FirstSTEP: A Preliminary Review of the Effects of a Summer Bridge Program on Pre-College STEM Majors

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Introduction and Literature Review

As today's economy becomes more global, technological, and highly competitive, it is essential that we strengthen the science, technology, engineering, and mathematics (STEM) skills of those who will be competing in the workforce. Individuals who are successful in developing STEM knowledge and skills will likely enjoy significant advantages over the ones who fall behind educationally. Since the 1990's, there has been continual improvement in preparing students to succeed in college; however, there is a growing concern that these students are not being sufficiently prepared in the STEM areas (Kuenzi, 2008). In recent years, there has been a considerable decline in the number of high school graduates choosing majors in STEM related fields in college. In 2006, only 15% of high school graduates enrolled in college were STEM majors (Chen, 2009) and the overall proportion of postsecondary STEM degrees awarded nationwide has remained around 17% (Kuenzi, 2008). The National Report Card on Higher Education (Callan, 2008) states that too many high school graduates fail to reach proficiency in math and science and are unprepared for college-level courses. Additionally, those who enroll in college have low completion rates, which affect the availability of college-educated workers who keep the nation competitive. Consequently, more emphasis should be placed on what can be done to help encourage and prepare students choosing STEM-based majors to enter college, be successful, and graduate. One solution is early intervention so students have a better chance of succeeding.

College summer bridge programs are one way to assist students in enhancing their academic success and to increase retention and degree completion rates. These programs are designed to give incoming freshmen entering college in the fall the tools needed to begin their college careers, and are becoming part of the effort to recruit, retain, and graduate an at-risk student population (Ackermann, 1991). The foci of bridge programs and the populations they serve vary greatly. Some of these programs are designed for specific populations, such as minority, low income, academically under-prepared, or gifted students; others are designed for students with particular majors, including math and science (Kezar, 2000). Those types of programs have very different curricula from other types of bridge programs in that they focus on familiarizing students with group and problem-based learning, and introduce students to lab work and what it means to work in math and science areas (Kezar). A number of summer programs are residential, with students living on campus, while others serve commuter populations. Bridge programs vary in length, lasting from less than a week to up to eight weeks. Common to almost all summer bridge programs is the inclusion of academic courses and the desired outcome of increased retention (Garcia, 1991). No matter the design or length of the program, the goal is still the same—to prepare incoming college freshmen to succeed and persist with their education.

Since the advent of pre-college summer programs, mixed results regarding the research on the effectiveness of these programs have been found. In his study of the effects of a pre-college summer program on freshmen's academic achievement and retention, Stewart (2006) found that students who participated in the summer program were retained and graduated at the same rate as students who did not participate in the summer program. The study, conducted at King's College in Pennsylvania from 1998 through 2001, compared 89 students who participated in the summer programs to a control group of 89 students with backgrounds similar to those in the program. Although results did not show statistically significant differences, retention rates for summer participants were higher than the college's average for three of the four years. Stewart also observed that the four-year mean grade point average (GPA) of students not in the summer program was higher than the GPA of students in the program.

York and Tross (1994) discovered that a summer bridge program at Georgia Tech helped students make a transition to college life, but the program did not show it was effective in increasing retention. In an analysis of longitu-

dinal data, Walpole, Simmerman, Mack, Mills, Scales, and Albano (2008) found the retention rate of students participating in a summer bridge program was higher than that of a control group of non-participating freshmen; however, there were no significant differences in GPAs between the two groups. Maggio, White, Molstad, and Kher's (2005) examination of data from six higher education institutions' prefreshman summer programs revealed that only high school GPA had a positive effect on college GPA. Additionally, program size and length had a negative effect on student achievement and retention. The larger the size of the summer program and the longer the program lasted, the lower the participants' cumulative college GPA and retention rate (Maggio, et al.).

In light of the previous studies, Ackermann's (1991) research examined the effects of a six week freshman summer program at the University of California at Los Angeles (UCLA) on underrepresented and low-income students and found that the program did improve academic performance and persistence rates of participants. The 645 students in the program could enroll in either a mathematics intensive or English intensive curricular component, and their academic performance indicated how successful the program was in preparing these students for college-level work. The first year mean cumulative GPA for the students in the program was 2.49, and 97% of these students continued into their second year at UCLA, compared to 90% of all underrepresented freshmen (Ackermann).

