of Higher Education, 2013). Corequisites allow underprepared students to enroll directly into college-level mathematics courses while giving them extra support to address academic deficiencies (Center for Community College Student Engagement, 2016); however, the structure and implementation of corequisites are quite disparate across public institutions. These various corequisite structures have not been evaluated for effectiveness by the literature. Although underprepared students have been shown to be successful in introductory statistics courses supported by a corequisite (Logue, Watanabe-Rose, & Douglas, 2016; Logue, Douglas, & Watanabe-Rose, 2019), less evidence is available regarding whether underprepared students will succeed in college algebra or mathematical reasoning and modeling courses supported by a corequisite. Ran and Lin (2019) concluded that positive effects seen in the corequisite models were largely due to pathway reform, that is encouraging non-STEM degree seeking students to take a statistics or reasoning and modeling course rather than college algebra.

Although some underprepared students may earn college-level credit faster in a corequisite system (Logue, et al., 2016; Schudde & Keisler, 2019), contradictory findings make it unclear whether those gains translate to higher graduation rates in a corequisite system as compared to a prerequisite system (Logue, et al., 2019; Ran & Lin, 2019). Boatman and Long (2018) found that the remedial sequence of courses benefited students placing at the lowest levels of developmental education; it has yet to be shown if corequisites benefit these students more or less than the traditional remedial sequence.

In response to statewide initiatives, nearly all public two-year institutions in Missouri have developed corequisite supports in place of or alongside traditional remediation. This study will explore the structure and effectiveness of corequisite support at these institutions and will address the following research question: Which corequisite structures and policies have produced the highest completion and persistence rates in entry-level mathematics courses at community colleges in the state of Missouri?

This section will consider research and historical developments in four major areas: (1) theories of college student retention and persistence, (2) research on the effectiveness of developmental education, (3) alternative approaches to developmental education, and (4) drivers of change in policy regarding developmental education.

Theories of Retention and Persistence

Theories of retention and persistence have received significant attention from researchers during the last several decades. Researchers have sought to understand why some students choose to continue at higher education institutions while others depart; in addition, researchers have attempted to identify characteristics that may predict behavior. This section will consider three major theories of retention and persistence: social and cultural reproduction theory, student retention theory, and academic momentum.

Social and Cultural Reproduction

Central to Bourdieu's theory of social and cultural reproduction is the concept of the *habitus*; Bourdieu (1979) defined *habitus* as "a system of durable, transposable dispositions which functions as the generative basis of structured, objectively unified practices" (p. vii). The habitus, or the lens in which different groups see and interact with the world, is shaped in part on the group's possession of *capital*. Bourdieu (1986) described capital as manifesting in three ways: economic capital (money and property), cultural capital (knowledge of social norms and education), and social capital (connections and networks of people). Bourdieu (1986) posited that individuals and groups possess different kinds of capital that allow them to establish and maintain their social standing. The unequal distribution of this capital limits opportunity for many people, and as capital is most commonly transmitted by familial or close relationships, it promotes the replication of the existing social structure in the subsequent generation (Bourdieu, 1986).

Bourdieu (1973/1977) argued that educational institutions create systems that favor individuals whose language and disposition (*habitus*) are characteristic of a high or middle social class; therefore, students' ability to effectively navigate educational institutions and succeed academically depended heavily on their background rather than their academic aptitude. Students from a middle or high social class integrate seamlessly into the educational setting since their attitudes and knowledge of the world reflect that of their teachers and institution, but students of a low socio-economic status or differing cultural backgrounds do not integrate as readily and struggle to understand the language and the unspoken norms of the institution (Bourdieu, 1973/1977). In addition, educational institutions declare only those students successful who acknowledge the institution's definition of success and their authority to dispense it (Harker, 1984). Students from low socio-economic status are more likely to choose to remove themselves from the unfamiliar and uncomfortable circumstances created at educational institutions (Hlinka, 2017; Rendón, Jalomo, & Nora, 2000).

Tinto's Theory of Student Retention

The work of Tinto (1975, 1993) has largely influenced the thinking and discussions surrounding student persistence and attrition. Tinto (1975, 1993) argued that persistence is largely dependent on the student's ability to transition into college life and to integrate into the social and intellectual communities of the institution. Tinto (1975) viewed withdrawal from college "as a longitudinal process of interactions between the individual and the academic and social systems of the college during which a person's experience in those systems…continually modify his goal and institutional commitment" (p. 94).

Tinto (1975) noted pre-entry disposition factors shape student persistence. Student characteristics such as family background, academic preparation, parental education level, parental income, gender, race, and ethnicity impact students' initial level of commitment to their educational goals and institution. The student's level of commitment is then modified by their academic and social experiences at the college or university. Some students struggle to adjust to college life and others may feel an incongruency with the values, interests, or preparation and the demands of the college community (Tinto, 1993). Student dropout decisions can be explained by their varying levels of goal and institutional commitment.

Tinto (1975) argued that events affecting dropout decisions external to the college environment could be observed in their effect on the student's changing commitment. In a later revision of his theory, Tinto (1993) described financial impacts on student persistence and the effect supportive or unsupported external communities had on retention; however, Tinto maintained that the impact of external circumstances including family and work demands were less important than events within the college environment.

Two-year institutions pose a challenging application for Tinto's theory as they frequently struggle to provide structured social environments, and commuter students frequently experience conflicting school, family, and work obligations (Tinto, 1993). Bean and Metzner (1985) argued that a lack of social integration was a defining characteristic of a non-traditional college student and social factors did not seem to influence non-traditional students' persistence decisions. Bean and Metzner (1985) conjectured that environmental variables—including finances, hours of employment, outside encouragement, family responsibilities, and opportunity to transfer—were the most influential in non-traditional student persistence decisions. In his later work, Tinto (1997) contended that social integration was as much a part of the community college persistence puzzle as four-year universities. Tinto (1997) asserted that well-structured, collaborative classrooms can help "bond students to the broader social communities of the college while also engaging them more fully in the academic life of the institutions" (p. 613).

Braxton, Hirschy, and McClendon (2004) revised Tinto's theory and developed a theory of student departure at commuter institutions. The theory linked student persistence to student entry characteristics, external environment, campus environment, student academic development, and institutional commitment. For commuter students, the community a student experiences is most frequently restricted to the classroom, and integration into a social community is significantly more difficult. Braxton, et al. (2004) found that student perceptions of the college's commitment to students, as evidenced by the actions of the administrators, staff, and faculty they encounter, is critical in establishing commitment to the institution and motivation to become members of the academic and social community.

Building upon Tinto's theory, Seidman (2012) developed a retention formula: Retention = Early Identification + (Early + Intensive + Continuous) Intervention (p. 272). Dissimilar to previous definitions of retention as program completion, Seidman (2012) defined retention as "student attainment of academic and/or personal goal(s)" (p. 270). Students may achieve their goals before, at, or after graduation; thus, a college must know and understand a student's goals before determining retention (Seidman, 2012).

Early identification implies that institutions must assess a student's skill level through standardized test scores and review of academic records, and Seidman (2012) asserted that "a common college-administered assessment prior to enrollment" was "ideal" (p. 272). Once a student is identified as "in need of assistance" either academically or socially, the college's intervention must be immediate and intense (Seidman, 2012, p. 274); the intervention must also continue until the desired change has occurred.

Academic Momentum

Another influential theory, academic momentum, attempts to explain why some students complete degrees and others do not. This perspective contends that a student's initial progress toward a degree establishes a lasting trajectory that strongly influences a student's eventual degree completion, and this effect is apparent apart from a student's socio-economic background and academic preparation (Attewell, Heil, & Reisel, 2012).

Adelman (1999, 2006) first observed in his longitudinal study of degree completion that students who enrolled in college directly after high school, maintained continuous enrollment, and earned more credit in their first year were more likely to graduate—a factor he termed academic momentum. Using data from the National Education Longitudinal Study (NELS) of 1988, Adelman (1999) developed a linear regression model comprised of 11 variables that contributed to bachelor's degree attainment and accounted for 43% of the variance in completion. Adelman (1999) found that continuous enrollment was one of two significant variables that supplied most of his model's "explanatory power" (p. vi). Later Adelman (2006) replicated his study and found similar results. Adelman (2006) stated, "that one of the most degree-crippling features of undergraduate histories is an excess volume of courses from which the student withdrew…" (p. xxii). It was also noted that students who completed less than 20 credits in their first year were one-third less likely to graduate, and students who completed at least 4 credit hours in the summer semester were more likely to graduate (Adelman, 2006).

Adelman's concept of academic momentum remained largely empirical and subsequent research did little to formalize the theory. Driscoll (2007) found high correlations between first term intensity and enrolling for the next semester as well as transfer and degree earning rates. Dricoll (2007) concluded that it is "worth exploring strategies that enable students to take as many credit courses as they can handle early on in their college career" (p. 12). Considering these findings, Doyle (2011) sought to determine if the observed relationship between more credit earned by community college students and transfer rates was merely a result of selection bias. Doyle (2011) concluded that there was "substantial evidence that increasing the number of credit hours taken in the first year is likely to increase transfer rates…[T]his result does not appear to be due solely to selection bias" (p. 199).

Attewell, et al. (2012) more formally delineated a theory of academic momentum, and they postulated that greater academic intensity increased the integration of students into the academic community through increased time with peers and faculty thus increasing persistence. Using data from NELS, Attewell, et al. (2012) found that after controlling for background and academic preparation, students who delay entry into college or attend part-time are less likely to complete a degree. They found little evidence of benefit for students taking 18 or more credit hours in their first semester, but significant evidence of benefit for students enrolling in summer semesters (Attewell, et al., 2012). In a later study, Attewell and Monaghan (2016) found that students who enroll in 15 credit hours in their first semester graduate at a significantly higher rate than academically and socially similar students who enrolled in fewer hours; in addition, students who increased their course load to 15 credit hours in their second semester were also more likely to graduate than their peers who took less. This increased likelihood of graduation did not hold for students working more than 30 hours a week (Attewell & Monaghan, 2016).

In response, Davidson and Blankenship (2017) argued that *earned college-level* credit hours rather than *attempted* credit hours as measured by Attewell, et al. (2012) established beneficial academic momentum. Davidson and Blankenship (2017) considered noncredit developmental education courses a "detriment to completing 30 credit hours during the first academic year" (p. 479). Considering all first-time, full-time freshman enrolled at public institutions in Kentucky, Davidson and Blankenship (2017) found that only 4% of students enrolled in two-year institutions earned 30 credit hours by the end of the first year, and 77% of students who earn 30 or more credit hours persisted to their second year as compared to only 48.7% of students who earned less than 30 credit hours.

Collecting data from five community colleges, Crosta (2014) found early intensity may be a useful measure of unobservable traits such as self-esteem and perceived academic ability, and early intensity was particularly important for students seeking transfer. Clovis and Chang (2019) observed the academic variables—credits earned, grade point average in the first year of college, and number of months between high school and enrollment in college—significantly predicted degree completion for both two-year and transfer students.

Wang (2017) sought the build a holistic theoretical model of momentum and argued that a student's momentum encapsulated more than credit hours accumulated (intensity), milestones reached, and persistence. Wang (2017) asserted the following:

> By deeply situating students' momentum within their course-taking trajectories and their experiences within courses, and by framing the cultivation of positive academic attitudes and beliefs as a core part of building momentum, a fuller and richer meaning of momentum is accounted for and can be used to better inform policy and practice aimed at fostering community college student success. (p. 261)

Belfield, Jenkins, and Fink (2019) sought to determine the predictive value of various early momentum metrics. They argued that community colleges needed short-term, reliable and actionable metrics to determine if reform efforts were succeeding. According to Belfield et al. (2019), improvement in graduation and transfer rates, though the ultimate goal, took too much time to calculate and therefore were not timely enough to aid educators in making decisions and corrections in their colleges policies.

Belfield et al. (2019) in a study of three community college systems (over 500,000 students) found that nine early momentum metrics measuring credit momentum, gateway course momentum, and persistence momentum did predict the long-term success of students. Among these metrics was the completion of the gateway mathematics course. Less than 20% of all students completed their gateway mathematics course in the first year, and for Black and Hispanic students, the completion rate was significantly lower.

Belfield et al. (2019) determined that less than one fifth of Black and Hispanic students were "on track" according to all early momentum metrics after their first year (p. 4), and they concluded that colleges who address these early momentum metrics may find that they also address troubling equity gaps in graduation and transfer rates.

Summary of Theories of Retention and Persistence

Researchers have given significant attention to theories of retention and persistence, and as a result, much has been learned about factors influencing them. Researchers suggest students must be integrated into the academic community and early intervention for student struggling academically or socially is necessary. Early academic momentum as measured by early credit accumulation and progress toward a degree may predict the likelihood that a student will graduate or transfer to a 4-year institution.

The impact of these theories, however, has not yet been substantial. The National Student Clearinghouse (NSC) reported overall retention rates of students entering two-year public colleges between 2009 and 2016 consistently hovered at or just below 50% (NSC, 2019). More work is needed to help colleges translate these theories into policies and structures that support student retention and persistence.

Effectiveness of Developmental Education of College Completion

More Americans than ever are going to college. In 1940, 4.6% of adults 25 years or older had obtained a bachelor's degree or higher; by 2016, the number had risen to 33.4% (U.S. Census Bureau, 2017). As more students are attending college, the number of students arriving underprepared for college-level courses has increased. In a national study, Attewell, Lavin, Domina, and Levey (2006) determined that as many as 58% of community college students were unprepared for college-level coursework in at least one subject. In order to address these skill deficits, colleges and universities have created sequences of courses, or developmental education courses, intended to provide additional instruction for underprepared students.

Complete College America (2012) contended that nearly four in ten students who are placed in developmental education never complete the remedial sequence of courses and only 9.5% graduate within three years. Logue, et al. (2019) insisted that "completion of mathematics remediation may be the single largest academic barrier to increasing overall college graduation rates" (p. 1); however, many argue that a sequence of developmental courses may make college accessible to the most underprepared students (Boatman & Long, 2018; Goudas & Boylan, 2012).

Students attending two-year colleges are 19.2% more likely to be assigned to developmental education mathematics courses than their academic equivalent peers attending four-year institutions (Monaghan & Attewell, 2015). Ngo (2019) argued that remedial was an incomplete notion. He proposed a new category, redundant college mathematics, for college courses in which content was the same or lower than a student's previously completed mathematics course or lower than a student's placement score indicated. Ngo (2019) found that 40% of students in remedial classes were also in redundant mathematics courses; in addition, female students were nearly 11% more likely than male students to be in a redundant college mathematics course.

The policies and practices of developmental education disproportionately impact underrepresented populations. Researchers have found that African American students, Hispanics students, and students with a low-income background are more likely to enroll in developmental education than White students with the same academic preparation

(Attewell, et al., 2006; Chen & Simone, 2016). Brathwaite and Edgecombe (2018) asserted that placement policy, in particular, contributes to inequitable student outcomes. Logue, et al. (2016) wrote, “Addressing the low pass rates in remedial mathematics courses could not only help overall graduation rates but could also help close performance gaps” (p. 578).

Several studies evaluating the effectiveness of developmental education found mixed or even negative results. Using a quasi-experiment regression discontinuity research design, Calcagno and Long (2008) determined remedial education had only limited benefit to students; that is, students who completed remedial mathematics courses were no more likely than their peers to pass subsequent mathematics courses or complete a degree. Calcagno and Long anticipated students who placed into remedial education to do better than their peers in nonremedial courses. “It would be expected that after successfully learning the skills needed for college-level work, a remedial student would be more likely than an academically-equivalent nonremedial student to complete these courses” (Calcagno & Long, 2008, p. 16). Calcagno and Long (2008) emphasized that the results included only students just above and below the cutoff for remediation and “should not be extrapolated to students with academic skills so weak that they scored significantly below the cutoff point” (p. 23).

In contrast with the previous study, Bettinger and Long (2009) concluded that “students in remediation are more likely to persist in college in comparison to students with similar backgrounds who were not required to take the courses” (p. 736). The study considered traditional-aged (18-20 years old), first-time, full-time students in Ohio who attended a four-year college or indicated their intent to pursue a four-year degree.

Bettinger and Long (2009) noted that students completing math and English remediation were less likely to drop out and more likely to complete a degree within 4 to 6 years; in addition, the authors found that students near the cutoff for remediation saw more positive results than the general sample.

In a different study using a regression discontinuity design to analyze the outcomes of Texas students scoring just above and below the cutoff score for developmental education, Matorell and McFarlin (2011) found "little indication that remediation improves academic or labor market outcomes" (p. 436). Matorell and McFarlin (2011) determined that students assigned to the developmental mathematics sequence attempted fewer academic credit hours and were less likely to complete one year of college. They also found "no evidence that the graduation rate changes sharply at the passing cutoff…These results imply that remediation has little effect on eventual degree attainment" (Martorell & McFarlin, 2011, p. 446).

Using the same data set of 24,140 first-time college students entering the Virginia Community College System, Jenkins, Jaggars, and Roksa (2009) and Dadgar (2012) concluded that students assigned to developmental courses are less likely to earn a degree. Jenkins, et al. (2009) found that most students assigned to remedial math courses never completed the sequence with 49% never enrolling in a math course and 32% failing the course. Few students (19%) assigned to three developmental math courses ever attempted a college-level mathematics course (Jenkins, et al., 2009). Dadgar (2012) found that students who were placed into three instead of two developmental courses were 9 to 15% less likely to earn a degree. Dadgar (2012) warned when although when comprehensively viewed, literature suggests mathematics remediation is "ineffective at every margin of remediation, it does not necessarily follow that a student at the bottom level of remedial math could be placed into college-level mathematics and not be harmed" (p. 29).

In contrast to many previous studies considering the effectiveness of developmental education, Boatman and Long (2011, 2018) sought to include a wider range of skill level in their study—specifically the lowest skilled students. The authors concluded that student remediation negatively affected students close to the cutoff, but for students scoring well below the cutoff, it had less negative or even beneficial results. Boatman and Long (2018) concluded "remedial courses can help or hinder students differently depending on their incoming levels of academic preparedness" (p. 29).

Goudas and Boylan (2012) responded to previous studies by arguing that the goal of developmental education is to attain equal rather than higher levels of success in college-level courses. Assuming this goal and given the results of the previous studies, Goudas and Boylan (2012) argued that researchers must conclude, "community college remediation is functioning as intended overall" (p. 4). Goudas and Boylan (2012) noted that Bettinger and Long's (2009) study has been almost entirely ignored, and they warned that based on the limitations discussed by Calcagno and Long (2008) and Martorell and McFarlin (2011) that "any reasonable scholar" must conclude the recommendations made in these studies "are tentative at best" and provide "a volatile foundation upon which to base policy" (p. 4).

Numerous studies in the past decade have called the effectiveness of lengthy developmental sequences into question. Many students who begin in these structures will never graduate. The extent at which these structures are to blame is still an open question demanding the attention of researchers.

Alternatives to Traditional Developmental Education Approaches

In a 2018 survey, the Education Commission of the States reported that 21 states "authorized the use of innovative developmental education instructional methods and interventions" (Whinnery & Pomopelia, 2018, para. 5). Current innovations focus on two factors to improve developmental education: (1) the speed at which a student completes developmental coursework, and (2) the relevancy, or alignment, of the courses to the student's area of study. Models seeking to accelerate a student's completion of remedial education are numerous; however, two strategies, the emporium model and corequisite remediation, have been encouraged by Missouri higher education policy (CBHE, 2013). This section will describe these models and examine the research surrounding their implementation and effectiveness. In addition, the use of technology in developmental education will be considered.

Emporium Model

In 1997, Virginia Tech introduced the emporium model to bolster student success rates and save institutions money; the model eliminated lecture and utilized interactive computer software to allow students to focus on skills they lack (Twigg, 2011). The personalized modules allowed students to move at their own pace through prerequisite content; instructors provided "on-demand, personalized assistance" (Twigg, 2011, p. 27). Twigg (2011) went as far as to label the emporium model as the "silver bullet for higher education" (p. 26).

Despite the initial enthusiasm and widespread adoption of this design, several recent studies—some of them very large—have shown students struggle in even greater numbers to complete remedial courses in the emporium model as compared to in-person developmental courses (Kozakowski, 2018; see also Childers & Lu, 2017). Boatman (2019) studied the emporium model's outcomes using statewide transcript and institutional data from students in Tennessee. Boatman (2019) found that students in emporium models were less likely to be successful in a college-level course than students in a traditional sequence.

Corequisite Remediation

Corequisite remediation allows underprepared students to enroll in the college-level course while also enrolling in additional academic support. Proponents of corequisite remediation suggest that this model could increase success in mathematics courses, overall persistence rates, and graduation rates by addressing many of the lingering problems of developmental education. Firstly, corequisite remediation allows students to begin to make progress toward their degree immediately instead of being referred to classes that cover high school or middle school material. Bailey (2009) noted the significant "psychological costs" of developmental education saying students were disheartened by returning to lower level material (p. 21). Secondly, corequisite remediation reduces the harm of misplacement. Bailey (2009) argued that *college ready* has yet to be defined and the skills necessary to be successful in college-level courses are difficult to identify and assess. Scott-Clayton, Crosta, and Belfield (2014) in their evaluation of two large community college systems determined that between 25% to 33% of students were "severely misplaced" into a course sequence (p. 381), and the researchers suggested that many students placed into developmental education courses could, in fact, be successful in college-level courses. Thirdly, corequisite remediation allows students to attempt more college-level credits in their first semester and reduces the number of exit points in subsequent semesters; thus, corequisite remediation increases students' academic momentum.

In a randomized controlled study, Logue, et al. (2016) found that underprepared students assigned directly into a college-level statistics course with corequisite support completed at a rate 16% higher than those assigned to a non-credit algebra course with or without corequisite, and students in the statistics course accumulated more college credit. This study is widely cited as evidence of the effectiveness of corequisite structures; however, it does not show corequisite remediation to be effective for algebra or quantitative reasoning courses.

In a different study of students enrolled in corequisite remediation at 13 community colleges located in Tennessee, Ran and Lin (2019) found students placed in corequisite remediation were 15% more likely to complete a college-level mathematics course in their first year and as likely to pass any additional mathematics coursework as students placed in a developmental sequence. Ran and Lin (2019) attempted to "disentangle the effects" of corequisite remediation reform and mathematics pathways reform (p. 3). Ran and Lin (2019) concluded that the positive effects on completion may have largely been due to reform of mathematics pathways noting students in the precalculus algebra pathway had similar completion rates in both the corequisite and prerequisite system.

In another study, Logue, et al. (2019) found that the students assigned to the statistics course with corequisite support graduated from college at a significantly higher rate than the students assigned to the algebra courses; however, Ran and Lin (2019) contradicted these findings. The researchers "did not find any significant effects on enrollment persistence, transfer to a four-year college, or degree completion" and concluded that "corequisite remediation is not a panacea" for all the problems surrounding college success (Ran & Lin, 2019, p. 4).

Technology Use in Developmental Education

Technology is increasingly being touted as a way to increase developmental education's effectiveness. Many institutions are integrating technology hoping to better assess skill deficits and personalize instruction. Many state level agencies and legislatures are directing the adoption of technology in developmental education. In 2011, Texas legislature passed SB 163 which directed public institutions to use "technology, to the greatest extent practicable consistent with best practices, to provide developmental education to students" (Sec. 61.07611); the bill required that the developmental education plan for every public institution include the use of technology to deliver content (TX SB 162, 2011). Similarly, the Tennessee Board of Regents directed institutions statewide to explore "technology-supported active learning strategies aimed at improving student learning outcomes, accelerating time to credit-bearing courses, and reducing instructional costs" (Crandall & Soares, 2015, p. 2).

Natow, Reddy, and Grant (2017) explored the criteria with which faculty or administrators make decisions on technology usage in developmental courses. They interviewed 127 individuals involved in developmental redesigns in 83 organizations across 36 states. Natow et al. (2017) found about 40% of participates cited "economic considerations" (p. 17) including cost of technology and expected savings to the institution as primary reasons for adopting technology. The next most common consideration cited by approximately 25% of respondents included "effectiveness of technology for education outcomes" and "state- or system-level influence" (Natow et al., 2017, p. 17).

