mathematics. And finally, we dedicate this volume to you, the reader, for taking the time and energy to engage with these issues.

CALCULUS: Crossing the Bridge to Success in STEM

Elaine A. Terry

Introduction

A private Jesuit Catholic university, Saint Joseph's is located in Lower Merion and Philadelphia counties. Founded in 1851 as Saint Joseph's College for men today the university is a coeducational institution with a student population of approximately 8,300 including undergraduate (day and evening), graduate and doctoral degree students. The undergraduate day program is approximately 77% white and 14% from an underrepresented group which includes African-American and Hispanic (non-Black). In any one academic year more than one hundred first-year students declare a STEM (natural sciences, mathematics, computer science) major. Many first-year STEM students experience difficulty handling the challenges of taking a college mathematics course (pre-calculus or calculus) and one or two lab science courses simultaneously. By the end of their freshman year some of them have made the decision to switch to a non-STEM major. Those that remain in STEM have the false belief that low and even failing grades will not prevent them from entering medical, professional or graduate school. While these are issues that may affect all STEM students, it is especially a difficulty for underrepresented students, who represent a small but significant number of STEM majors. Studies suggest that with early intervention underrepresented students can successfully complete an undergraduate STEM program. *CALCULUS: Crossing the Bridge to Success in STEM (CB-STEM)* was developed in order to equip first-year underrepresented students with the tools necessary for success in a STEM major. CB-STEM is a four-week summer pre-college non-residential program. It is the first intervention program at the University to address the gap in STEM education specifically for underrepresented (African-American, Hispanic (Non-Black) and First-Generation) students at the pre-freshman level. As a multi-faceted program, the primary goal is to provide incoming underrepresented students with the tools and resources that are beneficial for their first year in college as a STEM major.

To be considered for the program, students must meet the following criteria:

- Be admitted as a full-time student to the University.
- Be a first-time incoming college freshman with a declared STEM major.
- Be classified as a member of an underrepresented group which includes African-American, Hispanic, and First-Generation college students.
- Have completed pre-calculus or calculus in high school.

Students that are accepted into the program are expected to participate in academic and informational workshop classes. There is no cost to students to participate in the program.

The primary objectives of CB-STEM are:

- To increase participants' chances of passing their first college calculus course.
- To introduce students to: lecture format, classroom technology, laboratory class, faculty expectations, and college-level exams.
- To help students gain an understanding of good study habits, techniques, and skills.
- To introduce students to STEM faculty.
- To expose students to available academic resources at the University.
- To help students to connect with and build community with other first-year STEM students.

There are three academic workshops that are designed to make students aware of the rigorous requirements of the Saint Joseph's STEM major. The foundation of the program is the mathematics workshop, which uses *Previews to Calculus* worksheets to help teach and reinforce early calculus concepts including the limit and the derivative. More information about the mathematics workshop as well as a brief overview of the biology and chemistry workshops follow. A fourth seminar is designed to give students information that will be beneficial to them socially, academically, and professionally.

Natural Science and Informational Workshops

The three one-week academic workshops introduce students to the rigorous course expectations of the Saint Joseph's STEM curriculum. The workshops were organized in conjunction with two University professors from the departments of biology and chemistry. The three of us met to discuss the program and agree upon its structure. Each workshop met for sixty-minutes for four consecutive days. We discussed the difficulties that many students have with these courses as first-year STEM students. It was agreed that students would benefit by learning about course expectations, how to take notes, homework, and write lab reports. Students were also given information about studying for tests and test taking strategies. We all cited the lack of these skills as the primary reasons for lack of success as a first-year STEM student.

A fourth workshop is conducted by a University administrator who has experience working with underrepresented

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student populations. These are fifty-minute workshops that meet at least four times throughout the duration of the program. The aim of the workshop is to empower students with knowledge, skills and self-awareness that is necessary for success as a first year undergraduate STEM student. Topics of discussion are geared towards achieving success in the classroom and the importance of finding opportunities at the university that are relevant to STEM education. In addition, students are given information that will aid in the transition to college by helping them to find opportunities to become immersed in the university community as well as preparation for professional and graduate school and career opportunities.

The Mathematics Workshop

By the first day of the CB-STEM program all of the students have taken the University mathematics placement test. Because they have declared a STEM major, they have either placed into pre-calculus or calculus. In most cases, the students who placed into pre-calculus have not had calculus in high school. Those that place into calculus have a choice of two different University calculus courses based upon their declared major. The CB-STEM mathematics seminar exposes the pre-calculus students to the early concepts and language of calculus including limit, tangent line, derivative, and area below a curve. For the calculus students, the workshop serves as a review of calculus that gives them a deeper understanding of calculus concepts besides the usual drill and practice problems that many of them are accustomed to from high school calculus. The math workshop meets every day for four weeks for one hour fifteen minutes. Lectures are limited to thirty and no more than forty minutes. Students are required to take notes and encouraged to ask questions.

