Changing the Conversation: Building Success in a Community College Mathematics Classroom

Megan Selbach-Allen
Stanford University

Calculus remains a major barrier of entry into STEM for students without strong mathematics backgrounds. This study looks at one implementation of the STEM Core model, which provides an accelerated pathway through developmental math classes along with extensive support to get students calculus ready in one year. Viewing this program as a community of practice around math learning I examined course completion data and conducted interviews to understand how the model is impacting student success. Furthermore, I seek to understand what aspects of the model matter most to the students. Initial results of student success rates in the course sequence show significant positive outcomes, with nearly 65% of STEM Core students reaching Calculus I in one year. Interviews with students reveal how their success goes beyond course completion and the importance of the relationships they built with their instructors and one another.

Keywords: Community College, STEM pathways, Developmental Mathematics, Calculus

Within the context of science, technology, engineering, and mathematics (STEM) many studies have shown the reality of the “leaky pipeline” with students dropping out of STEM majors along the way to completing a degree or dropping out of school (Flynn, 2016). Historically, many faculty in these disciplines promoted this culture as they thought it was a filter removing students who would not be capable of succeeding, but this is not the case (Seymour & Hewitt, 1997). Unfortunately, the students who drop are not weaker academically but do have backgrounds already underrepresented in STEM fields and cite the realities of a “chilly climate” as a significant factor in why they step away from finishing their STEM degrees (Jorstad et al, 2017). Addressing the issues creating the leaky pipeline and students not persisting in STEM degrees is crucial to improving broader issues of diversity in STEM.

Research has shown the importance of teachers and effective teaching in students’ academic outcomes (Burroughs et al., 2019; Christe, 2013; Goe, 2007; Goh & Fraser, 1998; Sonnert et al., 2015). This research spans grades K-16 and all subject areas. Unfortunately, undergraduate mathematics often serves as a barrier for students attempting to pursue STEM degrees (Bressoud et al., 2015). Improving mathematics instruction and classroom environments is an important part of addressing the leaky pipeline and equity in STEM (Boaler & Selling, 2017).

Public two-year colleges educate roughly 35% of undergraduate students in the United States (Community College Research Center, 2022). They educate a disproportionate share of minority, first generation and low-income students. Community colleges are an important starting point for many students entering the college pipeline and 49% of students completing bachelor’s degrees had attended community college at some point in the previous 10 years (National Student Clearinghouse Research Center, 2017). While this is an important context of study because of its large share of the undergraduate student population in the US, it is also an understudied context (Mesa et al., 2014a; Fletcher & Carter, 2010).

To work on improving the environment of STEM classrooms in community colleges we need to know both what effective teachers are doing in their classrooms and how students are responding to their instruction. Related to that it is necessary to understand the social environment of these classrooms and what students are learning.

Theoretical Framework

Of greatest interest for this work is understanding the mathematics classroom learning environment in this school. The environment is impacted by broader structures of the NSF funded STEM Core program of which it is a part, but it is also uniquely shaped by the instructors, staff and environment of this particular school.

This work is situated in the idea of learning as a community of practice (Wenger, 1999). The STEM Core model changes the mathematics learning environment for the students to engage them not only in the classroom as an individual, but in all aspects of their life and as a part of a community. With a cohort model, students spend a full year with consistent instructors who know them and each other. The student cohorts become a community with genuine relationships forming among the students themselves and the teachers and staff who support them. With the funding provided by STEM Core students also have access to a dedicated student support specialist.

This study is conducted in partnership with the mathematics course instructor and seeks to better understand what is working with this implementation of the STEM Core model. The research questions for this work are:

RQ1: How is this implementation of the STEM Core model affecting student success rates?

RQ2: What do student interviews reveal about the most impactful aspects of the program over time?

Success is defined by the institution as obtaining a C or better in a course. This definition in assessing the impact of STEM Core on academic outcomes for students aligns with requirements for taking follow-on courses and meeting transfer requirements. However, in this work success is also defined more broadly. Student persistence in the face of failure or adversity along with taking up identities as knowers and doers of mathematics, engineering or computer science are also markers of success for this researcher and the administrators of the program.