Summary

In reaction to numerous studies finding development education sequences are ineffective, colleges and universities are trying new strategies to increase the speed at which students complete remedial coursework and the relevance of that coursework toward their degree. New models and technologies are widespread, but the speed of change is hindering researchers' ability to fully examine the impact of these methods. The emporium model, once thought to be a highly effective strategy for helping students, has been found by long term studies to harm outcomes particularly in underrepresented groups. Corequisite remediation, though promising, has yet to be fully examined, and its widespread implementation makes such an evaluation of critical importance.

Issues Driving Developmental Education Reform

Developmental education has been scrutinized by advocacy groups and policy-makers in recent years. In addition to its perceived ineffectiveness, three major issues drive this political push for developmental education reform: (1) colleges and universities are producing too few graduates to meet the current needs of the U.S. workforce, (2) the cost of higher education is increasing, and (3) students are burdened with a significant amount of educational debt (Boylan, Brown, & Anthony, 2017). Many policy-makers believe that developmental education is exacerbating all three of these critical issues.

Carnevale, Smith, and Strolh (2013) estimated by 2020, 65% of all jobs will require at least some education or training beyond high school, and Lund et al. (2019) found that workers with a high school diploma or less are four times more likely to lose their jobs in the next decade as a result of technological advances and automation. Hispanic and African American workers are the most vulnerable as traditional jobs are phased out and new jobs requiring different skillsets are created (Lund et al, 2019).

In response, well-funded groups, such as the Lumina Foundation, announced goals to significantly increase the number of Americans holding postsecondary credentials (Lumina Foundation, n.d.). In 2009, Complete College America (CCA) began advocating for structural and policy reforms that increase college completion rates (CCA, 2012). CCA authored a series of scathing reports claiming developmental education needlessly increased student debt and decreased graduation rates (CCA, 2011, 2012, 2014; Vandal, 2014). In 2012, CCA's report, *Remediation: Higher Education's Bridge to Nowhere*, advocated for the elimination of developmental education sequences and the creation of corequisite supports for college-level courses. CCA primarily worked to influence state-level public higher education policy seeking widespread reform. Walters (2012) explained "States are the principal target of the completion agenda because it is at the state level that political pressure can be more effectively linked to drivers of institutional change" (p. 34).

The influence of organizations such as the Lumina Foundation, CCA, and the Charles A. Dana Center (Dana Center) can be readily seen in Missouri higher education policy. The Missouri Department of Higher Education's (MDHE) "Big Goal for Higher Education" echoes the Lumina Foundation's "big goal" and calls for 60% of Missouri's population to have an advanced degree by 2025 (Lumina Foundation, n.d.; MDHE, n.d.). In 2012, Missouri passed House Bill 1042 that mandated all public college and universities replicate best practices in developmental education as identified by Missouri's Coordinating Board of Higher Education (CBHE) (MO HB 1042, 2012). Approved in 2013, the board's *Principles of Best Practices in Remedial Education* mandated that Missouri public institutions have multiple math pathways aligned with a student's program of study (CBHE, 2013). In addition, the document called for colleges and universities to provide significantly underprepared students with "self-paced, mastery-based routes" (i.e. the emporium model) and marginally underprepared students with "alternate routes" specifically suggesting a corequisite model of remediation (CBHE, 2013, p. 4).

In 2014, the Dana Center and CCA selected Missouri to participate in the *Building Math Pathways into Programs of Study* initiative (Dana Center, 2019; MMPT, 2015). With funding provided by the Dana Center and CCA, the state established the Missouri Mathematics Pathway Taskforce (MMPT) and began work developing transferable, consistent math pathways aligned to a student's program of study (Dana Center, 2019; MMPT, 2015). In 2016, Missouri joined CCA's *Corequisite at Scale* cohort and began working with public colleges and universities to offer college-level mathematics courses with corequisite support for each pathway (CBHE, 2015). The taskforce developed four pathways: Precalculus Algebra, Precalculus, Statistical Reasoning, and Mathematical Reasoning and Modeling. In the fall of 2018, 26 of 27 public college and universities in the state of Missouri offered at least two different mathematics pathways (MDHE, 2019).

In the *2018-2019 Annual Report on the Condition of College and Career Readiness*, MDHE (2019) reported that mathematics remediation rates for recent high school graduates at public institutions has dropped in the state by 33.2% since 2014, and in the fall of 2018, 20 public institutions offered corequisite support in place of or alongside a traditional remedial sequence for at least one of their mathematics pathways.

Conclusion

Community colleges serve nearly half of all undergraduate students in the U.S. (Bailey et al., 2015). While higher education professionals desire to create policies and structures to give students the best possible chance for success, the problems surrounding retention, persistence, and completion are complex. Of the many issues, how to help students arriving underprepared for college-level work is one of the most lingering. Public institutions are obligated to increase the effectiveness of developmental education and better support students arriving underprepared for college-level courses (Bettinger & Long, 2009; Merisotis & Phipps, 2000).

This study explored the diversity and investigated the effectiveness of the many corequisite structures now present at Missouri public two-year institutions. The ubiquitous nature of this reform makes it critically important to ascertain its impact on student success. Scholar-practitioners remain committed to creating environments where the greatest number of students will succeed and continue to earn a postsecondary credential.

SECTION FOUR: CONTRIBUTION TO PRACTICE

Presented at the annual convention of the Missouri Community College Association. The prerecorded, 40-minute session was viewed virtually on November 12, 2020 at 9AM. The session will remain available online to MCCA members for the following year. The Executive Summary and PowerPoint presentation were provided to all attendees.

EXECUTIVE SUMMARY

Transforming Mathematics Education at Missouri Community Colleges

Statement of Problem: Community colleges enroll 44% of undergraduate students in the US (CCRC, 2020), but less than four in ten community college students have earned a credential or degree after six years (Bailey, et al., 2015). Mathematics is frequently portrayed as a barrier to students' success. Recent Missouri statewide initiatives directed public institutions to reexamine their mathematics entry-level courses and to implement multiple reforms including corequisite remediation for most underprepared students. Missouri's 12 public community colleges independently responded creating a variety of different structures and policies surrounding entry-level, pathway, and corequisite courses. There has been little attention given to the effects of these changes.

Purpose of Study: Using a pragmatic parallel mixed method design, the purpose of this study was to explore the variety and effectiveness of the many structures and policies governing corequisite supports at Missouri two-year institutions.

Research Question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? To address this question, two subquestions were considered:

1. What corequisite mathematics course structures and policies are in place at community colleges in Missouri? (Qualitative Strand)
2. What is the impact of those structures and policies on the persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? (Quantitative Strand)

Review of Literature and Theoretical Framework: Adelman (2006) observed that students who maintain academic momentum are more likely to graduate. Later Attewell, Heil, and Reisel (2012) defined academic momentum as progress toward a degree.

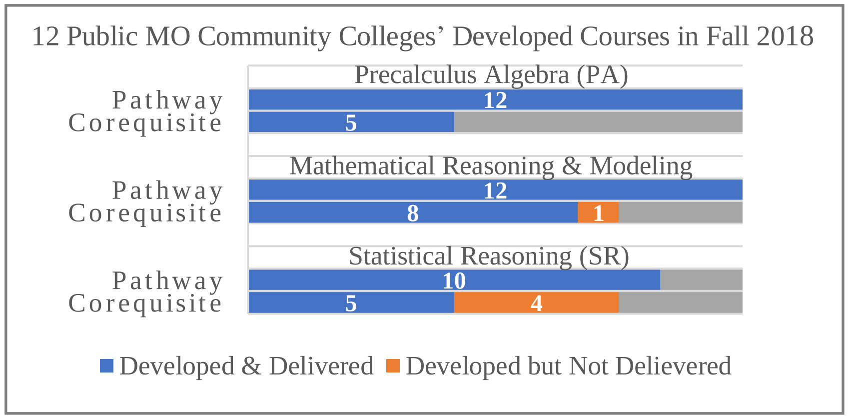
Participants & Data Sources: Data was collected through the interviews of twelve full-time mathematics faculty from each of the 12 public 2-year colleges, document analysis of academic catalogues from 2014 and 2018; in addition, EMSAS data was analyzed.

Data Analysis: Interviews were transcribed; data was identified and coded from each interview and documents analyzed. Using EMSAS data, chi-square test for homogeneity compared persistence and completion rates of entry-level mathematics courses for FTFT students in 2014 and 2018.

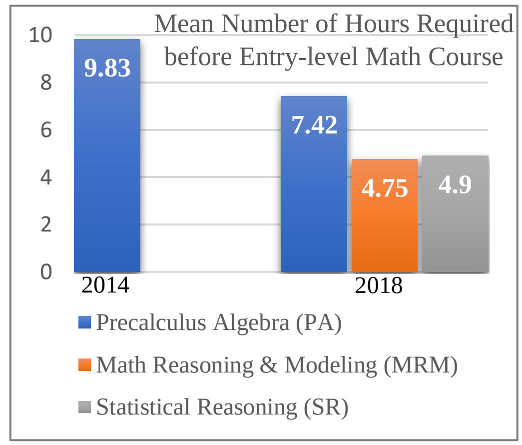
Findings:

- Four conceptualizations of corequisite courses were identified: (1) compressed sequences, (2) separate and prescriptive, (3) separate and nonprescriptive, and (4) embedded and nonprescriptive.

- By 2018, many community colleges had developed math pathway and corequisite support courses; although by Spring 2020, not all developed corequisites had been delivered.



- The mean number of hours planned for students placing at the lowest levels of developmental education before attempting the entry-level course decreased from 2014 to 2018 among the 12 public 2-year colleges.



- From 2014 to 2018, statewide persistence rates of FTFT students increased, but this increase did not appear to be consistent and widespread.

- Statewide completion rates of entry-level math courses increased at every college in the study from 2014 to 2018. In 2014, 20.5% of MO CC students completed a math course in their first two semesters; in 2018, 30.9% of students completed. The completion rate increased over 10% and difference was found to be statistically significant, χ^2 (1, N = 27665) = 388.079, $p < 0.001$.

- Three colleges were highlighted for overall completion rate of math entry-level courses. MACC had the highest completion rate in 2018. OTC and Crowder had a high completion rates and a large increase in completion rate between 2014 and 2018. For the non-STEM pathways (MRM and SR), both OTC and Crowder allow any student to enroll in the college-level pathway with corequisite without any prerequisite.

Future Research: This study found that the creation of math pathways and corequisite support courses positively impacted completion of entry-level math courses but did not substantively impact persistence rates. More research is needed to determine if completion of the math general education requirements significantly impacts persistence.

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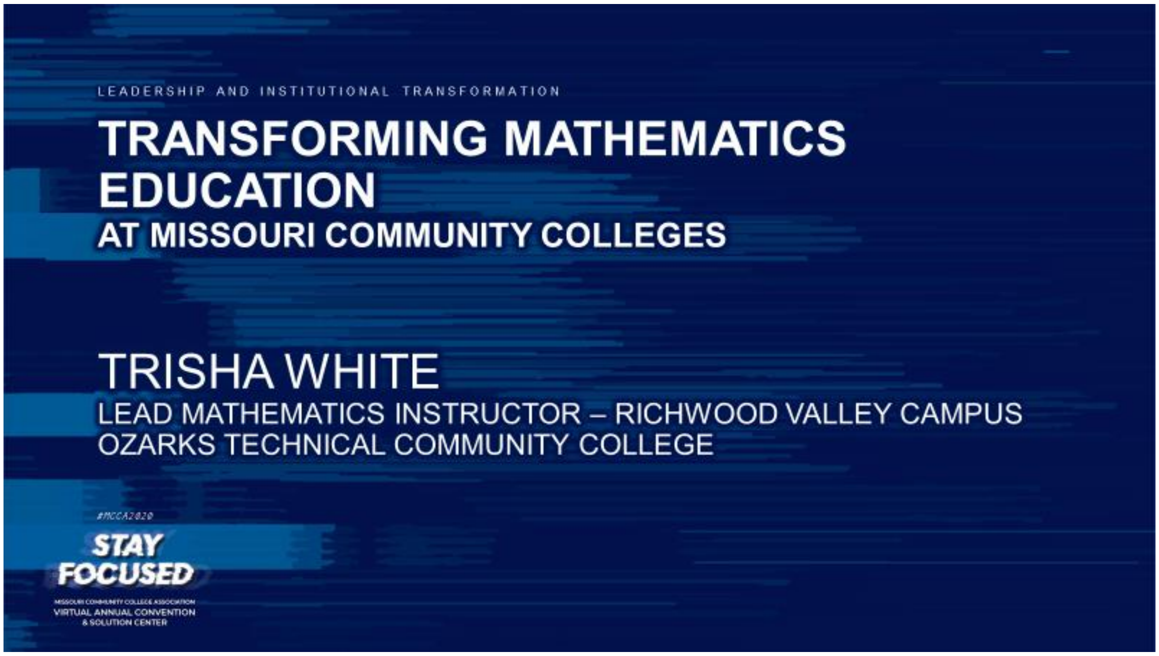
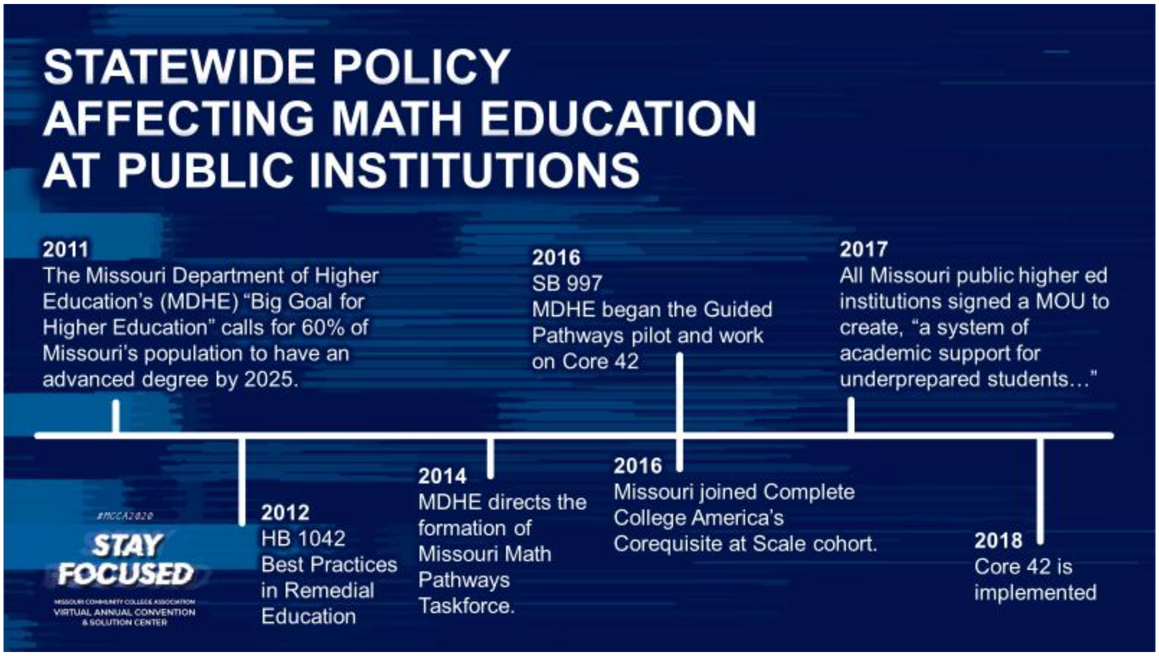
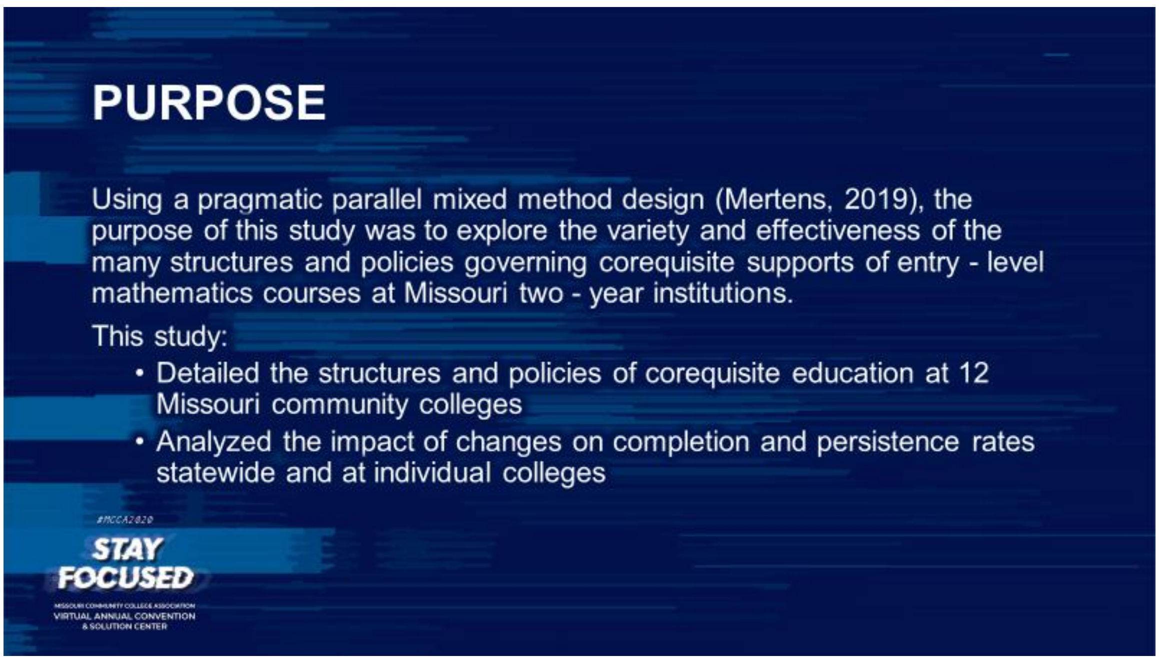
Bailey, T. R., Jaggars, S. S., & Jenkins, D. (2015). *Redesigning America's community colleges: A clearer path to student success*. Cambridge, MA: Harvard University Press.

Community College Research Center [CCRC]. (2020). Community college FAQs. Retrieved from https://ccrc.tc.columbia.edu/Community-College-FAQs.html

Power Point Presentation




STATEWIDE POLICY AFFECTING MATH EDUCATION AT PUBLIC INSTITUTIONS
2011
The Missouri Department of Higher Education's (MDHE) "Big Goal for Higher Education" calls for 60% of Missouri's population to have an advanced degree by 2025.
2012
HB 1042
Best Practices in Remedial Education
2014
MDHE directs the formation of Missouri Math Pathways Taskforce.
2016
SB 997
MDHE began the Guided Pathways pilot and work on Core 42
2016
Missouri joined Complete College America's Corequisite at Scale cohort.
2017
All Missouri public higher ed institutions signed a MOU to create, "a system of academic support for underprepared students…"
2018
Core 42 is implemented
#MCCA2020
STAY FOCUSED
MISSOURI COMMUNITY COLLEGE ASSOCIATION
VIRTUAL ANNUAL CONVENTION
& SOLUTION CENTER


PURPOSE
Using a pragmatic parallel mixed method design (Mertens, 2019), the purpose of this study was to explore the variety and effectiveness of the many structures and policies governing corequisite supports of entry - level mathematics courses at Missouri two - year institutions.
This study:
• Detailed the structures and policies of corequisite education at 12 Missouri community colleges
• Analyzed the impact of changes on completion and persistence rates statewide and at individual colleges
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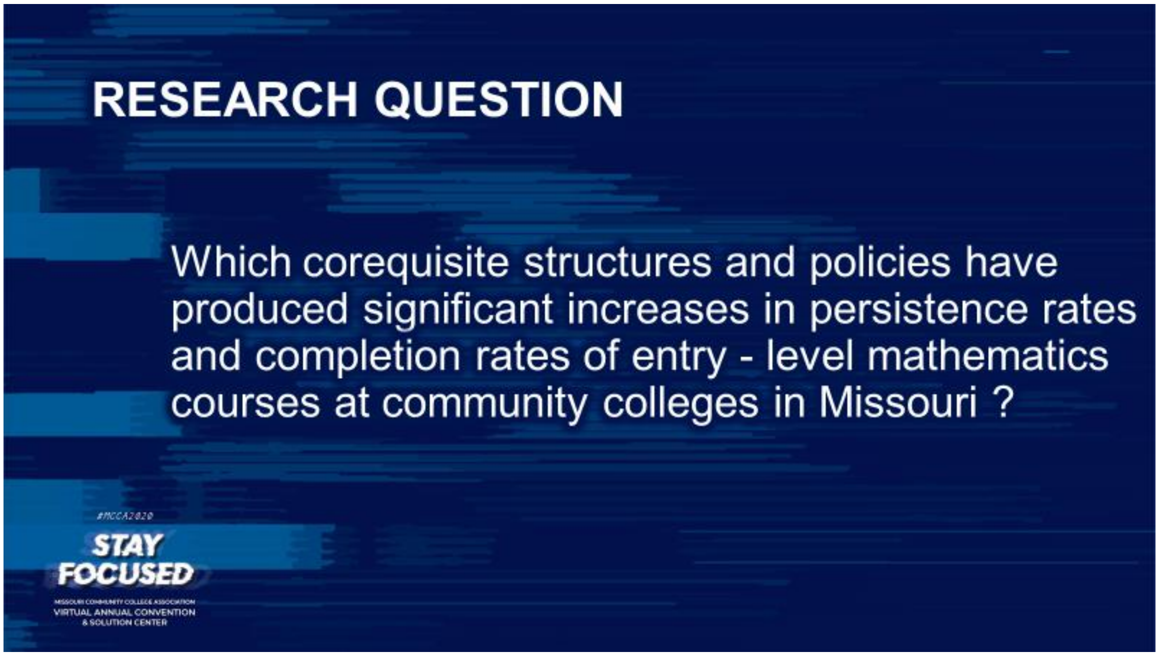
VIRTUAL ANNUAL CONVENTION
& SOLUTION CENTER


