Annual Report on the Condition of College and Career Readiness

Report to the Coordinating Board for Higher Education

Missouri Department of Higher Education

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Missouri Department of Higher Education

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Annual Report on the Condition of College and Career Readiness

Executive Summary

The *Annual Report on The Condition of College and Career Readiness* summarizes institutional efforts to replicate best practices in remedial education, as required by § 173.005.2(6) RSMo and outlined in the *Principles of Best Practice in Remedial Education*. This year's report focuses specifically on mathematics, including corequisite supports and the implementation of Math Pathways.

Missouri's public postsecondary institutions committed to implement Math Pathways statewide in 2018, and shifts in enrollment practices are already noticeable. Likewise, continued good faith efforts to replicate best practices in remediation has resulted in a sustained decline in the remediation rate of recent high school graduates. Highlights from the 2018-19 report include:

- Since 2014, the overall remediation rate for recent high school graduates has decreased by 30.6 percent.
    - In mathematics, the rate has decreased over this five year period by 33.2 percent.
    - The remediation rate for African-American students continues to steadily decrease, with 30 percent decrease in remediation in mathematics since 2014.

- All of the 25 institutions that offer remedial education in mathematics are using multiple measures (a best practice identified in the *Principles of Best Practice*) to place students into appropriate coursework, up 19 percent from the previous year.
    - Of those measures, 16 institutions are using more holistic measures, such as high school GPA, high school coursework, or both, an increase of 45 percent from the previous year.

- Enrollment trends in gateway mathematics courses show that students are more evenly distributed among the various mathematics courses in 2018 than in 2014.
    - In 2014, nearly 90 percent of students enrolled in either College Algebra or PreCalculus, with the remaining enrolled statistics or other mathematics course.
    - In 2018, about 40 percent enrolled in either Statistical Reasoning or Mathematical Reasoning & Modeling, a 231 percent increase over 2014.
        - At the four-year sector, where many pathways were already available, there has been a 143 percent increase in the number of students enrolling in an alternative pathway to Calculus.
        - At the two-year institutions, where only 3.2 percent were enrolled in an alternative pathway to calculus, there has been a 900 percent increase since 2014.

- For Fall 2018, 20 institutions offer mathematics corequisite supports, a 33 percent increase from 2017, when only 15 institutions offered corequiste supports.
    - Preliminary results on remedial education indicate that, over a three year period, nearly 70 percent of students enrolled in math corequisite supports pass a gateway math course with a grade of "C" or higher, compared to nearly 24 percent of students enrolled in traditional models of remediation

- While corequisite supports are similar in nature, they vary by course and by institution in terms of structure, type of instructor, and credit-bearing status. More research is needed to identify and determine best practices in corequisite education.

- Although data on student learning outcomes is limited, there is evidence to suggest that these efforts are positively affecting student completion and retention.

- MDHE staff recommend that all public institutions work to implement all math pathway offerings for students, and provide corequisite supports for every math pathway offered
    - This recommendation also includes expanding math pathways to independent institutions, especially those interested in participating with CORE 42

- MDHE staff also recommending revisiting *Principles of Best Practice in Remedial Education* to include practices with corequisite supports, updated cutscores (including high school GPA) if needed using more recent data, and to reflect many of the changes which have occurred since the documents initial release.

Annual Report on The Condition of College and Career Readiness

Background

House Bill 1042, signed into law in 2012, directed all public institutions of higher education in Missouri to "replicate best practices in remediation" in order to improve student retention and degree completion. To fulfill this mandate, the MDHE formed the Task Force on College and Career Readiness (TCCR). In 2013, the Coordinating Board for Higher Education approved *Principles of Best Practice in Remedial Education*, a guiding document developed collaboratively by representatives from Missouri's public and private institutions of higher education, the Missouri Department of Higher Education, and the TCCR. *Principles of Best Practice* is based on research from regional educational laboratories, higher education research organizations, and other organizations with subject matter expertise. The MDHE has for the past three years issued a Report on the Condition of College and Career Readiness in conjunction with the annual High School Graduates' Report to assess institutions' adoption of best practices in remedial education.

Methodology for 2018 Report

One best practice listed in *Principles* is the alignment of "gateway" courses, such as mathematics or English composition, with a student's intended program of study. Beginning in October 2014, the Missouri Department of Higher Education worked closely with the Missouri Mathematics Pathways Taskforce (MMPT) to explore options to increase student success in gateway mathematics courses. As a result, the Taskforce developed mathematics pathways and co-requisite mathematical models of education for students who require remedial education or extra assistance to successfully complete their gateway mathematics course.

In 2015, MDHE staff collected institutional information using a comprehensive survey and available data on remedial education for the first annual Report on the Condition of College and Career Readiness. In 2017, MDHE staff followed a similar process, disseminating a 13-question qualitative survey related to the best practices identified in *Principles*. Additionally, MDHE staff utilized data from the annual High School Graduates Report and data reported to Complete College America —data provided from each institution—around remedial education for the report for that year.

The 2019 *Report on the Condition of College and Career Readiness* focuses on the implementation of Math Pathways and mathematics corequisite remedial education. Data for the report were collected from a qualitative survey, from the Enhanced Missouri Student Achievement Study (EMSAS) files, and from student lower-division course-level data which was collected and analyzed for the first time in 2018. The course-level data will allow a depth to the Annual Report not previously available. Because 2018 was the first time data were collected—and January 2019 was the first instance of what will be an annual data collection cycle—the process of cleaning and analyzing the data was slower than anticipated. Once the process becomes more routine, however, data collection will be much smoother for both institutional staff and MDHE staff.

Summary of Remediation Rates

For the fifth consecutive year, the participation rate of recent Missouri public high school graduates in remedial education—which *Principles of Best Practice* defines as "coursework and programs designed ... to improve the skills of underprepared students, both traditional and non-traditional, so that they may be successful in entry-level, credit-bearing courses"—has declined (see Table 1). Data from the High School Graduates Report, which looks at the enrollment of recent graduates from Missouri public high schools indicates that overall rates of remediation have declined by over 30 percent for that five year period, and

remedial mathematics enrollment has decreased by 33 percent over six consecutive years of decline. However, those trends seem to be leveling off.

Table 1: Remedial Participation of Recent Missouri Public High School Graduates in Public Postsecondary Institutions

	Fall 2014	Fall 2015	Fall 2016	Fall 2017	Fall 2018	% change, 2014-2018
Mathematics	26.2%	23.8%	21.5%	17.6%	17.5%	-33.17%
English	12.3%	10.0%	11.4%	10.1%	8.2%	-33.58%
Reading	7.6%	6.1%	6.6%	6.0%	5.2%	-31.45%
Total	30.8%	28.2%	26.8%	22.8%	21.5%	-30.36%

Additionally, data from the High School Graduates Report indicate the rates of African-American students enrolled in remedial courses are trending significantly downward. In fact, the overall remediation rate for African-American students is at its lowest level, going back beyond 2012, and down nearly 30 percent from Fall 2014 (see Table 2). This is the third straight year of steady decline in African-American students enrolling in remedial education.

