

Jump Start: Lessons Learned from a Mathematics Bridge Program for STEM Undergraduates

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Abstract

The St. Mary's University Jump Start summer bridge program for precalculus was implemented for the first time in August 2014 and completed its third iteration in August 2016. This 12-day summer bridge program occurred immediately before the beginning of the fall semester. The primary intent of this program was to effectively provide prerequisite coursework to incoming first year STEM majors who did not meet the calculus I prerequisites to succeed in a calculus I course, and thus begin their degree programs on track. This paper investigates whether a 12-day summer bridge program can effectively ensure success in a first-semester calculus I course.

Section 1: Introduction

Faculty from the School of Science, Engineering and Technology (SET) at St. Mary's University noticed that many incoming STEM students were not meeting the prerequisites for entering their degree programs at the recommended math course, calculus I. The prerequisites to enroll in the course are either having college-level credit for precalculus, or meeting the placement threshold for calculus set by a placement exam (during 2014-2016, St. Mary's University used the ACT COMPASS exam's default cutoff score of 46 on trigonometry). These students were prevented from starting their degree programs on time and thus were delayed in graduating by at least one semester, and often by a full year. One remedy to this problem was to have these students earn the appropriate prerequisite credit prior to the start of their first semester. A summer bridge program would be a natural solution to aid student progression, but the design and efficacy of such programs is not well understood. Additionally, summer courses are typically accelerated by nature, which may not be conducive to the retention of knowledge. The primary intent of this bridge program was to provide prerequisite coursework to incoming first year STEM majors who did not meet the calculus I prerequisites, but the effectiveness of providing such an accelerated course was unknown. The purpose of this study is to determine the effectiveness of a mathematics summer bridge program for entering

St. Mary's University STEM students who do not meet the prerequisites for calculus I.

Research question

Our major research question for this paper is the following: Can providing the prerequisite coursework in a 12-day summer bridge program effectively ensure success in a first-semester calculus I course? We define *effectively* as students going through the Jump Start program (a summer bridge program described in Section 3.1.1) performing as well or better in calculus I than students who placed directly into calculus I by prerequisite or placement methods, as defined above.

Institutional overview

St. Mary's University is primarily a liberal arts institution, though it has a number of graduate programs and a law school. St. Mary's also offers many professional degrees through the school of business and the department of engineering, the latter of which has a number of Accreditation Board for Engineering and Technology (ABET)-accredited degree programs. St. Mary's has a Carnegie classification of M1: Master's Colleges and Universities, with an enrollment profile that is mainly undergraduate. As of 2016, the full-time undergraduate enrollment was approximately 2300 students, with approximately 53% female, 75% minority, 50% Pell Grant eligible, and 33% first generation (defined as neither parent having an associate's degree or above). The university is also classified as a Hispanic-serving institution (HSI).

Section 2: Literature review

For many years, summer bridge programs have been a widely used tool in higher education. Although there has been some concern whether summer bridge programs actually promote student success, studies show that these types of programs in mathematics, at least, have had a positive impact for students' success in institutions of higher education (Reisel, Jablonski, Kialashaki, Munson, & Hosseini, 2015; Wathington, Pretlow, & Barnett, 2016). Papadopoulos and Reisel claim that there is evidence suggesting that bridge programs succeed in advancing math

placement in students, but that these bridge program students may or may not outperform non-bridge program students (Papadopoulos & Reisel, 2008).

Review of the literature leads us to conclude that there are a number of components that contribute to a successful summer bridge program, as discussed below.

Residential- versus commuter-centered programs

Some summer bridge programs have been designed for a purely residential population, while others have attempted to support commuters via online instruction. At the College of Engineering and Applied Science (CEAS) at the University of Wisconsin-Milwaukee (UWM), a four-week summer bridge program was started by serving both populations with both an online program as well as a fully residential program, for comparison purposes. After two years of this dual approach, the online program was abandoned in favor of the fully residential program. The decision to proceed with a fully residential program was made based on academic reasons, as the on-campus model improved math course placement success more than the online model (Reisel, Jablonski, Hosseini, & Munson, 2012). The Women in Applied Science and Engineering (WISE) Summer Bridge Program at Arizona State University initially started as a commuter program in 1998, but, similar to the program at UWM, chose to move to a residential program the following year (Fletcher, Newell, Newton, & Anderson-Rowland, 2001).