RESEARCH QUESTION
Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry - level mathematics courses at community colleges in Missouri ?
STAY
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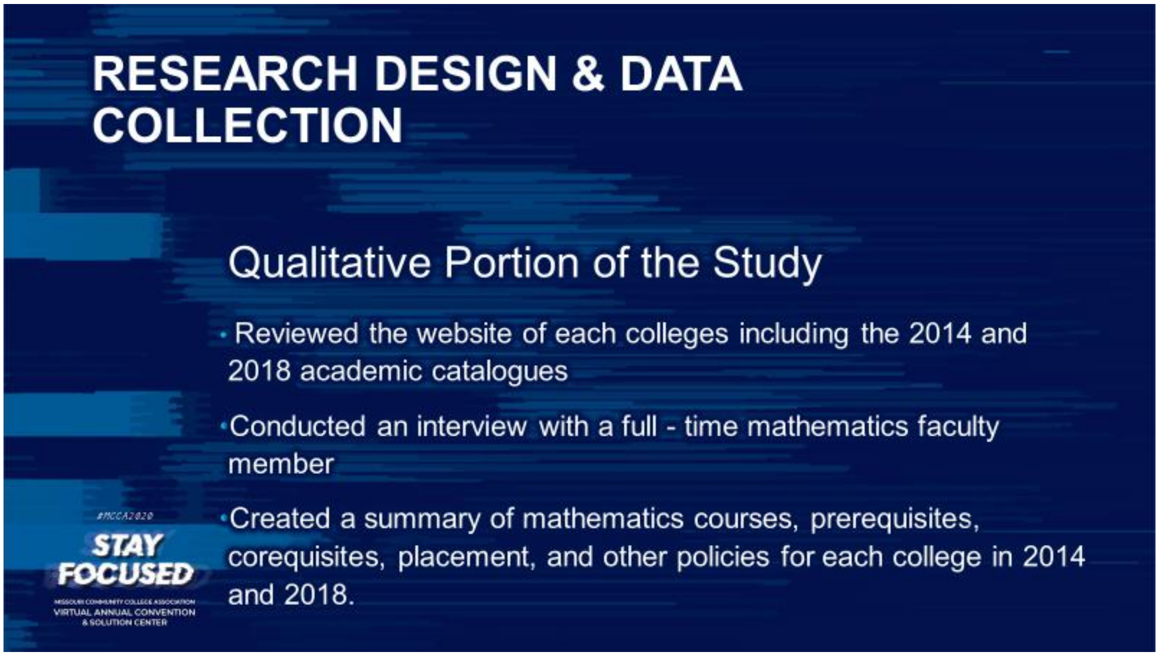
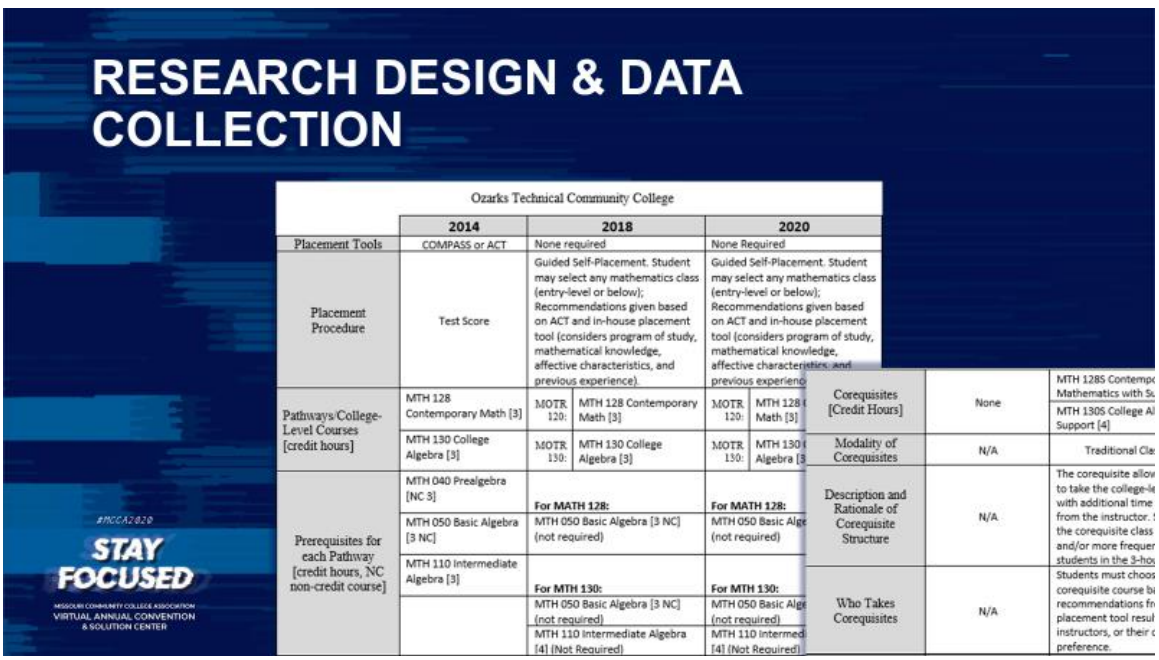
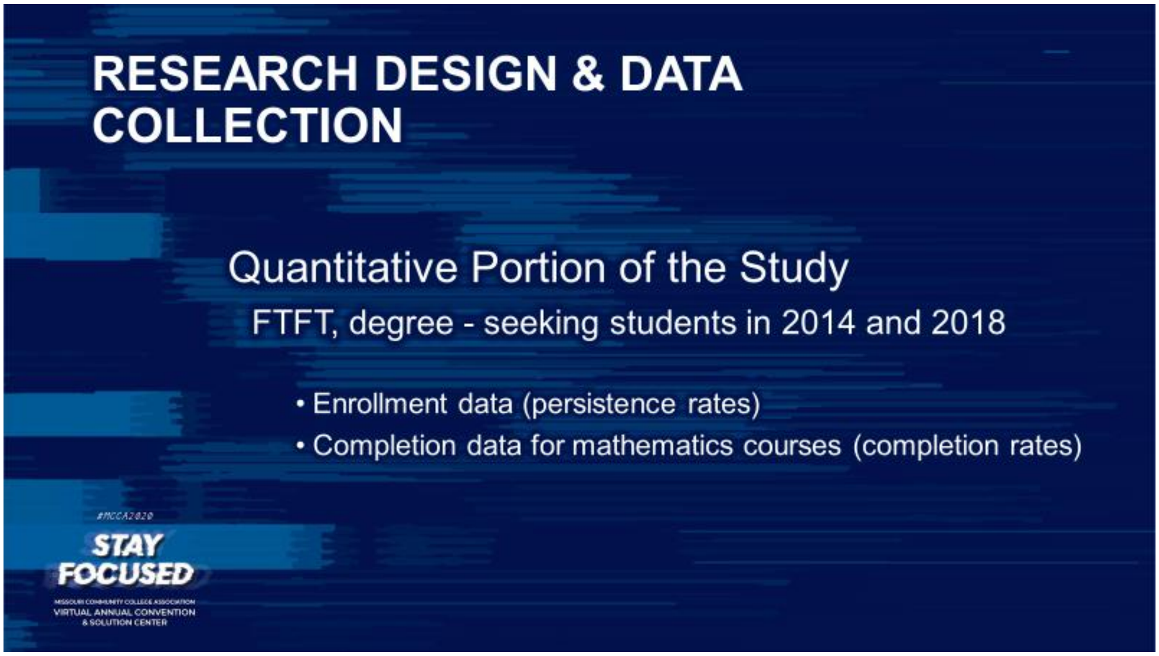
VIRTUAL ANNUAL CONVENTION
& SOLUTION CENTER


RESEARCH DESIGN
12 Missouri Public Community Colleges
• Crowder College
• East Central College
• Jefferson College
• Metropolitan Community College
• Mineral Area College
• Moberly Area Community College
• North Central Missouri College
• Ozarks Technical Community College
• St. Charles Community College
• St. Louis Community College
• State Fair Community College
• Three Rivers College
STAY
FOCUSED
VIRTUAL ANNUAL CONVENTION
& SOLUTION CENTER





Summaries were created for twelve community college (see Appendix A).


RESEARCH DESIGN & DATA COLLECTION
Quantitative Portion of the Study
FTFT, degree - seeking students in 2014 and 2018
• Enrollment data (persistence rates)
• Completion data for mathematics courses (completion rates)
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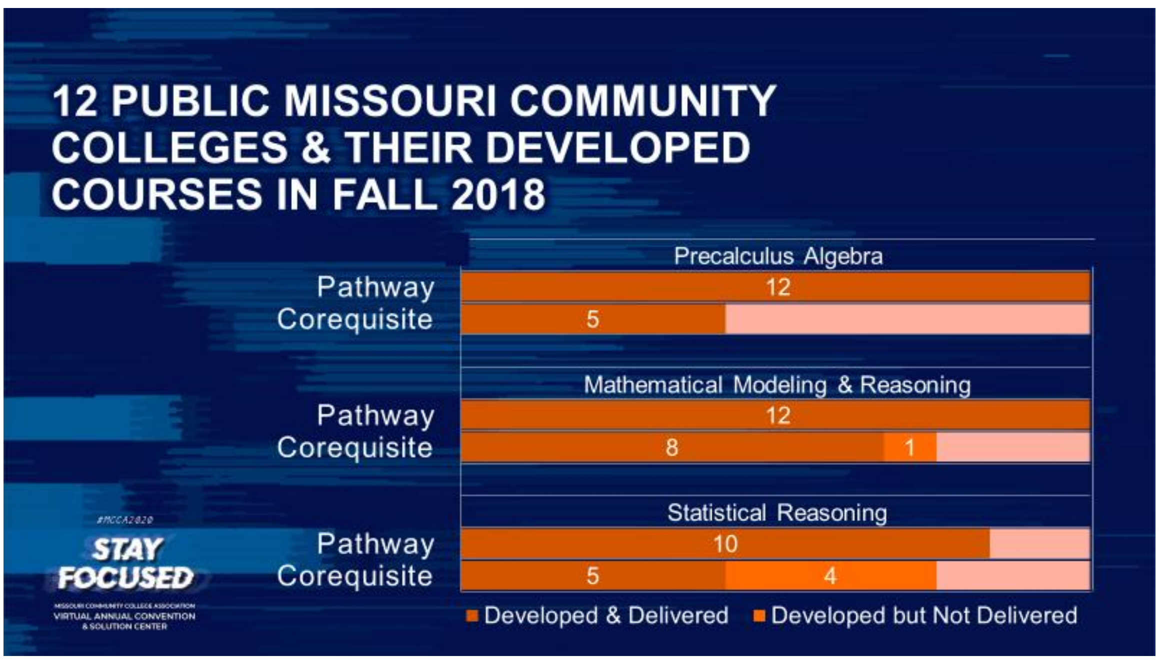
12 PUBLIC MISSOURI COMMUNITY COLLEGES & THEIR DEVELOPED COURSES IN FALL 2018
Precalculus Algebra
Pathway
12
Corequisite
5
Mathematical Modeling & Reasoning
Pathway
12
Corequisite
8
1
Statistical Reasoning
Pathway
10
Corequisite
5
4
Developed & Delivered
Developed but Not Delivered
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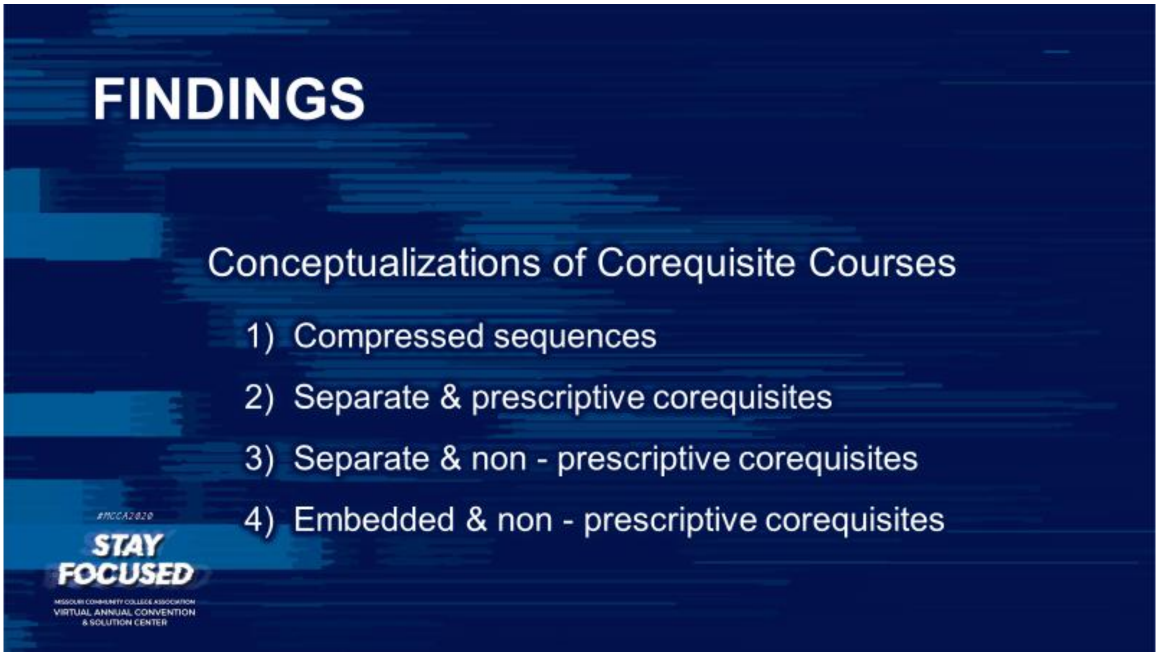

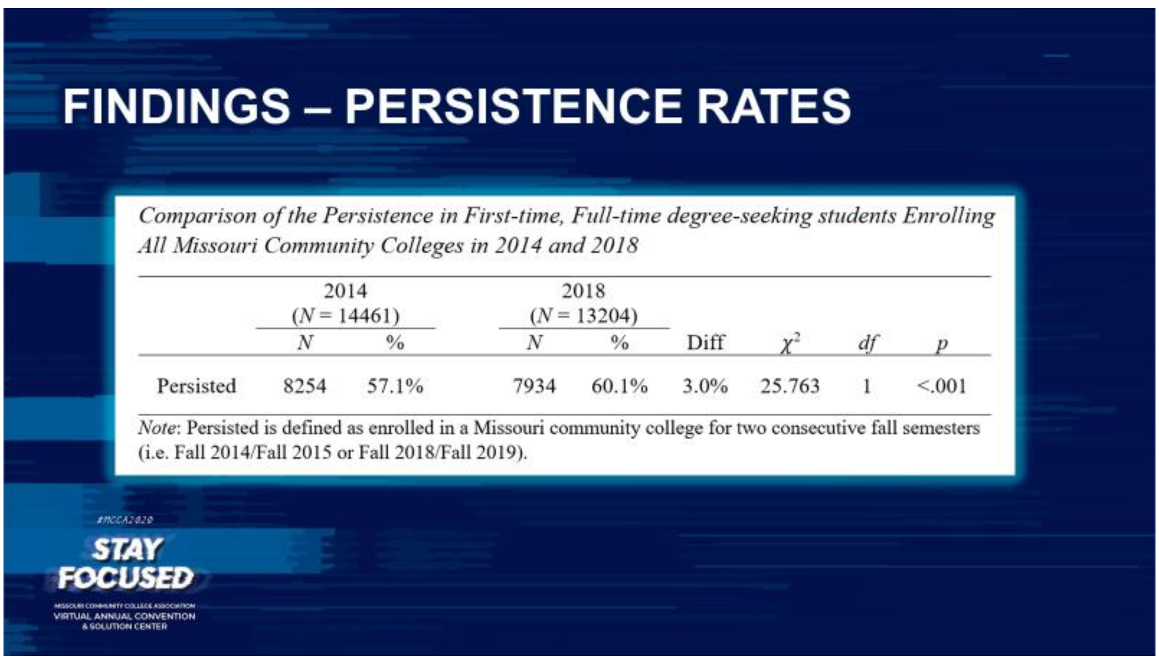

Comparison of the Persistence in First-time, Full-time degree-seeking students Enrolling All Missouri Community Colleges in 2014 and 2018

	2014 (N = 14461)		2018 (N = 13204)					
	N	%	N	%	Diff	χ^2	df	p
Persisted	8254	57.1%	7934	60.1%	3.0%	25.763	1	<.001

Note: Persisted is defined as enrolled in a Missouri community college for two consecutive fall semesters (i.e. Fall 2014/Fall 2015 or Fall 2018/Fall 2019).

For additional information on the calculations and data see Appendix B.

FINDINGS – MATH COMPLETION RATES

- 12 of 12 Community Colleges saw an increase in the completion rate of their entry - level mathematics courses between 2014 and 2018
- 11 of 12 saw a statistically significant increase

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FINDINGS – MATH COMPLETION RATES

Comparison of the Completion of College-level Mathematic Credit in the First Two Semesters among First-time, Full-time degree-seeking Students Enrolling All Missouri Community Colleges in 2014 and 2018

	2014 (N = 14461)		2018 (N = 13204)					
	N	%	N	%	Diff	χ^2	df	p
Completed	2971	20.5%	4077	30.9%	10.4%	388.079	1	<.001

Note: Completed is defined as earned college-level (non-developmental) credit in a Mathematics course in the first two semesters (i.e. Fall 2014/Spring 2015 or Fall 2018/Spring 2019) at a Missouri community college.

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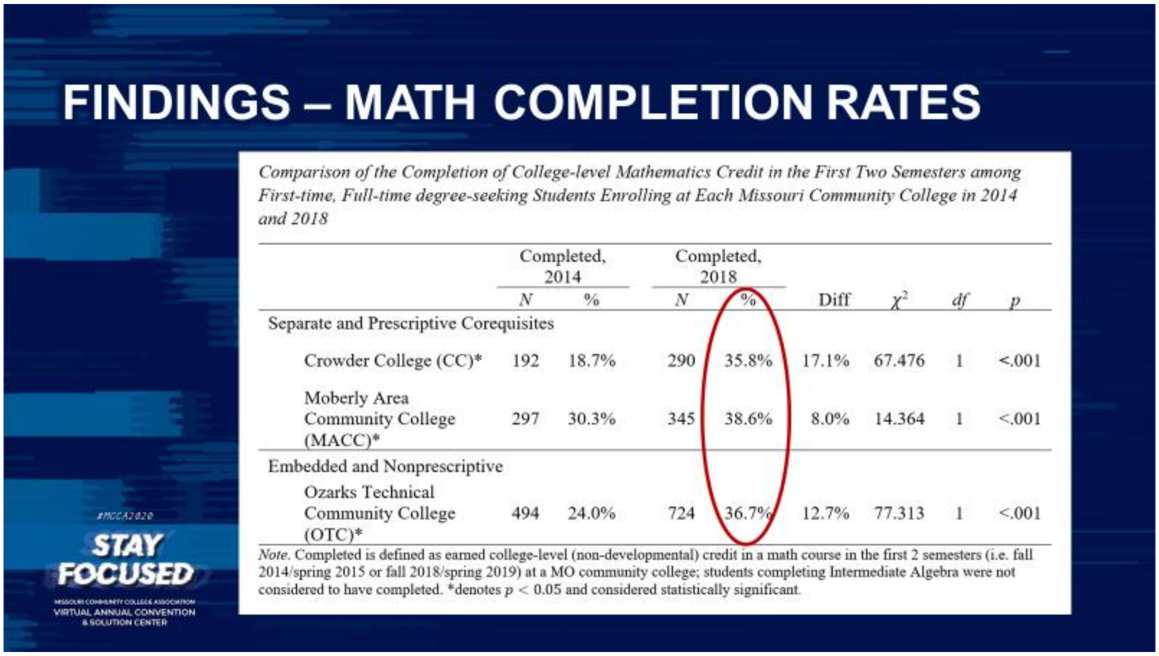
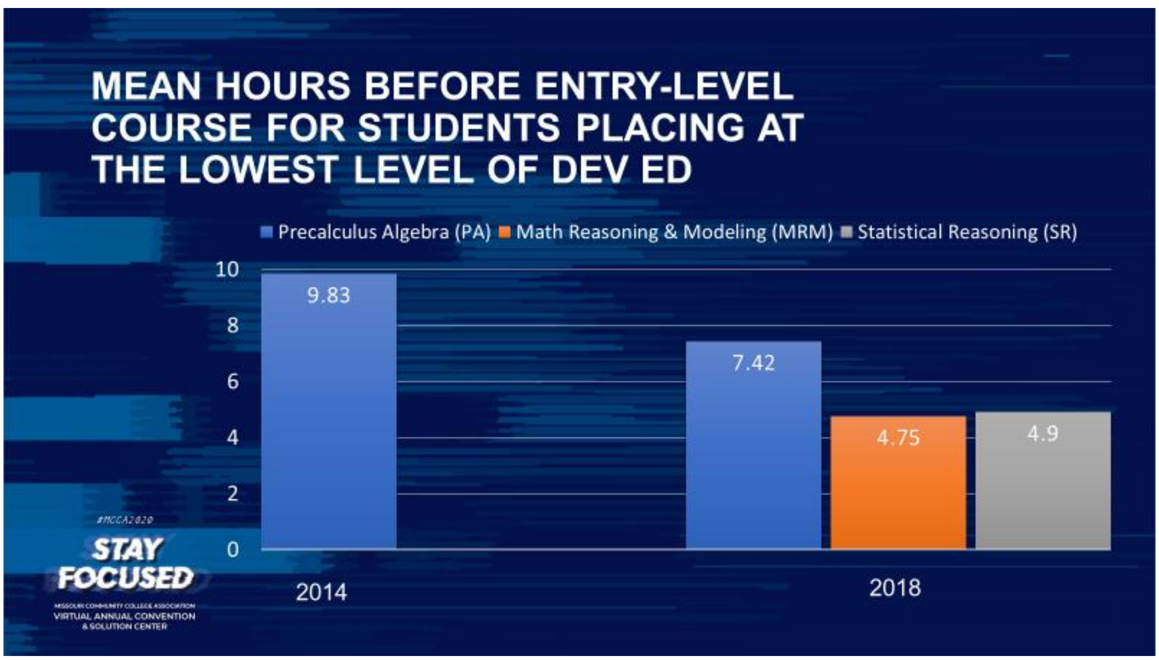
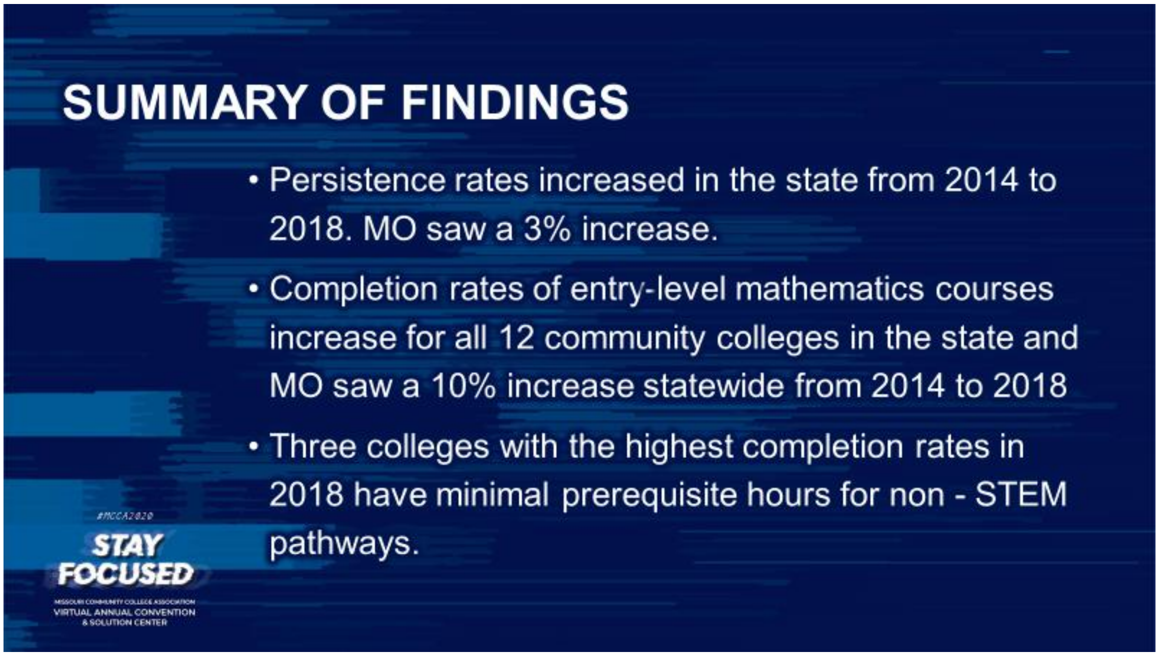


Comparison of the Completion of College-level Mathematics Credit in the First Two Semesters among First-time, Full-time degree-seeking Students Enrolling at Each Missouri Community College in 2014 and 2018

	Completed, 2014		Completed, 2018					
	N	%	*N*	%	Diff	χ^2	*df*	*p*
Separate and Prescriptive Corequisites								
Crowder College (CC)*	192	18.7%	290	35.8%	17.1%	67.476	1	<.001
Moberly Area Community College (MACC)*	297	30.3%	345	38.6%	8.0%	14.364	1	<.001
Embedded and Nonprescriptive								
Ozarks Technical Community College (OTC)*	494	24.0%	724	36.7%	12.7%	77.313	1	<.001

Note. Completed is defined as earned college-level (non-developmental) credit in a math course in the first 2 semesters (i.e. fall 2014/spring 2015 or fall 2018/spring 2019) at a MO community college; students completing Intermediate Algebra were not considered to have completed. *denotes $p < 0.05$ and considered statistically significant.




