AC 2008-1623: DO STUDENTS IN SUMMER BRIDGE PROGRAMS SUCCESSFULLY IMPROVE MATH PLACEMENT AND PERSIST? A META-ANALYSIS.

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Do Students in Summer Bridge Programs Successfully Improve Math Placement and Persist? A Meta-Analysis.

In attempting to learn more about the efficacy of summer bridge programs, we discovered a general dearth of relevant performance data in the literature. We identified and examined 12 engineering summer bridge programs that serve new freshmen whose math placement is at or below pre-calculus, and for which meaningful student performance data has been published. The data that we compiled suggests that bridge programs are very successful in helping students to advance in math placement by at least one level. Less clear is whether bridge students outperform control group students in the years beyond the bridge program (as measured by retention, graduation, and grades), but some evidence suggests that this is the case.

1. Introduction

New freshmen in many engineering programs matriculate with math placement below calculus. Many of these freshmen have difficulty with first year math courses due to inadequate math preparation, poor academic skills, lack of interest (particularly when introductory math is divorced from engineering applications), and other factors. The students' difficulty in math often results in a pattern of taking other courses out of sequence and related academic problems.

At least two principal approaches are commonly used to address these issues. One approach is to rearrange the curriculum to include more engineering content in the early years, and delay some math courses until students have more maturity and buy-in with the program. Another approach is to provide summer instruction during which students can improve their math placement hopefully gain greater understanding of fundamental concepts.

While we see merit in both approaches, we focus here on the latter approach of the summer bridge program. This is largely motivated by circumstance at UW-Milwaukee, where we teach; academic placement of new students is math-driven (and will be so for the foreseeable future), and most of our students – nearly 70% – matriculate with math placement below calculus[12]. Similar circumstances exist at many other schools as well.

To respond to our needs, our College of Engineering & Applied Science (CEAS) instituted a summer bridge program during Summer 2007 to help new freshmen engineering students improve their math placement, study skills, and acculturation to college life. The CEAS bridge program serves students whose math placement is below pre-calculus (i.e. students who are not yet eligible to take College Algebra or Trigonometry). Students at this level comprise approximately 35% of the entering freshman cohort in CEAS. We note that many students in the bridge program have already taken prerequisites for pre-calculus or even pre-calculus in high school, but due to their scores on the UW System Math Placement Test, these students are not eligible to enroll in pre-calculus in CEAS.

The current format of the bridge program is very basic, and is primarily focused on delivering instruction in pre-calculus. The program is free of charge, lasts 4 weeks, and culminates in the retaking of the Math Placement Test. No credit hours are earned through the bridge program.

Two modes of instruction are available: an in-class mode meets four days per week for 4 hours, and a distance-mode conducted online is also available. In each mode, the web-based interactive software ALEKS is used to diagnose student weaknesses, provide corresponding drill problems, and track the number of contact hours that students spend studying. A total of 32 students participated in 2007 (11 in-class, 21 online).

As we tracked the performance of our bridge students and seek funding to enhance it, we studied the literature to understand the experiences and performance of students in similar programs at other institutions. In this study, we focus on summer bridge programs that are math-centered and present our tabulations of academic performance data reported by these programs.

The paper by Ohland and Crockett[13] appears to be the only systematic review of engineering summer bridge programs. This work surveys 28 programs and documents various features about how these programs are organized and delivered, but student performance data is not presented. To our knowledge, our present paper is the first attempt to tabulate performance data of students in engineering summer bridge programs.

By carefully searching for information on each program cited in Ohland and Crockett[13], and by conducting our own search for bridge program data, we identified 11 summer bridge programs that are math-centered and for which student performance data has been published. We also include data of our newly instituted bridge program (Summer 2007) at UW-Milwaukee. Thus, we review data for 12 bridge programs, as summarized in Table 1. Note that references for each program are enumerated and comprise the first 12 references in the bibliography.

Institution and Program Name	Duration (weeks)	Residential (Y/N)	Minority-focus (Y/N)
Arizona State University: Women in Science & Engineering (WISE) [4]		Y	
Borough of Manhattan Community College/CUNY: STEM Talent Expansion Program [1]			
California State Polytechnic Institute, Pomona: Quest [5]	4	Y	Y
Clemson University: Math Excellence Workshop (MEW) [8]	6	Y	Y
Morgan State University: Pre-Freshman Accelerated Curriculum in Engineering (PACE) [11]	6	Y	Y
Old Dominion University: Engineering Learning Center (ELC) [6]		Y	
Pennsylvania State University: Pre-First Year Engineering & Science Program (PREF) [9]	6	Y	
Purdue University: Mathematics Summer Bridge Program [3]	1	Y	N
University of Alabama: Engineering Math Advancement Program (E-MAP) [2]	5	Y	
University of Michigan-Dearborn: Summer Bridge Program [10]	4	Y	
University of Wisconsin-Milwaukee: Summer Bridge Program [12]	4	N	N
Virginia Polytechnic Institute and State University: ASPIRE [7]	5	Y	
Blank cells indicate that affirmative data was not available.			