Manner of instruction

A key component of summer bridge programs is the manner in which the students receive instruction. Some programs have used software-based, self-study programs such as ALEKS, while others have followed a more traditional classroom-based instruction led by faculty and possibly assisted by student peer mentors or supplemental software programs such as ALEKS ("What is ALEKS?", 2016). The program at UWM showed that a purely online ALEKS-based program, with instructors available only as needed via email, was less likely to improve math placement than an in-class ALEKS-based program, where the instructors were available to provide immediate as-

sistance and feedback (Reisel et al., 2012). The 10-day FirstSTEP summer bridge program for incoming STEM majors at Middle Tennessee State University was designed to incorporate more traditionally-structured mathematics instruction, coupled with peer-led tutoring and individualized study plans, which culminated in positive results in terms of academic success and persistence rates (Raines, 2012). In contrast, the University of Alabama offered an “alternative curriculum” in its E-MAP summer bridge precalculus class which “involves all three forms of learning through the use of multi-media introduction of new material, one-on-one tutoring, and hands-on experience with applications” (Bochis et al., 2007, p. 12.907.9). A lead instructor and two teaching assistants met for two hours a day, with afternoon tutoring sessions led by teaching assistants. Lastly, the WISE Summer Bridge Program at Arizona State University offered traditional review courses in mathematics, physics and chemistry, coupled with computer-based curricula. These courses were designed to ensure that their incoming freshmen were better prepared for their initial coursework (Fletcher et al., 2001).

Inclusion of extracurricular and career events

Another important component of a successful summer bridge program is the inclusion of extracurricular and social events. The program at UWM included a secondary focus on engineering activities designed to educate and excite the students about their chosen career in engineering (Reisel et al., 2012). The FirstSTEP program involved a component in which various STEM faculty from the university gave presentations demonstrating the significance of mathematics in an array of STEM disciplines (Raines, 2012). The E-MAP program included “Living Laboratories” in their bridge program, which were hands-on labs that

allowed students to apply their math skills to engineering problems, enabling “student exposure to the practical side of each engineering discipline” available at the university (Bochis et al., 2007, p. 12.907.9). The E-MAP program also had weekly plant and project tours to expose students to potential employers.

Length of programs

Summer bridge programs vary greatly in length from institution to institution. The WISE program lasts only four days. The Mathematics Summer Bridge Program at Purdue University is a six-day program (Diefes-Dux, 2002). On the other side of the spectrum, EXCEL at Northwestern University and E-MAP are both five-week summer bridge programs.

Purpose of programs

The purpose of summer bridge programs varies greatly. The UWM program readied students for another attempt at the math placement exam at the end of the program. Alabama’s E-MAP program administered a final exam to determine calculus readiness (Reisel et al., 2012; Bochis et al., 2007). A third option was offered by the program at Purdue University, where the program prepared students for an exam, which (if passed) provided algebra and trigonometry course credit (Diefes-Dux, 2002).

Section 3: Methodology

Section 3.1: Research design

A quasi-experimental research design was implemented for this study. The study involved the comparison of performance in calculus I between two non-equivalent groups of calculus I students. The baseline group consisted of all calculus I students at St. Mary’s University from

2009–2013. Each of the students in the baseline group satisfied the prerequisites for calculus I. The prerequisites for calculus I consisted of college credit for precalculus or a satisfactory placement score on the COMPASS math placement test. The second group, who initially did not meet the prerequisites for calculus I, were enrolled in a 12-day summer bridge program called Jump Start, described in Section 3.1.1 below. Upon successful completion of the program, the Jump Start group was enrolled in calculus I in the subsequent fall semester. Final calculus I course grades for the two groups were collected and analyzed as described in Section 3.2 below.