SUMMARY OF FINDINGS
• Persistence rates increased in the state from 2014 to 2018. MO saw a 3% increase.
• Completion rates of entry-level mathematics courses increase for all 12 community colleges in the state and MO saw a 10% increase statewide from 2014 to 2018
• Three colleges with the highest completion rates in 2018 have minimal prerequisite hours for non - STEM pathways.
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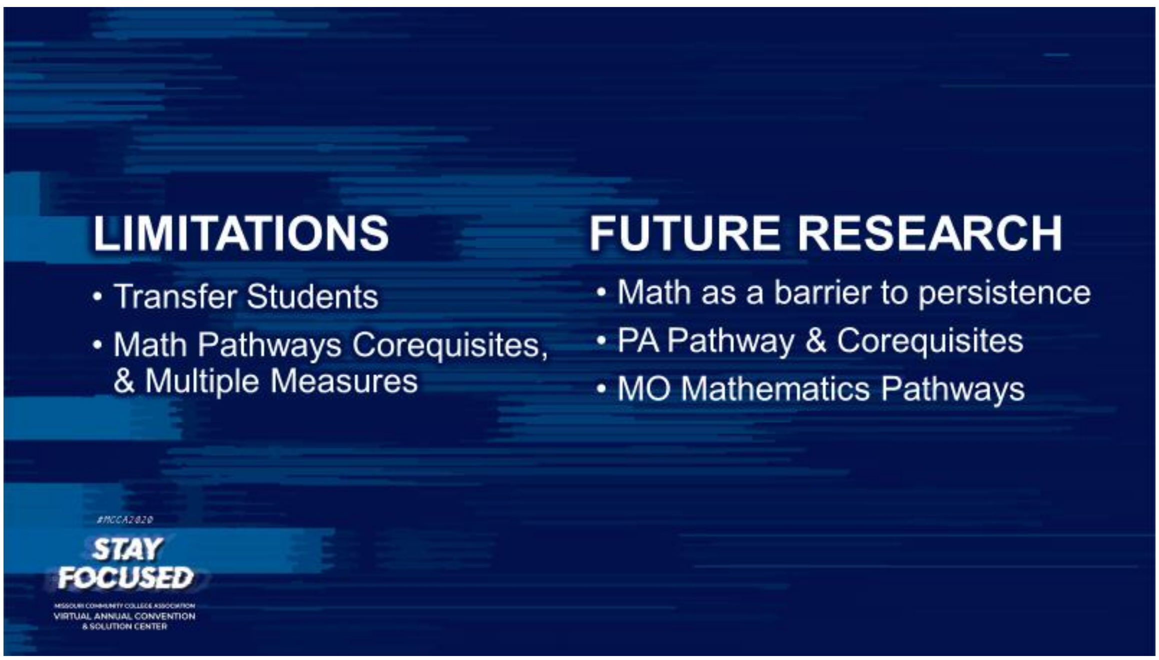
LIMITATIONS
• Transfer Students
• Math Pathways Corequisites, & Multiple Measures
FUTURE RESEARCH
• Math as a barrier to persistence
• PA Pathway & Corequisites
• MO Mathematics Pathways
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THANK YOU!
WOULD YOU LIKE TO TALK MORE? PLEASE GET IN TOUCH!
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@ALGTEACHERTRISH
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Appendix A

Summaries of Community College Structure and Policy

Crowder College

	2014	2018	2020
Placement Tools	COMPASS or ACT	Wonderlic (Basic Skills)/in-house test, ACT, or SAT	Accuplacer Next Gen, SAT, or ACT
Placement Procedure	Test Score	Wonderlic - Pass/Fail - if fail to AEL, and Test score OR HS GPA of 3.0, completion of Algebra 2 with minimum grade "B" in HS within 5 years may take college-level course	Test score OR HS GPA of 3.0, completion of Algebra 2 with minimum grade "B" in HS within 5 years may take college-level course
Pathways/College-Level Courses [credit hours]		MOTR 110: MATH 130 Elementary Statistics [3]	MOTR 110: MATH 130 Elementary Statistics [3]
	MATH 107 Introduction to Mathematics [3]	MOTR 120: MATH 125 Quantitative Reasoning [3]	MOTR 120: MATH 125 Quantitative Reasoning [3]
	MATH 111 College Algebra [3]	MOTR 130: MATH 135 Algebra for Calculus [3]	MOTR 130: MATH 135 Algebra for Calculus [3]
Prerequisites for each Pathway [credit hours, NC non-credit course]	MATH 91 Developmental Mathematics [1 NC], and MATH 92 Developmental Mathematics [1 NC], and MATH 93 Developmental Mathematics [1 NC], and MATH 94 Developmental Mathematics [1 NC]	**For MATH 130 and 125:** Pass basic skills test. **For MATH 135** Pass basic skills test, and MATH 108 Basic and Intermediate Algebra [5], or MATH 100 Intermediate Algebra [3]	**For MATH 130 and 125:** Pass basic skills test. **For MATH 135** Pass basic skills test, and MATH 108 Basic and Intermediate Algebra [5], or Math 100 Intermediate Algebra [3]
Grading and Progression	Credit / No credit; must complete each module to proceed	Pass prerequisite to move into MATH 135	Pass prerequisite to move into MATH 135
Modality of Prerequisites	Emporium	Traditional Classroom	Traditional Classroom
Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & *required* corequisite courses)	7Hours / Varied	**For MATH 130 and 125:** 5 Hours / 1 Semester **For MATH 135:** 8 Hours /2 Semesters	**For MATH 130 and 125:** 5 Hours / 1 Semester **For MATH 135:** 8 Hours /2 Semesters

Corequisites [Credit Hours] **Indicates corequisite has not been offered/has not made	None	MATH 085 Support for Elementary Statistics [2 NC]**	MATH 085 Support for Elementary Statistics [2 NC]**
		MATH 080 Support for Quantitative Reasoning [2 NC]	MATH 080 Support for Quantitative Reasoning [2 NC]
			College Algebra with Integrated Review (being developed) - postponed due to Core 42 delay of approval requests
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	The corequisite is a completely separate class with different instructors and its own assignments intended to support the college-level course by focusing on pre-skills, vocabulary, technology, study skills, and teamwork.	The corequisite is a completely separate class with different instructors and its own assignments intended to support the college-level course by focusing on pre-skills, vocabulary, technology, study skills, and teamwork.
Who Takes Corequisites	N/A	Required for students scoring above minimum basic skills and below cutoff for MATH 130 or 125. Optional for all students.	Required for students scoring above minimum basic skills and below cutoff for MATH 130 or 125. Optional for all students.
Embedded, Subset, Linked, Separate	N/A	Separate	Separate
Same Instructor	N/A	No	No
Grading Procedures	N/A	Grade not connected to college-level course. Credit/No Credit; 80% or better for credit	Grade not connected to college-level course. Credit/No Credit; 80% or better for credit
Retaking Entry-Level and Coreq	N/A	If fail college-level, must take both again.	If fail college-level, must take both again
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Textbook Workbook; Shared content included pre-skills, common assignments, and noncognitive skills; instructor may add	Connect Math, Shared content included pre-skills, common assignments, and noncognitive skills; instructor may add
Soft Skills/Study Skills Included	N/A	Yes, working as a team, test prep	Yes, working as a team, test prep
Limit to Number of Students in Corequisite	N/A	24	24 (hope to be able to lower this in the future)

East Central College

	2014	2018	2020
Placement Tools	COMPASS, ACT, or SAT	Accuplacer, ACT, or SAT	Accuplacer, ACT, or SAT
Placement Procedure	Test Score	Place with test score OR Any student earning a HS GPA of 3.0 may take the college-level course	Place with test score OR Any student earning a HS GPA of 3.0 may take the college-level course
Pathways/College-Level Courses [credit hours]		MOTR 110: MTH 150 Statistics [3]	MOTR 110: MTH 150 Statistics [3]
	MT 1343 Math for Art and Design [3]	MOTR 120: MTH 140 Contemporary Math [3]	MOTR 120: MTH 140 Contemporary Math [3]
	MT 1403 College Algebra [3]	MOTR 130: MTH 170 College Algebra [3]	MOTR 130: MTH 170 College Algebra [3]
Modality of Pathway Courses	Traditional Classroom and online	Traditional Classroom and online	Traditional Classroom and online
Prerequisites for each Pathway [credit hours, NC non-credit course]	MT 0333 Math Enrollment [NC 3] (repeated as necessary to complete all modules) OR MT 0103 Pre-Algebra [3 NC], and MT 0203 Introductory Algebra [3 NC], and MT 1303 Intermediate Algebra [3]	**For MTH 140 and 150:** MTH 070 Prealgebra [3 NC], and MTH 094 Fundamental Concepts in Mathematics [4 NC] **For MTH 170:** MTH 070 Prealgebra [3 NC], and MTH 080 Introductory Algebra [4 NC], and MTH 110 Intermediate Algebra [3]	**For MTH 140 and 150:** MTH 070 Prealgebra [3 NC], and MTH 094 Fundamental Concepts in Mathematics [4 NC] **For MTH 170:** MTH 070 Prealgebra [3 NC], and MTH 080 Introductory Algebra [4 NC], and MTH 110 Intermediate Algebra [3]
Grading and Progression	Repeat until mastery for each module **OR** Minimum course grade of "C" and minimum grade on final	Minimum Grade of "C" in previous course	Minimum Grade of "C" in previous course
Modality of Prerequisites	Emporium (MT 0033); Traditional Classroom (MT0103, 0203, 1303)	Traditional Classroom	Traditional Classroom
Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & required corequisite courses)	Emporium: Varied /Varied Traditional: 12 Hours / 4 Semesters	**For MTH 140 and 150:** 10 Hours / 3 Semester **For MTH 170:** 13 Hours / 4 Semesters	**For MTH 140 and 150:** 10 Hours / 3 Semester **For MTH 170:** 13 Hours / 4 Semesters

Corequisites [Credit Hours, NC indicates Non-Credit] **Indicates corequisite has not been offered/has not made	None	MTH 095 Statistics Expansion [1 NC]**	MTH 095 Statistics Expansion [1 NC]**
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	The corequisite is a separate course with unique content facilitated by the instructor of the college-level course intended to support students placing just below the cut off for MTH 150 or BUS 210 allowing them to enter the college-level course without a prerequisite.	The corequisite is a separate course with unique content facilitated by the instructor of the college-level course intended to support students placing just below the cut off for MTH 150 or BUS 210 allowing them to enter the college-level course without a prerequisite.
Who Takes Corequisites	N/A	Students placing just below the cutoff for MTH 150 or BUS 210. Optional for all students.	Students placing just below the cutoff for MTH 150 or BUS 210. Optional for all students.
Embedded, Subset, Linked, Separate	N/A	Separate	Separate
Same Instructor	N/A	Yes	Yes
Grading Procedures	N/A	Grade not connected to college-level course. ABCDF	Grade not connected to college-level course. ABCDF
Retaking College-Level and/or Coreq	N/A		
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Common content created by the math department	Common content created by the math department
Soft Skills/Study Skills Included	N/A	No	No
Limit to Number of Students in Corequisite	N/A		

Jefferson College

	2014	2018	2020
Placement Tools	COMPASS, ACT, or Accuplacer	Accuplacer, ACT (MATH), or in-house test	Accuplacer, ACT (MATH), or in-house test
Placement Procedure	Test Score	Place with test score OR Any student earning a HS GPA of 3.0 in the last 5 years	Place with test score OR Any student earning a HS GPA of 3.0 in the last 5
Pathways/College-Level Courses [credit hours]	MTH 130 Structure of the Real Number System [3]	MOTR 110: MTH 132 Introductory Statistics [3]	MOTR 110: MTH 132 Introductory Statistics [3]
	MTH 131 Survey of College Mathematics [3]	MOTR 120: MTH 131 Survey of College Mathematics [3]	MOTR 120: MTH 131 Survey of College Mathematics [3]
	MTH 134 College Algebra [3]	MOTR 130: MTH 134 College Algebra [3]	MOTR 130: MTH 134 College Algebra [3]
Prerequisites for each Pathway [credit hours, NC non-credit course]	MTH 001 Basic Mathematics [3 NC], and MTH 002 Beginning Algebra [3 NC], and MTH 128 Intermediate Algebra [3]	**For MTH 131, 132, 134**: (Option 1) MTH 110 Introductory Algebra [3] OR (Option 2) MTH 084 Elementary Algebra [4 NC], and MTH 128 Intermediate Algebra [3]	**For MTH 131, 132, 134:** (Option 1) MTH 110 Introductory Algebra [3] OR (Option 2) MTH 084 Elementary Algebra [4 NC], and MTH 128 Intermediate Algebra [3]
Grading and Progression	Minimum grade of "B" for MTH 001, minimum grade of "C" for MTH 002 and 128	For MTH 110, Minimum grade of "D." For MTH 084, minimum grade of "C."	For MTH 110, Minimum grade of "D." For MTH 084, minimum grade of "C."
Modality of Prerequisites	Traditional Classroom	Traditional Classroom	Traditional Classroom
Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & required corequisite courses)	12 Hours / 4 Semesters	**For MTH 131, 132, 134:** (Option 1) 9 Hours / 2 Semester OR (Option 2) 10 Hours / 3 Semesters	**For MTH 131, 132, 134:** (Option 1) 9 Hours / 2 Semester OR (Option 2) 10 Hours / 3 Semesters
Corequisites [Credit Hours, NC indicates Non-Credit] **Indicates corequisite has not been offered/made	None	MTH 092 Support for Introductory Statistics [3 NC]	MTH 092 Support for Introductory Statistics [3 NC]
		MTH 091 Support for Survey of College Mathematics [3 NC]	MTH 091 Support for Survey of College Mathematics [3 NC]
		MTH 094 Support for College Algebra [3 NC]	MTH 094 Support for College Algebra [3 NC]
Modality (Coreq)	N/A	Traditional Classroom	Traditional Classroom

Description and Rationale of Corequisite Structure	N/A	The corequisite is a separate course that is scheduled immediately following the college-level course. The course supports the college-level course by including review material, previewing coming skills, and incorporating reflection activities to identify and remove non-cognitive barriers. The course allows for regular instructor-student interaction.	The corequisite is a separate course that is scheduled immediately following the college-level course. The course supports the college-level course by including review material, previewing coming skills, and incorporating reflection activities to identify and remove non-cognitive barriers. The course allows for regular instructor-student interaction.
Who Takes Corequisites	N/A	Required for students placing below the college-level course OR students completing MTH 084 Elementary Algebra with "C" or better. Optional for any student.	Required for students placing below the college-level course OR students completing MTH 084 Elementary Algebra with "C" or better. Optional for any student.
Relationship to college class.	N/A	Separate Course. Students subset of College-level course	Separate Course. Students subset of College-level course
Same Instructor	N/A	Yes	Yes
Grading Procedures	N/A	Performance in the college-level course affects the grade in the corequisite. Unique assignments and activities in corequisite also impact final grade. ABCDF	Performance in the college-level course affects the grade in the corequisite. Unique assignments and activities in corequisite also impact final grade. ABCDF
Retaking Entry-Level and Coreq	N/A	No specific policy for repeating the corequisite; case-by-case basis	No specific policy for repeating the corequisite; case-by-case basis
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Corequisite has specific objectives; Instructors may emphasis content as desired.	Corequisite has specific objectives; Instructors may emphasis content as desired.
Soft Skills/Study Skills Included	N/A	Yes, corequisite includes test preparation, reflection activities, and note-taking activities.	Yes, corequisite includes test preparation, reflection activities, and note-taking activities.
Coreq size limit	N/A	15 students	15 students

Metropolitan Community College

	2014	2018	2020
Placement Tools	ACT or COMPASS	ACT or Accuplacer	ACT or Accuplacer
Placement Procedure	Test Score	Score combining both ACT and HS GPA OR Accuplacer Test Score	Score combining both ACT and HS GPA OR Accuplacer Test Score
Pathways/College-Level Courses [credit hours]	MATH 119 College Mathematics [3]	MOTR 110: MATH 115 Statistics [3]	MOTR 110: MATH 115 Statistics [3]
	MATH 120 College Algebra [3]	MOTR 120: MATH 119 Mathematical Reasoning & Modeling [3]	MOTR 120: MATH 119 Mathematical Reasoning & Modeling [3]
	MATH 120R College Algebra with Review [5]	MOTR 130: MATH 120 College Algebra [3]	MOTR 130: MATH 120 College Algebra [3]
Modality of Pathway	Traditional Classroom	Traditional Classroom and Online	Traditional Classroom and Online
Prerequisites for each Pathway [credit hours, NC non-credit course]	MATH 20 Basic Mathematical Operations [3 NC] (or MATH 20L Basic Mathematics/Lab [3 NC]), and	**For MATH 115 or 119:** MATH 31 Pre-College Mathematics [3 NC], and Math 85 Mathematical Literacy [3 NC] or MATH 95 Algebra Principles [5 NC]	**For MATH 115 or 119:** MATH 31 Pre-College Mathematics [3 NC], and Math 85 Mathematical Literacy [3 NC] or MATH 95 Algebra Principles [5 NC]
	MATH 40 Introductory Algebra [3 NC] (or MATH 40L Introductory Co-Laboratory Algebra [3 NC]), and		
	MATH 110 Intermediate Algebra [3] (or MATH 110R with Review [5])	**For MATH 120:** MATH 31 Pre-College Mathematics [3 NC], and MATH 95 Algebra Principles [5 NC]	**For MATH 120:** MATH 31 Pre-College Mathematics [3 NC], and MATH 95 Algebra Principles [5 NC]
Grading and Progression	Grade "S" in MATH 31 & 85 or a minimum grade of "C" in MATH 95	Grade of "S" in MATH 31 or a minimum grade of "C" in MATH 85 and MATH 95	Grade of "S" in MATH 31 or a minimum grade of "C" in MATH 85 and MATH 95
Modality of Prerequisites	Traditional Classroom	Traditional Classroom and online	Traditional Classroom and Online
Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & *required* corequisite courses)	12-14 Hours / 4 Semesters	**For MATH 115 and 119:** 9 Hours / 3 Semester	**For MATH 115 and 119:** 9 Hours / 3 Semester
		For MATH 120: 11 Hours /3 Semesters	**For MATH 120:** 11 Hours /3 Semesters

Corequisites [Credit Hours] **Indicates corequisite has not made/been offered	None	None	MATH 99 College Algebra Support [2 NC]
Modality of Corequisites	N/A	N/A	Traditional
Description and Rationale of Corequisite Structure	N/A	N/A	The corequisite is a separate course that offers greater individualized coaching and review.
Who Takes Corequisites	N/A	N/A	Students who place just below the cutoff for MATH 120. Any student in MATH 120 may choose to take it.
Relationship with college-level class	N/A	N/A	Separate
Same Instructor	N/A	N/A	Highly Encouraged
Grading Procedures	N/A	N/A	
Retaking Entry-Level and Coreq	N/A	N/A	Corequisites are not required to be retaken.
Offered online?	N/A	N/A	New Fall 2020
Shared Content for Corequisite	N/A	N/A	A general outline exists, but content is left up to the instructor.
Soft Skills/Study Skills Included	N/A	N/A	Instructors may choose to add this content.
Limit to Number of Students in Corequisite	N/A	N/A	25

Mineral Area College

	2014	2018		2020	
Placement Tools	COMPASS or ACT	ACT or Accuplacer		ACT or Accuplacer	
Placement Procedure	Test Score	Test score OR HS GPA and Test Score		Test score OR HS GPA and Test Score	
Pathways/College-Level Courses [credit hours]		MOTR 110	MAT1260 Elementary Statistics [3]	MOTR 110	MAT1260 Elementary Statistics [3]
	MAT1530 Foundation of Mathematics [3]	MOTR 120:	MAT1205 Application of College Math [3]	MOTR 120:	MAT1240 Quantitative Reasoning [3]
			MAT1240 Quantitative Reasoning [3]		
	MAT1230 College Algebra [3]	MOTR 130:	MAT1270 PreCalc: Algebraic Reasoning [3]	MOTR 130:	MAT1270 PreCalc: Algebraic Reasoning [3]
			MAT1215/1225 Math for Elementary Teachers 1 [6]		MAT1215/1225 Math for Elementary Teachers 1 [6]
Modality of Pathways	Traditional Classroom and Online	Traditional Classroom and Online (MAT1215 not online)		Traditional Classroom and Online (MAT1215 not online)	
Prerequisites for each Pathway [credit hours, NC non-credit course]	MAT0020 Arithmetic Skill I [1 NC], and	**For MAT 1260, 1205, 1240, 1215/1225**		**For MAT 1260, 1205, 1240, 1215/1225**	
	MAT0030 Arithmetic Skills II [1 NC], and	MAT0930 Fundamentals of Mathematics [3 NC]		MAT0930 Fundamentals of Mathematics [3 NC]	
	MAT0040 Arithmetic Skill III [1 NC], and	**For MAT1270**		**For MAT1270:**	
	MAT0110 Elementary Algebra I [1 NC], and	MAT0930 Fundamentals of Mathematics [3 NC], and		MAT0930 Fundamentals of Mathematics [3 NC], and	
	MAT0120 Elementary Algebra II [1NC], and	MAT1185 Fundamentals of Algebra [5]		MAT1185 Fundamentals of Algebra [5]	
	MAT0130 Elementary Algebra III [1 NC], and				
	MAT1130 Intermediate Algebra [3]				
Grading and Progression	Minimum grade of "C" or better	Minimum grade of "C" or better		Minimum grade of "C" or better	
Modality of Prerequisites	Emporium (MAT0020-MAT0130) Traditional Classroom (MAT1130)	Traditional Classroom and Online		Traditional Classroom and Online	
Maximum Number of Hours in Sequence /Number of Semesters to Complete (including pathway and *required* corequisite courses)	12 Hours/Varied	**For MAT 1260, 1205, 1240, 1215** 7 Hours / 2 Semesters		**For MAT 1260, 1205, 1240, 1216** 7 Hours / 2 Semesters	
		For MAT 1215/1225 9 Hours / 3 Semesters		**For MAT 1215/1225** 9 Hours / 3 Semesters	
		For MAT1270: 12 Hours / 3 Semesters		**For MAT1270:** 13 Hours / 3 Semesters	

Corequisites [Credit Hours] **Indicates corequisite has not yet been offered/has not made	None	MATH0905 CoReq: Applications of College Math [1 NC] MATH0940 CoReq: Quantitative Reasoning [1 NC] MAT0960 CoReq: Elementary Statistics [1 NC] MAT0970 CoReq: PreCalc: Algebraic Reasoning [1 NC]	MATH0905 CoReq: Applications of College Math [1 NC] MATH0940 CoReq: Quantitative Reasoning [1 NC] MAT0960 CoReq: Elementary Statistics [1 NC] MAT0970 CoReq: PreCalc: Algebraic Reasoning [1 NC]
Modality of Coreq	N/A	Emporium	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	The corequisite course is a computer-aided, emporium-style course. It provides "just in time" instructor to assist students in completing the pathway course.	The corequisite course is a traditional classroom course providing students with "just in time" instruction and additional time with the instructor.
Who Takes Corequisites	N/A	Students placing just below the college-level course, and all students progressing up through the developmental sequence.	Students placing just below the college-level course, and all students progressing up through the developmental sequence.
Relationship with the pathway course	N/A	Students in the pathway course may take any section of the corresponding corequisite course.	The pathway course and corequisite course are scheduled back-to-back and treated as though they were the same course.
Same Instructor	N/A	Not required	Same instructor
Grading Procedures	N/A	Pass/No Pass - Linked to college-level course. If ABCD in college-level course, then pass corequisite.	Pass/No Pass - Linked to college-level course. If ABCD in college-level course, then pass corequisite.
Retaking Entry-Level and Coreq	N/A	If fail college-level course, must take both again.	If fail college-level course, must take both again.
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	All students complete the same modules consisting of pre-skills and review material.	Content is selected and developed by the instructor to support students in the pathway course.
Soft Skills/Study Skills Included	N/A	No	Determined by the instructor.
Limit to Number of Students in Corequisite	N/A	No unique limit.	No unique limit
Attendance Taking institution			

