
AC 2011-51: EVALUATION OF THE IMPACTS OF MATH COURSE PLACEMENT IMPROVEMENT ACHIEVED THROUGH A SUMMER BRIDGE PROGRAM

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EVALUATION OF THE IMPACTS OF MATH COURSE PLACEMENT IMPROVEMENT ACHIEVED THROUGH A SUMMER BRIDGE PROGRAM

Abstract

A summer bridge program for incoming engineering and computer science freshmen was conducted in 2009. The primary purpose of this program was to improve the mathematics course placement for incoming students who initially place into a course below Calculus I as determined through our math placement examination. The students retake the university's math placement examination after completing the bridge program to determine if they may enroll in a mathematics course more advanced than the one into which they initially placed. If a student improves his or her math placement, the program is considered successful for that student.

The mathematics portion of the bridge program centers on using the ALEKS software package for targeted, self-guided learning. In 2009, the program took place exclusively in an on-campus format and also featured a required residential component and additional engineering activities for the students. The program's duration was 4 weeks, and students were expected to improve their math placement by at least one semester. It is expected that improving their math placement will reduce the student's time-to-graduation which should in turn improve retention rates and eventually graduation rates. However, the program will not effectively reduce the time-to-graduation if students do not succeed in their subsequent math courses. Data from the 2009 cohort have been collected and analyzed to judge the effectiveness of the program with respect to the students' performance in future math courses. It was found that in all categories of bridge program students, the students performed as well as the class average, while some categories of students clearly benefited from attending the summer program.

In addition, further factors were considered with regards to the students' success in the bridge program. These factors resulted in some changes which were implemented in the 2010 summer bridge program. The 2010 program saw a larger percentage of students improve their math course placement, with 83% of the students improving their math placement in 2010 vs. 68% in 2009. These factors are discussed as well.

Introduction

In the United States today, there is great interest in the education and graduation of more students in the Science, Technology, Engineering, and Mathematics (STEM) disciplines.^{1,2} There are two primary tasks that are needed for this goal to be accomplished. First, more students need to be attracted to pursue college-level studies in the STEM fields. Second, once those students are attracted to a STEM field, the colleges and universities must provide an attractive, nurturing environment designed to allow a wide range of students to succeed, while still providing a rigorous education.

The College of Engineering and Applied Science (CEAS) at the University of Wisconsin-Milwaukee (UWM) has generally been able to attract as many students into its engineering and computer science programs as for whom it can provide quality educations. But the graduation rates have been much lower than desired. For example, the 6-year graduation rate for Fall 2004 incoming freshmen for the college was 26.3%. Recognizing that this type of rate is undesirably low in that it indicates that students who have shown interest in engineering and computer science are not receiving degrees and achieving their goals in these STEM fields, CEAS has sought to improve this by creating a bridge program for incoming freshmen who may not be academically prepared for engineering and computer science studies in college.

The bridge program has two components. One focus of the program is to provide students with exposure to activities in engineering and computer science so as to excite them about their future studies and provide motivation to the students to encourage them to continue with their studies. But the primary focus of the bridge program is the improvement of the students' math course placement. Such programs are somewhat common.³⁻⁷ At UWM, all incoming students must take a math placement examination to determine into which math course they will enroll. CEAS has determined that one of the greatest predictors of the eventual graduation of incoming freshmen from CEAS is the students' original math placement. Based on studies of students over several years, it was found that students who place below Intermediate Algebra nearly never graduate from the college, students who place into Intermediate Algebra (Math 105) graduate at a rate of about 13%, students who place into College Algebra/Trigonometry (Math 116/117) graduate at a rate of about 43%, and students who place into Calculus (Math 231) graduate at about 44%. While none of these graduation rates are impressive, there is clear improvement which can be made by improving the math placement of students to at least the College Algebra level. One thing that should be noted is that nearly all of the incoming freshmen students have completed high school math courses through at least Intermediate Algebra, and most through at least College Algebra; some have taken Calculus courses in high school. Based on their high school studies alone, without a placement test these students would likely be placed into either College Algebra or Calculus I. However, the placement test has noted deficiencies in their mastery of the lower-level material. Therefore, the purpose of the math component of the bridge program is not to teach the students completely new material, but rather to reinforce familiar concepts through additional practice and tutorial instruction.