Section 3.1.1: Jump Start program description

To address the research question, a pilot summer mathematics bridge program (deemed “Jump Start”) was developed around an intensive 12-day precalculus course immediately preceding the start of the fall semester. Students who passed the Jump Start course with a minimum grade of C would earn four units of college credit for the course. In addition, the students could enroll in calculus I during their first fall semester, allowing them to stay on track to take calculus- and physics-dependent sequenced courses during the appropriate semesters, according to their degree plans. In addition to the academic component, the Jump Start program also included an extracurricular and career-preparation component to fit the needs of incoming St. Mary’s University STEM students.

Recruitment for the program

During the first year of Jump Start (2014), students were recruited directly by faculty advisors during summer orientation. These students had taken courses in high school preparing them for calculus (such as a high school precalculus course covering college algebra and trigonometry), but had only placed into precalculus during their initial calculus readiness placement test. These students were encouraged by faculty advisors to “jump start” their basic knowledge by taking a 12-day precalculus course for four units of college credit, enabling them to start their first semester in calculus I. The Jump Start program in subsequent years was offered to any student who placed into precalculus, based solely on SAT/ACT score. The students were also expected to attend a June orientation session and to make a commitment to attend all activities offered by the program.

Participants

To provide a better profile of the participants, Table 1 shows a breakdown by major of all Jump Start participants for

Major	Number of Students					
	2014		2015		2016	
Engineering	13	43.33%	15	50.00%	16	48.48%
Biology	11	36.67%	4	13.33%	8	24.24%
Biochemistry	0	0.00%	1	3.33%	0	0.00%
Chemistry	0	0.00%	0	0.00%	1	3.03%
Physics	1	3.33%	3	10.00%	4	12.12%
Forensic Science	0	0.00%	1	3.33%	0	0.00%
Math	3	10.00%	1	3.33%	1	3.03%
Computer Science	2	6.67%	5	16.67%	3	9.09%
Gender						
Female	11	36.67%	10	33.33%	9	27.27%
Male	19	63.33%	20	66.66%	24	72.73%
Total	30	100.00%	30	100.00%	33	100.00%

Table 1: Jump Start Precalculus 2014, 2015, and 2016 Cohort Majors Breakdown with Percentages

each of the first three years. The number of students in this program was approximately 30 per year, and roughly 30% female, during the years 2014–2016.

Length of program, method of instruction, and inclusion of peer mentors

Jump Start students were allowed to move into their dormitories 2.5 weeks before the start of the fall semester. During each of the 12 days of the course (which ran on weekdays only), students attended a four-hour lecture session from 8:00am–12:00pm run by a full-time faculty member from the Mathematics Department. A full precalculus course was presented, complete with daily in-class quizzes based on the previous day's assigned homework, three in-class exams, and a final exam. It was stated in the syllabus that the consequences for missing two or more sessions would result in being dropped from the course (however, this did not occur in any of the three iterations of the program). The Jump Start program also employed student peer mentors, who were St. Mary's students well versed in the mathematics the Jump Start students were studying. The mentors attended all lectures and aided the professor during quizzes and exams. The mentors also led the required study/tutoring sessions each afternoon, as well as exam preparation study sessions on evenings before exams.

Purpose of the program

Different from other programs, Jump Start students who earned a minimum grade of C received four semester hours of credit for precalculus. Students earning A, B, C were allowed to enroll in calculus I at the beginning of the fall semester. The academic goal of the Jump Start program was to prepare entering SET students for success in calculus I during their first semester by “jump starting” their precalculus skills.

Extracurricular and career/social events for a mainly residential population

Jump Start students were introduced to aspects of college life during designated activities that occurred outside of the classroom. For example, the Dean and Chairs of various SET departments gave presentations. Many non-academic university departments gave students information sessions. Students were exposed to issues concerning financial aid, academic advising, and career development. They were also introduced to alumni during a panel and networking dinner. The peer mentors were available for extracurricular questions, as were the staff members of the St. Mary's Office of Student Retention Title V STEM Program. Further, the program was designed as a residential program, though a few of the students lived off campus. Students were able to move into their permanent dorm rooms for the year early, and they were given access to dining options on campus. Hence, before starting the rigors of college life they were given the chance to get to “know the ropes” before the rest of the incoming first year class. They were strongly encouraged to become a community of learners by forming a network of students with the common goal of succeeding in college. Many social activities, including off-campus outings to local destinations of interest, were also planned for the Jump Start students to help form strong personal bonds.