Moberly Area Community College

	2014	2018	2020
Placement Tools	COMPASS or ACT Math	ACT Math, SAT Math, Accuplacer, in-house test	ACT Math, SAT Math, Accuplacer, in-house test
Placement Procedure	Test Score OR Graduated from HS within 3 years, and HS GPA of 3.0, and College GPA of 2.0, and (reduced) test score	Test score OR Graduated from HS within 3 years, and HS GPA of 3.0, and College GPA of 2.0, and (reduced) test score	Test score OR Graduated from HS within 3 years, and HS GPA of 3.0, and College GPA of 2.0, and (reduced) test score
Pathways/College-Level Courses [credit hours]	MTH 140 College Algebra [3]	MOTR 110: MTH 160 Elementary Statistics [3] MOTR 120: MTH 142 Quantitative Reasoning [3] MOTR 130: MTH 140 Precalculus Algebra [3]	MOTR 110: MTH 160 Elementary Statistics [3] MOTR 120: MTH 142 Quantitative Reasoning [3] MOTR 130: MTH 140 Precalculus Algebra [3]
Prerequisites for each Pathway [credit hours, NC non-credit course]	MTH 016 Computer Assisted Pre-Algebra I [3 NC], and MTH 017 Computer Assisted Pre-Algebra II [3 NC], and MTH 018 Computer Assisted Pre-Algebra III [3 NC], OR MTH010 Fundamentals of Math [3 NC], and MTH011 Fundamentals of Algebra [3 NC], and MTH 100 Intermediate Algebra [3]	**For MTH 160 and 142:** MTH 010 Fundamentals of Mathematics [3 NC] **For MTH 140:** MTH 010 Fundamentals of Mathematics [3 NC], and MTH 100 Intermediate Algebra [3]	**For MTH 160 and 142:** MTH 010 Fundamentals of Mathematics [3 NC] **For MTH 140:** MTH 010 Fundamentals of Mathematics [3 NC], and MTH 100 Intermediate Algebra [3]
Grading and Progression	Successful completion of modules; Minimum grade of "C" or better in MTH 010, 011, 100	Minimum grade of "C" or better	Minimum grade of "C" or better
Modality of Prerequisites	Emporium (MTH 016-018); Traditional Classroom (MTH 010, 011, 100); Online (MTH 011, 100)	Traditional Classroom	Traditional Classroom
Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & *required* corequisite courses)	12 Hours/Varied	**For MTH 160 and 142:** 8 Hours / 2 Semesters **For MTH 140:** 9 Hours /3 Semesters	**For MTH 160 and 142:** 8 Hours / 2 Semesters **For MTH 140:** 9 Hours /3 Semesters

Corequisites [Credit Hours] **Indicates corequisite has never made/ been offered	None	MTH 060 Elementary Statistics Corequisite [2 NC] MTH 042 Quantitative Reasoning Corequisite [2 NC]	MTH 060 Elementary Statistics Corequisite [2 NC] MTH 042 Quantitative Reasoning Corequisite [2 NC]
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom; MTH 042 offered virtually
Description and Rationale of Corequisite Structure	N/A	The corequisite course is separate course that provides support and supplemental instruction for students concurrently enrolled in the college-level course.	The corequisite course is separate course that provides support and supplemental instruction for students concurrently enrolled in the college-level course.
Who Takes Corequisites	N/A	Students enrolling in MTH 142 and 160 who completed MTH 010 or students placing just below college-level must enroll in the corequisite. Optional for any student.	Students enrolling in MTH 142 and 160 who completed MTH 010 or students placing just below college-level must enroll in the corequisite. Optional for any student.
Relationship with college-level course	N/A	Linked. Corequisite students from the same section of college-level course attend the same corequisite section.	Linked. Corequisite students from the same section of college-level course attend the same corequisite section.
Same Instructor	N/A	Yes	Yes
Grading Procedures	N/A	Grade not connected to college-level course. Pass/ Fail; Pass is 75% or above	Grade not connected to college-level course. Pass/ Fail; Pass is 70% or above
Retaking Entry-Level and Coreq	N/A	If corequisite is passed, it does not need to be retaken (even if college-level course is failed).	If corequisite is passed, it does not need to be retaken (even if college-level course is failed).
Offered online?	N/A	No	Virtual/Synchronous Corequisites
Shared Content for Corequisite	N/A	Content developed by the department and provided to instructors.	Content developed by the department and provided to instructors.
Soft Skills/Study Skills Included	N/A	Instructors may include these topics if they want to do so.	Instructors may include these topics if they want to do so.
Limit to Number of Students in Corequisite	N/A	12 Students	12 Students
Attendance	Attendance Taking Institution		

North Central Missouri College

	2014	2018	2020
Placement Tools and Procedure	COMPASS or ACT	ACT Math, Accuplacer	ACT Math, Accuplacer
	Place with test score	Place with test score OR Students with a HS GPA of 3.3 or higher may take one level higher than their placement.	Place with test score OR Students with a HS GPA of 3.3 or higher may take one level higher than their placement.
Pathways/College-Level Courses [credit hours]	MT 121 Math Concepts [3]	MOTR 110: MT 125 Elementary Statistics [3]	MOTR 110: MT 125 Elementary Statistics [3]
	MT 122 College Algebra [3]	MOTR 120: MT 119 Contemporary Math [3]	MOTR 120: MT 119 Contemporary Math [3]
	MT 125 Elementary Statistics [3]	MOTR 120: MT 121 Math Concepts [3]	MOTR 120: MT 121 Math Concepts [3]
		MOTR 130: MT 122 College Algebra [3]	MOTR 130: MT 122 College Algebra [3]
Modality of Pathway Courses	Traditional Classroom; Online	Traditional Classroom; Online	Traditional Classroom; Online
Prerequisites for each Pathway [credit hours, NC non-credit course]	**For all math courses:**	**For MT 125, 119:**	**For MT 125, 119:**
	DS 048 Pre-Algebra [3 NC]	DS 048 Pre-Algebra [3 NC], and DS 049 Basic Algebra [3 NC]	DS 048 Pre-Algebra [3 NC], and DS 049 Basic Algebra [3 NC]
	DS 049 Basic Algebra [3 NC]	**For MT 125W, 119W:** DS 048 Pre-Algebra [3 NC]	**For MT 125W, 119W:** DS 048 Pre-Algebra [3 NC]
	MT 110 Intermediate Algebra [3]	**For 122:**	**For 122:**
		DS 048 Pre-Algebra [3 NC], and DS 049 Basic Algebra [3 NC], or DS 049W Basic Algebra w Workshop [6 NC], and	DS 048 Pre-Algebra [3 NC], and DS 049 Basic Algebra [3 NC], or DS 049W Basic Algebra w Workshop [6 NC], and
		MT 110 Intermediate Algebra [3]	MT 110 Intermediate Algebra [3]
		For 122W:	**For 122W:**
		DS 048 Pre-Algebra [3 NC], and DS 049 Basic Algebra [3 NC], or DS 049W Basic Algebra with Workshop [6 NC]	DS 048 Pre-Algebra [3 NC], and DS 049 Basic Algebra [3 NC], or DS 049W Basic Algebra with Workshop [6 NC]
Grading and Progression	Minimum 75% or better to pass DS courses; Minimum grade of "D" or better in MT courses.	Minimum 75% or better to pass DS courses; Minimum grade of "D" or better in MT courses.	Minimum 75% or better to pass DS courses; Minimum grade of "D" or better in MT courses.
Modality of Prerequisites		Traditional Classroom and online	Traditional Classroom and online

Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & *required* corequisite courses)	12 Hours / 4 Semesters	**For MT 125 and 120** 9 Hours/2-3 Semesters **For MT 122** 12 Hours / 2-4 Semesters	**For MT 125 and 121** 9 Hours/2-3 Semesters **For MT 123** 12 Hours / 2-4 Semesters
Corequisites [Credit Hours] **Indicates corequisite has not been offered/has not made	None	MT 125W Elementary Statistics with Workshop [6] MT 199W Contemporary Math with Workshop [6] MT 122W College Algebra with Workshop [6]	MT 125W Elementary Statistics with Workshop [6] MT 199W Contemporary Math with Workshop [6] MT 122W College Algebra with Workshop [5]
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	The corequisite course allows students to move faster through the mathematics sequence by combining 2 courses into one in any semester.	The corequisite course allows students to move faster through the mathematics sequence by combining 2 courses into one in any semester.
Who Takes Corequisites	N/A	Students placing into any course may take the next higher course in the sequence with corequisite.	Students placing into any course may take the next higher course in the sequence with corequisite.
Relationship with College-level Course	N/A		For 125W and 119W: Embedded. College-level course portion mixed students (125 and 125W); corequisite students stay on. For 122W: Completely separate class and separate students.
Same Instructor	N/A	Same	Same
Grading Procedures	N/A	ABCDF; College-level course and corequisite receive one combined grade	ABCDF; College-level course and corequisite receive one combined grade.
Retaking Entry-Level and Coreq	N/A	Required to retake corequisite.	Required to retake corequisite.
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Course content in set by the department for all courses.	Course content in set by the department for all courses.
Soft Skills/Study Skills Included	N/A	Individual instructors may include some topics	Individual instructors may include some topics.
Limit to Number of Students in Corequisite	N/A		

Ozarks Technical Community College

	2014	2018		2020	
Placement Tools	COMPASS or ACT	None required		None Required	
Placement Procedure	Test Score	Guided Self-Placement. Student may select any mathematics class (entry-level or below); Recommendations given based on ACT and in-house placement tool (considers program of study, mathematical knowledge, affective characteristics, and previous experience).		Guided Self-Placement. Student may select any mathematics class (entry-level or below); Recommendations given based on ACT and in-house placement tool (considers program of study, mathematical knowledge, affective characteristics, and previous experience).	
Pathways/College-Level Courses [credit hours]		MOTR 110:		MOTR 110:	
	MTH 128 Contemporary Math [3]	MOTR 120:	MTH 128 Contemporary Math [3]	MOTR 120:	MTH 128 Contemporary Math [3]
	MTH 130 College Algebra [3]	MOTR 130:	MTH 130 College Algebra [3]	MOTR 130:	MTH 130 College Algebra [3]
Prerequisites for each Pathway [credit hours, NC non-credit course]	MTH 040 Prealgebra [NC 3]	**For MATH 128:**		**For MATH 128:**	
	MTH 050 Basic Algebra [3 NC]	MTH 050 Basic Algebra [3 NC] (not required)		MTH 050 Basic Algebra [3 NC] (not required)	
	MTH 110 Intermediate Algebra [3]	**For MTH 130:**		**For MTH 130:**	
		MTH 050 Basic Algebra [3 NC] (not required)		MTH 050 Basic Algebra [3 NC] (not required)	
		MTH 110 Intermediate Algebra [4] (Not Required)		MTH 110 Intermediate Algebra [4] (Not Required)	
Grading and Progression	For MTH 040 and 050, minimum grade of "B" or better; for MTH 110 minimum grade of "C" or better.	No requirement to proceed to pathway/college-level course.		No requirement to proceed to pathway/college-level course.	
Modality of Prerequisites	Traditional Classroom and Online	Traditional Classroom and Online		Traditional Classroom and Online	
Maximum Number of Hours in Sequence / Number of Semesters to Complete (including college-level and required corequisite courses)	12 Hours / 4 Semesters	**For MTH 128:** 3 Hours / 1 Semester (Required) 3-7 Hours/ 1-2 Semesters (Optional)		**For MTH 128:** 3 Hours / 1 Semester (Required) 3-7 Hours/ 1-2 Semesters (Optional)	
		For MTH 130: 3 Hours / 1 Semester (Required) 3-11 Hours/ 1-3 Semesters (Optional)		**For MTH 130:** 3 Hours / 1 Semester (Required) 3-11 Hours/ 1-3 Semesters (Optional)	

Corequisites [Credit Hours]	None	MTH 128S Contemporary Mathematics with Support [4] MTH 130S College Algebra with Support [4]	MTH 128S Contemporary Mathematics with Support [4] MTH 130S College Algebra with Support [4]
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	The corequisite allows students to take the college-level course with additional time and support from the instructor. Students in the corequisite class meet longer and/or more frequently than students in the 3-hour course.	The corequisite allows students to take the college-level course with additional time and support from the instructor. Students in the corequisite class meet longer or more frequently than students in the 3-hour course.
Who Takes Corequisites	N/A	Students must choose to take the corequisite course based on recommendations from placement tool results, advisors, instructors, or their own preference.	Students must choose to take the corequisite course based on recommendations from placement tool results, advisors, instructors, or their own preference.
Relationship with college-level course.	N/A	Corequisite is its own course; entirely separate from other courses. Students are not mixed.	Corequisite is its own course; entirely separate from other courses. Students are not mixed.
Same Instructor	N/A	Yes	Yes
Grading Procedures	N/A	Same as pathway course. ABCDF. Assisted work must not exceed 15% of grade.	Same as pathway course. ABCDF. Assisted work must not exceed 15% of grade.
Retaking Entry-Level and Coreq	N/A	Corequisite is not required to be retaken.	Corequisite is not required to be retaken.
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Content is left up to the instructor.	Content is left up to the instructor.
Soft Skills/Study Skills Included	N/A	Content is left up to the instructor.	Content is left up to the instructor.
Limit to Number of Students in Corequisite	N/A	No	No
Attendance Taking institution	Attendance Taking Institution		

Saint Charles Community College

	2014	2018		2020	
Placement Tools	COMPASS	ACT Math, Accuplacer, college created exam		ACT Math, Accuplacer, college created exam	
Placement Procedure	Test Score	Test score OR Combination of HS GPA and ACT Math Score OR Combination of HS GPA and college created exam		Test score OR Combination of HS GPA and ACT Math Score OR Combination of HS GPA and college created exam	
Pathways/College-Level Courses [credit hours]	MAT 155 Contemporary College Math [4]	MOTR 110:	MAT 157 College Statistics - Gen Ed [4]	MOTR 110:	MAT 157 College Statistics - Gen Ed [4]
	MAT 156 College Algebra - Educators [4]	MOTR 120:	MAT 155 Contemporary College Math [4]	MOTR 120:	MAT 155 Contemporary College Math [4]
	MATH 158 College Algebra - Gen Ed [4]	MOTR 130:	MAT 158 College Algebra - Gen Ed [4]	MOTR 130:	MAT 158 College Algebra - Gen Ed [4]
	MATH 162 College Algebra - STEM [4]		MAT 162 College Algebra - STEM [4]		
Prerequisites for each Pathway [credit hours, NC non-credit course]	MAT 096 Pre-Algebra [4 NC]	**For MAT 155, 157, 158, and 162**		**For MAT 155, 157, 158, and 162**	
	MAT 098 Beginning Algebra [4 NC]	MAT 096 Pre-Algebra [4 NC], and		MAT 096 Pre-Algebra [4 NC], and	
	MAT 121 Intermediate Algebra [4]	MAT 098 Beginning Algebra [4 NC], and		MAT 098 Beginning Algebra [4 NC], and	
		MAT 121 Intermediate Algebra [4]		MAT 121 Intermediate Algebra [4]	
Modality of Pathway	Traditional Classroom and Online	Traditional Classroom and Online		Traditional Classroom and Online	
Grading and Progression	Pass/Fail for MAT 096; Minimum grade of "C" or better in MTH 098 and 121	Minimum grade of "D" or better		Minimum grade of "D" or better	
Modality of Prerequisites	Traditional Classroom and Online	Traditional Classroom and Online		Traditional Classroom and Online	
Maximum Number of Hours in Sequence / Number of Semesters to Complete (including college-level and required corequisite courses)	**For MAT 155, 156, 158, 162** 16 Hours / 4 Semesters	**For MAT 155, 157, 158, and 162** 16 Hours / 4 Semesters		**For MAT 155, 157, 158, and 162** 16 Hours / 4 Semesters	

Corequisites [Credit Hours] **Indicates corequisite has not yet been offered/has not made	None	MAT 055 Supplement to Contemporary College Math [2 NC]**	MAT 055 Supplement to Contemporary College Math [2 NC]**
		MAT 057 Supplement to College Statistics - Gen Ed [2 NC]**	MAT 057 Supplement to College Statistics - Gen Ed [2 NC]**
		MAT 058 Supplement to College Algebra - Gen Ed [2 NC]	MAT 058 Supplement to College Algebra - Gen Ed [2 NC]
		MAT 062 Supplement to College Algebra – STEM [2 NC]**	
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	The corequisite course supports the learning outcomes of the college-level course by providing additional time for students with each other and the material. Students receive additional time with the instructor.	The corequisite course supports the learning outcomes of the college-level course by providing additional time for students with each other and the material. Students receive additional time with the instructor.
Who Takes Corequisites	N/A	Student placing just below the cutoff for MAT 155, 157, 158, and 162 may take the course with corequisite. Any student may choose to take the corequisite.	Student placing just below the cutoff for MAT 155, 157, 158, and 162 may take the course with corequisite. Any student may choose to take the corequisite.
Relationship with pathway course.	N/A	Students from the pathway course may take any section of the corequisite offered by the same instructor.	Students from the pathway course may take any section of the corequisite offered by the same instructor.
Same Instructor	N/A	Same	Same
Grading Procedures	N/A	Pass/Fail Grading is left up to the instructor.	Pass/Fail Grading is left up to the instructor.
Retaking Entry-Level and Coreq	N/A	Students who pass the college-level course automatically pass the corequisite. Student failing the corequisite are not required to retake it.	Students who pass the college-level course automatically pass the corequisite. Student failing the corequisite are not required to retake it.
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Content is left up to the instructor with the understanding that content centers on just-in-time assistance with course concepts and with prerequisite concepts.	Content is left up to the instructor with the understanding that content centers on just-in-time assistance with course concepts and with prerequisite concepts.
Soft Skills/Study Skills Included	N/A	Content is left up to the instructor.	Content is left up to the instructor.
Limit to Number of in Corequisite	N/A	No unique limit.	No unique limit.
Attendance Taking institution	Attendance Taking Institution		

Saint Louis Community College

	2014	2018	2020
Placement Tools	COMPASS and ACT	Math Index Score, ACT Math, Accuplacer	Math Index Score, ACT Math, Accuplacer
Placement Procedure	Test Score	Test score OR Math Index Score (Based on HS GPA and test score)	Test score OR Math Index Score (Based on HS GPA and test score)
Pathways/College-Level Courses [credit hours]	MTH 160A College Algebra with Technology [4]	MOTR 110: MTH 180 Introductory Statistics [4]	MOTR 110: MTH 180 Introductory Statistics [3]
	MTH 160B College Algebra - Non-Tech Majors [4]	MOTR 120: MTH 161 Quantitative Reasoning [4]	MOTR 120: MTH 161 Quantitative Reasoning [3]
	MTH 160C College Algebra [4]	MOTR 130: MTH 160 Precalculus Algebra [4]	MOTR 130: MTH 160 Precalculus Algebra [4]
	MTH 161 Application of College Mathematics [4] SP14		
Modality of Pathways	Traditional Classroom and online	Traditional Classroom and online	Traditional Classroom and online
Prerequisites for each Pathway [credit hours, NC non-credit course]	MTH 004 Hands-on Arithmetic Workshop [3 NC], and	**For MTH 161 and 180**	**For MTH 161 and 181**
	MTH 020 Pre-Algebra [3 NC], and	MTH 020 Pre-Algebra [3 NC], and	MTH 020 Pre-Algebra [3 NC], and
	MTH 025 Hands-on Algebra Workshop [3 NC] (optional), and	MTH 050 Mathematical Literacy [3 NC]	MTH 050 Mathematical Literacy [3 NC]
	MTH 030 Elementary Algebra [3 NC], or	**FOR MTH 160:**	**FOR MTH 160:**
	MTH 040 Elementary Algebra and Basic Math [5 NC] (Combines MTH 020 and 030), and	MTH 020 Pre-Algebra [3 NC], and	MTH 020 Pre-Algebra [3 NC], and
		MTH 030 Elementary Algebra [3 NC], or	MTH 050 Mathematical Literacy [3 NC]
	MTH 140 Intermediate Algebra [3], and	MTH 040 Elementary Algebra and Basic Math [5 NC], and	MTH 140 Intermediate Algebra [3]
		MTH 140 Intermediate Algebra [3]	
Grading and Progression	Minimum Grade of "C" or higher	Minimum grade of "C" or better	Minimum grade of "C" or better
Modality of Prerequisites	Traditional Classroom and Online (only MTH 140)	Traditional Classroom and Online (only MTH 140)	Traditional Classroom and Online (only MTH 140)
Maximum Number of Hours in Sequence / Number of Semesters to Complete (including college-level and required corequisite courses)	15-16 Hours / 4-5 Semesters	**For 161 and 180:** 10 Hours / 3 Semesters **For 160:** 12-13 Hours / 3 - 4 Semesters	**For 161 and 180:** 9 Hours / 3 Semesters **For 160:** 13 Hours / 4 Semesters

Corequisites [Credit Hours; NC non-credit course]	None	MTH 056 Principles of Quantitative Reasoning [2 NC] MTH 058 Principles of Introductory Statistics [2NC]	MTH 056 Principles of Quantitative Reasoning [2 NC] MTH 058 Principles of Introductory Statistics [2 NC]
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	Corequisites exist to support the pathway course. The instructor selects and develops content that addresses the skill deficiencies of students and reinforces the content of the pathway course.	Corequisites exist to support the pathway course. The instructor selects and develops content that addresses the skill deficiencies of students and reinforces the content of the pathway course.
Who Takes Corequisites	N/A	Students placing high in MTH 050 Math Literacy take the pathway course with the required corequisite. Any student in the pathway course may choose to take the corequisite. (Students taking MTH 020 or 050 are never required to take a corequisite.)	Students placing high in MTH 050 Math Literacy take the pathway course with the required corequisite. Any student in the pathway course may choose to take the corequisite. (Students taking MTH 020 or 050 are never required to take a corequisite.)
Relationship with college-level course.	N/A	Students from the pathway course are encouraged to take certain sections of the corequisite (matching instructors).	Students from the pathway course are encouraged to take certain sections of the corequisite (matching instructors).
Same Instructor	N/A	Same instructor is highly encouraged.	Same instructor is highly encouraged.
Grading Procedures	N/A	ABCDF; If student passes pathway course, student passes corequisite.	ABCDF; If student passes pathway course, student passes corequisite.
Retaking Pathway and Coreq	N/A	Students are not required in any case to retake the corequisite.	Students are not required in any case to retake the corequisite.
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Course profiles have been developed for each corequisite course that include learning outcomes. Specific content and assignments are left up to the instructor.	Course profiles have been developed for each corequisite course that include learning outcomes. Specific content and assignments are left up to the instructor.
Soft Skills/Study Skills Included	N/A	Not included in learning outcomes; the instructor may include if desired.	Not included in learning outcomes; the instructor may include if desired.
Limit to Number of Students in Corequisite	N/A	The pathway course is intended to be made up of no more than half corequisite students.	The pathway course is intended to be made up of no more than half corequisite students.
Attendance Taking institution	Attendance Taking Institution		

State Fair Community College

	2014	2018	2020
Placement Tools	COMPASS or ACT	ACT Math, Accuplacer, SAT Math, HiSET	ACT Math, Accuplacer, SAT Math, HiSET
Placement Procedure	Test Score	Test score OR Students placing close to the cutoff of MATH 113, 114, or 119 with a HS GPA of 3.5 in mathematics courses, may take the next course higher.	Test score OR Students placing close to the cutoff of MATH 113, 114, or 119 with a HS GPA of 3.5 in mathematics courses, may take the next course higher.
Pathways/College-Level Courses [credit hours]	MATH 114 College Algebra [3]	MOTR 110: MATH 119 Statistical Reasoning [3]	MOTR 110: MATH 119 Statistical Reasoning [3]
	MATH 116 Finite Math [3]	MOTR 120: MATH 113 Mathematical Reasoning and Modeling [3]	MOTR 120: MATH 113 Mathematical Reasoning and Modeling [3]
	MATH 117 Contemporary Mathematics [3]	MOTR 130: MATH 114 Precalculus Algebra [3]	MOTR 130: MATH 114 Precalculus Algebra [3]
Modality of Pathway Courses	Traditional Classroom and Online	Traditional Classroom and Online	Traditional Classroom and Online
Prerequisites for each Pathway [credit hours, NC non-credit course]	MATH 004 Basic Math [3 NC]	**For MATH 113 or 119** MATH 061 Pre-Algebra [3 NC]	**For MATH 113 or 119** MATH 061 Pre-Algebra [3 NC]
	MATH 061 Pre-Algebra [3 NC]		
	MATH 064 Elementary Algebra [3 NC]	**For MATH 114:** MATH 061 Pre-Algebra [3 NC], and	**For MATH 114:** MATH 061 Pre-Algebra [3 NC], and
	MATH 112 Intermediate Algebra [3]	MATH 110 Intermediate Algebra with Review [5]	MATH 110 Intermediate Algebra with Review [5]
Grading and Progression	Minimum grade of "C" or better, and for MATH 004 and 061, a minimum grad of "C" on the department final.	Minimum grade of "C" or better	Minimum grade of "C" or better
Modality of Prerequisites	Traditional Classroom and Online (MATH 061-112)	Traditional Classroom and Online	Traditional Classroom and Online
Maximum Number of Hours in Sequence / Number of Semesters to Complete (including college-level and required corequisite courses)	15 Hours / 5 Semesters	**For MTH 113 and 119:** 8 Hours / 2 Semesters	**For MTH 113 and 119:** 8 Hours / 2 Semesters
		For MTH 140: 11 Hours /3 Semesters	**For MTH 140:** 11 Hours /3 Semesters