Santa Rita and Bacote (1996) reported on the results of 52 high risk and low-income minority students in a six-week summer program at Bronx Community College (BCC). The academic component of the program provided intensive instruction in mathematics, English composition, and reading comprehension. The researchers found the program was successful in preparing students for the academic challenges of college and improved persistence rates of these same students. The mean cumulative GPA of students going through the summer program for the first year at BCC was 2.49 (approximately a C+ average), while 93% of the students continued into their second year at BCC, compared to 83% of all students. Santa Rita and Bacote concluded that "grades played an important role in a student's decision to persist" and summer bridge programs could help improve persistence rates (p. 14).

The five-week summer bridge program at Bowling Green State University is a component of their Academic Investment in Math and Science (AIMS) undergraduate program designed to better prepare STEM majors, particularly under-represented minorities and women, to succeed academically (Gilmer, 2007). The intent of the summer program is to help freshmen adjust to college life and be exposed to the type of mathematics and science coursework they would encounter in the fall semester. Among the program findings was a positive correlation between students' math achievements in the summer bridge program and their first fall semester GPAs. Furthermore, retention of these students was better than that of comparison groups (Gilmer). Fletcher, Newell, Newton, and Anderson-Rowland (2001) found the one-year retention rates for women in an applied science and engineering bridge program at Arizona State University were 80% in 1998 and 70% in 1999. The one-year retention rate for non-bridge participant women during the same time period was 60%. Based on their preliminary findings, Fletcher and colleagues concluded the summer bridge program was effective and increased student retention in academic majors. The findings of these researchers and others (Hicks, 2005; Garcia, 1991) suggest summer bridge programs can help students prepare for their first semester in college and increase the retention rates of these same students.

One of the challenges for higher education institutions today is to ensure that all students have a reasonable chance to succeed. Despite efforts to set standards, many students leave high school not ready to thrive in college, which has led to the development of programs to help these unprepared students bridge the gap. Pre-college summer bridge programs have been in existence for many years and are considered to be one strategy to help improve academic achievement and increase retention and graduation rates. However, despite the number of programs that exist, there is still little empirical data regarding the efficacy of these programs (Kezar, 2000).

Bridge Program

Purpose

The pre-college summer bridge program at Middle Tennessee State University (MTSU) is an element of a five-year National Science Foundation (NSF) grant (project number 0969571), FirstSTEP, which focuses on the retention of STEM majors coming into the university with ACT math subscores ranging from 19 to 23 inclusive. The purpose of the bridge

program is to address mathematics deficiencies through structured mathematics instruction, peer-led learning, individualized study plans, and exposure to STEM applications of mathematics. This study was undertaken to preliminarily examine the effects of the two-week program on academic achievement and retention of at-risk STEM majors during their first year at MTSU. The findings examined in this paper are based on an on-going longitudinal study to determine whether the summer bridge program is working and which, if any, components of the program need to be revised.

Setting

The FirstSTEP summer bridge program took place at MTSU, an open admissions, coeducational, state-funded institution that offers both comprehensive undergraduate and select graduate degree programs. Located in the center of the state, MTSU has been classified as a doctoral/research-intensive institution. Student enrollment in Fall 2010 was 26,430, of which 23,401 were undergraduates and 3,777 were first-time freshmen. Of the undergraduate students, approximately 4,793 had declared majors in STEM related fields (3,037 male and 1,756 female). The average ACT mathematics subscore was 20.5 with an average overall composite score of 22. Fifty-three percent of students enrolled at MTSU were female, 47% male, 74% White, 16% Black, and 10% other (2010 Fact Book, MTSU).

Participants and Recruitment

FirstSTEP was first offered in the summer of 2010 with the intent of bringing students already accepted for admission to MTSU onto campus prior to their first semester. Participants were selected based upon: a) ACT mathematics subscores, b) acceptance into MTSU for the Fall 2010 semester with a declared STEM major, and c) the expectation they would be taking precalculus their first semester at MTSU. To recruit the students, letters and emails were sent to prospective participants and their parents. Thirty-five applications were received and all applicants were accepted. Of these students, who came from across the state of Tennessee, 14 were male and 21 female. In terms of ethnicity, 17 were White, 15 were African American, 2 were Asian, and 1 was Hispanic.