In order to reinforce the mathematical concepts from the brief lectures students are given *Previews to Calculus* worksheets. The worksheets are intended to challenge students to rethink how mathematics problems are solved. The exercises are written so as to reinforce conceptual understanding from the lectures and to stimulate interest in learning calculus in a less routine manner. There are worksheets that cover topics including the infinitesimal, slopes of graphs, rate of change, and area below a graph. The applications in the worksheets illustrate how calculus can be applied to other disciplines including the natural sciences, business, and economics. Teaching assistants, current undergraduate STEM students, serve as tutors to help students with any problems they may experience while working on the worksheet.

The first worksheet, Preview #1, is presented below. It opens with a brief description of calculus; discussing the meaning of calculus as the study of *change* and how the tools in calculus are used to describe numerically how something is changing at a given instance. To see this the worksheet begins with a problem that students should be able to complete. They are encouraged to work the problem and write a brief explanation of what the value they obtain means. Average rate of change (ARC) is defined and discussed. Two problems are given that encourage students to use an average rate of change formula that is appropriate for the given problem and to discuss the values obtained. Units must be included with the answer in order to get students to understand the idea of time dependent rate of change.

Preview #1: What is Calculus

In short, calculus is the study of change. You might ask: What is meant by change in mathematics? Change of what? The most important concept in calculus involving change is known as the derivative. Derivatives help to compute the rate of change of something; they help to answer the questions: How fast or slow is something changing at a certain instant? What is the rate at which something is increasing or decreasing at a given instant?

In this first preview an example is given that you should be able to work through. Following this example, two questions are asked that will illustrate the need for a mathematical tool that models movement, change.

Example 1.1

The number N of rabbits in a colony can be modeled by the polynomial function below:

$$N = f(t) = 120t - 0.4t^4 + 1000$$

where t is the time in months since observing began.

(a) What is the number N of rabbits in the colony when observing began? Briefly explain what your answer means.

(b) What is the number N of rabbits in the colony 4 months from when observing began? Does this represent an increase or decrease in the number of rabbits in the colony? Briefly explain what your answer means.

(c) What is the number N of rabbits in the colony 5 months from when observing began? Does this represent an increase or decrease in the number of rabbits in the colony? Briefly explain what your answer means.

Definition: Recall that for a given function $y = f(t)$, that the average rate of change, ARC, of f over an interval $[t_1, t_2]$ can be found using a difference quotient as follows:

$$ARC = \frac{f(t_2) - f(t_1)}{t_2 - t_1}$$

Use the ARC difference quotient for the following problems.

(d) What is the average rate of change of rabbits from month 3 to month 4? Include units with your answer and briefly explain what your answer means.

(e) What is the average rate of change of rabbits from month 5 to month 6? Include units with your answer and briefly explain what your answer means.

In calculus we would ask the following questions as it relates to the increase/decrease of rabbits in the colony:

Q1: What is the RATE OF CHANGE of the number of rabbits increasing/decreasing in the colony AT 3 months?

Q2: What is the RATE OF CHANGE of the number of rabbits increasing/decreasing in the colony AT 5 months?

The two questions at the end of the worksheet are discussed. What do they mean? How do we find the answer? Students are then asked to complete another worksheet that contains tables with the values that will aid in getting a better idea of rate of change at a given instance. They are then encouraged to review the results that they obtained and to use them to try answering Q1 and Q2. Discussion is held about the difference between average rate of change (ARC) and (instantaneous) rate of change. Again, units for instantaneous rate of change are discussed to reinforce that we are not just looking for the *number* of rabbits but the *rate* at which the number of rabbits is changing with respect to a certain time.

Use the rabbit colony function $N = f(t) = 120t - 0.4t^4 + 1000$ to complete the following tables with the appropriate values. Use the tables to help answer Q1 and Q2. Approximate to four decimal places.

Table 1A

t, months	N, # of Rabbits	Time Interval	Average Rate of Change
3.9		[3.9, 4]	
3.99		[3.99, 4]	
3.999		[3.999, 4]	
3.9999		[3.9999,4]	

Table 1B

t, months	N, # of Rabbits	Time Interval	Average Rate of Change
4.9		[4.9, 5]	
4.99		[4.99, 5]	
4.999		[4.999, 5]	
4.9999		[4.9999,5]	

2019 CALCULUS: Crossing the Bridge to Calculus COHORT

While we were unable to recruit the 12–14 students that we proposed, we had four very astute students in the first cohort, one male and three females. Of the four, two had taken calculus in high school with the other two having taken pre-calculus. Three of them enrolled in a calculus course as they were declared STEM majors. The psychology major had the option of following the calculus path or taking a different general education math course. She chose to enroll in *The Whole Truth About Whole Numbers*, which is described as a number theory course for non-math majors.

As the table below indicates, from an academic standpoint, the students had a successful first year. However, there is some concern about the physics major due to the drop in GPA.

Student	Major	Fall GPA	Fall Math	Sp GPA	Sp Math
#1	Computer Science	3.81	Pre-Cal B	3.71	Calc. I A-
#2	Psychology	3.80	Whole Truth A-	3.90	NA
#3	Physics	3.14	Calc. I B	2.93	Calc. II B-
#4	Biology	3.93	Calc. I A	3.88	NA

A survey was administered via Survey Monkey. Following are results from some of the questions that were asked.