While some students who have low math placements eventually do not graduate because they simply did not have the mathematical aptitude to succeed in math-intensive disciplines, an equally important factor is that low math placement delays the student's ability to take engineering and computer science courses. The curricula in the college have been designed with most courses expecting a Calculus background, and that students should begin their freshman year by taking Calculus I. If the students have to wait a semester or a year or more to take Calculus I, it is more difficult to maintain the students' interest in engineering or computer science. They quickly run out of technical courses that they can take. The students are also looking at needing to pay an additional year of tuition to graduate. By improving the students' math placement, we expect that we will improve the overall graduation rates by keeping the students engaged in engineering and computer science studies and by decreasing their time to graduation.

To facilitate the math instruction, CEAS has used the ALEKS⁸ software program. Below, some of the features of students' use of ALEKS in terms of their success in improving their math placement are discussed. However, the benefits of improving math course placement may be jeopardized if the students then struggle in their subsequent math course and fail to advance through Calculus at a higher rate. Therefore performance in the bridge program is only one component of evaluating the utility of the bridge program; subsequent math course success needs to be accounted for in any evaluation. In this paper, we analyze the 2009 bridge program students' performance in their Fall 2009 courses. Their performance in Spring 2010 was also considered; however, this performance may be more influenced by their Fall 2009 course than the summer bridge program. Finally, some modifications to the bridge program were made for the 2010 summer bridge program, and the impact of those changes on the success of students in the 2010 bridge program is discussed.

Description of the Program

As mentioned above, the four-week summer bridge program instituted in 2009 at CEAS involves two parts. In the morning session, students use the ALEKS software package designed to provide them with individualized instruction on mathematical topics most needed by them to improve their mastery of the material necessary for them to succeed in college-level math courses (College Algebra or Calculus). The afternoon sessions concentrate on engineering activities to provide the students with practical examples to help them understand why they need the mathematics courses. The focus of this paper is the mathematics instruction.

In both 2009 and 2010, the bridge program was a residential program, with all students living in an on-campus dormitory and participating in supervised and structured programs during the day while being given free-time in the evenings. The mornings of the program were devoted to 2.5 hours of structured work on mathematics, with students working in a computer lab on the ALEKS software. Instructors were available to provide more hands-on explanations and assistance as needed. Before beginning the program, students had taken the university's math placement exam, and their individualized programs were set up to best help the students master the material which they most needed in order to place into a higher course. The students' progress was continually monitored, and students were encouraged to work more on the material in the evenings if necessary. Occasionally, additional work was provided to the students to be worked on during the evenings and weekends. The students retook the math placement exam on the second-to-last day of the bridge program. If they improved their math placement as a result of the program, the students received a \$1,000 scholarship. The program was designed based on lessons learned from running non-residential programs in previous years.⁹

Description of ALEKS and Observations on ALEKS Usage

ALEKS is a web-based assessment and teaching system.⁸ ALEKS uses adaptive questioning to learn the extent of a student's knowledge of a subject, and then designs its instruction to address the topics for which the student is ready. ALEKS does not rely on multiple choice questions, but rather has the students enter answers using math symbols for each problem.

Students progress through ALEKS at their own pace, and the program focuses on only the material that the individual student needs to learn. The students can spend as much time as they need to on a topic, and then move to the next topic without waiting for the rest of the class to master the material.

The students are placed into the different courses, ranging from Basic Math to Pre-Calculus, based on their raw Mathematics Placement scores. On the Mathematics Placement examination, they are tested on Basic Math, Algebra, and Trigonometry. The raw scores range from 0 to 850 in each category. The students need a minimum of 450 in Basic Math to place into any course other than Basic Math at UWM. If they score above a 450 in Basic Math then their scores in Algebra and Trigonometry determine the course they are placed into. This information is what was used to place them into the corresponding ALEKS course for the Bridge program. The one exception to this is if the student had a Basic Math score that was under 500. Any student that had under a 500 in Basic Math was placed into a Basic Math course so they could review those topics. After they had mastered the Basic Math topics they were placed into the course indicated by their placement scores. Then, as the students master all the topics in the first course, they move into the next course. In this way a student has the opportunity to increase their placement scores beyond one course.