As an incentive to encourage students to apply for the summer bridge program, each participant received a $400 stipend and was promised a $250 stipend each semester for the following two years as long as they continued in the FirstSTEP program and remained STEM majors. Participants also received $1000 for a summer immersion experience after their freshman year, during which they worked with STEM majors and faculty on a research project. Additionally, the grant provided free residential housing for ten participants based on need and distance from the campus. Other participants could also reside on campus but had to pay for their housing.

Description

The bridge program consisted of ten days of instruction, activities, and applications during the last two weeks in July. At their first meeting, participants were introduced to the FirstSTEP program and were given a mathematics pretest consisting of 27 questions in the MyMathTest program, an online assessment system that would target and track individual students' needs. Based on the outcomes of this assessment, each participant was given an individualized study plan that reflected his or her strengths and knowledge gaps. Participants were also given a pre-program survey to complete. For the remainder of the summer program, the participants had individual learning time each day to work on their study plans.

On days two through nine, participants received mathematics instruction on specific topics including factoring, properties of exponents, simplifying radical and rational expressions, mathematical modeling, and solving quadratic, rational, and radical equations. Participants also were involved in peer led learning sessions every afternoon and were exposed to STEM applications of mathematics presented by university faculty from STEM areas.

One of the objectives was to have the majority of the summer bridge participants enrolled in the same section(s) of precalculus in the fall. That way, participants could continue with the social and academic support begun in the bridge program and start to build a sense of campus community. Thus, academic advisors were on-hand and assisted the participants in getting registered for their fall semester classes. The last day of the summer bridge program, participants were given a mathematics posttest and exit survey.

This was the first cohort to participate in FirstSTEP, and this cohort will be followed for two years to determine the impact the program has on academic achievement and retention of STEM majors. Each semester following the summer program, participants will take a one-hour seminar that will focus on preparing the

ACT Math Subscore	*N*	*% Earning A, B, or C*	*% Earning D, F, or W*
19	6	66.7	33.3
20	11	45.5	54.5
21	4	75	25
22	5	80	20
23	9	77.8	22.2

Table 1. Precalculus Grade Distribution by ACT Math Subscore

students to do research and will include help sessions for their precalculus and calculus courses. After their first year at MTSU, participants will be involved in a summer immersion program where they will be paired with STEM faculty members to work on a research project. Any summer bridge participant who does not follow through with all aspects of the program will not be allowed to continue in FirstSTEP.

Program Findings

According to ACT (2006) data, students must take not only the right number of math courses in high school, but the right kinds of courses too. These courses should be rigorous and prepare students for the demands of college. All of the students participating in the summer bridge program had taken geometry, algebra I, and algebra II in high school. Of the 35 participants in the program, 23 had taken a precalculus or statistics course, and of those, four had completed AP calculus. One student had taken trigonometry, five had taken advanced algebra and trigonometry, and six had not gone beyond algebra II.

The mean ACT math subscore of bridge participants was 20.7. Out of 14 students with subscores of 22 and 23, nine earned a C or better in college precalculus. Twelve of the 21 students with subscores of 19–21 also earned a C or better in the course. Table 1 illustrates that, in general, the higher the math subscore one has, the more successful one will be in precalculus. The mean ACT math subscore of those passing the course was 21.14 and of those not passing, 20.14.

The pretest and posttest taken by the participants covered the same topics as the mathematical instruction they received over the length of the program, which is content similar to what these students should have been exposed to in their high school mathematics courses. Examination of the scores on the pretest and posttest found a mean score of 21.6 (out of 100) on the pretest and 59.1 on the posttest. After completing the bridge program, all participants showed improvement to some extent from pretest to posttest. On average, participants increased their test scores from pre to post by 47.9%. Students who passed precalculus the subsequent semester with an A, B or C had an average of 69.4 on the posttest while students with a D, F or W had a posttest average of 43.6.