Corequisites [Credit Hours]	None	MATH 111 Review of Essential Mathematics [2] (MATH 111 can be paired with either MATH 113 or 119)	MATH 111 Review of Essential Mathematics [2] (MATH 111 can be paired with either MATH 113 or 119)
Modality of Corequisites	N/A	Traditional Classroom	Traditional Classroom
Description and Rationale of Corequisite Structure	N/A	Corequisite courses support the learning outcomes of either MATH 113 or 119. Students enroll in a specific section of MATH 111 and content is specifically aligned to their college-level course. The corequisite course reviews essential mathematical ideas and provides a space for students to work more closely with their instructor.	Corequisite courses support the learning outcomes of either MATH 113 or 119. Students enroll in a specific section of MATH 111 and content is specifically aligned to their college-level course. The corequisite course reviews essential mathematical ideas and provides a space for students to work more closely with their instructor.
Who Takes Corequisites	N/A	Students placing just below MATH 113 or 119 may enroll courses with corequisite. Students placing into and passing MATH 061 must take MATH 111 with either MATH 113 or 119.	Students placing just below MATH 113 or 119 may enroll courses with corequisite. Students placing into and passing MATH 061 must take MATH 111 with either MATH 113 or 119.
Relationship with college-level course.	N/A	Separate - Linked (All corequisite students in same college-level course take same section of the corequisite.)	Separate - Linked (All corequisite students in same college-level course take same section of the corequisite.))
Same Instructor	N/A	Same	Same
Grading Procedures	N/A	ABCDF; Grade heavily dependent on participation and engagement.	ABCDF; Grade heavily dependent on participation and engagement.
Retaking Entry-Level and Coreq	N/A	If the student fails both courses, he/she must retake both. Students may fail the corequisite and pass the college-level course.	If the student fails both courses, he/she must retake both. Students may fail the corequisite and pass the college-level course.
Offered online?	N/A	No	No
Shared Content for Corequisite	N/A	Content is created by the lead instructors. Individual instructors may choose which material to use and when to use it.	Content is created by the lead instructors. Individual instructors may choose which material to use and when to use it.
Soft Skills/Study Skills Included	N/A	Yes. Study skills and non-cognitive ability topics are included in both the college-level courses and corequisite courses.	Yes. Study skills and non-cognitive ability topics are included in both the college-level courses and corequisite courses.
Limit to Number of Students in Corequisite	N/A	12 corequisite students in college-level course	12 corequisite students in college-level course
Attendance Taking institution	Non-attendance Taking Institution		

Three Rivers College

	2014	2018		2020	
Placement Tools	ASSET or ACT	ACT, Accuplacer		ACT, Accuplacer	
Placement Procedure	Test Score	Test score		Test score OR Self-Guided Questionnaire (considers performance in previous math courses and confidence on math topics)	
Pathways/College-Level Courses [credit hours]		MOTR 110:		MOTR 110:	
	MATH 161 College Mathematics [3]	MOTR 120:	MATH 161 Mathematical Reasoning and Modeling [3]	MOTR 120:	MATH 161 Mathematical Reasoning and Modeling [3]
	MATH 163 College Algebra [3]	MOTR 130:	MATH 163 College Algebra [3]	MOTR 130:	MATH 163 College Algebra [3]
	MATH 131 Mathematics for the Elementary Teachers [3]	Other:	MATH 162 Mathematics for Elementary Teachers [4]	Other:	MATH 162 Mathematics for Elementary Teachers [4]
Prerequisites for each Pathway [credit hours, NC non-credit course]	MATH 01 Transitional Math I [4 NC]	**For MATH 161:** MATH 01 Transitional Math I [4 NC]		**For MATH 161:** MATH 02 Transitional Math II [4 NC]	
	MATH 02 Transitional Math II [4 NC]	MATH 02 Transitional Math II [4 NC]			
	MATH 103 Intermediate Algebra [4]				
		For MATH 162: MATH 02 Transitional MATH I[4 NC]		**For MATH 162:** MATH 02 Transitional MATH [4 NC]	
		For MATH 163: MATH 01 Transitional Math I [4 NC]		**For MATH 163:** MATH 02 Transitional Math II [4 NC]	
		MATH 02 Transitional Math II [4 NC]		MATH 103 Intermediate Algebra [4]	
		MATH 103 Intermediate Algebra [4]			
Grading and Progression	Completion of Content.	Minimum grade of "C" or better		Minimum grade of "C" or better	
Modality of Prerequisites	Emporium	Emporium		Emporium	
Maximum Number of Hours in Sequence / Number of Semesters to Complete (including college-level and required corequisite courses)	15 Hours / Varies	**For MTH 161:** 11 Hours / Varies		**For MTH 161:** 7 Hours / 2 Semesters	
		For MTH 163: 15 Hours / Varies		**For MTH 163:** 11 Hours / Varies	

Corequisites [Credit Hours]	None	None	None
Modality of Corequisites	N/A	N/A	N/A
Description and Rationale of Corequisite Structure	N/A	TRC chose to flatten the developmental sequence, combine course content, and accelerate students through the course sequence.	TRC chose to flatten the developmental sequence, combine course content, and accelerate students through the course sequence.
Who Takes Corequisites	N/A	N/A	N/A
Relationship with college-level course.	N/A	N/A	N/A
Same Instructor	N/A	N/A	N/A
Grading Procedures	N/A	N/A	N/A
Retaking Entry-Level and Coreq	N/A	N/A	N/A
Offered online?	N/A	N/A	N/A
Shared Content for Corequisite	N/A	N/A	N/A
Soft Skills/Study Skills Included	N/A	N/A	N/A
Limit to Number of Students in Corequisite	N/A	N/A	N/A
Attendance Taking institution	Attendance Taking Institution		

Appendix B

Data Cleaning Decisions

Many decisions were made regarding which cases to include in the study. Only first-time, full-time (FTFT) and degree-seeking students were selected. Any student marked as a high school student was deleted. Six cases were deleted because they were marked first-time, full-time in both 2014 and 2018, and also five cases were deleted because that they were claimed by two different institutions. Fifteen additional cases were deleted because they were enrolled for the first-time in 2015 or 2016. After all deletions, 27,665 cases remained.

Persistence

A student was considered as persisted if they were enrolled in consecutive fall semesters (i.e. Fall 2014/2015 or Fall 2018/2019). The researcher identified students who transferred between community colleges in the study (i.e. students enrolled in one college Fall 2014 and another college in Fall 2015). The researcher identified 509 transfer students. These students were included in the statewide persistence rate calculations. They were excluded in the individual college persistence rate calculations.

Entry-level Math Completion Rates

The original data set contained 1,375,653 cases including courses and outcomes for community college students in the summer, fall, winter-intersession, and spring semester in the 2014-2015 and 2018-2019 academic year. The researcher first worked to identify mathematics courses. Each course was identified with a Classification of Instructional Programs (CIP) code. A 2701, 2703, or 2705 designated a mathematics, technical mathematics, or statistics course. Some mathematics courses were designated a 270 in error. The data included 107,997 cases designated as mathematics courses.

Courses designated 3201, 320, 9000, or 900 could be a variety of different courses including mathematics courses. The researcher went through these courses and identified the mathematics courses by considering course title. The data included 45,766 cases designated as developmental (3201) or miscellaneous (9000) that appeared to be mathematics courses. Courses with other CIP codes were deleted. Any courses marked as dual credit or concurrent enrollment were deleted.

Several errors in the field indicating the academic term were identified. It was quickly determined that the 2,022 cases with errors were from Crowder College. The researcher called Chett Daniels, Director of Institutional Research at Crowder College, and he was able to correct the mistakes. Each course was coded for level (i.e. developmental, corequisite, or college-level). Errors in the data regarding course level were also corrected by researcher. Intermediate Algebra courses were given a separate course-level designation by the researcher. These courses were not considered college-level at any college by the study.

The data set included 21 different grade designations including A, B, C, D, F, AW, CR, P, PR, R, S, TD, X, etc. The researcher worked to identify the meaning of each designation by looking at the registrar's webpage at multiple colleges. The grade designations were identified as receiving credit or not receiving credit. If a reasonable determination could not be made, the case was deleted. After all deletions, 150,300 cases remained.

Finally, the researcher matched the course data with the same list of FTFT, degree-seeking students created in the persistence rates calculations. Any case not matched with a FTFT student was deleted. If a student appeared to take identical classes at two institutions, that student was assigned to the institution that claimed FTFT status. The data was restructured so that each individual made only one case, and 27,665 cases remained.

If students completed a college-level (non-developmental) mathematics course (excluding Intermediate Algebra) with a passing grade in the summer, fall, winter-intersession, or spring semester of their first academic year, they were considered to have completed.

SECTION FIVE: CONTRIBUTION TO SCHOLARSHIP

Article Title: Transforming Mathematics Education at Missouri Community Colleges

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To be submitted to the *Community College Review*

Abstract

In an effort to raise graduation rates, the Missouri Department of Higher Education and Workforce Development directed public institutions to establish policies and create corequisite support structures to allow some underprepared students to take entry-level mathematics courses without first completing non-credit remedial courses. The present study explored the variety and effectiveness of corequisite structures implemented at 12 independent public community colleges in Missouri. Using a pragmatic parallel mixed method research design, this study used highly structured interviews and data from the Enhanced Missouri Student Achievement Study to address the research question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? This study described the unique structures and policies implemented at the colleges and using a chi-square test for homogeneity, compared the statewide and college persistence rates and completion rates of entry-level mathematics courses for students beginning in Fall 2014 and Fall 2018. The findings indicated that the statewide persistence rates increased but the increase was neither widespread nor consistent amongst the 12 individual colleges in the study; however, the increase in completion rates of entry-level mathematics courses was widespread and consistent with 11 of the 12 colleges seeing statistically significant increases. The study identified four conceptualizations of corequisite supports and noted that colleges allowing underprepared students greater access to non-STEM pathway courses with corequisite support saw the highest completion rates of entry-level mathematics courses.

Keywords: community colleges, mathematics pathways, corequisite remediation

Every year in the United States, nearly 10 million students seek the skills and education necessary to attain better opportunities at community colleges (Bailey, Jaggers & Jenkins, 2015). Access to education remains a core value of community colleges; thus, many 2-year institutions maintain open enrollment policies that allow anyone to enter regardless of educational background. Using data from the National Education Longitudinal Study (NELS), Attewell, Lavin, Domina, and Levey (2006) determined that 58% of community college students were identified as underprepared for college-level work and placed in at least one remedial course. Remedial or developmental courses are considered below college-level and do not receive credit towards any degree or credential. Monaghan and Attewell (2015) found that students attending community colleges were 19.2% more likely to be assigned to mathematics remedial courses than their academic equivalent peers attending universities.

Graduation rates for underprepared students placed in remedial education courses were significantly lower than students placed directly into college-level courses (Adelman, 1992; Complete College America 2012); moreover, several recent studies have concluded that traditional developmental sequences typically made of up of two or three courses may even harm rather than benefit students placed into them (Calcagno & Long, 2008; Martorell & McFarlin, 2011; Xu & Dadgar, 2018).

In a corequisite system, underprepared students are registered for college-level mathematics courses and concurrently enrolled in additional credit hours that provide support for their academic deficiencies (Center for Community College Student Engagement, 2016), and some underprepared students earn more college-level credit faster in a corequisite system and graduate at a higher rate (Logue, Watanabe-Rose, &

Douglas, 2016; Logue, Douglas, Watanabe-Rose, 2019). In response to statewide initiatives, nearly all Missouri public community colleges have established corequisite remediation structures for at least one mathematics entry-level course (MDHE, 2019), but each of the twelve independent public community colleges conceptualized and implemented its corequisite classes differently. The ubiquitous nature of corequisite remediation in Missouri makes the evaluation of effectiveness and the identification of good practices of urgent concern.

Purpose

Using a pragmatic parallel mixed method design (Mertens, 2019), the purpose of this study was to explore the variety and effectiveness of the many structures and policies governing corequisite supports at Missouri two-year institutions. Both quantitative and qualitative data were collected simultaneously, analyzed, and integrated to answer the study's research question (Mertens, 2019). This study included interviews of mathematics faculty at 12 public community colleges in Missouri to determine how each college structured its remedial education courses. Policies governing placement, grading, progression, and content delivery were gathered for analysis. Concurrently, this study analyzed student level data collected as part of the Enhanced Missouri Student Achievement Study (EMSAS) by the Missouri Department of Higher Education and Workforce Development (MDHEWD). Statewide and individual college persistence rates and completion rates of entry-level mathematics courses were calculated. Data from the 2014-2015 academic year (before the widespread implementation of mathematics pathways and corequisite courses) were compared to data from the 2018-2019 academic year.

Research Questions

This mixed method study examined the research question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? In order to answer this question, two subquestions were examined with each question requiring a different kind of data. The subquestions were:

(1) What corequisite mathematics course structures and policies are in place at community colleges in Missouri? (Qualitative Strand)

(2) What is the impact of those structures and policies on persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? (Quantitative Strand)

Theoretical Framework and Existing Literature

Using data from the National Education Longitudinal Study, Adelman (1999, 2006) observed that students who enroll in college soon after high school, maintain continuous enrollment, and earn more credit in their first year were more likely to graduate. He termed this factor *academic momentum*. Adelman (2006) determined that students who lost academic momentum and failed to complete at least 20 hours of college credit in the first year were one-third less likely to graduate from college.

In a further investigation of these observations, Driscoll (2007) found high correlations between first term intensity and enrolling for the next semester as well as transfer and degree earning rates. Interested in these findings, Doyle (2011) sought to determine if the observed relationship between more credit earned by community college students and transfer rates was merely a result of selection bias. Doyle (2011) concluded that there was “substantial evidence that increasing the number of credit hours taken in the first year is likely to increase transfer rates… [T]his result does not appear to be due solely to selection bias” (p. 199).

Later, Attewell, Heil, and Reisel (2012) attempted to delineate a theory of academic momentum contending that students’ progress towards a degree in their initial semester, or early momentum, influences the likelihood of graduation. Students beginning college part-time were less likely to graduate, and initial progress towards a degree was related to graduation regardless of a student’s sociodemographic background or academic preparation. Grounded in Tinto’s (1993) theory of college student retention, Attewell, et al. (2012) posited that greater academic intensity increased the integration of students into the academic community through increased time with peers and faculty thus increasing persistence. In a later study, Attewell and Monaghan (2016) found that students who enroll in 15 credit hours in their first semester graduate at a significantly higher rate than academically and socially similar students who enrolled in fewer hours; in addition, students who increased their course load to 15 credit hours in their second semester were also more likely to graduate than their peers who took less, but this increased likelihood of graduation did not hold for students working more than 30 hours a week. Attewell and Monaghan (2016) noted differences based on credit-load, observing “undergraduates who take more credits in their first semester are younger, whiter, more affluent and more likely to have college educated parents…less likely to have dependents or to work full-time” (p. 687). Belfield, Jenkins, and Lahr (2019) conducted a study on full-time students in Tennessee. They found that only 28% of community college students took 15 or more credit hours in their first semester, but the researchers could not control for occupational or financial status.

In response to previous studies, Davidson and Blankenship (2017) argued that *earned college-level* credit hours rather than *attempted* credit hours established beneficial academic momentum. Considering all first-time, full-time freshman enrolled at public institutions in Kentucky, Davidson and Blankenship (2017) found that only 4% of students enrolled in two-year institutions earned 30 college-level credit hours by the end of the first year, and 77% of these students persisted to their second year as compared to only 48.7% of students who earned less than 30 credit hours in their first year. Davidson and Blankenship (2017) considered noncredit developmental education courses a “detriment” to establishing beneficial academic momentum (p. 479).

Legislation and State-led Initiatives Affecting Mathematics Instruction at Community Colleges in Missouri

In 2011, Governor Jay Nixon and Missouri Department of Higher Education (MDHE) announced “Missouri’s Big Goal for Higher Education” seeking 60% of working age adults to have a postsecondary credential by 2025 (MDHE, n.d.). In the same year, 64% of students entering a public two-year college in Missouri took at least one developmental course (Radford, Pearson, Ho, Chambers & Ferlazzo, 2012). In 2012, Missouri signed HB 1042 into law requiring public institutions to replicate best practices in developmental education (MO HB 1042, 2012). The Coordinating Board of Higher Education’s (CBHE) *Principles of Best Practices in Remedial Education* identified mathematics pathways (aligning different entry-level mathematics courses to areas of study) and corequisite remediation as best practices (CBHE, 2013).

In the fall of 2014, MDHE, now the Missouri Department of Higher Education and Workforce Development (MDHEWD), formed the Missouri Mathematics Pathways Task Force (MMPT) and directed it to explore options and make recommendations for increasing student success rates in entry-level mathematics courses (MMPT, 2015). The initiative was funded in part by Complete College America in collaboration with the Charles A. Dana Center at the University of Texas at Austin. The taskforce was made up of mathematics faculty from 26 different public colleges and universities across the state and staff members of MDHE (MMPT, 2015). The task force developed four mathematics pathways: Precalculus Algebra, Precalculus, Statistical Reasoning, Mathematical Reasoning and Modeling. The task force agreed upon a set of common student learning outcomes (SLOs) which each course must fulfill in order to be accepted as a pathway course by the state (MDHEWD, 2017).

In 2016, Missouri Governor Jay Nixon signed a bill including the "Higher Education Core Curriculum Transfer Act" (Sections 178.785-178.789 RSMo) which directed the creation of a 42-hour common course curriculum for general education (MO SB 997, 2016). By legislative mandate, mathematics pathways courses meeting the SLO's and accepted into CORE 42 transferred to all Missouri public 2-year and 4-year institutions and to participating private institutions as fulfilling the general education requirement (MDHEWD, n.d.). As a result, community colleges no longer were concerned about transferability and all of them developed at least two pathway courses by Fall 2018.

In 2016, Missouri was selected by Complete College America to participate in its Corequisite at Scale Initiative and formed the Missouri Corequisite at Scale Taskforce

(MCST) (MDHE, 2016). States participating in CCA's initiative committed to scaling corequisite remedial education—that is, 75% of students needing remediation receive it in a corequisite model (MDHE, 2016). Missouri urged its public colleges and universities to offer support of mathematics pathway courses using the corequisite model alongside or in place of the prerequisite model (CBHE, 2015).

In the spring of 2017, nearly all Missouri public institutions signed a memorandum of understanding that stated the institution would create, "a system of academic support for underprepared students that includes…support for the vast majority of underprepared students while students are enrolled in the gateway course or learning gateway content, as a corequisite" (E. Anderson, personal communication, April 8, 2017). All Missouri public institutions have experienced significant change in their mathematics course structures and content in the last three years (MDHE, 2019).

The 12 community colleges included in this study are separate and independent open enrollment institutions established in local elections (MCCA, 2017). Each college confers associate degrees and a variety of certificates serving the local needs of its own region (MCCA, 2017). In fall of 2018, 82,293 students attended these 12 community colleges representing approximately 36% of all students attending public higher education institutions in Missouri (MDHE, 2018). Although colleges may collaborate, each community college decided independently how to respond to legislation and state-led initiatives. The ambiguous nature of the mandates led to disparate structures and policies surrounding mathematics pathways and corequisites courses.

Methods

This study utilized a pragmatic parallel mixed method design (Mertens, 2019). Creswell (2014) stated that mixed method approaches involve "collecting both quantitative and qualitative data" and "integrating the two forms of data" (p. 4). The qualitative and quantitative data in this study was collected and analyzed concurrently (Creswell, 2014**).** This study included 12 public community colleges represented by the Missouri Association of Community Colleges (MCCA). Two institutions, despite being public two-year colleges, were not included in this study, i.e., State Technical College and Missouri State University, West Plains.

Answering Subquestion 1 (Qualitative Strand)

In order to answer the first subquestion (What corequisite mathematics course structures and policies are in place at community colleges in Missouri?), the academic catalogs of each community college in the study for the 2014-2015 and 2018-2019 academic year were analyzed. A summary and holistic description of the policies and structures of remedial, corequisite, and pathway courses was developed for each community college. Data such as credit type (i.e. college-level or non-credit), number of credit hours, grading procedures, course progression, and modalities were identified for each college in the Fall of 2014 and 2018. Then highly structured interviews—that is, interviews with predetermined questions and order—were conducted with mathematics department chairs or full-time mathematics faculty at each of the 12 community colleges (Merriam & Tisdell, 2016).

Each interview was recorded and transcribed. Data pertinent to the research question was identified and categorized. The summary and description of each college was corrected and enhanced by the information collected in the interviews. Finally, interviewees were given the opportunity to review and correct the summaries; that is, the study employed "member checking" as a validation strategy (Creswell, 2014, p. 201). Individuals from 9 of the 12 colleges responded and reviewed summaries.

Answering Subquestion 2 (Quantitative Strand)

In order to answer the second subquestion (What is the impact of those structures and policies on persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri?), student-level data collected as part of the Enhanced Missouri Student Achievement Study (EMSAS) by the Missouri Department of Higher Education and Workforce Development was analyzed. The study considered first-time, full-time (FTFT), degree-seeking students enrolled in the Fall 2014 and Fall 2018 at the 12 public community colleges in the study.

Persistence rates. Student persistence rates were calculated. A FTFT student enrolled in consecutive fall semesters (i.e. Fall 2014/2015 or Fall 2018/2019) was considered to have persisted. A chi-square test for homogeneity (Triola, 2018) was conducted using the following hypotheses:

H_0: The number of students not persisting to the next semester is independent of remedial structures.

H_1: The number of students not persisting to the next semester is dependent on remedial structure.

Completion rates. Completion was defined as earned college credit (i.e., assigned a passing grade) in a pathway (entry-level) mathematics course. Despite commonly considered college-level, Intermediate Algebra was not counted as a completion because Intermediate Algebra most commonly leads to the Precalculus Algebra pathway course. The number of students at each institution and statewide having completed a college-level mathematics course in the summer, fall, intersession, or spring semester of their first academic year was counted for the 2014 and 2018 cohorts. A chi-square test for homogeneity was conducted using the following hypotheses:

H_0: The number of students completing an entry-level math requirement is independent of remedial structures.

H_1: The number of students completing an entry-level math requirement is dependent on remedial structures.

In both the persistence and completion comparisons, the *Yate's Continuity Correction* was not used; instead the *Pearson Chi-Square* statistic was reported (Field, 2018).

Integration of the Qualitative and Quantitative Data

Qualitative and quantitative data from each college was analyzed independently—consistent with the parallel mixed method approach (Mertens, 2019). The researcher conducted a "side-by-side comparison" of the qualitative and quantitative data from each college (Creswell, 2014, p. 222). The researcher noted commonalities and differences in structure and compared completion and persistence rates. Finally, patterns were identified that may suggest better practices in the implementation of corequisite remediation.

Limitations

This study did not attempt to follow students that transferred to any institution not among the 12 public community colleges in the study. Any student who transferred outside the group between consecutive fall semesters was considered to have not persisted. Any student who transferred during the first academic year before completing an entry-level mathematics courses was considered to have not completed. Students completing Intermediate Algebra were considered to have not completed a college-level mathematics course although a limited number of degree programs may accept the course as fulfilling its mathematics requirement.

The 2014 and 2018 cohorts were compared using a chi-square test for homogeneity. The sample size in the study, particularly for statewide comparisons, was very large; thus, small differences detected among the two cohorts were found to be statistically significant (Field, 2018). Statistically significant results needed to be carefully considered in the larger context in order to determine if the difference was substantive, that is, practically significant.