Literature Review

In 2012, Ann Sitomer and colleagues (2012) laid out a research agenda for mathematics education researchers specifically focused on community colleges. They acknowledged that there is much overlap with the long history of mathematics education research in K-12 classrooms and with the more recent research in undergraduate mathematics education (RUME) work, but they also note ways in which community colleges and the math learning they encompass are distinct. In a research commentary written a few years later Mesa and colleagues (2014a) also called for the need to expand research specifically in the math classrooms of community colleges. They note the difficulty and limitations of transferring the findings of work done in one setting (ie K-12 classrooms or 4-year colleges) to another (ie community colleges) as while there may be some similar characteristics there will also be many differences. In their commentary they also explicitly note the lack of research conducted specifically within classrooms and focusing on instruction. The research in classrooms that did exist tended to be conducted by practitioners and focused on particular interventions and more in line with sharing "what works" with other practitioners and not producing generalizable knowledge. They described the state of math education research in this setting as having, "the same feel of disorganized guerrilla warfare" (Mesa et al., 2014a, p. 179). Community colleges are constantly under pressure to improve student outcomes and are often looking for a quick fix. While instructors want to do better for their students, there is a lack of an organized research agenda to help them know the best ways to do so. In laying out their research agenda they reiterated the same four areas highlighted earlier by Sitomer and colleagues (2012).

Since the writing of these two commentaries additional important work in understanding community college mathematics instruction and learning has been done. A large video study of community college instructors sought to connect how they talked about instruction to their actual instructional practices in the classroom (Mesa et al., 2014b). While this study provided a significant amount of insight into instruction the authors note the need for more studies focusing on what students are learning, "what do students learn and understand as they experience particular teaching approaches" (Mesa et al., 2014b, p. 146). A further study of community college faculty teaching developmental math that sought to apply the framework of mathematical knowledge for teaching resulted in a proposal for the need to add an amendment of "the Caring Map" to make sense of the concept at the community college level (Nabb & Murawska, 2019). Studies using quantitative longitudinal methods have considered the variance of students' pathways through developmental mathematics and what drives varied student outcomes (Howell & Walkington, 2022). However, community college mathematics students themselves, especially their individual experiences, remain understudied.

Methods and Data Sources

This study uses past-performance data from 2015-2019 on student success rates in Algebra II through Calculus III, success is defined as obtaining a C or better in the course. It should be noted all course completion data is from before the implementation of AB705 in California which dis-incentivized colleges from offering developmental mathematics classes and led to a restructuring of the course sequence at this college along with changing the placement system for students. Updated course completion data is not yet available.

These course records are supplemented with student interviews (n=10) to understand what students viewed as the most salient aspects of their experience with the program. The students interviewed were alumni of STEM Core who had completed the one-year program up to four years prior. Volunteers were sought through messages on a facebook group for alumni in the program. Due to this sampling methodology the views expressed by students in the interviews may be biased but they still provide useful insight into what mechanisms might be driving the program success rates revealed by institutional data. Student demographic characteristics matched roughly with the overall demographics of the program, 8 students were male identifying and 2 were female identifying. The students also held a diversity of racial and ethnic identities. Further details of students' demographic characteristics are not included to protect student privacy and confidentiality.

During the roughly 30-minute interviews students were asked about many different aspects of the program. By interviewing students from multiple cohorts of students the researcher sought to better understand the longitudinal impact of this program for students after their first year of classes and when the intensive support structures of the program were no longer present.

Preliminary Results

Research Question 1

The first 5-years of the STEM Core program at this institution has produced results that show significant increases in student success in the courses from developmental math through calculus. Table 1 shows the results for cohorts of students in the program from four cohorts. As stated earlier in this paper success is defined as passing the course with a C or better. The number of enrolled students for a given course may exceed prior course numbers because students may take the course multiple times before obtaining a C or better and students are able to join the STEM Core cohort at any point in the pathway as long as they have met the prerequisite. Of students who start the STEM Core program with Algebra II 64% complete Calculus within one year compared to only 16% percent of students statewide (Mejia, Rodriguez, & Johnson, 2016).