In the fall 2010 semester, 34 out of the 35 participants finished their college precalculus class, with one student withdrawing from the course. Twenty-one of these students successfully completed the course with an A, B or C while 14 did not. During the spring 2011 semester, 18 students took calculus I, 11 took precalculus again, 4 students did not take a math class, and 2 were not in school. Ten of the students taking calculus I and eight who were retaking precalculus successfully completed their courses. Table 2 shows the distribution of grades for those semesters. At MTSU, suc-

	Fall 2010 Precalculus Grade	*Spring 2011 Precalculus Grade*	*Spring 2011 Calculus I Grade*
A	4	0	1
B	8	3	7
C	9	5	2
D	8	0	4
F	5	2	3
W	1	1	1

Table 2. Precalculus and Calculus I Course Grades By Semester

Statement	*Strongly Disagree*	*Disagree*	*Agree*	*Strongly Agree*
The format of the bridge program is effective.	1	3	21	10
The mix of individual, small group work and presentations was effective.	5	1	22	7
Working with MyMathTest helped me learn math.	1	2	13	19
Working with the study plan helped me learn math.	1	2	10	22
Participating in the summer bridge program helped me feel better prepared for precalculus in the fall.	1	3	21	10
Participating in the summer bridge program helped me feel more positive about my ability to learn math.	0	4	20	11

Table 3. Post Summer Bridge Survey

cessful completion of precalculus and calculus I means obtaining an end-of-course grade of a C or better.

Participants were asked to complete a post program survey at the end of summer bridge and rate statements with four choices from "Strongly Disagree" to "Strongly Agree". Table 3 presents the results from five of the survey questions. Based on survey results, participants were decidedly satisfied with the program. All 35 participants completed the survey and 88.6% felt the format of the program was effective. Additionally, 88.6% said that after participating in the program, they felt better prepared for precalculus in the fall and felt more positive about their ability to learn math. The mix of individual and small group work along with STEM application presentations was effective for 82.9% of the participants, while 91.4% felt working with MyMathTest and the individual study plans helped them learn math.

During their first fall semester, summer bridge participants were required to take a seminar course. As part of the course, they completed a questionnaire at the beginning and end of the course with Likert-type responses on a five point scale from 1 = "Not Very Sure" or "Not At All" to 5 = "Very Sure" or "Very". Tables 4 and 5 reveal the results for the fall seminar surveys. When asked if they were confident in their ability to do college-level mathematics, only 63.3% were confident and only 66.7% were certain they had the skills and abilities to succeed in their chosen STEM major. Seventy percent felt academically prepared for their next semester and were certain they would not change their major. Moreover, only 60% of the 30 respondents felt the seminar course was helpful.

The persistence rate of these students is one indicator of the success of the FirstSTEP summer bridge program. From Fall 2010 semester to Spring 2011, the retention rate was 91.4% (one student withdrew in the Fall 2010 semester and 2 students did not take classes in the Spring 2011 semester). Out of the 32 students who completed the spring semester, 27 have registered for Fall 2011 classes (five students have not registered yet, but will be able to register throughout the summer). Thus the first year retention rate was 77.1%, which was higher than the university's retention rate for first-time freshmen for the 2009–2010 academic year. These students will be followed to determine whether they continue at the university and as STEM majors.

Question	*Not Very Sure*	*Neutral*	*Sure/Very Sure*
How certain are you that you will stick with your current major all the way through graduation?	5	4	21
How certain are you that you have the skills and abilities to succeed in your major?	2	8	20
How confident are you in your ability to do college-level mathematics?	3	8	19

Table 4. Fall 2010 Freshman Seminar Pre-Survey

Question	*Not At All*	*Neutral*	*Very*
How prepared do you feel, academically, for your next semester of college?	0	9	21
How helpful did you find this course?	2	10	18

Table 5. Fall 2010 Freshman Seminar Post-Survey

Another indicator of success is the academic performance of the summer bridge participants. The mean GPA for the Fall 2010 semester was 2.60; it fell slightly during the Spring 2011 semester to 2.36. The mean cumulative first year GPA for these students was 2.54, approximately a C+ average. Institution retention rates and cumulative GPA's for freshmen in the 2010–2011 academic year were unavailable for comparison.