A perusal of Table 1 indicates that with the exception of one program (Purdue), most programs run for 4-6 weeks. The vast majority also offer on-campus residence for the bridge cohort; our program at UW-Milwaukee, which for the moment is an exception, intends to provide residential living in the future. We note that the paper by Ohland et al.[8] is a very comprehensive longitudinal analysis of the Math Excellence Workshop at Clemson, and provides insight into care that must be taken in performing longitudinal analysis on student performance of early year programs, particularly because attrition in both experimental and control groups causes sample sizes to decay.

We sought two general types of information: (1) immediate student success after participation in the bridge program, measured principally by improvement in math placement; and (2) long-term student success after the bridge program, as measured by retention, graduation, and grade point average. As will be seen, the types of data collected and reported by the various programs is not uniform, and we were able to find no measure for which more than 6 programs reported essentially equivalent data.

Even when similar measures were available, ambient background data on students was not sufficiently available to ensure that the data has uniform meaning across the studies that were compared. Similarly, although in several cases data is given comparing bridge students with control group students (especially Section 3), the controls vary from institution to institution. For example, whereas some bridge programs that are minority-focused were compared with control groups that are also minority-focused, other programs were compared with control groups from the general population of engineering students. Furthermore, even within a given study, control groups might vary over the duration of a longitudinal study. For example, improvement in bridge students' math placement at the end of the bridge program might be reasonably compared with improvement in math placement of non-bridge students who chose to retake a placement test during the summer. Later, bridge students' performance in first semester calculus might be compared to peers who were initially placed in first semester calculus. In our data presentation, "control" data generally refers to whatever reasonable measures were selected by the authors of the papers that we reviewed. For these reasons, and also because of the relatively small amount of data available, we did not attempt to perform any analysis of statistical significance.

Nevertheless, despite these difficulties, our initial tabulation reveals that bridge programs appear to deliver immediate success in helping students to improve math placement prior to matriculation. In addition, our data shows that bridge program participants plausibly fare no worse, and sometimes better, than non-bridge students, including those whose initial math placement was calculus. Clearly more research must be done in order to determine if these observations are valid, but we hope that our initial effort here is useful to educators and administrators as they devote resources to bridge programs.

2. Success in Bridge: Improvements in Math Placement

We first tabulated data to document improvement in math placement resulting from participation in a summer bridge program. The commonly reported measures of success were the number of levels by which placement increased (e.g., by one or two courses), and advancement to calculus. The results are reported in Table 2. Note that most data in Table 2 is not compared with a control group. We conjecture that this is because establishing such control groups is not trivial. Ideally, this requires collecting data from non-bridge students who are academically comparable to bridge students and who retook the placement test during the summer, but this is presumably a small population. Another approach might be to extract data from comparable students enrolled in traditional pre-calculus, and compare calculus placement between the two groups.

Table 2. Improvement in Math Placement Reported by Program Publications.						
School	N	Min/Max Participant Level	Advance 1+ Level	Advance 2+ Levels	Attain Calculus Placement (vs. control)	Data Years
Arizona State University						
Borough of Manhattan CC						
California State Polytechnic, Pomona		2/2				
Clemson University	131	2/2			78% (70%)	1992-1998
Morgan State University	91	1/2			70% (17%)	1999-2000
Old Dominion University	25				70%	1999
Penn State University						
Purdue University	129	2/2			87% (59%)	2000-2001
University of Alabama	N/A	2/2	84%	41%	90%	2005-2006
University of Michigan-Dearborn	68	1/2	81%	27%		
University of Wisconsin-Milwaukee	32	1/1	72%	50%	25%	2007
Virginia Tech		2/2				
N = number of participants. Min/Max Participant Level = math placement of bridge participants per the following code: 1 = below pre-calculus; 2 = pre-calculus. Some control group data is available for Attained Calculus Placement, and is provided in (parentheses). Students who advanced at least 2 levels are counted in both Advance +1 and Advance +2. Blank cells indicate that affirmative data was not available.						

Although we performed no statistical analysis, the data in Table 2 is encouraging. Seven of the institutions studied report significant rates of improvement in math placement by at least one level and/or high rates of calculus placement. This is true even for the three programs that admit students below pre-calculus. We note that one reason for the apparently low rate of calculus placement resulting from our program at UW-Milwaukee (25%) is that this program serves *only* students whose placement is below pre-calculus. All of the other programs surveyed allow or require pre-calculus placement.