Additionally, preliminary data shows that students in the STEM Core have higher success rates in English courses 77% versus 71% for the institution, even though English is not a part of the program. This difference indicates that the impact of the STEM Core model goes beyond helping students perform better in their STEM classes but may be helping them become better students overall.

Preliminary data also shows that success rates, while still high, decrease for courses that come after the program. Specifically, Calculus II success rates are significantly lower for students in their first attempt at the course but data shows that students who are not successful in their first attempt are taking the course again. The overall success rate for Calculus II for STEM Core students was 40% versus the overall institutional rate of 64%. However, a deeper look at the data revealed an interesting pattern. The results for one cohort show the success rate listed as 48% because 22 students passed in 46 attempts. However, this STEM Core cohort only included 29 students who had completed Calculus I, thus 76% of the STEM Core students who completed Calculus I also completed Calculus II, but some required multiple attempts.

Table 1: Shows student success rates in math courses in the institution as a whole and in the STEM Core cohort.

Course	**Typical success rates (3-year average)**	**STEM Core students**
Algebra II	56.4% (n=3311)	93.8% (n=145)
Trigonometry	60.9% (n=1542)	95.7% (n=164)
Precalculus	75.7% (n=1209)	89.7% (n=156)
Calculus I	65.8% (n=1376)	79.4% (n=136)

Research Question 2

Interviews with students revealed that nine of the students identified as still being involved in STEM either in their educational or career trajectory. Nine of the students had attempted calculus II with eight completing the course. One student dropped the course the first time and intends to retake again in the future and four of the eight who completed the course required more than one attempt to do so.

Students' discussion of their various experiences in calculus II shared a common theme of the drastic drop in the support they felt from their prior year taking calculus as a part of the STEM Core program. One student shared how her STEM Core instructors had warned their class not to expect the same level of support in future classes and worked to prepare them. Three of the students mentioned going back to their STEM Core instructor to seek advice and support. He encouraged them that failure was okay and that they would ultimately succeed.

The importance of the community they had found in the STEM Core program was a common theme among interviewees. They talked about how they trusted the faculty and staff in the program and built relationships with their classmates that extended beyond the classroom. One student mentioned that he was currently at a 4-year university and rooming with friends from the STEM Core program.

Another common theme in the interviews was how the program helped students connect with internships that helped lead to other jobs. These students who generally came from low-income families and were the first in their family to attend college appreciated how the STEM Core program provided guidance on the importance of internships and how to apply to them. They shared how these real-world connections have helped set them up with practical experiences and networks that they can leverage as they move forward in their careers.

Discussion

For students entering college at a developmental mathematics level the research says their chances of succeeding in a STEM major are very small (Bullock et al., 2017), but this work interrogates that 'truth.' It reveals through the success of students in one program how a model that supports students as whole people and builds community can lay the groundwork for long term success.

An important point to note about this program is that it is not 'remedial.' Any student who has an interest in pursuing a STEM degree can be admitted into the program. The main, initial appeal of the program to most of the students interviewed was that it would help them complete their math courses faster. This program leverages students' motivation and desire to succeed instead of labeling them as in need of remediation.

The instructors and staff of the STEM Core program studied in this work are incredibly dedicated and experienced. Their work may not be possible to replicate in all circumstances, but this work should lead institutions to consider whether implementing cohort models, emphasizing community building and considering wider supports for students might lead to higher success rates.

Finally, from a theoretical perspective this work could be seen as an empirical example of the mathematical knowledge for teaching (MKT) revised framework offered by Nabb & Murawska in their 2020 paper. They shared how understudied the domain of community college classrooms is and looked at the MKT framework that had arisen from K-12 instructional research, but they added one important area based on interviews with instructors: caring. The instructors and staff in this program care deeply for their students and that care is clear to the students in the program. While the students did learn content, the much more important messages they received was about their capabilities as students and that while they might struggle along the way they had a path to success.

Questions and Points for Audience Discussion

This work has served as a pre-study to a more in-depth study that will be undertaken during the upcoming 2022-23 academic year. I will be conducting a full ethnographic study of a cohort participating in this program and will attend and observe the mathematics classroom throughout the program. I am interested in what questions this work raises for audience members that I can consider in more detail in the longer study and what additional insights could be gleaned from further analysis of the interview data already collected.