When comparing the cumulative GPAs with persistence, the students who left during or after the fall semester had a 1.02 GPA and the five students not registered for the Fall 2011 semester had a GPA of 1.33. The 27 students who are registered for Fall 2011 classes have a GPA of 2.77, approximately a B- average. Grades may indeed play a role in a student's decision to persist.

The relationship between the final grades in precalculus and the posttest scores from the summer bridge program was also examined to see if posttest scores were any kind of predictor for how these students would do in precalculus. There was a moderately strong positive correlation ($r = 0.678$, $p < 0.0001$) between the posttest scores and precalculus final grades. Students with higher posttest scores tended to have higher final grades in precalculus.

Conclusions

The results of this study suggest that student participation in the FirstSTEP summer bridge program positively impacted academic performance and persistence rates of the students involved. After their first year in college, bridge participants had a mean cumulative GPA of 2.54 and from the Fall 2010 semester to Spring 2011, 91.4% persisted. These students increased their test scores from pretest to posttest in the summer program, and those with higher posttest scores were more likely to have higher final grades in their precalculus course. Thus, the mathematics instruction participants received in the summer appeared to benefit these students in their college mathematics course. Additionally, survey findings indicated students seemed to have positive reactions to the summer bridge program. However, the findings of this study are not conclusive since a control group was not available for comparisons. A longitudinal study that compares participants and non-participants over a longer period of time is warranted and necessary to help determine whether the summer bridge program will be beneficial.

According to Adelman (2006), the highest level of mathematics reached in high school

beyond algebra II is the key toward completing a degree in college. Furthermore, students who take academically intensive mathematics courses in high school and succeed have higher graduation rates in college (Adelman). Twenty-nine of the program participants stated they had taken mathematics courses above algebra II in high school, but only 18 of these students (62.1%) successfully completed college precalculus. Since students self-reported this information, it would behoove program directors to look at actual high school transcripts to determine whether students took precalculus or whether they had other courses that were not as rigorous.

ACT (2006) developed College Readiness Benchmarks which are the minimum ACT subscores required for students to have a high probability of success in college-level courses. The subscore in mathematics is 22, indicating that students whose subscore is at or above 22 have a 75% or greater chance of earning a C or better in a first year college mathematics course (ACT). In order to take a college-level math course at MTSU, students have to have an ACT math subscore of 19 or above. Bridge participants had math subscores from 19 to 23 inclusive, and 60% of those students passed their first college math course, precalculus. Looking at the percentage of students passing precalculus based on their math subscore, those with higher subscores generally had higher pass rates. This suggests that some of these students may require more remediation than others in the program and might need additional tutoring and study plan time.

A disconcerting find is that during the summer program, a relatively high percentage of participants reported they felt positive about their ability to learn math. At the end of the fall semester, fewer students reported they were confident in their mathematical abilities. Additionally, only 60% of the participants felt the fall seminar course was helpful. From these results and student comments, the format of the seminar course should be changed.

One issue college students have is the difficulty transitioning from high school to college, and the freshman year is typically the most challenging adjustment period. The summer bridge program and the fall seminar course could help make this transition a little easier. The bridge program could be expanded to include a brief college orientation and evening activities to help start building a sense of campus community. Previous bridge participants and current STEM majors could become peer advisors and tutors and work with incoming freshmen during the summer program and fall seminar course. Bridge participants should also be introduced to STEM faculty early on. These faculty should serve as advisors and mentors, encouraging students in their coursework and the STEM fields.

Summary

Interest in STEM fields is declining and the nation is facing a serious shortage of skilled workers in these areas. The past decade has seen a decrease in the number of students obtaining degrees in STEM fields. The U.S. Government Accountability Office (2006) reported that in academic year 2003–2004, 27% of degrees awarded were in STEM fields, compared to 32% ten years earlier. By attracting students to STEM fields and improving their chances for success, the number of students graduating and receiving degrees could increase substantially.

Summer bridge programs can provide precollege experiences to help attract and retain future STEM majors by exposing them to experiences they would encounter in college math and science coursework along with increasing their academic preparedness. Moreover, bridge programs with an effective emphasis on academics can have a strong impact on student retention.

As the job market becomes more competitive and the global demand for expertise in math, science, and technology increases, it is vital for institutions of higher education to create and offer summer bridge programs that will retain and assist students in completing STEM degrees and joining the competitive workforce.

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