Table 2: Recent Missouri Public High School Graduate Enrollment in Remediation: African-American Students

	Fall 2014	Fall 2015	Fall 2016	Fall 2017	Fall 2018	% change, 2014-2018
Math	44.0%	40.4%	43.1%	35.4%	30.8%	-29.95%
English	32.1%	23.8%	32.6%	28.1%	23.4%	-27.07%
Reading	23.9%	18.3%	23.6%	19.3%	17.1%	-28.41%
Total	52.5%	47.0%	52.6%	46.0%	38.2%	-27.16%

While the number and percentage of students enrolling in remediation continues to decline—for the sixth straight year of students needing mathematics remediation—Pell-eligible students (Table 3), non-white students (Table 4), and women (Table 5) remain disproportionally enrolled in mathematics remediation. Table 3 shows that while 35 percent of all undergraduate students in 2017 were Pell-eligible—a proxy for low socioeconomic status—nearly 54 percent of students enrolled in remedial math courses were Pell-eligible, a difference of nearly 19 percentage points.

Table 3: Percentage of Pell-Eligible Students, Headcount and Enrolled in Math Remediation

Pell Eligible Students	Fall 2014	Fall 2015	Fall 2016	Fall 2017
Total Undergrad Headcount	39.6%	38.0%	36.9%	35.5%
Enrolled in Math Remediation	59.7%	57.8%	57.4%	53.9%
Difference	20.1%	19.8%	20.5%	18.4%

Table 4: Percentage of Non-White Students, Headcount and Enrolled in Math Remediation

Non-White Students	Fall 2014	Fall 2015	Fall 2016	Fall 2017
Total Undergrad Headcount	28.5%	26.6%	27.1%	27.4%
Enrolled in Math Remediation	37.0%	33.9%	37.7%	39.2%
Difference				

Table 5: Percentage of Female Students, Headcount and Enrolled in Math Remediation

Female Students	Fall 2014	Fall 2015	Fall 2016	Fall 2017
Total Undergrad Headcount	56.1%	56.0%	56.1%	56.1%
Enrolled in Math Remediation	60.3%	60.7%	60.6%	60.8%
Difference				

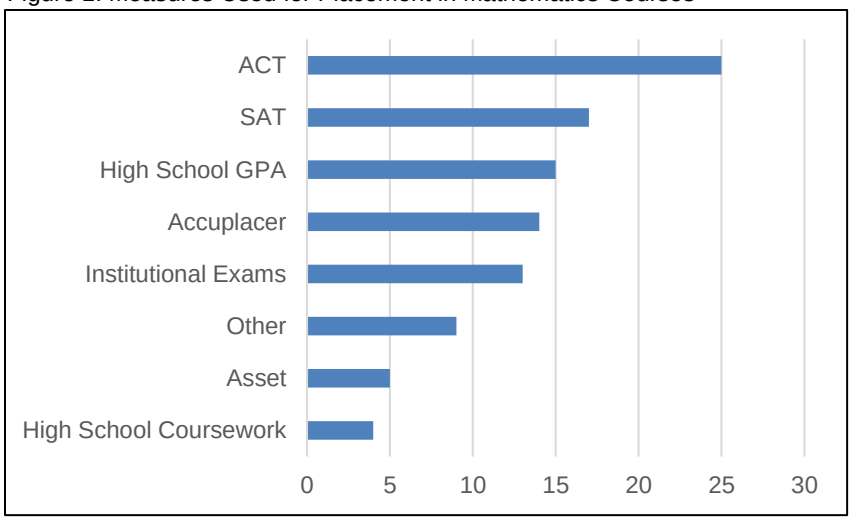
While our data indicate that these disparities exist, more research is needed to ascertain why these student populations are disproportionately represented among those needing remedial math.

Placement for Mathematics Courses

The best practice for placing students into appropriate college-level courses must be based on at least two measures to provide a more accurate and holistic assessment of a student's ability to succeed in college-level coursework. Institutions may use an assortment of assessment instruments to place students in college-level courses, including—but not limited to— SAT or ACT scores, high school grade point average, high school end-of-course examination scores, or an institutional created assessment instrument. Institutions using an assessment identified in the *Principles of Best Practice in Remedial Education* must also use the statewide placement score listed in the document. All institutions using, for example, the ACT subscore in mathematics, must use 22 as the cut score for determining the appropriate mathematics placement for students. (see Section 9.2 in *Principles of Best Practice in Remedial Education*)

As of Fall 2018, all 25 institutions which offer remediation use multiple measures for placement—a 19 percent increase over the previous year. While all institutions used college entrance exams, such as the ACT and SAT, to place students in appropriate courses, all used at least one additional measure for placement (see Figure 1).

Figure 1: Measures Used for Placement in Mathematics Courses



A number of institutions are incorporating more holistic measures, such as high school GPA and high school coursework, to place students into gateway mathematics courses. There were 16 institutions using high school GPA or coursework (or a combination of the two) for placement in 2018, a 45 percent increase from the previous year. It is, of course, difficult to determine causation, but MDHE staff believe that the decline in the remediation rate can be explained largely by the increased use of multiple measures and the more widespread use of measures such as high school GPA and coursework. Despite concerns about "grade inflation," research suggests that high school GPA is the single best predictor of

postsecondary success; it can be more easily and accurately normalized than entrance or placement exams and it captures non-cognitive qualities like “persistence” and “grit.”

Math Pathways and Corequisite Supports

Missouri’s public postsecondary institutions committed to implement Math Pathways statewide in Fall 2018 by offering at least two separate pathways from which students can choose, and shifts in enrollment practices are already noticeable. Likewise, continued good faith efforts to replicate best practices in remediation have resulted in a sustained trend of declines in the remediation rate of recent high school graduates, and increased rates of success for students enrolled in math remediation and earning a grade of “C” or higher in gateway math courses within one or two academic years. While early results show great promise, much work lies ahead to ensure the continued success and sustainability of these changes, which should result in higher levels of retention and increased graduation rates.

Math Pathways

The Missouri Math Pathways Initiative has developed alternative mathematics course to College Algebra, a course designed during the Cold War to prepare American students for Calculus and the science fields. Outside of these fields, however, few students need Calculus for their chosen field of study or future profession, and they may be better served by other mathematics courses such as Statistics or Mathematical Modeling. The Missouri Mathematics Pathways Taskforce (MMPT) finalized student learning outcomes (SLOs) for four courses covering three pathways: PreCalculus and PreCalculus Algebra (formally College Algebra) as a STEM/Business path, Statistical Reasoning for a Statistics path, and Mathematical Reasoning & Modeling for an applied Mathematics path. Renaming College Algebra to PreCalculus Algebra was a conscious decision by the MMPT, indicating to students that the course is preparation for calculus.

