PATTERNS OF STEM-MATH ENROLLMENT AND COMPLETION

EXECUTIVE SUMMARY

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ACKNOWLEDGEMENTS

We would like to thank former senior Colorado Community College System staff members Casey Sacks and Maret Felzien, who provided a wealth of history and insight about developmental education reforms in Colorado; Danen Jobe, Colorado Community College System's Director of Academic Programs and Curriculum; and the department chairs, faculty and advisers from the 13 community colleges, one of which has three campuses in the study, who spoke with us during the course of this study. We would also like to thank the Rutgers team — Michelle Van Noy, Tracy Cangiano and Angel Butts.

RECOMMENDED CITATION

McKay, H., Bahr, P. R., Michael, S., Douglas, D., Boyle, J., and Smith, M. (2022). Patterns of STEM-Math Enrollment and Completion [Executive Summary]. Strong Start to Finish and the Education Commision of the States.

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EXECUTIVE SUMMARY

Introduction

The ascendancy of a technological, knowledge-based economy has increased focus on science, technology, engineering and math (STEM) education. Both community and four-year colleges have worked to increase entry into STEM education and ensure student success. Concurrently, scholars are examining issues of equity in access to STEM programs, addressing questions including: Are STEM pathways equally accessible for diverse populations, especially Black and Hispanic[1] students?[2] What pre-college and higher education factors contribute to different patterns of enrollment? And do all enrolled students complete their STEM programs at similar rates of success?

This study will investigate these questions within the context of the Colorado Community College System and suggest practices and policies to promote equity based on these findings. Of note, while gender and socioeconomic status are important areas for discussion, they are not addressed in this paper.

Context and Background

Over the past decade, many community college systems have worked to address barriers to equity[3] — the goal of equal access to and equivalent rates of completion — in STEM-eligible math courses. Solutions have included establishing new strategies for assessment and course placement, restructuring developmental education offerings and developing more supportive, inclusive campus cultures that actively recognize and integrate diversity across all aspects of college learning and life.

Among these reform-minded systems is the Colorado Community College System which, in 2013, redesigned and restructured developmental education across all 13 of its colleges. Of note, this paper looks at 13 colleges, but includes three separate campuses for Front Range Community College in the body below. As such, we refer to the collection of schools and campuses in the study as 15 colleges and campuses throughout.[4] This developmental education restructuring involved establishing new strategies to assess and place students into college-level courses as well as offering corequisite courses (concurrent enrollment in a lab and college-level course) in STEM and non-STEM pathways. The Colorado Community College System, therefore, provides a rich opportunity to study how such changes have affected the enrollment of Black, Hispanic and White students into college-level STEM or non-STEM math pathways over time.

We chose to study math placement for two reasons: First, because math has emerged as the "single biggest obstacle to retention and completion"[5] for all college students and, second, because community colleges often view students' first math courses as the gateway to further study in STEM. These two facts combine to position math placement as a significant barrier to

entry into STEM fields. We know that for some, this barrier is higher than for others. Research tells us that, for decades, a disproportionate number of Black, Brown, Hispanic, Asian American and Indigenous students, those with low incomes, and returning adults have been placed in developmental education math courses.[6, 7] Historically, these placements have resulted in low rates of course completion and program retention.[8, 9, 10] Moreover, a disproportionate number of students from these groups have also been diverted into non-STEM-eligible math pathways.[11] These diversions potentially limit students' options for transfer to four-year institutions and, thus, completion of a higher academic degree. This, in turn, limits students' employment opportunities. It can also cut short students' prospects to pursue a career in STEM and thus the middle- and high-income salaries those careers often carry with them. It is also worth noting that because these diversions disproportionately affect Black, Brown, Hispanic, Asian American and Indigenous students, those with low incomes and returning adults, they prevent companies from experiencing the benefits of a diverse workforce, which includes higher revenues, greater creativity and innovation, and richer employee experiences.[12]

Findings from this report can help inform policy and practice reforms in college-level math education, advising, assessment and placement. They can also provide state and federal agencies with insights into some of the factors that contribute to racial-ethnic differences in student enrollment in STEM pathways.

Research Questions and Purpose

While we know a wide range of pre-college personal and community factors, as well as college-based institutional factors, influence a student's likelihood to enroll in and successfully complete a STEM or non-STEM math pathway, this report will focus on institutional factors. This report is focused on Black, Hispanic and White populations, as those were the populations large enough to examine in our data set. Our research questions are:

1. Between 2010 and 2019, how did rates of enrollment of Black, Hispanic and White students in STEM-eligible first math courses change at Colorado Community College System colleges?

2. Between 2010 and 2019, how did rates of completion of STEM-eligible first math courses change among Black, Hispanic and White students at Colorado Community College System colleges?

3. Which aspect(s) of the redesign of developmental education in Colorado's community college system (changes in assessment/placement, advising and the establishment of corequisite courses), if any, likely contributed to the observed changes?

Methodology

We base our report on a mixed-methods study that included qualitative and quantitative research activities. We first analyzed Colorado Community College System student enrollment and completion data from 2010 through 2019 by students' race-ethnicity — focusing on Black, Hispanic and White students.[13] We used this quantitative data to identify patterns and trends in enrollment in and successful completion of STEM-eligible math courses. These analyses were used to address our first two research questions.