The greatest limitation of this study stems from the timing of major statewide initiatives in Missouri. Public Missouri community colleges responded to multiple mandates between 2014 and 2018 and were urged to institute the following: (a) the creation of entry-level mathematics pathway courses with common student learning outcomes and guaranteed transferability, (b) the development and implementation of multiple measures in order to place students in developmental and entry-level mathematics pathway courses, and (c) the creation of corequisite courses supporting the mathematics pathway courses and reducing the use of developmental, non-credit sequences. The simultaneous implementation of these reforms made disentangling their effects very difficult if not entirely impossible.

Findings

Description of Structures and Policies Surrounding Corequisite Mathematics Courses at Missouri Community Colleges (Subquestion 1)

In this study, a mathematics pathway course is defined as a course accepted into Missouri's Core Transfer Curriculum (CORE 42) and fulfills the general education requirement for mathematics at any Missouri public college or university. Three of the pathways are considered entry-level or gateway mathematics courses: (a) the Mathematical Reasoning and Modeling (MRM) pathway, (b) the Statistical Reasoning (SR) pathway, and (c) the Precalculus Algebra (PA) pathway. The remaining pathway, Precalculus, may or may not be considered entry-level, and no community college has developed a corequisite for this course; thus, it will not be considered here.

The PA pathway is considered by most institutions to be for students entering fields in science, technology, engineering, and math (STEM). The MRM and SR pathways are considered to be for students studying other non-STEM fields.

Pathway and corequisite development. In 2018, every college in the study had MRM and PA pathway courses developed and accepted into Core 42. Most schools (10) also developed a SR pathway course. Five schools had developed a corequisite support for the PA pathway, nine schools had developed a corequisite support for the SR pathway, and nine schools had developed a corequisite support course for the MRM pathway. Table 1 displays the mathematics pathway and corequisite courses created at each college by Fall 2018.

Table 1

Number of Community Colleges with Established Mathematics Pathways and Corequisites in Fall 2018

	Precalculus Algebra (PA) Pathway[a] (MOTR 130)	Mathematical Reasoning & Modeling (MRM) Pathway[a] (MOTR 120)	Statistical Reasoning (SR) Pathway[a] (MOTR 110)
Crowder College (CC)	*P*	*PC*	*PCN*
East Central College (ECC)	*P*	*P*	*PCN*
Jefferson College (JC)	*PC*	*PC*	*PCN*
Metropolitan Community College (MCC)	*P*[b]	*P*	*P*
Mineral Area College (MAC)	*PC*	*PC*	*PC*
Moberly Area Community College (MACC)	*P*	*PC*	*PC*
North Central Missouri College (NCMC)	*PC*	*PC*	*PC*
Ozarks Technical Community College (OTC)	*PC*	*PC*	
St. Charles Community College (SCCC)	*PC*	*PCN*	*PCN*
St. Louis Community College (STLCC)	*P*	*PC*	*PC*
State Fair Community College (SFCC)	*P*	*PC*	*PC*
Three Rivers Community College (TRC)	*P*	*P*	

Note. *P* denotes an established pathway course. *PC* denotes an established pathway and corequisite course. *PCN* denotes an establish pathway course and developed corequisite course, but as of Spring 2020, no corequisite course had been delivered.

[a]Mathematics pathway courses are accepted into Missouri's Core Transfer Curriculum (Core 42) and fulfill the general education mathematics requirement at any Missouri public college or university.

[b]Began offering a corequisite in Fall 2019.

The most common corequisites developed among the 12 public community colleges were paired with the MRM and SR pathway courses. The least common corequisite developed by Missouri public community colleges was for the PA pathway. Only 8 (of 9) MRM and 5 (of 9) SR corequisite courses existing in 2018 had at least one section delivered by spring of 2020. Several colleges noted difficulty in enrolling enough students into the corequisite sections for the course to remain on the schedule of offered courses.

Prerequisite courses. In 2014, all Missouri community colleges required students to complete the same sequence of algebra-based prerequisite courses for all college-level mathematics courses. In 2015, The Missouri Mathematics Pathways Task Force (MMPT) reported that the Missouri Coordinating Board of Higher Education's (CBHE) policy regarding prerequisites for entry-level mathematics courses stated, "The mathematics requirement for general education should have the same prerequisite(s) and level of rigor as College Algebra" (as cited in MMPT, 2015, p. 7), or that is, Intermediate Algebra should be a prerequisite for every entry-level mathematics course. MMPT strongly recommended that this policy be removed (MMPT, 2015), and CBHE later discarded the policy before Fall 2018.

Unfettered by statewide policy, most institutions created distinct prerequisite requirements for the PA pathway course and the SR and MRM pathway courses. All institutions with the MRM and SR pathways created the same (if any) developmental sequence for both non-STEM pathways. As shown in Table 2, most schools retained but compressed their developmental sequences as they developed and implemented corequisite courses.

Table 2

Planned Prerequisite Credit Hours and Sequence of Courses for Students Placing at the Lowest Level of Developmental Mathematics Education among 12 Missouri Community Colleges

Measures of Remedial Sequence	2014			2018								
	All Courses			MRM Pathway Courses			SR Pathway Courses			PA Pathway Courses		
	M	SD	Min-Max	M	SD	Min-Max	M	SD	Min-Max	M	SD	Min-Max
Credit hours planned before entry-level course	9.83 (*n* = 12)	2.27	4-12	4.75 (*n* = 12)	3.29	0-12	4.90 (*n* =10)[a]	3.11	0-12	7.42 (*n* = 12)	3.35	0-12
Courses planned in the sequence before entry-level[b] course	3.25 (*n* = 8)[c]	0.43	3-4	1.27 (*n* = 11)[d]	0.86	0-3	1.40 (*n* =10)[a]	0.80	0-3	1.82 (*n* = 11)[d]	0.83	0-3

Note. In 2014, all entry-level mathematics courses at public Missouri community colleges had the same prerequisite sequence including Intermediate Algebra. In 2018, community colleges established different prerequisite sequences for their Mathematical Reasoning and Modeling (MRM), Statistical Reasoning (SR), and Precalculus Algebra (PA) pathways.

[a] Only 10 of the 12 community colleges in Missouri had established a SR pathway in Fall 2018.

[b]Intermediate Algebra was not considered an entry-level course.

[c] Four community colleges utilized the emporium model in 2014 and number of courses did not apply.

[d] One community college utilized the emporium model in 2018 and number of courses did not apply.

Only 5 institutions created structures including corequisites for both the STEM and non-STEM pathways. The STEM pathway most often possessed a longer prerequisite sequence than the other pathways. More than half of the colleges in the study (7) had not created a corequisite option for the PA pathway in 2018. Only two community colleges, Jefferson College (JC) and St. Charles Community College (SCCC), required the same prerequisite sequence for all its pathways, and Ozarks Technical Community College (OTC) required no prerequisite courses for its pathways.

In 2014, the average number of prerequisite credit hours planned before beginning any entry-level course for a student placing at the lowest level of developmental education at a Missouri public community college was 9.83 hours; by 2018, the average number of planned prerequisite hours had fallen to 4.75 hours for a student in the MRM pathway and to 4.90 hours for a student in the SR pathway. The decline was not as drastic for students in the PA pathway; the lowest placing students were planned to complete on average 7.42 hours before attempting the PA pathway course.

Placement. Placement (i.e. required enrollment) into corequisite courses varied among the colleges. Five colleges, East Central College (ECC), Metropolitan Community College (MCC), North Central Missouri College (NCMC), St. Charles Community College (SCCC), and St. Louis Community College (STLCC), created corequisite courses exclusively for incoming students placing just below the cut score for the pathway course. In addition to placement test scores (e.g. ACT, ACCUPLACER), all five of these schools considered high school grade point average (HSGPA) when determining in which course(s) a student must enroll. Some colleges considered previously taken math courses in placement decisions. At these five colleges, students scoring below a combined measure (e.g. test score and HSGPA) entered a developmental, non-credit sequence and were never required to enroll in corequisite courses at any time.

Crowder College (CC) created corequisite courses for all underprepared students entering its non-STEM pathway courses. That is students scoring at any level below its combined measure (including HSGPA, test scores, and recently taken math courses) were able to take the non-STEM pathway courses with corequisite support; however, CC students were required to pass a basic skills test to avoid adult education. For students in the STEM pathway, CC students were placed into a sequence of prerequisite courses with no option for corequisite support.

Four schools, Jefferson College (JC), Mineral Area College (MAC), Moberly Area Community College (MACC), and State Fair Community College (SFCC), enrolled incoming students scoring just below a similar combined criteria of multiple measures into the pathway and corequisite courses, but they also required students completing any part of the non-credit developmental sequence to enroll in the corequisite course once they reached the pathway course. One college, Ozarks Technical Community College (OTC), did not require corequisite courses for any student. OTC's placement mechanism, "Guided Self-Placement," offered course recommendations based on the student's degree program, ACT score, HSGPA, previous experience in math class, and current math knowledge, but ultimately, left enrollment decisions in pathway and corequisite courses up to the student. Every college in the study offering corequisites (11) allowed any student taking a pathway course to opt into a corequisite course. Table 3 displays which students are required to take corequisite courses at each community college in the study.

Table 3

Students Required to Take Corequisite Courses at Missouri Community Colleges

	Precalculus Algebra (PA) Pathway[a]	Mathematical Reasoning & Modeling (MRM) Pathway[a]	Statistical Reasoning (SR) Pathway[a]
Crowder College (CC)		*U*	*U*
East Central College (ECC)			*M*
Jefferson College (JC)	*M, D*	*M, D*	*M, D*
Metropolitan Community College (MCC)	*M*[b]		
Mineral Area College (MAC)	*M, D*	*M, D*	*M, D*
Moberly Area Community College (MACC)		*M, D*	*M, D*
North Central Missouri College (NCMC)	*M*	*M*	*M*
Ozarks Technical Community College (OTC)	*NR*	*NR*	
St. Charles Community College (SCCC)	*M*	*M*	*M*
St. Louis Community College (STLCC)		*M, D*	*M, D*
State Fair Community College (SFCC)		*M*	*M*
Three Rivers Community College (TRC)			

Note. *M* denotes marginally underprepared, incoming students (i.e. students scoring just below the cutoff for a pathway course). *U* denotes all underprepared, incoming students (i.e. students scoring below the cutoff for the pathway course). *D* denotes students who completed any prerequisite developmental course. NR denotes that corequisites are not required for any student.
[a]Mathematics pathway courses are accepted into Missouri's Core Transfer Curriculum (Core 42) and fulfill the general education mathematics requirement at any Missouri public college or university.
[b]Began offering a corequisite in Fall 2019.

Conceptualization of corequisite courses. In Missouri, public community colleges are independent institutions (MCCA, 2017). In creating corequisite offerings, colleges determined what worked best for their own students and faculty and made decisions regarding content, structures, and policies independently. Emerging from the analysis of data from the qualitative portion of the study, the researcher identified four major conceptualizations of corequisites. Each of the 12 institutions in the study could be placed into one of four types: (a) compressed sequences, (b) separate and prescriptive, (c) separate and nonprescriptive, (d) embedded and nonprescriptive.

Compressed sequences. Compressed sequence corequisites merge developmental and pathway courses. This strategy reduces the number of classes students are required to complete before attempting the mathematics pathway course. Prerequisite content is included in the entry-level course, and the additional skills and objectives are treated largely the same as the original content of the pathway course. Two colleges, North Central Missouri College (NCMC) and Three Rivers College (TRC), chose this strategy in developing their pathway and corequisite courses. TRC eliminated the longer developmental sequence completely and did not create corequisite courses. NCMC preserved its traditional, slower sequence as an option and defined the accelerated, combined courses as its *corequisites*. Each of its 6-credit hour corequisite courses replaced a two-course sequence and awarded college-level credit to students if any portion of the content received college credit in the traditional sequence.

Separate and prescriptive corequisites. Many schools chose to create a separate course taken at the same time as the pathway course. These corequisite courses were distinct from the pathway course with unique, predetermined objectives and content. Instructors could add topics to their individual courses, but they were required to cover prescribed content. These corequisite courses covered prerequisite skills, utilized just-in-time review, and previewed upcoming topics in the pathway course. Six schools (CC, ECC, JC, MAC, MACC, and SFCC) chose this strategy in developing their corequisite courses. These courses ranged from 1- to 3-credit hours, and all except SFCC considered the corequisite courses as developmental, non-credit courses.

Among these six institutions, the linkage between the corequisite and the pathway course ranged from tightly coupled to disconnected. Two institutions (MACC and SFCC) linked a section of the corequisite to a particular section of the pathway course with the same instructor (i.e. the corequisite was a subset of the students who were in the same section of the pathway course). Two other schools (ECC and JC) required that the instructor of the pathway course also be the instructor of the corequisite course but allowed students to take any section of their pathway instructor's corequisite courses. The remaining two colleges (CC and MAC) allowed students to enroll in any combination of pathway and corequisite courses regardless of instructor.

Among the six in this category, five colleges offered their corequisite in the traditional classroom. The remaining college, MAC, created a corequisite utilizing the emporium model. Its students worked through computer aided modules of prerequisite content. After one year, the college determined that students struggled with the amount of work the corequisite required and did not recognize or understand the connection between the corequisite content and the pathway content. By 2020, this college had abandoned this modality and created traditional classroom corequisite courses.

Grading practices also varied widely among these six colleges. Three of these schools' corequisites courses were pass/fail and three were graded traditionally (ABCDF). One school (JC) made a major portion of the corequisite's grade (ABCDF) the grade of the pathway course. At another school (MAC), a passing grade in the pathway course resulted in a passing grade for the corequisite and a failing grade in the pathway course resulted in a failing grade for the corequisite. All of these corequisites courses had their own graded assignments, quizzes, and projects. For many, participation and attendance also factored into the final grade.

Several different policies governed the retake of corequisite courses if a student failed the pathway course. Two schools (EC, JC) had no articulated policy on retaking a corequisite at all. Two schools (CC, MAC) determined that students failing the pathway course must retake both the pathway and the corequisite (regardless of the outcome in the corequisite), and two institutions (MACC, SFCC) required students who passed the corequisite but failed the pathway course to retake only the pathway. Only SFCC allowed students to pass the pathway and fail the corequisite. This policy created a scenario where a student could possibly receive an “F” that could not be replaced by retaking the course since corequisite courses cannot be taken in isolation. All other institutions in this group awarded a passing grade in the corequisite course if the pathway course was completed successfully.

Separate and nonprescriptive corequisites. Some schools chose to create separate corequisite courses with only general objectives. Instructors were given nearly complete freedom to spend the time with the students in any way they saw fit. Three institutions, Metropolitan Community College (MCC), St. Charles Community College (SCCC), and St. Louis Community College (STLCC), chose this strategy while developing their corequisite courses.

These corequisite courses were non-credit developmental, 2-credit hour courses. All courses were delivered in the traditional classroom with the content of the class left up to the instructor. Grading procedures were also left to the instructor's discretion although these schools automatically awarded a passing grade to students who passed the pathway course. These institutions under no circumstances required students to retake the corequisite.

Of these three colleges, only one (SCCC) required that students have the same instructor for the pathway and corequisite courses. Students at SCCC were allowed to enroll in any section of the corequisite with the same instructor of their pathway course. The remaining two colleges highly recommended but did not require students to take the same instructor for the pathway and corequisite courses.

Embedded and nonprescriptive. The final institution, Ozarks Technical Community College, embedded the corequisite content and credit hours into the pathway course. This institution offered a 3-credit hour pathway course or a 4-credit hour pathway with corequisite support. Both courses were awarded college-level credit. Instructors were given the freedom to use the additional time as they saw fit. Since one grade was given for the pathway and corequisite content, instructors were directed to allow no more than 15% of the overall grade to be from assisted work (e.g. homework and classroom activities). The policies governing grading and retaking failed courses were the same for both the pathway course and the pathway course with corequisite support.

Online corequisite courses. All 12 community colleges in the study offered their mathematics pathway courses online; however, in 2018 none of them offered corequisite courses online. By 2020, MACC had developed what they termed a *virtual corequisite* course. This school offered a virtual corequisite option exclusively to students enrolled in the online mathematics pathway courses. *Virtual* differed from *online* instruction in that students were required to login at a specific time to attend class; that is, according to the college's definition online instruction was asynchronous and virtual instruction was synchronous. The virtual sections of the corequisite class put a heavy emphasis on connection and building community.

Inclusion of soft and study skills instruction. Most schools in the study did not formally include soft or study skill topics in their pathway or corequisite courses although all colleges allowed instructors to add such topics if they desired. The three colleges (CC, JC, SFCC) that did include these skills focused on test preparation, collaboration skills, note-taking, and reflection activities. SFCC found these topics very helpful and chose to move the topics into the pathway course.

Impact of Structures and Policies on Persistence and Completion Rates (Subquestion 2)

Persistence rates. Persistence rates of full-time, degree seeking students enrolled in Missouri community colleges for the first-time in Fall 2014 and Fall 2018 were compared using the chi-square test of homogeneity ($\alpha = 0.05$). For statewide results, students enrolled at any Missouri community college for two consecutive fall semesters (Fall 2014/2015 or Fall 2018/2019) were considered to have persisted. Students who transferred to any institution not among the 12 community colleges in the study were considered to not have persisted.

In 2014, 57.1% of first-time, full-time students (N = 14,461) persisted to the Fall 2015 semester, and in 2018, 60.1% of students (N = 13,204) persisted. As shown in Table 4, the 2018 cohort was more likely to persist and the difference between the cohorts was statistically significant, $\chi^2(1, N = 27{,}665) = 25.763$, $p < 0.001$.

Table 4

Comparison of the Persistence in First-time, Full-time Degree-seeking Students Enrolling at Missouri Community Colleges in Fall 2014 and Fall 2018

	2014 (N = 14461)		2018 (N = 13204)					
	N	%	N	%	Diff	χ^2	df	p
Persisted	8254	57.1%	7934	60.1%	3.0%	25.763	1	<.001

Note: Persisted is defined as enrolled in a Missouri community college for two consecutive fall semesters (i.e. Fall 2014/Fall 2015 or Fall 2018/Fall 2019).

The analysis was then repeated for each of the 12 community colleges in the study excluding 509 students who transferred among the public community colleges. As seen in Table 5, though the results were significant for the state, only three community colleges, MCC, χ^2 (1, N = 4,797) = 10.801, p = 0.001, STLCC, χ^2 (1, N = 4,585) = 31.866, p < 0.001, and OTC, χ^2 (1, N = 3,979) = 5.162, p = 0.023, saw a statistically significant change in persistence rates among their 2014 and 2018 cohorts.

These three colleges are also the largest community colleges in the state and accounted for nearly half of the statewide sample (N = 27,665). Moreover, STLCC singularly increased its persistence rate by 8.3%, and due to its sizable enrollment, STLCC may have largely driven the statewide increase in persistence rates. During the same time, OTC's persistence rate decreased by 3.6%. The change in other colleges' persistence rates ranged between −2.1% to +4.8%. Although the statewide increase in persistence rate was found to be statistically significant, the change among individual community colleges was neither widespread nor consistent; therefore, the statewide increase may not be substantively significant for this study.

Table 5

Comparison of the Persistence in First-time, Full-time Degree-seeking Students Enrolling at Individual Missouri Community Colleges in 2014 and 2018

	Persisted, 2014		Persisted, 2018					
	N	%	*N*	%	Diff	χ^2	*df*	*p*
Compressed Sequence								
North Central Missouri College (NCMC)	169	54.7%	189	54.8%	0.1%	.001	1	.982
Three Rivers College (TRC)	368	51.3%	301	53.4%	2.1%	.529	1	.467
Separate and Prescriptive Corequisites								
Crowder College (CC)	542	54.0%	465	58.1%	4.1%	2.910	1	.088
East Central College (ECC)	314	56.8%	333	61.6%	4.8%	2.577	1	.108
Jefferson College (JC)	525	58.0%	453	59.7%	1.7%	.477	1	.490
Mineral Area College (MAC)	427	57.5%	289	55.5%	-2.0%	.538	1	.463
Moberly Area Community College (MACC)	545	56.4%	534	60.3%	3.9%	2.908	1	.088
State Fair Community College (SFCC)	514	61.6%	524	59.5%	-2.1%	.831	1	.362
Separate and Nonprescriptive Corequisite								
Metropolitan Community College (MCC)*	1255	54.3%	1467	59.0%	4.7%	10.801	1	.001
St. Charles Community College (SCCC)	868	66.4%	779	67.2%	0.8%	.201	1	.654
St. Louis Community College (STLCC)*	1320	53.7%	1318	62.0%	8.3%	31.866	1	<.001
Embedded and Nonprescriptive								
Ozarks Technical Community College (OTC)*	1214	60.0%	1102	56.4%	-3.6%	5.162	1	.023

Note. Persisted is defined as enrolled in the same community college for two consecutive fall semesters (i.e. Fall 2014/Fall 2015 or Fall 2018/Fall 2019). *denotes $p < 0.05$ and considered statistically significant.

Completion rates of entry-level mathematics courses. The completion rates of a college-level mathematics course requirement of full-time, degree seeking students enrolled in Missouri community colleges for the first-time in Fall 2014 and Fall 2018 were compared using the chi-square test of homogeneity ($\alpha = 0.05$). Students who completed a mathematics course with a satisfactory grade earning college-level credit in the summer, fall, intersession, or spring semester of their first academic year were considered to have completed. Students completing developmental (non-credit) courses and students completing Intermediate Algebra were not considered to have completed.

In 2014, 20.5% (N = 14,461) of Missouri community college students completed a college-level mathematics course in their first academic year; in 2018, 30.9% (N = 13,204) of students completed. As shown in Table 6, the completion rate increased over 10% and the difference in completion rate was found to be statistically significant, χ^2 (1, N = 27,665) = 388.079, $p < 0.001$.

Table 6

Comparison of the Completion of College-level Mathematics Courses in the First Academic Year Among First-time, Full-time Degree-seeking Students Enrolling at Missouri Community Colleges in Fall 2014 and Fall 2018

	2014 (N = 14461)		2018 (N = 13204)					
	N	%	*N*	%	Diff	χ^2	*df*	*p*
Completed	2971	20.5%	4077	30.9%	10.4%	388.079	1	<.001

Note: Completed is defined as earned college-level (non-developmental) credit in a mathematics course in the first academic year (i.e. Summer 2014/Fall 2014/Intersession 2015/Spring 2015 or Summer 2018/Fall 2018/Intersession 2019/Spring 2019) at a Missouri community college.

The analysis was then repeated for each community college as shown in Table 7. This calculation excluded 32 students who transferred among community colleges between the fall and spring semester. Most notably, all twelve community colleges had a

Table 7

Comparison of the Completion of College-level Mathematics Courses in the First Academic Year Among First-time, Full-time Degree-seeking Students Enrolling at Individual Missouri Community Colleges in Fall 2014 and Fall 2018

	Completed, 2014		Completed, 2018					
	N	%	*N*	%	Diff	χ^2	*df*	*p*
Compressed Sequence								
North Central Missouri College (NCMC)*	67	20.7%	96	27.2%	6.5%	3.924	1	.048
Three Rivers College (TRC)	109	14.9%	108	19.0%	4.1%	3.811	1	.051
Separate and Prescriptive Corequisites								
Crowder College (CC)*	192	18.7%	290	35.8%	17.1%	68.476	1	<.001
East Central College (ECC)*	127	22.0%	169	30.8%	8.8%	11.174	1	.001
Jefferson College (JC)*	189	20.0%	224	28.5%	8.5%	16.861	1	<.001
Mineral Area College (MAC)*	82	10.7%	180	33.7%	23.0%	102.98	1	<.001
Moberly Area Community College (MACC)*	297	30.3%	345	38.6%	8.3%	14.364	1	<.001
State Fair Community College (SFCC)*	131	15.2%	198	22.0%	6.8%	13.585	1	<.001
Separate and Nonprescriptive Corequisite								
Metropolitan Community College (MCC)*	495	21.2%	825	33.0%	11.8%	84.873	1	<.001
St. Charles Community College (SCCC)*	346	25.6%	364	30.5%	4.9%	7.364	1	.007
St. Louis Community College (STLCC)*	442	17.6%	554	25.9%	8.3%	46.297	1	<.001
Embedded and Nonprescriptive								
Ozarks Technical Community College (OTC)*	494	24.0%	724	36.7%	12.7%	77.313	1	<.001

Note. Completed is defined as earned college-level (non-developmental) credit in a math course in the first academic year (i.e. Summer 2014/Fall 2014/Intersession 2015/Spring 2015 or Summer 2018/Fall 2018/Intersession 2019/Spring 2019) at a MO community college; students completing Intermediate Algebra were not considered to have completed. *denotes $p < 0.05$ and considered statistically significant.

greater percentage of their students complete a college-level mathematics course in 2018 as compared to 2014. MAC saw the greatest increase in completion from 10.7% (N = 764) in 2014 to 33.7% (N = 534) in 2018—a statistically significant increase, $\chi^2 (1, N = 1{,}298) = 102.980$, $p < 0.001$; in fact, all but one college saw statistically significant increases in completion rates.