The students are given an initial assessment in ALEKS when they start any of the ALEKS courses. When they finish the initial assessment, ALEKS gives them an individualized pie that includes all the items that are in that particular course. Some of the items are included as mastered, some are ready to learn, and others are not available based on how the student answered the questions on the initial assessment. ALEKS uses an artificial intelligence based learning tree to organize the items. This way a student is only given items to learn for which they are ready. For instance, if a student has not factored any quadratics they are not given topics about solving quadratics. After the students are done with the initial assessment they start working on the items in their pie that they are ready to learn. ALEKS provides explanations for each topic, and there is at least one instructor in each classroom; therefore the students have multiple instruction options for each topic. As they learn new topics other topics become available based on the learning tree for that given course. Periodically the students are given a progress assessment to make sure they are retaining the topics they have learned. If they get a question wrong that they had previously learned, the topic will be put back in their pie to relearn. ALEKS is a mastery learning system, so there is no partial credit.

Once the students finish all the topics in their pie they are given a comprehensive assessment to determine if they have retained all the items in their pie. The progress assessments mostly give questions that the students have currently worked on, and some that they are ready to learn. The comprehensive assessments give questions on any topic in the pie from the most basic material to the last item that they learned. If the student earns a 92% or better on this assessment they are moved to the next course. The 92% is based on percent mastery of the entire course, not 92% of the questions correct on the assessment. If they do not get a 92% they relearn the topics they got wrong, and try the comprehensive assessment again. Figure 1 shows an assessment summary from ALEKS.

06/24/2010-06/25/2010 Assessment (2 hours 27 minutes)

Last login: 07/18/2010
Enroll date: 06/21/2010
Total Hours: 46 hours 54 minutes (44 hours 36 minutes from college)
Total Hours in this course: 32 hours 50 minutes (30 hours 36 minutes from college)

From host: 65.29.6.247:129.89.178.232
Hours/week: 12.2 (11.6 from college)

[Course Calendar](#)

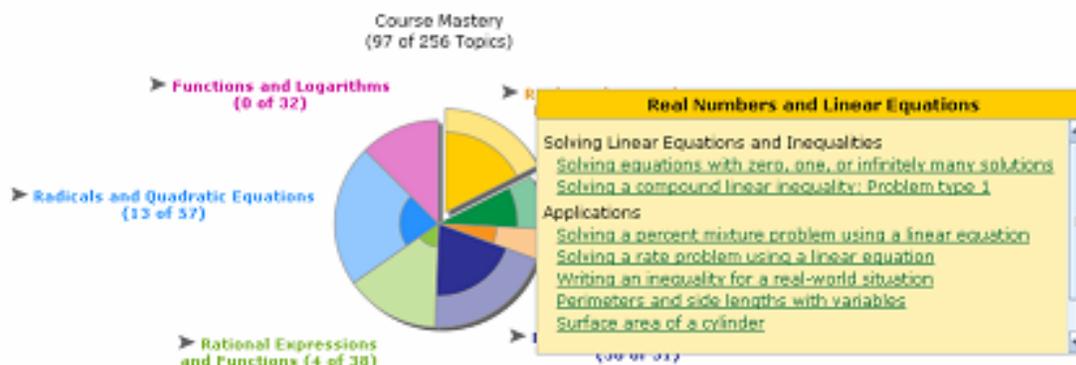


Figure 1: Typical assessment summary from ALEKS software.