Cost of program

The cost of the program for each student was \$600/\$550 per residential/commuter student in 2014 and \$750/\$650 per residential/commuter student in both 2015 and 2016, which covered all program expenses, including room and board. This cost was added to each student's fall semester bill. The tuition for the course was billed to each student's fall tuition, as the course officially

goes on the transcript as a fall semester course.

Section 3.2: Data collection and analysis

To obtain a better picture of the students in the Jump Start group we collected final grades from the summer bridge Jump Start program. To build a more complete STEM profile, each student's major was also reported. To compare the Jump Start group with the baseline group, we collected final letter grades of the Jump Start participants in the subsequent calculus I course for the years 2014, 2015, and 2016. The data for the baseline group consisted of the final letter grades of all calculus I students enrolled at St. Mary's University during the fall and spring semesters from fall 2009 to fall 2013. This historical data was collected from the Office of Institutional Effectiveness at St. Mary's University, and includes the final letter grades of students meeting the prerequisites for calculus I.

To compare the two groups, we defined success in calculus I as a grade of A, B, or C on the first attempt of the course (grades required by the University to progress in the calculus sequence). Therefore, for the purposes of this study, *failure* in calculus I would be earning a grade of D, F, or W (withdraw). Within the baseline group, we calculated the DFW rates (as a percentage) for each semester from 2009–2013. These DFW rates were compared to the DFW rates calculated for the Jump Start group for each of the years 2014–2016. The percent decrease in DFW rates from the baseline group to the Jump Start group was calculated on a semester-by-semester basis, and an average percent decrease in DFW rate was computed for each Jump Start year.

Section 4: Results

The frequency and the percentage of the grades of the Jump Start participants for each of the three years is shown

in Table 2. It should be noted that for each of the three years, the precalculus course was taught by the same instructor using the same materials and administering the same examinations.

In the first year, it is worth noting that half of the students received A's, and there were no grades of D, F, or W. The final grades for the 2015 and 2016 cohorts included fewer A's than in 2014, but still a minimal number of D's, F's and W's. The median grade of students in the 2014 cohort was an A-, outperforming the median grade for the 2015 and 2016 cohorts, which was a B. It should also be noted that only one student withdrew from the program over the program's first three years.

Precalculus Grades	Number of Students					
	2014		2015		2016	
A	15	50.00%	4	13.33%	6	18.18%
A-	4	13.33%	5	16.67%	2	6.06%
B+	4	13.33%	6	20.00%	5	15.15%
B	3	10.00%	2	6.67%	4	12.12%
B-	1	3.33%	4	13.33%	4	12.12%
C+	1	3.33%	3	10.00%	4	12.12%
C	2	6.67%	4	13.33%	6	18.18%
D	0	0.00%	1	3.33%	1	3.03%
F	0	0.00%	1	3.33%	0	0.00%
W	0	0.00%	0	0.00%	1	3.03%
Total	30	100.00%	30	100.00%	33	100.00%

Table 2: Jump Start Precalculus 2014, 2015, and 2016 Cohort Final Grades Breakdown with Percentages