References

Boaler, J., & Selling, S. K. (2017). Psychological Imprisonment or Intellectual Freedom? A Longitudinal Study of Contrasting School Mathematics Approaches and Their Impacton Adults' Lives. *Journal for Research in Mathematics Education*, *48*(1), 78-105.

Bressoud, D. M., Mesa, V., & Rasmussen, C. L. (Eds.). (2015). *Insights and recommendations from the MAA national study of college calculus*. MAA Press.

Bullock, D., Callahan, J., & Cullers, J. (2017). Calculus Reform: Increasing STEM Retention and Post-Requisite Course Success While Closing the Retention Gap for Women and Underrepresented Minority Students.

Burroughs, N., Gardner, J., Lee, Y., Guo, S., Touitou, I., Jansen, K., & Schmidt, W. (2019). A review of the literature on teacher effectiveness and student outcomes. *Teaching for excellence and equity*, 7-17.

Christe, B. L. (2013). The importance of faculty-student connections in STEM disciplines. *Journal of STEM Education: Innovations and Research*, *14*(3).

Community College Research Center (CCRC) at Teachers College Columbia University. (2022). *Community College FAQs*. https://ccrc.tc.columbia.edu/community-college-faqs.html.

Fletcher, L. A., & Carter, V. C. (2010). The important role of community colleges in undergraduate biology education. *CBE—Life Sciences Education*, *9*(4), 382-383.

Flynn, D. T. (2016). STEM field persistence: The impact of engagement on postsecondary STEM persistence for underrepresented minority students. *Journal of Educational Issues*, *2*(1), 185-214.

Goe, L. (2007). The link between teacher quality and student outcomes: A research synthesis. *National comprehensive center for teacher quality*.

Goh, S. C., & Fraser, B. J. (1998). Teacher interpersonal behaviour, classroom environment and student outcomes in primary mathematics in Singapore. *Learning Environments Research*, *1*(2), 199-229.

Howell, E., & Walkington, C. (2022). Factors associated with completion: Pathways through developmental mathematics. *Journal of College Student Retention: Research, Theory & Practice*, *24*(1), 43-78.

Jorstad, J., Starobin, S. S., Chen, Y., & Kollasch, A. (2017). STEM aspiration: The influence of social capital and chilly climate on female community college students. *Community College Journal of Research and Practice*, *41*(4-5), 253-266.

Mejia, M. C., Rodriguez, O., & Johnson, H. (2016). Preparing students for success in California’s community colleges. *Public Policy Institute of California*.

Mesa, V., Wladis, C., & Watkins, L. (2014a). Research problems in community college mathematics education: Testing the boundaries of K-12 research. *Journal for Research in Mathematics Education*, *45*(2), 173-192.

Mesa, V., Celis, S., & Lande, E. (2014b). Teaching approaches of community college mathematics faculty: Do they relate to classroom practices?. *American Educational Research Journal*, *51*(1), 117-151.

Nabb, K., & Murawska, J. (2019). Mathematical knowledge for teaching developmental courses at the community college: An unexplored terrain. *Community College Journal of Research and Practice*.

National Student Clearing House Research Center. (Spring, 2017). *Contribution of Two-Year Public Institutions to Bachelor’s Completions at Four-Year Institutions*. https://nscresearchcenter.org/wp-content/uploads/SnapshotReport26.pdf

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving* (p. 134). Westview Press, Boulder, CO.

Sitomer, A., Strom, A., Mesa, V., Duranczyk, I. M., Nabb, K., Smith, J., & Yannotta, M. (2012). Moving from Anecdote to Evidence: A Proposed Research Agenda in Community College Mathematics Education. *MathAMATYC Educator*, *4*(1), 35-40.

Sonnert, G., Sadler, P. M., Sadler, S. M., & Bressoud, D. M. (2015). The impact of instructor pedagogy on college calculus students' attitude toward mathematics. *International Journal of Mathematical Education in Science and Technology*, *46*(3), 370-387.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.