ALEKS also records how much time each student spent in a particular course, and how much time they spent in all the courses they have taken with ALEKS. The amount of hours that a student spent in ALEKS, and their final percent mastery of the course they were in at the end of the Bridge program were found to be very indicative of how they performed on the retake of their placement test. These results are summarized in Table 1. The data are for the 2009 Bridge program students. Looking at these results, students who mastered more than 75% of the appropriate pie for the course were all able to place ahead in the next course, while only 40% of the students below this level of mastery improved their math course placement. This is logical, as this correlates to a person knowing at least 75% of the class. It can also be seen that putting in more time on ALEKS was beneficial to improving math course placement, as 17 of 23 (74%) of students who put in more than 40 hours on ALEKS during the Bridge program improved their placement, while only 50% of the students who spent less than 40 hours on ALEKS improved their placement. These results indicate that it is important to encourage the students to spend more time on ALEKS outside of the morning class, as well as to stress the importance of finishing up as much of the course material as they can.

Table 1: Performance factors for a subgroup of the 2009 Bridge program students with regards to ALEKS usage and Mathematics Placement exam results.

	Placement scores increased (out of 24 students)	Placement scores did not increase (out of 12 students)
Final ALEKS scores greater than 75%	16	0
Final ALEKS scores less than 75%	8	12
Hours greater than 40	17	6
Hours less than 40	7	7

Student Performance in Subsequent Courses

In the 2009 bridge program, 24 of 36 students who completed the program improved their math course placement, as determined by retaking the math placement exam at the end of the program. One additional student placed higher due to receiving AP credit. So, overall, 25 of the 37 (67.6%) students are considered to have improved their math placement. Note, the one student who received AP credit for Calculus I chose to take the Calculus I course in the Fall 2009 semester. Of the students who improved their math placement, 8 improved their math placement by 2 courses. Seven of these improved from Intermediate Algebra (Math 105) to Calculus I (Math 231), while one improved from Basic Algebra (Math 095) to College Algebra/Trigonometry (Math 116/117). Two students did not take a math course in the Fall 2009 semester. This results in 35 students being considered in the analysis of course performance. Furthermore, one student withdrew in mid-semester. This student is counted in the statistics for math course performance. That student was taking Math 116, and is considered to have not passed the course.

Figures 2-4 contain bar graphs of aggregate student performance for the Fall 2009 semester in Math 231 (Fig. 2), Math 116/117 (Fig. 3) and Math 105 (Fig. 4) for the 2009 bridge students. Note that student success in the course is being defined as receiving a C or higher in the course. This is done because admittance into the next sequential math course requires a grade of C or better in the previous course. Therefore, while a grade of “C-“ might not be considered failing from the university’s perspective, it is failing for the student as the student must retake that course to advance in the UWM math sequence. In addition, in Figure 3 the combined results from performance in Math 116 and 117 are shown. This does not mean that a student necessarily received below a C in both courses. Rather, if they were taking both courses (6 students took both courses, 6 students took only Math 116, and 1 student took only Math 117 – some students place out of one both not both courses), they were placed into the “C- or Worse” category if they received that grade in one of the courses. In this case, 3 of the 6 students taking both received a C or better in one of the two courses and only had to retake the other course. Of those 3 students, two persisted in the program in the Spring 2010 semester and received a grade of C or

Math 231 - Fall 2009

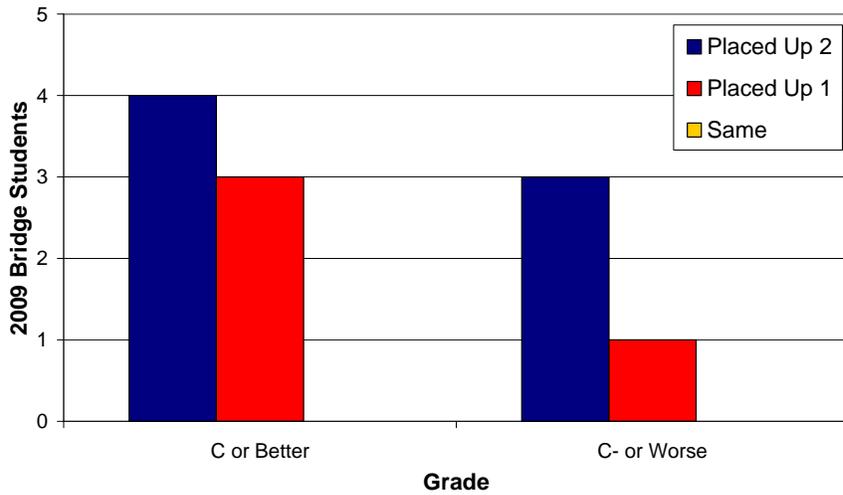


Figure 2: Performance of 2009 Summer Bridge Students who placed into Calculus I for the Fall 2009 semester.