		JUMP START COHORT DFW RATES		
		SUBSEQUENT FALL SEM: MT2412		
		JS 2014	JS 2015	JS 2016
		26.1%	67.9%	37.9%
	BASELINE MT2412 DFW Rates (%)	2014 DFW % Decrease	2015 DFW % Decrease	2016 DFW % Decrease
Fall 2009	32.4%	6.3%	-35.5%	-5.5%
Spring 2009	29.8%	3.7%	-38.1%	-8.1%
Fall 2010	25.4%	-0.7%	-42.5%	-12.5%
Spring 2010	40.7%	14.6%	-27.2%	2.8%
Fall 2011	23.8%	-2.3%	-44.1%	-14.1%
Spring 2011	36.0%	9.9%	-31.9%	-1.9%
Fall 2012	39.5%	13.4%	-28.4%	1.6%
Spring 2012	46.3%	20.2%	-21.6%	8.4%
Fall 2013	31.4%	5.3%	-36.5%	-6.5%
	AVG	7.8%	-34.0%	-4.0%

Table 3: Jump Start DFW Rates as Compared with Baseline DFW Rates

Table 3 presents the DFW rates (as defined in Section 3.2) in the subsequent calculus I course for each cohort of Jump Start compared with the DFW rates of each semester of the baseline data.

Interestingly, for all but two of the baseline semesters, the Jump Start 2014 cohort's DFW rates were improved on average, and the average DFW rate decreased by 7.8%. However, the average DFW rates for the Jump Start 2015 and 2016 cohorts were significantly worse than the baseline, especially with the 2015 cohort. The 2015 cohort had higher DFW rates compared to each of the baseline semesters, and had an average DFW rate increase by 34% from the baseline. The 2016 cohort had higher DFW rates than the baseline for six of the nine semesters, and an average DFW rate increase of 4%.

Section 5: Discussion of results

Academic component of program

There is a clear distinction between the results from the 2014 cohort and the following two cohorts. These differences could possibly be attributed to the method of recruitment used for the 2014 cohort versus the method used for the other two cohorts. The 2014 cohort was a handpicked (by faculty advisors) group of students, all of whom had taken a high school precalculus course. Further, each one of these students had taken the COMPASS placement test, which placed them into precalculus. Hence, the students in the 2014 cohort were better prepared for the rigor and accelerated pace encountered in

the program.

In 2015, the mathematics department changed its placement policy for precalculus to one using SAT/ACT scores, based on the results from a study concerning mathematics placement at St. Mary's University (Lurie & Wagner-Krankel, 2014). Hence, the recruitment method applied to the 2015 and 2016 cohorts was more standardized, but no longer contained the input of faculty advisors. In addition, without COMPASS results, there was no guarantee that students placing into the Jump Start program had ever had a high school precalculus course. It was initially conjectured that this was the reason there were so many A's in the first year of Jump Start followed by a noticeable decrease in the number of A's in the following two years. However, looking at student transcripts yielded no evidence to support this conjecture. In fact, it was discovered that only two students in the 2014 cohort, one student in the 2015 cohort, and four students in the 2016 cohort did not have a high school precalculus course. Unfortunately, no information was available regarding how well the students did in their high school precalculus class. Perhaps faculty advisor conversations would have dissuaded underperforming high school precalculus students from taking an accelerated college-level precalculus course.

With the 2014 cohort, the students had demonstrated competency in algebra using a national standardized content exam. Further, discussions with faculty advisors gave evidence that these students had been exposed to trigonometry while in high school. Due to the placement change, these assurances no longer existed for the 2015

and 2016 cohorts. Ultimately, the Jump Start summer bridge program seems most effective for students who have not only been exposed to trigonometry in high school, but more importantly, demonstrated sufficient competency in algebra during high school. From the data, it is clear that the 2014 program effectively provided prerequisite coursework to bring students to the level deemed calculus I ready without the summer bridge program.

Non-academic component of program

The impact of including student peer mentors in the Jump Start program has been very positive. They provided insights into campus life from a fellow student's perspective. They helped the students get a head start on developing the mindset and maturity necessary for success in college life, and to realize the importance

of time management, by allocating sufficient time to complete homework, study for exams and quizzes, and still make some time for social interaction with their peers. These peer mentors are valuable not only as tutors during the program itself, but also as mentors for the program participants, providing advice throughout their college career. For instance, the peer mentors from the 2016 Jump Start program continued meeting with small groups of Jump Start students on a weekly basis during the fall 2016 semester. The mentors served as peer coaches who facilitated discussions and activities on academic skills topics like test preparation, overcoming procrastination, and career exploration.