3. Retention and Graduation

Although the improvement in math placement data is encouraging, the overall credibility and success of bridge programs must be judged against longer term measures of student success. At a minimum, students who earn advancement in math placement in bridge programs should perform nearly as well as non-bridge students who attain the same placement levels without intervention. For example, will students who earn calculus placement in a bridge program persist as long as students who naturally place into calculus over the duration of an engineering program?

The commonly reported long term measures bridge student performance are passing rate of Calculus I, 1-year retention, and graduation. These data are summarized in Table 3. Some programs also reported GPA data, but we omitted this from the table for simplicity and because fairly little data of this nature was reported.

Table 3. Success of Bridge Students after Completion of Bridge Program.

		Pass Calc I		1-Yr Retention		Graduation		
School	Max N	Prog	Ctrl	Prog	Ctrl	Prog	Ctrl	Data Years
Arizona State University				75%	60%			1998-1999
Borough of Manhattan CC	15			93%				N/A
California State Polytechnic, Pomona	131			79%	76%	56%		1994-1996
Clemson University	109	70%	61%	80%	N/A	47%	37%	1992-1998
Morgan State University								
Old Dominion University								
Penn State University	213					74%	43%*	1991-1999
Purdue University	129	62%	76%	88%	82%			2000-2001
University of Alabama		67%	68%	95%	94%			2005-2006
University of Michigan-Dearborn								
Virginia Tech University				88%	86%			2005-2006
Authors' Institution								

Max N = maximum number of students in study set from which data was derived. Control groups are controlled for minority status, as per minority-focused designation in Table 1. *This is an upper bound because it represents the complement of the reported 5-yr attrition rate of 57%, and outpaces the 5-yr graduation rate for all students (56%). Blank cells indicate that affirmative data was not available.

The data in Table 3 is largely inconclusive. Three programs provided data indicating pass rates of Calculus I by bridge students and a corresponding control group, with one showing higher rate for the bridge students (Clemson), one showing lower rate (Purdue), and one showing nearly identical performance (Alabama). Seven institutions reported 1-yr retention rates; only one showed notable difference between bridge and control group students (Arizona State), and in this case bridge students persisted at a higher rate than control group students. Three institutions provided graduation data, with two indicating that bridge students graduate at higher rates than control group students (Clemson, Penn State).

Not shown in Table 3 is that three institutions (Clemson, Penn State, Virginia Tech) reported some grade-based evidence that bridge students outperform control group students and one institution (Purdue) reported that control group students slightly outperformed bridge students on the basis of grades. We note that Ohland et al.[8] observed that as time went on, performance gains of bridge students compared with control group students diminish with time.

4. Discussion and Conclusions

We focused our attention on compiling data from engineering summer bridge programs that principally aim to help students improve their math placement. We discovered relatively little literature that provided performance data of bridge program students; only 12 programs were identified that provided such data, and among these 12, the data and type of data that was reported varied from program to program.

From the data that we did collect, no statistically significant conclusions can be made. However, the results are encouraging in that the majority of the data indicates that bridge students perform at least as well as non-bridge students on a variety of measures. We conclude that it is therefore reasonable for institutions to continue investing resources to provide bridge programs, especially when there are ample numbers of students who stand to benefit.

Further efforts to collect and tabulate assessment data are necessary to more firmly substantiate the benefits of bridge programs, and to inform changes in these programs to improve their effectiveness. A coordinated effort to collect and analyze bridge program data, including a standard protocol specifying the type of data to be collected, would be most useful. Such an effort should then allow conclusions to be made regarding performance gains of bridge students compared to control groups. Still, we suspect that it will be difficult to isolate bridge program effectiveness, especially as time elapses from the students' initial participation in the bridge programs, because many other factors will also influence student performance.

Finally, we note that even though we have focused on bridge programs that are oriented around math improvement, we share others' views (e.g., White et al.[11]; Ohland and Crockett[13]) that bridge programs need not and should not be remedial. This is because student placement in a bridge program is not necessarily a measure of intellectual ability or curiosity. Well-structured programs that incorporate engineering exploration, advanced applications, and socialization into college and engineering, will all serve to prepare students for success. In fact, perhaps students in such bridge programs will outperform even those who had intrinsically higher aptitude scores, but who were not exposed to exploratory activities. As a practical matter, identifying bridge programs as remedial is also ill-advised because it can attach a stigma that will discourage participation. Therefore, casting bridge programs in an exploratory, rather than remedial, context will foster both student and program success.

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