Math 116/117 - Fall 2009

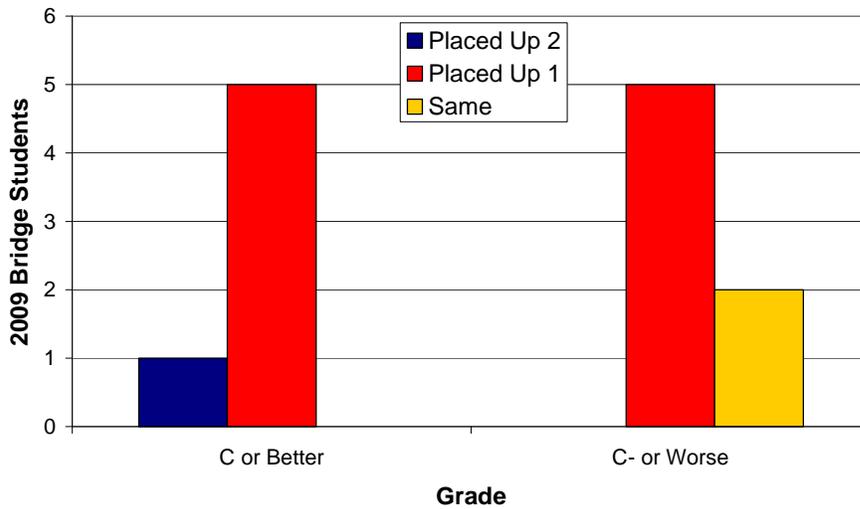


Figure 3: Performance of 2009 Summer Bridge Students who placed into College Algebra / Trigonometry for the Fall 2009 semester.

Math 105 - Fall 2009

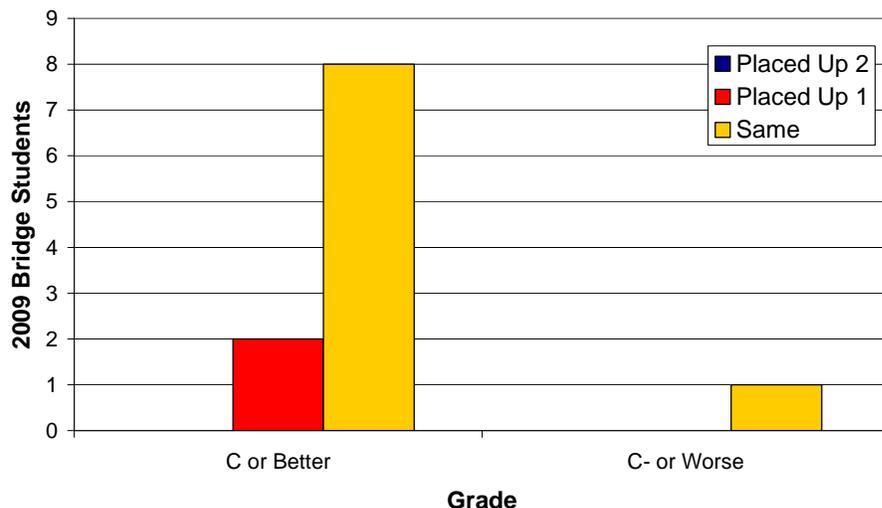


Figure 4: Performance of 2009 Summer Bridge Students who placed into Intermediate Algebra for the Fall 2009 semester.

better in the class that they had not succeeded in during the Fall 2009 semester, and advanced to Calculus I in the Fall 2010 semester.