One of the most valuable and unexpected results of the Jump Start program over each of the three years was that the students achieved a sense of the campus culture prior to the start of their first semester. By moving into their dormitories 2.5 weeks early, the students assimilated to campus life and experienced the culture of the St. Mary's University community. They spent time not only with each other, but also with the peer mentors, both on campus as well as off campus during social excursions, which aided in the formation of a support system of friends from the start of their college career.

Below are comments from an informal survey (for grant reporting purposes) of former Jump Start students regarding their experiences with the program.

"[Y]ou get to start school early and get adjusted before others get on campus. You're able to get [credit for] a whole class if you can handle the two weeks."

"It's intense but puts you where you need to be."

"Overall I loved it, we all became a close little family and it will be nice to see familiar faces around school. If I could do it for other courses I would."

"I have become closer to... my peers and [the program] gave me a good grasp on how my college life will be like..."

Section 6: Conclusion

Although students have shown they can pass the Jump Start precalculus course, it is difficult to conclusively determine whether a 12-day summer bridge program can effectively provide prerequisite coursework to students without the calculus I prerequisites to succeed in a first semester calculus I course. When the students were placed by COMPASS into precalculus for the first iteration of the program, the subsequent fall calculus I DFW rates were, on average, greatly improved over the baseline historical data. On the other hand, when the recruitment process was based solely on SAT/ACT scores the next two iterations, sans external placement exam, the subsequent calculus I DFW rates increased from the baseline data, though noticeably less in the third iteration than in the second iteration. In fact, for three of the nine semesters, this cohort outperformed the baseline data. For upcoming iterations of Jump Start, discussions are underway to reintroduce faculty advising prior to prospective participants' self-enrollment into the program. We believe that the results of this study provide us reason to consider implementing a proper experimental design study with randomized control and Jump Start groups.

From a non-academic perspective, the program enabled the students the opportunity to move into their permanent dorm rooms and achieve a sense of ownership of the campus 2.5 weeks before the semester starts. Further, the Jump Start students were able to establish a positive support system of peers prior to the beginning of the semester. These two aspects of the program helped provide the students with a valuable early transition to college life.

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Jason Shaw, Ph.D., joined the Mathematics Department at St. Mary's University in 2010, where he is currently an associate professor. He earned his Ph.D. in Mathematics from the University of Colorado in 2008. His research interests are generally in universal algebra, and specifically in classifying the clones of finite groups. He also serves on the Actuarial Science Committee and has completed the first two actuarial exams: Exam P: Probability and Exam FM: Financial Mathematics.



Ian Martines, Ph.D., joined the Mathematics Department at St. Mary's University in 2009, where he is currently an Associate Professor and Associate Dean of the School of Science, Engineering, and Technology. He earned his Ph.D. in Mathematics from The University of Texas at Arlington in 2008. He currently serves as Engineering Mathematics Coordinator and teaches courses in both the Mathematics and Engineering departments. His scientific research areas are numerical analysis and mathematical ecology, but he also actively researches elements of student retention in STEM disciplines.



Necia Wolff, MLIS, is a librarian and professor at the Louis J. Blume Library at St. Mary's University, where she has worked since 1999. She specializes in information literacy pedagogy that addresses the information needs of academic researchers who come from a range of disciplines and with varied levels of expertise. In addition, Professor Wolff is the Blume Library webmaster and leads ongoing development of a learning-focused, collaboratively-authored academic library website.



Ms. **Paulina Cano** currently serves as a STEM Academic Coordinator for the Title V, Fostering Success in STEM Education Grant at St. Mary's University, where she has worked since 2015. Her role is to coordinate student support services to aid in student retention and graduation. Previous to her work at St. Mary's, she worked as an Academic Adviser and Lecturer at the University of Texas at El Paso (UTEP). She received her Master of Business Administration from UTEP and is currently pursuing a Doctoral degree in Applied Demography at the University of Texas at San Antonio.



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