1. How helpful was the CB-STEM program to you adjusting to the academic requirements of SJU? Results: 1 responded a great deal; 2 responded a lot; 1 responded a little
2. How likely are you to recommend the CB-STEM program to other Freshmen STEM students? Results: 2 responded very likely and 2 responded likely
3. How satisfied are you with the STEM major you have chosen and the department in which your major is housed at SJU? Results: 3 responded satisfied and 1 responded neither satisfied nor dissatisfied
4. How likely are you to recommend SJU to someone seeking to study a STEM subject? Results: 3 responded likely and 1 responded neither likely nor unlikely

There are various reasons for the small number of participants in the program. Including the fact that we are unable to provide housing, students tend to work during the summer and/or may have other academic opportunities that are preferred to our program. Also, the program ran during the week of orientation for first-year students. This is a time when students are on campus for registration and other activities. We plan to be more cognizant of these issues in the future when planning. Two students that had been accepted into the program but chose not to participate confided in me that they regret that they did not participate in the program given the difficulties they were experiencing as biology majors. Both students have changed their major.

Conclusion

The primary aim of CB-STEM is to ensure that underrepresented students have the opportunity to successfully complete their degree in a STEM field at Saint Joseph's University. Beyond helping students feel academically prepared for calculus and a STEM major, CB-STEM also helps students acquire social-emotional skills, identify personal behaviors that may affect their success at the University, and identify and reflect on their goals for the future. Overall CB-STEM is important to creating a sense of belonging, a shared identity and stressing the importance of academic success in STEM.

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Course Redesign: Pathways Towards Transformation

Geillan Aly

Build a community to help inspire and thrive

The drive towards enhancing diversity is not just about righting sociohistorical wrongs, it is also about calling upon the strength of multiple perspectives to make larger advances towards a goal. We are smarter together and greater strides are made when multiple ideas, experiences, and knowledge bases come together to tackle a problem. A diverse group of individuals unencumbered by bias or asymmetrical power relationships are more creative, innovative, and productive (Smith-Doerr, Alegria, & Sacco, 2017; Wooley, Chabris, Pentland, Hashmi, & Malone, 2010). Thus, faculty looking to revamp their courses should look to others for guidance, advice, and input. Furthermore, if the overall goal is to support nonhegemonic students, faculty would benefit from learning to listen to, work with, and implement the suggestions of others who can provide valuable insights they may not have previously considered.

Build Communities Among Faculty and other Stakeholders

The larger university community can be a strong resource to tap as you endeavor to change your mathematics classes. As many mathematics classes, and in particular Calculus classes, are intended to serve other departments, these departments should be consulted to provide input into specific course objectives, programming, and to help provide real-world applications and problems for students (Kilty et al. (CS 15); Terry (CS 26); Zobitz et al. (CS 30)). Look to your institution's central resource for teaching to help develop revitalized pedagogical practices or to more objectively evaluate your program (Bennett et al. (CS 3); Canner et al. (CS 6); Chang & Chen (CS 7); Fuller et al. (CS 11)). Aligning with and educating academic advisors on the affordances of specific programs or special sections can increase student enrollment and participation (Mawhinney et al. (CS 18)). Your Office of Institutional Effectiveness and administrative support staff can help assess the effectiveness of policies on a longitudinal basis and potentially raise the profile of related endeavors. This in turn may lead to generating more institutional support and resources (Benken et al. (CS 2); Canner et al. (CS 6); Chang & Chen (CS 7); Oliver et al. (CS 21)). Bringing together a team of stakeholders, instructors, and experts from the mathematics department and the school of education can maximize individual investment and minimize objections to proposed changes (Johnson et al. (CS 14)).

Developing a community of practice strengthens and supports the pedagogical skills of participating mathematics faculty (Fuller et al. (CS 11); Jensen-Vallin et al. (CS 13)). When instructors work collectively, such as through weekly meetings, everyone has the opportunity to contribute to the process and feel invested in the changes. This also gives adjunct professors and instructors the opportunity to share concerns and suggestions, giving voice to those who often teach students but may have limited agency in the structure of their courses. At Lamar University, community interaction has been strengthened through social teas and luncheons with topical themes that are aimed at improving teaching, learning technology, and teaching towards equity (Jensen-Vallin et al. (CS 13)). Participants in California State University Channel Islands' professional development program gave adjunct professors who felt invisible and voiceless a supportive community in which they could interact and learn (Soto et al. (CS 22)). Having new or inexperienced instructors co-teach allowed instructors to master new teaching techniques and develop camaraderie (Byrne et al. (CS 5)).

When multiple sections of a course are offered, it is more difficult to standardize students' learning experience. Differences in instructor styles and expectations are certainly expected. However, it is only when these differences result in significant inconsistencies such as rigor or covered content, that students can be subject to an inequitable educational experience (Akin & Viel (CS 1); Chang & Chen (CS 7); Jensen-Vallin et al. (CS 13); Mingus et al. (CS 20)). Inequitable class structures may also result in an inequitable workload among the instructors. For example, one instructor may be favored because students have a better classroom experience with them or because they have lower grading

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