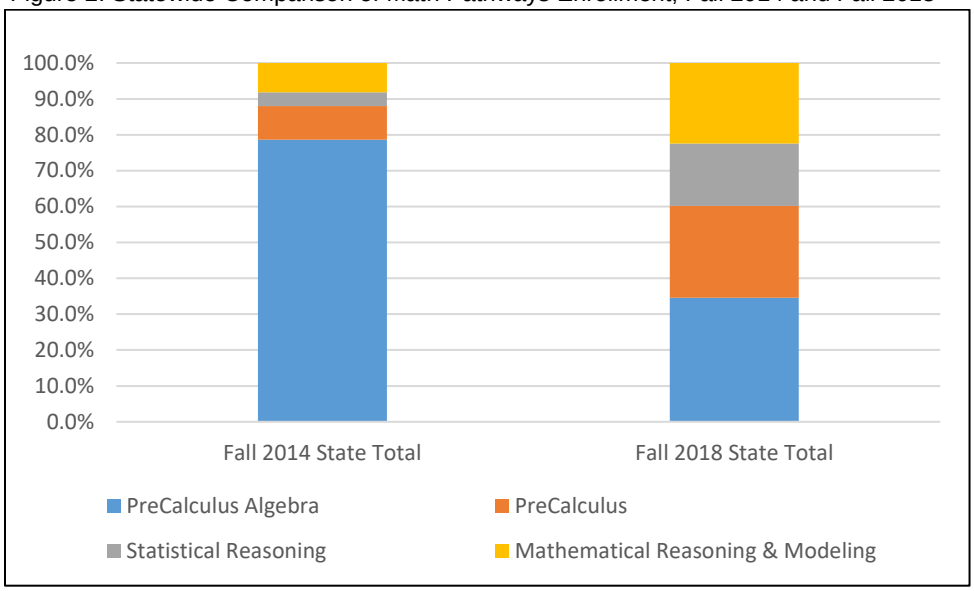
When MDHE began work on designing and implementing math pathways at Missouri’s postsecondary institutions in 2014, only Southeast Missouri State University was offering multiple mathematics options for students in a meaningful way. The number of institutions offering multiple mathematics pathways has increased every year since. For fall 2018, each institution (with the exception of Truman State University) agreed to implement at least two math pathways, one of which would be an alternative to PreCalculus. To date, 26 of the 27 institutions are offering or committed to offer at least two approved mathematics pathways courses. Table 6 illustrates the pathways offered by each sector, while Appendix A has the offerings disaggregated by institution.

Table 6: Math Pathways Offering by Sector, Fall 2018

	PreCalculus Algebra	PreCalculus	Statistical Reasoning	Mathematical Reasoning & Modeling
2-Year Subtotal	13	8	10	13
4-Year Subtotal	13	13	9	10
State Total	**26**	**21**	**19**	**23**

Course-level data available to MDHE—from AY 2014-15 to AY 2017-18—indicate that 75.9 percent of students who took a gateway math course over this period did so within their first two years of enrollment. A comparison of enrollment trends from Fall 2014 to Fall 2018, the first year of statewide implementation of math pathways, show that there has been a noticeable shift in enrollment patterns (see Figure 2). These shifts indicate great structural change, as institutions allow the application of more math courses to general education requirements, add more sections (and potentially more instructors) to meet student demand.

Figure 2: Statewide Comparison of Math Pathways Enrollment, Fall 2014 and Fall 2018



When breaking down these enrollment trends by sector, other patterns and evidence of structural changes emerge. The enrollment distribution is more even among the four-year institutions (see Figure 3), where nearly a quarter of students are enrolled in each pathway. At the two year institutions have had a 900 percent increase in the number of students enrolling in an alternative pathway to calculus (see Figure 4). In 2014, over 96 percent of all students at a two-year institution enrolled in PreCalculus course; in 2018 that dropped to 68 percent, with the remaining 32 percent enrolled in an alternative to the PreCalculus track. Additionally, while statistical reasoning does not appear to be a course offering at two-year institutions in 2014, over 11% of all students in this sector enrolled in a statistics course in 2018.

Figure 3: Comparison of Math Pathways Enrollment 4-year sector, Fall 2014 and Fall 2018

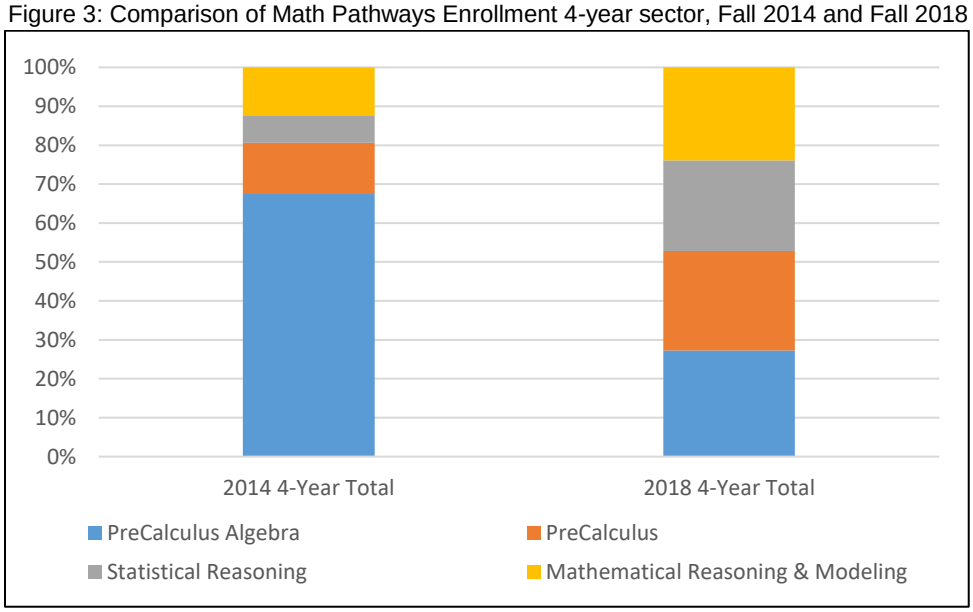
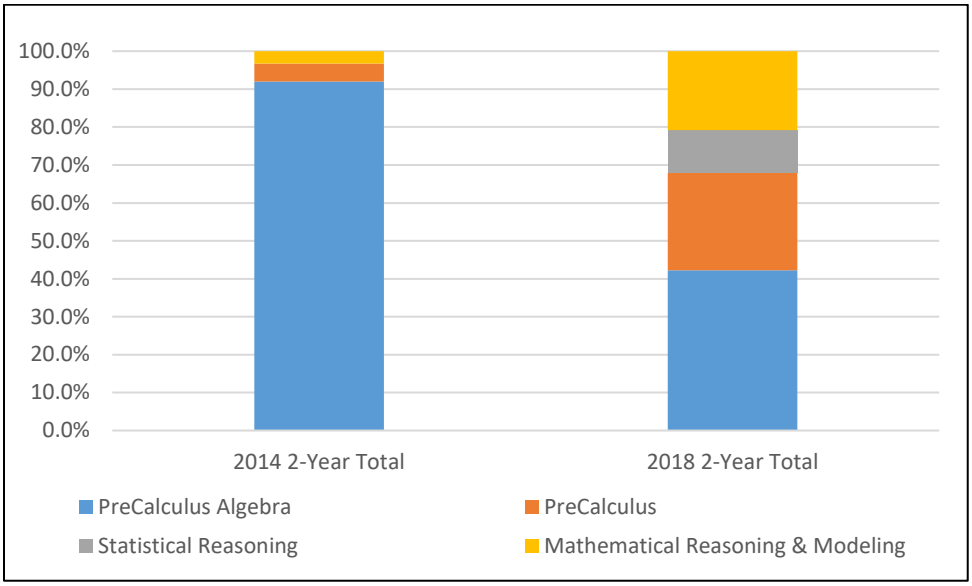