When analyzing all of the results, it must be remembered that the sample sizes are small in each subcategory, and so most of the focus will be on the general observations in the results. First, considering the results from Calculus I as shown in Figure 2, there are two categories of students to be considered: one group placed up one course in the bridge program (from Math 116/117 to Math 231) and one group placed up two courses (from Math 105 to Math 231). Generally, the students who placed up 2 courses did an exceptional amount of work on their math in the bridge program. As shown in Fig. 2, 3 of the 4 students (75%) who placed up one course into Calculus I received a C or better and were able to advance into Calculus II for the following semester. The success rate of 75% in this group is what would normally be expected as a passing rate for this small number of students. As these students succeeded at a rate similar to that experienced by students who did not improve their placement in a bridge program, and as these students were either more advanced in their math studies or at a similar level (the student who did not advance would have been no better off than in Calculus I in the Spring 2010 semester without advancing in the bridge program), the bridge program was successful for these students with regards to their math course advancement.

Judging the success for the students who placed up 2 levels is not as clear. The students who placed up 2 levels only succeeded in advancing into Calculus II at a rate of 57% (4 out of 7). On the one hand, the bridge program was very successful for the students who advanced two levels and continued on with a grade of C or better in Calculus I. Conversely, the students who did not receive a grade of C or better may have been more successful if they had only advanced one level. Considering that these students would still be more advanced than if they had not

participated in the bridge program with regards to their Spring 2010 math course, the bridge program was moderately successful for these students. Note, of those 3 students, one passed Math 231 in the Spring 2010 semester, one failed it again, and one did not take a math course in the Spring 2010 semester. As the sample size of students grows from subsequent bridge programs, determining additional factors that impact student performance for students who place up 2 levels may help clarify which students should advance two levels, and who should be limited to only a one course advance from a bridge program.

Figure 3 shows the data for the students who took Math 116 and/or Math 117 in the Fall 2009 semester. One student advanced two levels into this Math level, and passed both courses: this student clearly benefited from the bridge program. Two students began the Bridge program in Math 116/117 and remained at that placement level after the bridge program. Both of these students failed to advance to Math 231 through receiving a C or better in Math 116. For those two students, the bridge program did not help their math advancement. There were 10 students who advanced one level into Math 116/117 through the bridge program. As shown in Fig. 3, 5 of these students (50%) received a C or better. At first, that may not appear very good, but it is actually consistent for students as a whole in those courses. For example, the average grade in Math 116 in the Fall 2009 semester for all students was below a C (the GPA for the course was 1.84/4.0). So, for 50% of these students, the bridge program was successful in helping them accelerate their math course sequence, and for the other 50% of these students, the bridge program did not hurt their math sequence, and probably aided it somewhat considering the large failure rate in the Math 116 course overall; i.e., even many of the students who advance to Math 116 after taking Math 105 do not advance out of Math 116 in their first attempt. As mentioned previously, 3 of the 5 students who placed into this level and took both courses failed one in the Fall 2009 semester, and two of these passed that course in the Spring 2010 semester.

The results from Math 105, shown in Fig. 4 are much more definitive. Only one of the eleven students (9%) did not receive a grade of C or better in Math 105. While only two students placed into Math 105 after the bridge program, it is likely that there were some residual effects on the other students' math skills after participating in the bridge program. While the bridge program may not have been necessary for all of the students who remained in Math 105 after the bridge program, the program did not hurt their progress. The program did aid the math progress of the two students who placed into Math 105 after completing the bridge program.

While ultimately the purpose of the bridge program is to accelerate the students' completion of their required math course sequence, and subsequently improve retention and graduation rates of these STEM students, it is also of interest to compare the bridge students' performance to others in the course. Figure 5 contains such a comparison for the four Math courses of interest. The three groups compared are the bridge program participants, all the CEAS freshmen in that course, and then all the students campus-wide taking the course. In this last group, there will be students who are more mature, and who have taken other math courses at UWM or other colleges and universities. Math 105 is considered a terminal math course for many programs at UWM, and so even if the students in those other programs have not taken other math courses in college, they may be well advanced beyond their first semester at UWM before they took the course.