To collect our qualitative data, we conducted telephone interviews with math department chairs and faculty at 13 Colorado Community College System campuses as well as with student advisers at 12 of those locations. The interviews focused on changes in developmental education and math courses, college advising, assessment and math placement practices since the System's 2014 developmental education redesigns. We also asked if and how colleges were taking specific steps to address the historic patterns of inequity in STEM-eligible math enrollment among Black, Hispanic and White students (e.g., increasing activities focused on campus climate, increasing racial-ethnic diversity among staff and faculty, and confronting systemic and individual racial-ethnic biases). These data cover the period from 2010–2021 and primarily serve to answer research question three.

The qualitative research activities were impacted by COVID-19-related restrictions, which prevented in-person campus visits to interview students and faculty, and to observe classes and campus life.

Key Findings

- **Rates of enrollment in STEM-eligible math courses for students in their first year at Colorado community colleges increased from 12% in 2010 to 56% in 2019.** Rates of enrollment in these courses became more similar among Black, Hispanic and White students over time. But there was variation among colleges, with some approaching parity among racial-ethnic groups and persistent differences at others. Increases in rates of enrollment in such courses were likely the result of Colorado's developmental education redesign, which increased the number of STEM-eligible mathematics courses — specifically, corequisite courses in algebra. It may also have been due to advisers whose default was to recommend STEM-eligible courses to the majority of new students.

- **Rates of success in first college-level math courses in general, and STEM-eligible college-level math courses in particular, increased between 2010 and 2019.** In terms of equity, system-wide trends indicated that Black and Hispanic students' odds of success in college-level math courses all increased and became more similar over time. This success is likely the result of policies that increased enrollment in both non-STEM and STEM-eligible college-level courses during the redesign. Specifically, policies such as multiple-measure waiver trees,[14] self-placement and the elimination of standalone developmental education likely led more students to attempt and succeed in college-level courses.

- Colleges that made more comprehensive systemic changes and focused on equity issues (e.g., Community College of Denver, Community College of Aurora) saw both greater rates of overall success and more equitable outcomes among racial/ethnic groups.

Conclusion and Recommendations

This report presents considerations for practitioners as they think about the pathways for Black and Hispanic students into math education, the path they take into STEM-eligible or non-STEM pathways, and their success in their chosen pathways.

- **Interventions to encourage Black and Hispanic students to consider STEM-eligible math pathways may have to occur before entry into college.** Most students have already made decisions about their program of study — and thus, their math pathways — prior to entering college. Our qualitative data suggest that most students decide on their program of study, often dictating their math pathway, prior to their first experience with their institution and prior to any significant interaction with college staff and faculty. These choices are indicated while filling out application paperwork. Often, only undecided students had detailed interactions about their math pathway with advisers or college faculty/staff. This information points to some important areas for consideration. Math choices are impacted by experiences that happen prior to college — in high school, in families, as a part of culture. Alternatively, although admittedly resource-intensive, colleges could require meaningful education and career focused conversations with an adviser as a part of the application process with a focus on math pathways.
- **Innovation in math placement practices shows promise.** Our research showed innovative placement policies and practices, like the use of the waiver tree and self-placement, can influence math pathway choices and outcomes. Community College of Denver, one of the most successful colleges in the study in terms of both parity in placement and student success in math classes, employs a unique system for math placement, including the use of default placement into corequisite courses and diagnostic exams during their first class. The results of these diagnostic exams lead to conversations about whether the math class is the right fit or they should transfer to another course. This system shows promise, and we recommend further examination.
- **Colleges should consider implementing corequisite models and eliminating standalone developmental education to improve enrollment and success rates in STEM-eligible math.** Movement toward corequisite education led to greater enrollment and success in college-level and STEM-eligible math courses both overall and across racial-ethnic subgroups. This study supports the vast literature on developmental education reforms. The first adopters of corequisites and other reforms had earlier and better positive outcomes for students.

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1. The Colorado Community College System data set uses the identifier Hispanic — thus, while we prefer to use the more precise term "Latinx" for persons with Latin American ancestry, we use Hispanic throughout this report.

2. The authors recognize that diverse populations are differentially affected by pre-college and college experiences. These populations include students who are racially minoritized, female, from low-income households and returning adults. We are also mindful of the intersectionality of such demographics. However, the demographics of Colorado's community college system and the data we were able to access limited the focus of our study to Hispanic, Black and White students regardless of age or gender category, first-generation status, or income level.

3. For this report, we define "equity" as equivalent access to and equivalent rates of successful completion for different populations.

4. The 13 CCCS colleges are: Arapahoe Community College; Colorado Northwest Community College; Community College of Aurora; Community College of Denver; Front Range Community College; Lamar Community College; Morgan Community College; Northeast Junior College; Otero Community College; Pikes Peak Community College; Pueblo Community College; Red Rocks Community College; and Trinidad State Junior College. Because we treated the three campuses of FRCC as distinct institutions (Boulder County, Larimer and Westminster), the study includes a total of 15 research sites in all. This decision was based on interview content, which suggested that there was a fair amount of difference across the three FRCC campuses both in terms of their student populations and in their policies and practices.

5. Logue, 2016.

6. Ngo & Melguizo, 2020.

7. Bahr, 2013.

8. National Center on Education and the Economy, 2013.

9. Barnett, Kopko, Cullinan, & Belfield, 2020.

10. Park et al., 2018.

11. Ngo & Melguizo, 2020.

12. Glassdoor Team, 2017.

13. Overall, Colorado community colleges have low numbers of Asian, Black and Indigenous students, although the numbers for each of these groups vary by college. Given the historic underrepresentation of Black and Hispanic students in STEM pathways, we focused on these two groups for this report.

14. A waiver tree is a term we use to describe the Colorado Community College System's post-redesign math placement method, which uses any college-level indicator a student has available to place them in college-level math.