Figure 4: Comparison of Math Pathways Enrollment 2-year sector, Fall 2014 and Fall 2018



While the number of math pathway course offerings has increased across the state, and the distribution of students enrolling in these courses has become more equal, the average statewide section size has decreased; in other words, there are fewer students per section on average around the state in 2018 than in 2014. The average section size in 2014 across all pathways courses was 23.5; in 2018, it was 22.5. However, there is some nuance when disaggregated by sector. At the four year sector, the average number of students per section in PreCalculus and Statistical Reasoning actually went up slightly, but there was a large decrease was in PreCalculus Algebra; in 2014 there were 35.6 students per sections and in 2018 there were 26.6 students. At the two-year sector, there was a drop in students per section in PreCalculus but a slight increase in PreCalculus Algebra and Mathematical Reasoning & Modeling (see table 7).

Table 7: Average Student Enrollment per Section, Fall 2014 and Fall 2018

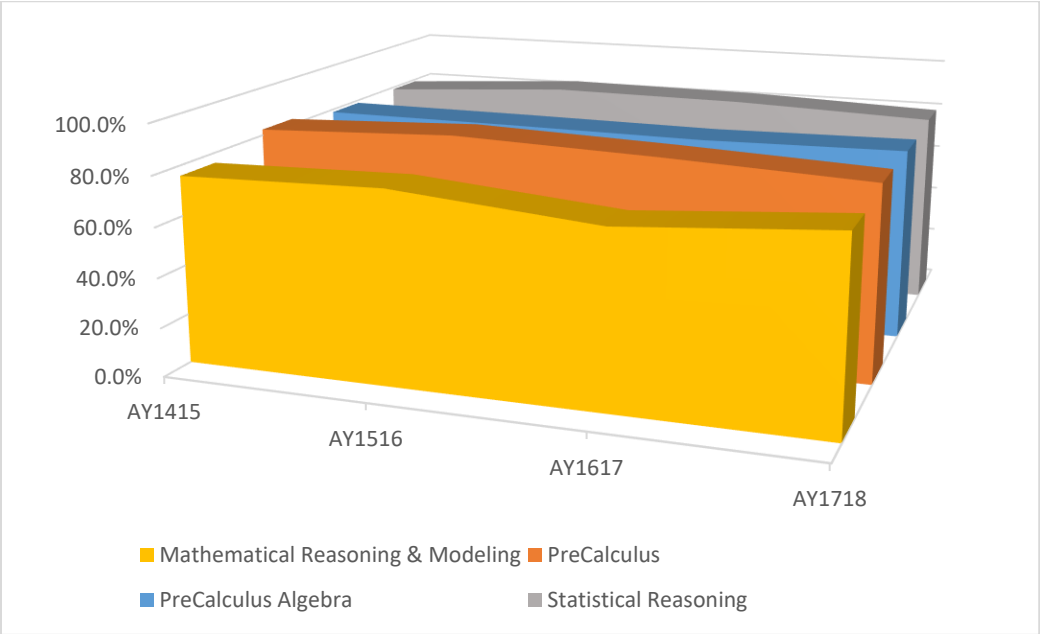
	PreCalculus Algebra	PreCalculus	Statistical Reasoning	Mathematical Reasoning & Modeling	Total
2-Year Sector, Fall 2014	18.3	19.5	-	14.3	18.1
2-Year Sector, Fall 2018	20.7	17.9	15.9	17.6	18.7
4-Year Sector, Fall 2014	35.6	26.7	27.8	28.2	32.4
4-Year Sector, Fall 2018	26.6	28.3	29.1	27.8	27.9
Statewide Average, Fall 2014	23.2	24.0	27.8	23.3	23.5
Statewide Average, Fall 2018	22.8	22.1	23.1	22.0	22.5

Even with this improvement, there is still much work to be done. While 19 institutions offer Statistical Reasoning, a marked improvement from 2014, it is the least most commonly offered math pathway at both the two- and four-year sectors. Additionally, some institutions which offer Statistical Reasoning are having a difficult time filling sections; two institutions at the two-year sector have no students enrolled, and four institutions across both sectors have three or fewer sections.

Additionally, while more students are enrolling in various pathways, more data and research are needed to evaluate success of students in each pathway and, where needed, in subsequent path courses. MDHE

staff hypothesized that has students move out of traditional college algebra (the PreCalculus Algebra pathway) and into pathways that are more relevant to their field of study and future career aspirations, the successful completion rate—earning a grade of "C" or higher—would increase for each of the pathway courses. Preliminary results indicate that successful completion rates have remained steady or slightly increased in some cases. However, successful completions rates decreased significantly for Mathematical Reasoning & Modeling in Academic Year 2016-17 (see Figure 5) before rebounding the following year, though this appears to be a data anomaly.

Figure 5: Successful Completion Rates of Math Pathways Courses of Undergraduate Students



Additionally, over a four-year period, all gateway math courses have an average successful completion rate of 78.7 percent; table 8 demonstrate how each of the pathways compare to all gateway math courses per academic year, and the average over the four-year period. Data are limited, however, as MDHE only has available course completion data, and not course enrollment data, which may inflate the completion rate calculations.

Table 8: Completion of Math Course with a grade of "C" or higher

	Mathematical Reasoning & Modeling	PreCalculus	PreCalculus Algebra	Statistical Reasoning	All Gateway Math Courses
AY1415	76.0%	82.4%	78.8%	79.1%	78.7%
AY1516	77.8%	85.7%	78.4%	83.9%	79.0%
AY1617	70.8%	83.0%	77.6%	83.1%	77.7%
AY1718	76.9%	79.4%	78.8%	80.3%	78.8%
Four-Year Average	**75.9%**	**82.6%**	**78.5%**	**81.2%**	**78.7%**