Integration of Findings

Though persistence rates increased statewide in Missouri, among individual colleges there did not seem to be a widespread, substantive increase in persistence rates between 2014 and 2018; however, there did appear to be a widespread, substantive increase in mathematics entry-level course completion between 2014 and 2018. Across the state, completion rates increased over 10% and 11 (of 12) institutions saw statistically significant increases.

The creation and implementation of multiple mathematics pathways (MRM, SR, and PA) and supporting corequisite courses appeared to have a positive effect. In 2014, the majority of students were required to take College Algebra; in 2018, only students in the STEM (PA) pathway were required to take College Algebra (or a similar course). This pathway seemed to pose the greatest challenge to creating and implementing corequisite supports. In 2018, only 5 institutions (of 12) had created corequisite support courses for its STEM pathway. In contrast, 9 of 12 and 9 of 10 institutions had created corequisite support courses for the MRM and SR pathways respectively.

Regarding completion of entry-level mathematics courses, three institutions stood out for significant improvement and overall rate. In 2014 and 2018, MACC had the highest completion rate of any community college in the study. In 2018, MACC's completion rate was 38.6%, and MACC saw a modest increase of 8.0% over 2014. OTC had a completion rate of 36.7% in 2018, increasing their completion rate by 12.7% over 2014. CC had a completion rate of 35.8% in 2018, and CC saw a large 17.1% increase from 2014 to 2018.

It is worth noting that both CC and OTC allow any student entering the college to immediately enroll in their non-STEM pathway(s) with corequisite support without any required prerequisite courses. Many community colleges relegate corequisite courses to entering students scoring just below the placement criteria for the pathway course. This in many cases limits the number of students who are eligible to take corequisite courses. CC and OTC's policies make corequisite courses accessible to a large number of students entering the college (i.e., any student underprepared for the non-STEM pathway course). Their open policies allow many more students to enter into college-level pathway courses in their first semester of mathematics courses.

Among Missouri public community colleges, the average number of planned prerequisite non-credit hours required for students placing in the lowest level of developmental education is 4.75 hours for the MRM pathway and 4.9 hours for the SR pathway. Of the three colleges with the highest completion rates, both CC and OTC require 0 hours of prerequisite courses for their non-STEM pathways and MACC requires 3 hours. These three schools represent the three lowest number of planned prerequisite hours for non-STEM pathways in the state. These findings seem to indicate that for non-STEM pathways corequisite structures and policies that allow for the greatest access to corequisite courses and minimal prerequisite courses produce the highest completion rates.

Only one community college did not see a statistically significant increase in completion rates of entry-level mathematics courses. The study categorized the college's corequisites as compressed sequences. The other college in the same category of corequisite conceptualization had a marginally significant increase ($p = 0.048$). Based on the findings of this study, the compressed sequences conceptualization of corequisites, although more effective than previous developmental sequence structures, does not seem to produce the highest completion rates.

Conclusion

This study used a pragmatic parallel mixed method design (Mertens, 2019) to detail the structures and policies of corequisite mathematics education and to analyze the impact of changes on persistence rates and completion rates of entry-level mathematics courses at 12 Missouri community colleges. The conceptualizations of corequisites at the colleges were placed into four distinct categories: (a) compressed sequences, (b) separate and prescriptive, (c) separate and nonprescriptive, and (d) embedded and nonprescriptive. The findings of this study clearly show that more students completed entry-level mathematics courses within the first academic year in 2018 than in 2014 regardless of the conceptualization of the corequisite implemented by the college; however, it seems that colleges creating structures allowing most or all of their underprepared students to immediately take non-STEM pathway courses with corequisite support generated the highest completion rates of entry-level mathematics courses. It also indicates that simply compressing existing content into a fewer number of courses (i.e. compressed sequences) does not appear to be as effective as other corequisite conceptualizations.

Discussion

Community colleges serve a large portion of undergraduate students in the U.S. and many of these students arrive underprepared for college-level mathematics courses (Bailey, et al., 2015; Monaghan & Attewell, 2015). Corequisite education allows many underprepared students to limit or avoid developmental sequences and to enroll directly into college-level courses (Center for Community College Student Engagement, 2016). The statewide initiatives in Missouri required all 12 public community colleges to reimagine their entry-level mathematics pathways, prerequisite sequences, and student support structures. The loosely coupled organization (Weick, 1976) of Missouri community colleges and state agencies allowed for various structures, policies, and conceptualizations of corequisite remediation to exist.

This study asked the question: Which corequisite structures and policies have produced significant increases in persistence rates and completion rates of entry-level mathematics courses at community colleges in Missouri? The answer is that all 12 institutions, regardless of the conceptualization of corequisites, improved their individual mathematics entry-level completion rates and contributed to a nearly 10% statewide increase in mathematics entry-level completion between 2014 and 2018. The highest preforming schools created structures that offered wide access for underprepared students to non-STEM pathway courses through corequisite supports. This study supports previous research (Logue et al., 2016) that shorter developmental sequences and increased use of corequisite courses enable more students to complete their entry-level general education mathematics courses.

Colleges which utilized a compressed sequences conceptualization of corequisites did not experience increases in completion of entry-level mathematics to the same extent as others in the study. This may indicate that all the content previously required in developmental sequences may not be essential to the successful completion of every pathway course. Particularly in the non-STEM pathways, students were able to be successful without large amounts of prerequisite content.

Despite the result of a statistically significant increase in the statewide persistence rate, there is less evidence that the reforms surrounding pathways and corequisites had a widespread and consistent impact on individual institution's persistence rates. In this study, only the largest two colleges experienced statistically significant increases in their persistence rates while 11 of the 12 colleges in the study experienced a statistically significant increase in completion of entry-level mathematics courses. The theory of academic momentum contends that early progress toward a degree positively impacts degree completion (Attwell, Heil, & Reisel, 2012). It follows that if a student's initial academic progress positively influences degree completion, then it must also increase persistence. It was anticipated that a significant and widespread increase in the rate of completion of entry-level mathematics courses would similarly impact persistence rates. Unexpectedly, this was not found to be true.

Previous studies have mixed results regarding the connection between completion of math sequences and persistence. Crisp and Delgado (2014) found that successful completion of developmental sequences did not impact persistence outcomes; in contrast, Logue, et al. (2019) claimed that "completion of mathematics remediation may be the single largest academic barrier to increasing overall college graduation rates" (p. 1). In this study, notably the only school (OTC) with a statistically significant decrease in persistence rate also saw one of the highest overall rates of completion of entry-level mathematics courses.

Recommendations for Future Research

In regard to future research, this study leaves several unanswered questions. First, the concurrent implementation of three major statewide reforms in mathematics education made it impossible to disentangle the effects of the different initiatives. More research is needed to determine the importance of any one of these reforms or even if they all have positive effects. Second, the large increase in statewide completion rates paired with the more modest increase in persistence rates presents another area requiring additional analysis. While failure to complete the remedial sequence decreases the likelihood that a student will persist (Chen & Simone, 2016), it does not immediately follow that completion of an entry-level mathematics course increases the likelihood a student will persist or graduate. It is possible that completion of an entry-level mathematics course is not as linked to a student's persistence as sometimes believed.

This study utilized a chi-square test for homogeneity requiring categorical variables. Each student was determined to have simply persisted or not persisted, completed or not completed. Other measures of success are required to achieve a better understanding of what is happening with different student populations.

Lastly, of the 12 colleges in the study, only 5 institutions chose to create and implement corequisite courses for the Precalculus Algebra (STEM) pathway; in contrast 9 institutions created corequisite courses for the Statistical Reasoning and Mathematical Reasoning and Modeling (non-STEM) pathways. Why did fewer institutions choose to create corequisite supports for the STEM pathway? These observations lead to additional questions regarding the nature of each pathway and the effectiveness of the corequisites paired with the pathway. Additional research is necessary to address these lingering questions.

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SECTION SIX: SCHOLARLY PRACTITIONER REFLECTION

Underprepared students pose a major challenge in my professional practice. As a community college instructor, I am committed to helping my students overcome obstacles that may threaten their ability to earn a degree. One major reason why I chose to become a mathematics instructor was to help individuals master a subject that many found difficult and complicated. For the first five years of my career, I worked to improve my curriculum and pedagogy. I worked to create activities and build community in my classroom, but still some students did not succeed. I discovered that the difficult content of my courses was not the only thing standing in the way of students graduating.

So many other factors affected my students' success: motivation, social skills, self-discipline, problem solving skills, tenacity, maturity, etc. I began to research these elements, and I worked as best I could to influence these noncognitive factors. Only a few years ago, I began to consider the impacts of our institutional and statewide policy on students. I came to recognize the far-reaching effects of policy and how it affects "the lives and well-being of large numbers" of individuals (Bardach & Patashnik, 2016, p. xv). I recognized the importance of policy and learned about possible alternatives, but how could I gain a voice in the conversation?

I remember the first time I listened to research regarding the ineffectiveness of developmental education. I listened to the speaker present her data and state conclusions, and I did not know how to assess the things I heard. I did not have any idea what questions I needed to ask. I did not know how research worked. I simply accepted what the speaker or researchers were telling me because they were the experts, and I was not.

My dissertation research considers a topic in which I am deeply passionate about: the success of my students in mathematics. My research considers policy that affects the more than 80,000 Missouri community college students. My work has allowed me to engage in conversations with community college practitioners and scholars. The dissertation process has taught me how to both do research well and evaluate the research of others. This process has greatly influenced my work as a scholar and as an educational leader.

Impact of the Dissertation Process

Several of the lessons I learned during the dissertation process apply to both my work as a practitioner and my work as a scholar.

Decisions of the Researcher

One of the most difficult parts of my dissertation was cleaning and recoding the data set I obtained from the Missouri Department of Higher Education and Workforce Development. I had to discover ways to identify the data I needed. The data set I worked with contained 1,375,653 cases, so nothing could be done manually. My study required that I make many determinations. There were 21 unique entries indicating the grade. Which ones meant the student passed? What constitutes an entry-level mathematics course? Do I include technical mathematics classes? What about major specific classes such as Math for Culinary Arts? There were no right or wrong answers, but these decisions affected the findings of my study, and it is likely another researcher would have made slightly different decisions.

As a scholar, I learned how essential it was that I clearly document and later communicate my decisions to those reading my study. These decisions are just as important as the findings; I recognized that conclusions without this context cannot be properly understood. I want to enter into a larger academic discussion, and so I must provide other scholars the information they need to evaluate and respond to my findings. As an educational leader, I learned how important it was to understand and carefully consider presuppositions and judgements along with the conclusions. Just because a study exists does not mean it is a good one, and just because it is a good one, does not mean that it applies to my context.

No One is Watching

The data I received was not error free. Thousands of cases had to be corrected, and I called directors of institutional research, emailed faculty, and read the websites of registrars in order to repair the data. After exhausting all other avenues, sometimes I had to decide to remove a case from the study. It struck me that no one was watching me as I worked. No one was making sure I made good decisions. No one would know if I took a shortcut and chose not to do the research to repair a certain case. There was no answer key to check my work.

My responsibility as a researcher began to weigh heavily on me. It was possible that my colleagues could use my study to make decisions about policy—policy that could affect the lives of hundreds or even thousands of students! Stone (2012, p. 26) wrote “actions have side effects, unanticipated consequences, second- and third-order effects, long-term effects, and ripple effects.” The reality that no one was hovering over me and verifying my work is sobering. It still unnerves me a little. My colleagues and my students are relying on me to conduct my research accurately and with integrity.

I see how it may be easy for a researcher to ignore difficult data that complicates or contradicts the outcome of the study. Creswell (2014) exhorts researchers to disclose all results regardless of its effect on the study. So much time goes into research, and every researcher wants a useful result, but this whole system is built on the premise that the researcher can be trusted. Creswell (2014, p. 92) wrote, "Researchers need to… promote the integrity of research; guard against misconduct and impropriety that might reflect on their organization or institutions; and cope with new, challenging problems." As a scholar, I am committed to upholding a high standard of reliable and trustworthy research. I take that trust placed in me very seriously.

My personal values affect nearly every aspect of my work as a scholar and as an educational leader. I am committed to respect for all people. As a teacher, I strive to do my work to the best of my ability because I believe it affects the lives and opportunities of those I teach. As I move into the role of scholar and educational leader, this is true all the more. In influencing policy, I have the potential to affect the lives of so many more students. I may not be able to see their faces as I do in my classroom, but I may influence their access to opportunity all the same.

Community is Necessary

We need each other. As a scholar, my lonely work on my study helped me to recognize the importance of the community of researchers. Only the community can conduct redundant studies, double check results, and create a preponderance of data. This process has helped me realize that a single study should not drive recommendations. Researchers make mistakes. Researchers need accountability. Only together, can researchers provide a body of work in which effective policy recommendations can be made.

As an educational leader, community is likewise absolutely essential. Acona, Malone, Orlikowski and Senge (2007/2011) asserted "incomplete leaders differ from incompetent leaders in that they understand what they're good at and what they're not and have good judgment about how they can work with others to build on their strengths and offset their limitations" (p. 181). I believe the most essential quality of a leader is the ability to assemble a group of diverse individuals to collaborate and lead together. We all have blind spots and days in which we are not at our best. In other words, we need each other.

Caring for People

As part of my study, I conducted 13 interviews with mathematics faculty across the state. These interviews were conducted via Zoom, and Seidman (2013) wrote that interviewers must work diligently and intentionally to convey consideration, interest, respect, and presence especially when conducting interviews remotely. Some individuals I knew well from work on various statewide initiatives. Other individuals I did not know prior to the interview. I was surprised to discover that several of my interviewees were very hesitant to participate in my research. Perhaps, they were worried that they would say something wrong and get into trouble with someone at their college. Even though the subject matter of the interviews was very objective, it was scary for them.

I did what I could to allay their fears. I allowed one participant to provide written responses so that her supervisor could check them before they were returned to me. I contacted the Vice President for Instruction at another college to ask for permission for the faculty member to participate in the study. I was not asking for my participants' opinion on the structures their college implemented. Even so, it was scary for them to participate in research and have their thoughts carefully recorded. Seidman (2013, p. 97) wrote that interviewing is both a "research methodology and a social relationship"—a relationship that must be "individually crafted." As the researcher, it was my obligation to do everything in my power to mitigate the fear and behave in a way that honored the individual and their unique comfort level.

I learned how important it was to protect your participants. Creswell (2014, p. 92) wrote, "Researchers need to protect their research participants; develop a trust with them." I was fully transparent with my interviewees and delineated what exactly they could expect. Finally, I gave them the opportunity to view and correct my findings; that is, I confirmed the findings by "member checking" (Creswell, 2014, p. 201). I think that was very important to some of them. It allowed them to answer with confidence—if they were mistaken, they could correct it later.

As an educational leader, I learned the importance of trust. Northouse (2016, p. 173) wrote, "trust has to do with being predictable or reliable, even in situations that are uncertain." No matter how carefully a supervisor might present it, data can feel evaluative. I never want an individual whom I supervise to be weary of telling the truth to anyone including myself. If I wish to hear the truth, I must intentionally cultivate trust. Participating in formal or informal research is scary.

Protecting the Integrity of My Findings

I spent many days reading research I had heard previously in different contexts. In the past, I have attended multiple seminars facilitated by Complete College America, the Dana Center, the California Acceleration Project, or some other organization. The same studies I read in their entirety for my research were used in those seminars to promote a point of view. In my opinion, some findings were conveyed in a manner faithful to the study—others were not. I saw how some individuals, whether intentionally or unintentionally, misrepresented the findings of studies in order to promote certain agendas. AERA (2011) asserts that educational researchers must "strive to advance scientific and scholarly knowledge and to serve the public good" (p. 147). In order to do this, scholars and educational leaders must approach research thoughtfully trying our best to put our agendas and opinions aside.

As I was writing the findings of my study, I kept this in mind. I worked to clearly communicate the conclusions in such a way that would be difficult to unintentionally misconstrue. This included clearly indicating the limitations of my research. I remembered how I once read research—introduction first, then skip to the conclusions. I wanted to write my findings in a way that was accessible to any educator but precise enough for any scholar. I frequently thought about Bardach and Patashnik's (2016, p. 73) "Grandma Bessie Test." Could I explain my conclusions to my grandma? If not, then I need to do more thinking.

Mission Creep

I investigated an issue that was important to me—a problem of practice that engaged my passion. As a result, I readily lost focus and started down many paths of inquiry that had nothing to do with my research question. In every meeting, my advisor, Dr. MacGregor, would ask me, "Does that answer your research question?" Most often my response was "no." I am just so interested in so many things surrounding my study!

Finally, I clearly recognized the necessity in the alignment of purpose, research questions, methods, data analysis, and reporting. Any misalignment caused confusion and threatened the validity of the study, but it is so easy to lose alignment over the course of months of research. Later at the urging of my advisor, I slightly revised my research questions. A small misalignment between the questions and the data collected made the data analysis phase and findings unwieldy. I was surprised to find how the small change in wording made the findings clearer and easier to report.

Conclusion

The dissertation process is a difficult one. I did not always feel like I was making progress. I would complete a task only to find a reason to do it again considering something else. It was slow and painful at times, but it was worth it. So many of the things I gained were unexpected. I built relationships with mathematics instructors across the state and with individuals at Missouri Department of Higher Education and Workforce Development. I built confidence in myself and my ability to competently address research and consider alternatives. My dissertation journey has taught me how to interact with research. I feel better prepared to evaluate the evidence others present to support their opinions. Because I now speak the language of a scholar, I can evaluate the evidence myself and determine its limitations. As a leader, I feel like I will no longer be bullied by an individual equipped with data and research.

The idea of leaders as "purveyors of hope" rings true for me in my daily practice as both a leader and a scholar (Helland & Winston, 2005, p. 42). In higher education when a student loses hope, they disappear. I believe it is my duty as a committed leader and scholar to create and sustain hope. Preskill and Brookfield (2009) wrote that educational leaders "hold no illusions about how difficult the struggle is that they face…Their hope is born of the unyielding day-to-day work that ordinary people do to make their communities better" (p. 172). I am excited to engage in this difficult work using my new knowledge and skill to make my community better.

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APPENDICES

Appendix A

Interview Protocol

Introduction

Thank you for agreeing to meet with me today. I am a graduate student at the University of Missouri-Columbia and this interview is an important part of my dissertation research regarding the implementation of corequisite mathematics in the state of Missouri.

Participation

Take time to read through the informed consent document. Remember your participation is voluntary and you may choose to not answer a question or withdraw from the interview at any time. May I record the interview?

Do you have any questions before we get started?

Interview

I. In 2014, what was the structure of your developmental math courses?
    1. How did students place into these courses?
    2. How did students advance through the sequence?
    3. What mathematics pathways did you offer?
    4. Did you offer any corequisites in 2014?

II. What is the structure of your developmental (non-credit) math courses today?
    1. How do students place into these courses?
    2. How do students advance through the sequence?
    3. What mathematics pathways do you offer? Are all pathways included in Core 42?

III. Describe the corequisite courses at your college?
    1. **Scope**
        i. Which mathematics pathways have a corequisite courses?
        ii. Are corequisites offered online?
    2. **Placement**
        i. How are students placed into gateway and corequisite courses?
        ii. Does any corequisite have a prerequisite? Under what circumstances?

3. **Scheduling/Staffing**
    i. Is the corequisite a separate course or embedded in the college-level course?
    ii. How many credit hours is the corequisite? College-level course?
    iii. Is the corequisite course taught by the same instructor as the college-level course?
    iv. What are the qualifications for instructors of corequisite courses?
    v. Is the class size limited?
    vi. What days of the week does the gateway course/corequisite meet?
    vii. What are the policies surrounding attendance?
4. **Grading**
    i. How is the corequisite course graded?
    ii. If a student fails a college-level course with corequisite, what happens next?
5. Content
    i. How does the corequisite support the college-level course?
    ii. What is included in your corequisite course?
        1. Does it have its own course objectives? Content?
        2. Who decides what to include? Department, instructor, or other?
        3. Is the content the same across all sections of the corequisite?
        4. Does the corequisite course explicitly address study skills or soft skills? How so?

IV. Do you have any plans to make changes to your current structure?

V. What challenges have you encountered as you have implemented corequisites?

Wrap-up

VI. Is there anything else that could be important to this study that I did not address?

VII. Is there anyone else I should talk to?

VIII. Do you have any questions for me?

Appendix B

Interview Informed Consent Form

Please consider this information carefully before deciding whether to participate in this research.

Description: I am a graduate student at the University of Missouri - Columbia in the Educational Leadership and Policy Analysis program, and my research considers the structures and impacts of corequisite education at Missouri community colleges.

Purpose of the Research: This study seeks to understand the various structures of corequisite education at Missouri community colleges and to identify promising practices.

Your Participation: If you decide to volunteer, you will be asked to participate in an interview. You will be asked several questions regarding the structure of your college's entry-level and developmental mathematics courses. With your permission, I will record the interview. After the interview, you will be given the opportunity to review the researcher's summary and make any corrections you deem necessary.

Time Requirements: The interview will take about one hour. If you agree, you may be contacted for follow up questions.

Participation and Withdrawal: Your participation in this study is voluntary, and you may refuse to participate or withdraw from the study at any time. You may withdraw by informing a researcher that you no longer wish to participate (no questions will be asked). In addition, you may skip any question during the interview but continue to participate in the rest of the study.

To Contact the Researchers: If you have questions or concerns about this research, please contact Trisha White, 660-909-3965, whitet@otc.edu.You may also contact the faculty member supervising this work: Dr. Cindy MacGregor, MU-MSU Site Coordinator, 417-836-6046, cmacgregor@missouristate.edu. If you have questions about your rights as a research participant, please contact the University of Missouri – Columbia Institutional Review Board at 573-882-3181 or irb@missouri.edu.

Appendix C

Document Analysis Guide

College:

	2014	2018	2020
Placement Tools			
Placement Procedure			
Pathways/College-Level Courses [credit hours]			
Prerequisites for each Pathway [credit hours, NC non-credit course]			
Grading and Progression			
Modality of Prerequisites			
Maximum Number of Hours in Sequence/Number of Semesters to Complete (includes college-level & *required* corequisite courses)			
Corequisites [Credit Hours, NC non-credit course] **Indicates corequisite has not been offered/has not made			
Modality of Corequisites			
Description and Rationale of Corequisite Structure			
Who Takes Corequisites			
Embedded, Subset, Linked, Separate			
Same Instructor			
Grading Procedures			
Retaking Entry-Level and Corequisite			
Offered online?			
Shared Content for Corequisite			
Soft Skills/Study Skills Included			
Limit to Number of Students in Corequisite			
Attendance Taking			

VITA

Trisha White began teaching as an adjunct mathematics instructor at Ozarks Technical Community College in southwest Missouri in 2010 after spending two years teaching at an international high school in Jerusalem, Israel. In 2011, Trisha was hired as an Instructor of Developmental Mathematics, and later, she became Lead Mathematics Instructor at OTC's Richwood Valley Campus. During the 2012-2013 academic year, Trisha participated in a national project, Global Skills for College Completion, which focused on using reflection and teaching communities to better instructional practices. In 2014, Trisha was awarded OTC's Excellence in Education Award, and in 2015, she was awarded the Governor's Award for Excellence in Teaching. She has served on several statewide committees including the Missouri Mathematics Pathways Taskforce and co-chaired the Missouri Mathematics Advisory Committee. In 2019, she was awarded the American Mathematical Association of Two-Year College's Teaching Excellence Award. Trisha is committed to her students' success and eagerly looks for new ideas to improve their opportunities.