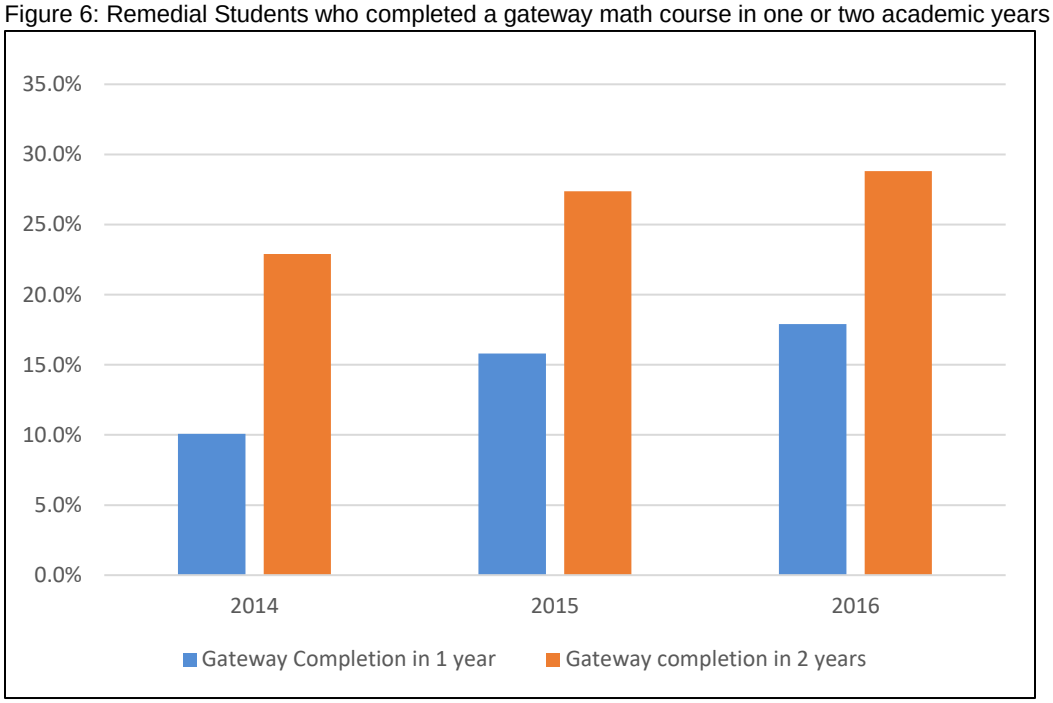
Mathematics Corequisite

One of the recommendations of *Principles* was that institutions should offer alternative models of remedial education, including corequisite models. Traditional models of remediation require an underprepared student to first pass a course or series of courses, usually at a cost to the student but bearing no college credit, before enrolling in a credit-bearing course; this extra cost and time can often be burdensome for

students. Corequisite remediation models, known as “just-in-time” remediation, provide scaffolding, support, and guidance while students are concurrently enrolled in the gateway course. In Missouri, a taskforce of mathematics faculty developed the outcomes of the corequisite supports, aligning them to the SLOs of each of the math pathways courses. Early results from Missouri, and other states and institutions, show positive outcomes for students taking courses with corequisite supports.

Using course level data from AY 2014-15 through AY 2016-17, we can trace the success rates of students from fall cohorts who enrolled in a remedial math course and passed a gateway math course within one or two academic years. Over that three year period, 14.2 percent of students enrolling in math remediation, on average, successfully complete a gateway math course with a grade of “C” or higher—in one academic year; however, 26.1 percent of those students complete within two academic years. Figure 6 illustrates how the gateway completion rate has steadily increased over this three year period.

Figure 6: Remedial Students who completed a gateway math course in one or two academic years



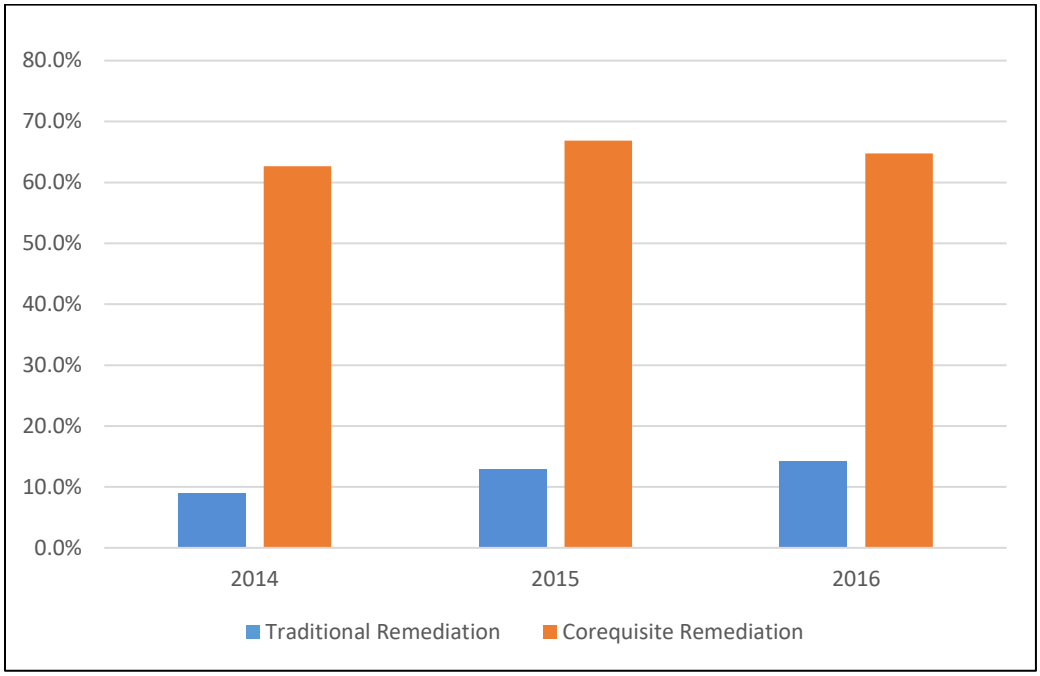
NOTE: Indicates that students completed the course with a grade of “C” or higher

When disaggregated by remediation type, however, a more nuanced picture develops (see Table 8). Over a three year period, an average of 65.2 percent of students enrolled in corequisite models of remediation pass a gateway course within one academic year, compared to 11.7% over that same period—a difference of 53.5 percentage points (see figure 9).. That gap narrows for students completing a gateway course within two academic years, as the success rates for students in traditional remediation more than doubles to just under 23 percent. However, there is still a 45.5 percentage point difference between success rates of students enrolled in the two types of remediation and successfully completing a gateway course within two academic years.

Table 9: Successful Gateway Course Completion, Corequisite and Traditional Models

	Corequisite Model		Traditional Remediation	
	Gateway Completion in 1 year	Gateway completion in 2 years	Gateway Completion in 1 year	Gateway completion in 2 years
2014	62.7%	68.7%	8.9%	21.9%
2015	66.9%	69.5%	13.0%	25.0%
2016	64.8%	69.6%	14.2%	25.6%

Figure 7: Successful Gateway Course Completion by Remediation Type, within one academic year



Students who are more underprepared will obviously need more remediation support, and perhaps more courses in a remedial sequence. MDHE evaluated ACT composite scores and math subscores for students enrolled in each type of remediation, which are the only proxy for content readiness available in EMSAS files, to determine if there were any appreciable difference between these students. Our data indicate that for these three years, the median ACT composite scores for students needing remediation was 19, and a math subscore of 17. When disaggregated by remediation type, the median ACT composite score for students in corequisite supports was 20, while the math subscore was 19; for students in traditional models, the composite score was 18, with a math subscore of 17, a two point difference between the two models. When looking at students who did not pass a gateway course in two years, the median math subscore was 18 for students enrolled in corequisite and 16 for those in traditional remediation.

MDHE further disaggregated the data by sector. Students at two-year public institutions who did not pass a gateway course within two academic years at a median ACT composite score of 17, with a math subscore of 16; students at public four-year institutions had a median composite score of 19, with a math subscore of 17. Interestingly, these scores are constant for students at two-year institutions who successfully complete a gateway course within two years, though the scores are slightly higher at the

four-year institutions—a composite score of 20 and a math subscore of 18. Of particular note in comparing the two sectors, only 33.7 percent of remedial students at two-year institutions had ACT scores, while 72.5 percent did at four-year institutions. Therefore, with the data available to MDHE, it is difficult to determine if there are appreciable differences between students enrolled in these two models. More data and research are necessary on this particular point.

For fall 2018, 20 institutions offer mathematics corequisite supports, a 33 percent increase from 2017 when only 15 institutions offered corequisite supports. While every institution is implementing at least one alternative path to PreCalculus Algebra, not every institution offers a corequisite support, nor does each institution offer corequisite supports for every pathway they offer. Additionally, while corequisite supports are similar in nature, they vary by course and by institution in terms of structure, type of instructor, and credit-bearing status. In some cases, the corequisite is offered as a stand-alone course into which students enroll concurrently with the gateway course, similar to a lab component to a science course. In other cases, the corequisite component is embedded with the gateway course, and students requiring additional supports are enrolled in sections with an additional hour or two attached.

A survey of institutional practices reveals the following about corequisite supports:

- PreCalculus Algebra: 11 institutions offer corequisite support, eight of the corequisite supports are separate courses, five have the same instructor as the gateway course, and five are credit-bearing
- Statistical Reasoning: 10 institutions offer corequisite support, nine are separate courses, three have the same instructor as the gateway course, and four are credit-bearing
- Mathematical Reasoning & Modeling: 15 institutions offer corequisite support, 12 are separate courses, five have the same instructor as they gateway course, and seven are credit-bearing

While preliminary results from the corequisite model show great promise, and institutions have taken great strides to implement corequisite supports, there is much work to do be done. Mapping backwards from the student learning outcomes, corequisite competencies have been developed for each of the pathways (see Appendix B). However, not every institution offers a corequisite for each of the pathways offered; only around half of the institutions at each sector offer corresponding corequisite supports for the pathways, the exception being Mathematical Reasoning & Modeling at the four-year sector (see Table 10). Ideally, each institution would offer all of the pathways and the corequisite supports that align to them.

Table 10: Math Pathways and corresponding corequisite support offered, by sector

	PreCalculus Algebra		Statistical Reasoning		Mathematical Reasoning & Modeling	
	Pathway	Coreq	Pathway	Coreq	Pathway	Coreq
2-Year Sector	13	6	10	5	13	7
4-Year Sector	13	5	9	5	10	8
State Total	**26**	**11**	**19**	**10**	**23**	**15**

Next Steps & Recommendations

All institutions are now using multiple measures to place students in mathematics courses, and more institutions than ever are incorporating high school GPA and/or coursework in placement practices. Some states have already established high school GPA thresholds—Massachusetts uses a 2.7, for example—but nothing of the sort has occurred in Missouri. The annual remediation survey attempted to capture an

approximation of these data, but was ultimately unsuccessful; MDHE staff learned that high school GPA is not something that all institutions collect—especially among the two-year institutions. Where GPA is provided, these scores are usually self-reported, making the values potentially inflated and therefore unsuitable for analysis.

MDHE staff are in the process of coordinating with DESE to analyze GPA for Missouri high school students to determine a statewide cut score. MDHE staff also plan to work jointly with DESE on a project working to align secondary and postsecondary mathematics, to ensure that students are both college and career ready. This project is in the early phases of planning and organization, and more information will be provided at a later date.

Alongside the work of Math Pathways, MDHE staff are working with institutions to develop Guided Pathways or Meta-majors, to help students in enrollment decisions. Data indicate that while students often switch majors, they often do so within related fields. For example, a student may switch from sociology to anthropology, but both are within the broader discipline (or meta-major) of the social sciences, and share many of the same framework and courses. MDHE staff, working along with institutions, are working to align the math pathways with meta-majors and/or programs of study, to ensure that students are taking the most applicable math. While this work is on-going, MDHE staff believe this will have be successful in increasing retention rates and overall completions.

While corequisite mathematics remediation is being offered at 80 percent of institutions—not including Missouri University of Science & Technology or Truman State University—corequisite supports are not necessarily available for all math pathway courses offered at these institutions; nor are all pathways offered at every institution. MDHE staff recommend that institutions offer each pathway and provide corequisite supports to ensure student success. Further, MDHE staff are in the process of working with independent institutions to offer math pathways in ongoing efforts to expand the CORE 42 general education transfer curriculum.

Additionally, there is great variation in the institutional practices around mathematical corequisite supports. MDHE staff will work to determine if there are certain practices that are more beneficial for students—resulting in higher retention and completion rates—by analyzing the course level data and the EMSAS files. If there are some practices which have better results than others, MDHE staff will work the Missouri Mathematics Advisory Council to update *The Principles of Best Practice in Remedial Education* to reflect these updated observations. Alongside this, MDHE staff feel updating *Principles of Best Practice* in general would be beneficial, for instance revisiting statewide cutscores (to include high school GPA as well) using more recent data and to reflect many of the changes that have occurred since the document was initially released.

This year's Report on the Condition of College and Career Readiness has focused exclusively on mathematics. Good work is being done to reduce the need for remediation in English, and several institutions are implementing corequisite support for their English courses. MDHE staff will take a closer look at the effectiveness of efforts to reduce the need for remediation in English and to improve student learning outcomes.

Appendix A: Institutional Math Pathways Offerings

	PreCalculus Algebra	PreCalculus	Statistical Reasoning	Mathematical Reasoning & Modeling
Crowder College	No	Yes	Yes	Yes
East Central College	Yes	No	Yes	Yes
Jefferson College	Yes	Yes	Yes	Yes
Metropolitan Community College - Kansas City	Yes	Yes	Yes	Yes
Mineral Area College	Yes	No	Yes	Yes
Missouri State University-West Plains	Yes	Yes	No	Yes
Moberly Area Community College	Yes	Yes	Yes	Yes
North Central Missouri College	Yes	No	No	No
Ozarks Technical Community College	Yes	Yes	No	Yes
St. Charles Community College	Yes	Yes	Yes	Yes
St. Louis Community College	Yes	Yes	Yes	Yes
State Fair Community College	Yes	No	Yes	Yes
State Technical College of Missouri	Yes	No	Yes	Yes
Three Rivers College	Yes	No	No	Yes
2-Year Subtotal	***13***	***8***	***10***	***13***
Harris-Stowe State University	Yes	Yes	Yes	No
Lincoln University	Yes	Yes	Yes	Yes
Missouri Southern State University	Yes	Yes	No	Yes
Missouri State University	Yes	Yes	No	Yes
Missouri Western State University	Yes	Yes	Yes	Yes
Missouri University of Science & Technology	Yes	Yes	Yes	No
Northwest Missouri State University	Yes	Yes	Yes	Yes
Southeast Missouri State University	Yes	Yes	Yes	Yes
Truman State University	Yes	Yes	No	No
University of Central Missouri	Yes	Yes	Yes	Yes
University of Missouri	Yes	Yes	Yes	Yes
University of Missouri - Kansas City	Yes	Yes	No	Yes
University of Missouri-St. Louis	Yes	Yes	Yes	Yes
4-Year Subtotal	***13***	***13***	***9***	***10***
State Total	**26**	**21**	**19**	**23**

Appendix B: Competencies for Corequisite Supports

Precalculus Algebra Recommended Competencies

Recommended Competencies	Student Learning Outcomes
The Corequisite at Scale Task Force offers the following *possible* topics of study for a Precalculus Algebra, corequisite course. These topics include just-in-time learning of foundational skills and review of credit-bearing, course content.	The Missouri Math Pathways Task Force has determined the following Student Learning Outcomes as the minimum requirements of a credit-bearing, entry-level, college course in precalculus algebra reasoning.
I. Foundations of Functions **Students will use multiple representations of different function types to investigate quantities and describe relationships between quantities. Specifically, students will be able to:**	
Use multiple representations of functions to interpret and describe how two quantities change together.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Use interval notation • Interpret radical and rational expressions • Evaluate functions • Apply the order of operations • Recognize relationship between inputs and outputs of functions • Sketch graphs of common functions • Interpret inequality symbols	▪ Identify constraints on quantities and domains. ▪ Distinguish dependent and independent variables. ▪ Identify domains and ranges. ▪ Effectively communicate using function notation.
Measure, compute, describe and interpret rates of change of quantities embedded in multiple representations.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Calculate and interpret slope • Explain a rate of change in terms of slope including appropriate units	▪ Identify constant rates of change. ▪ Determine average rates of change. ▪ Be able to estimate instantaneous rates of change.
Use appropriate tools and representations to investigate the patterns and relationships present in multiple function types.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Graph basic functions • Solve algebraic equations • Identify domains and ranges • Use calculators or computer software in accordance to requirements in Pathways course	▪ Work effectively with the following functions: linear, quadratic, exponential, logarithmic, rational, piecewise and absolute value.
II. Analysis of Functions **Students will describe characteristics of different function types and convert between different representations and algebraic forms to analyze and solve meaningful problems. Specifically, students will be able to:**	
Create, use and interpret linear equations and convert between forms as appropriate.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*

• Read information from graphs, figures, tables, etc. • Perform operations with fractions	▪ Identify important values (i.e. slope and intercepts) from multiple representations. ▪ Determine equations of lines given one point and the slope, two points or statements about proportional relationships.
Create, use and interpret exponential and logarithmic equations and convert between forms as appropriate.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Use properties of logarithms • Use rules of exponents • Understand inverse relationships between exponential and logarithmic functions	▪ Explain exponential growth as constant percentage rate of change. ▪ Interpret half-life and doubling time to create decay and growth models. ▪ Recognize similarities and differences between linear and exponential functions. ▪ Recognize the role of *e* as a natural base ▪ Describe long-term behavior of exponential models. ▪ Apply the inverse relationship between exponential and logarithmic functions.
Create, use and interpret polynomial, power and rational functions.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Perform operations on polynomials • Create graphs of basic functions • Solve algebraic equations • Identify where a function is increasing, decreasing, or constant • Use the quadratic formula • Find domain of rational functions • Use function notation (i.e. evaluate $f(-x)$)	▪ Recognize how power functions are different from exponential functions. ▪ Determine whether a graph has symmetry and whether a function is even or odd. ▪ Determine end behavior, maximum, minimum and turning points of a graph. ▪ Find roots of a function and correctly graph the function. ▪ Graph rational functions and find vertical, horizontal and oblique asymptotes.
II. Analysis of Functions (continued)	
Students will describe characteristics of different function types and convert between different representations and algebraic forms to analyze and solve meaningful problems. Specifically, students will be able to:	
Construct, use and describe transformations, operations, compositions and inverses of functions.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• State the domains and ranges of functions • Perform operations on functions • Perform integer operations • Define the term “function” • Sketch the graphs of basic functions • Solve for the indicated variable	▪ Describe how the graph of a function can be the result of vertical and horizontal shifts, stretches, compressions, and reflections of the graph of a basic function. ▪ Perform arithmetic operations with functions and describe the domain. ▪ Create new functions by composing basic functions and describe the domain. ▪ Decompose a composite function into basic functions.

	▪ Determine if a function is one-to-one, and if so, find the inverse and describe its domain and range.
III. Algebraic Reasoning **Students will identify and apply algebraic reasoning to write equivalent expressions, solve equations and interpret inequalities. Specifically, students will be able to:**	
Use algebraic techniques to simplify expressions and locate roots.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Factor polynomials • Solve algebraic equations • Simplify radicals • Solve compound inequalities • Graph inequalities in one variable • Perform integer operations • Define the imaginary unit	▪ Solve quadratic equations by factoring, the square root property, completing the square, and the quadratic formula. ▪ Solve quadratic, absolute value, polynomial and rational inequalities. ▪ Perform operations with complex numbers. ▪ Determine complex roots of polynomials.
Use algebraic reasoning to simplify a variety of expressions and find roots of equations involving multiple function types.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Use rules of exponents • Solve algebraic equations	▪ Apply properties of exponents and logarithms. ▪ Solve polynomial, radical, rational, exponential, and logarithmic equations.
Use rational exponents to express and simplify a variety of expressions and solve equations.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Use rules of exponents • Identify and factor out the greatest common factor	▪ Factor out common rational powers. ▪ Simplify fractional expressions involving rational exponents.
Solve and apply systems of equations and inequalities.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Translate written statements into algebraic equations • Perform operations on real numbers • Solve equations	▪ Set up and solve systems of equations. ▪ Perform matrix operations. ▪ Use matrices to solve systems of linear equations. ▪ Graph systems of inequalities.

Statistical Reasoning Recommended Competencies

Recommended Competencies	Student Learning Outcomes
The Corequisite at Scale Task Force offers the following *possible* topics of study for a statistical reasoning, corequisite course. These topics include just-in-time learning of foundational skills and review of credit-bearing, course content. Instruction on the efficient use of technology and study skills are also advised.	The Missouri Math Pathways Task Force has determined the following Student Learning Outcomes as the minimum requirements of a credit-bearing, entry-level, college course in statistical reasoning.

I. Data Exploration

Students will analyze data using graphical and numerical methods to study patterns and departures from patterns, using appropriate technology as needed. Specifically, students will be able to:

Construct and interpret graphical displays of distributions of univariate data.

Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Plot points and intervals on a number line • Perform signed number arithmetic • Read to understand information from tables and graphs	▪ Create and interpret dotplots, boxplots, stem and leaf plots and histograms. ▪ Analyze center, shape and spread, as well as clusters, gaps, outliers and other unusual features.

Summarize distributions of univariate data and compare multiple distributions.

Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Use summation notation • Plot an ordered pair (x, y) in a rectangular coordinate system • Round decimal values • Understand powers and square roots of numbers • Understand order of operations	▪ Compute measures of center (median, mean), measures of spread (range, interquartile range, standard deviation) and measures of position (quartiles, other percentiles and standardized scores). ▪ Compare groups using back-to-back stem and leaf plots, parallel boxplots and dotplots.

Explore bivariate data.

Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Find the slope of line segment connecting two points, the equation of a line, and graph the equation of a line • Find the vertical distance between a point and a line • Round decimal values	▪ Analyze scatterplots for patterns, linearity, and outliers. ▪ Calculate and interpret the correlation coefficient.

I. Data Exploration (continued)	
Students will analyze data using graphical and numerical methods to study patterns and departures from patterns, using appropriate technology as needed. Specifically, students will be able to:	
Explore categorical data.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Read to understand information from a table or a graph	▪ Create and interpret frequency tables and bar charts. ▪ Compare distributions of categorical data.

II. Statistical Design **Students will critically evaluate a data-collection plan to answer a given research question. Specifically, students will be able to:**	
Identify characteristics of good study designs. Understand what conclusions are appropriate for a given design and whether conclusions can be generalized to a larger population.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Read carefully through a problem • Know and understand key terms • Read carefully to identify important information in a word problem	▪ Identify the population of interest. ▪ Determine whether an observational or experimental study is appropriate and feasible. ▪ Explain the difference between and importance of random selection and random assignment in study design.
Know the elements of planning and conducting an observational study.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Distinguish between a sample and a population • Differentiate between key terms	▪ Verify basic elements of statistically valid sample survey. ▪ Determine when a census or a sample survey is appropriate. ▪ Identify potential sources of bias in sampling and surveys.
Know the elements of planning and conducting an experimental study.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Recognize and differentiate between key terms • Identify dependent and independent variables	▪ Verify basic elements of statistically valid experimental design. ▪ Explain the purpose of including a control group and blinding in an experiment. ▪ Identify potential sources of confounding in an experiment.

III. Probability and Simulation **Students will use probability concepts and simulation. Specifically, students will be able to:**	
Determine and interpret probabilities.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*

• Convert among fractions, decimals, and percents • Operate with fractions	▪ Interpret a probability as a long-run relative frequency of occurrence. ▪ Calculate the probability of a specified event in a chance experiment with equally likely outcomes.
Use probability distributions to describe the behavior of discrete and continuous random variables.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Decide upon appropriate units of measurement in collection data • Perform signed number arithmetic • Plot numbers on a real number line, find a mean value and a range • Represent an inequality as an interval on the number line • Shade an area under the normal distribution	▪ Distinguish between discrete random variables and continuous random variables. ▪ Compute and interpret the mean and standard deviation of the probability distribution of a discrete random variable. ▪ Demonstrate an understanding of the mean, standard deviation and shape of continuous probability distributions (uniform, normal and skewed).
Understand distributions.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Recognize and differentiate between key terms	▪ Distinguish between the distribution of a sample and a sampling distribution. ▪ Describe the sampling distributions of a sample mean and sample proportion in terms of center, shape and spread. ▪ Explain how these relate to sample size. ▪ Identify when the use of the normal distribution is appropriate.
IV. Statistical Inference **Students will use statistical models to draw conclusions from data. Specifically, students will be able to:**	
Estimate population parameters including confidence intervals when appropriate.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Understand order of operations • Realize properties of inequalities	▪ Verify that the appropriate conditions have been met. ▪ Construct one-sample confidence intervals for means and for proportions. ▪ Construct two-sample confidence intervals for means. ▪ Interpret confidence intervals in context and explain the meaning of the confidence level associated with a confidence interval estimate.
Conduct tests of significance when appropriate.	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Understand order of operations • Represent an inequality as an interval on the number line • Interpret probability	▪ Verify that the appropriate conditions have been met. ▪ Carry out one-sample hypothesis tests for means and proportions.

• Use function notation	▪ Carry out two-sample hypothesis tests for means. ▪ Interpret the meaning of rejection of the null hypothesis and of failure to reject the null hypothesis, in context. ▪ Demonstrate an understanding of the use of a p-value to reach a conclusion and of the difference between practical significance and statistical significance.
V. Regression Modeling	
Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Find the slope of line segment connecting two points, the equation of a line, and graph the equation of a line • Understand slope as a ratio of change	▪ Determine the equation of the least-squares regression line and interpret its slope and intercept in context.

Mathematical Reasoning Recommended Competencies

Possible Corequisite Topics	Student Learning Outcomes
The Corequisite at Scale Task Force offers the following *possible* topics of study for a mathematical reasoning, corequisite course. These topics include just-in-time learning of foundational skills and review of credit-bearing, course content.	The Missouri Math Pathways Task Force has determined the following Student Learning Outcomes as the minimum requirements of a credit-bearing, entry-level, college course in mathematical reasoning.

I. Proportional Reasoning

Students will draw conclusions or make decisions in quantitative-based situations using proportional reasoning. Specifically, students will be able to:

Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Simplify and evaluate algebraic expressions • Use order of operations • Use estimation • Simplify fractions • Write fractions/percentage in decimal forms • Find a percentage increase/decrease • Perform operations with fractions and decimals • Solve linear equations • Solve proportion equations • Solve linear inequalities	• Use ratios, proportions, rates and percentages to explain, draw conclusions, or make decisions. • Use units and unit conversions to explain, draw conclusions, or make decisions.

II. Statistical Reasoning

Students will read, interpret, analyze and synthesize quantitative data (e.g., graphs, tables, statistics, survey data, etc.) and make reasoned estimates and inferences. Specifically, students will be able to:

Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Find the slope of a line • Determine an equation of a line • Find the intercepts of a line and interpret their meaning • Substitute values and evaluate an expression • Use exponential notation and properties • Use radicals • Plot points in the Cartesian Coordinate System • Graph linear equations by plotting points • Use subscript and summation notation • Shade a described area	▪ Collect and organize data in graphs and tables. ▪ Use descriptive statistics to interpret and analyze quantitative data. ▪ Use probability to interpret and analyze quantitative data. ▪ Communicate statistical findings effectively.

III. Mathematical Modeling

Students will create, apply and use mathematical models to solve problems. Specifically, students will be able to:

Possible Corequisite Topics	*Pathways Initiative Student Learning Outcomes*
• Plot points in Cartesian Coordinate System • Solve a system of equations graphically • Translate phrases into mathematical expressions • Translate applications into equations • Solve linear inequalities in two variables • Graph exponential functions • Find the slope of a line • Use exponential notation and properties • Use logarithms and properties • Use order of operations • Simplify radicals • Evaluate complex expressions using technology	▪ Describe and contrast linear rate and non-linear rate through verbalization and writing. ▪ Create linear and exponential functions from quantitative data and explain the results. ▪ Interpret and analyze linear and exponential functions that model data.