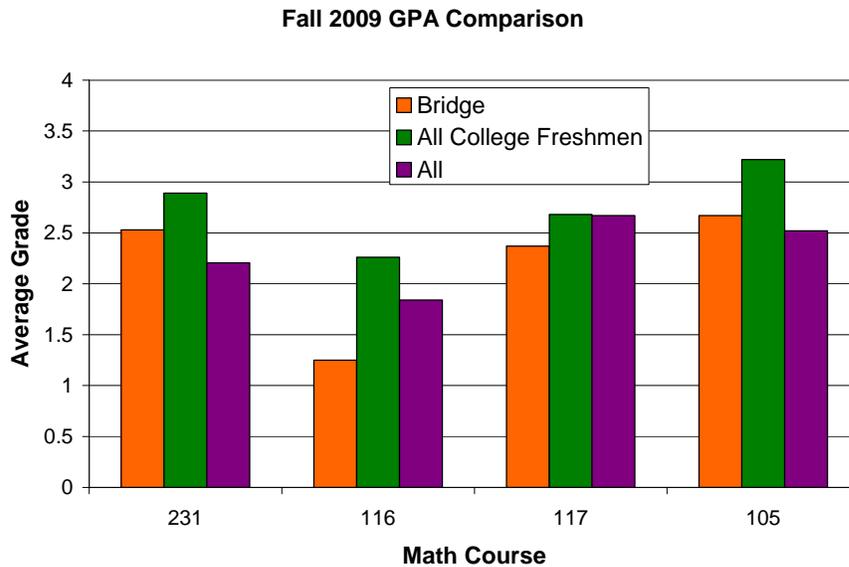


Figure 5: Comparison of the average course grade for 4 Math courses from the Fall 2009. The groups considered are the bridge program participants, all the CEAS freshmen, and all students taking the course.

What can be seen in Fig. 5, again considering the sample size of the bridge program students, is that the bridge program students tended to do worse in these courses than their CEAS peers. The discrepancy is greatest in Math 116, but there the bridge program students' average grade was reduced by several grades of F which more significantly impact the average of the smaller sample size. It should also be noted that many students in the bridge program were identified as being weaker than their peers, which is why they were in the bridge program in the first place. Therefore, it is not surprising that these students would not do as well than their peers. When comparing to all students in the course, the bridge students did slightly better in Math 231 and Math 105, and slightly worse in Math 117: all of these results are subject to consideration of the much smaller sample size of bridge program students in comparison to all students in the courses. For a similar reason when comparing students from the 2009 bridge program to their UWM peers in Math 116, the Math 116 group noticeably did worse than the course as a whole. Overall, these results lend support to the idea that the bridge program helps many students, while providing harm to few if any students.

Complete analysis of the students' performance in the Spring 2010 semester has not been included here for two reasons. First, several students from the bridge program did not take a math course in the Spring 2010 semester, which reduced the number of students to be analyzed. Second, it is believed that the experiences the students' had in their Fall 2009 math course will have a larger influence on their Spring 2010 performance than the bridge program. As a result, it is not considered that this analysis will be of much use.

Based on the results of the 2009 bridge program, some changes were made for the 2010 bridge program. In the 2009 program, one group of students had two teachers who were very interactive during the program, while the other smaller group of students had an instructor who

took a more hands-off approach. Six of the 12 students (50%) who did not improve their math placement were in the class of the hands-off instructor, while only 14 of the students overall were in that class (38%). In addition, only 5 of these 14 students (36%) remained in CEAS after one year. Considering these results, it was decided to use a more interactive hands-on approach with all the instructors for the 2010 program. In addition, both undergraduate and graduate student mentors were brought into the classroom for 2010 to provide additional supplemental instruction, and several mentors were available to provide math tutoring in the evenings if the students desired additional assistance.

A second change that was made for the 2010 program was to allow students to continue to work on their own after the formal bridge program ended but before the start of the Fall 2010 semester in order to allow for an additional attempt at improving their math course placement. However, only a few students took advantage of this opportunity.

The changes implemented in the 2010 program led to 39 of 47 students (83%) who participated in the program improving their math course placement. Eight students improved their placement by two levels. From the perspective of only this factor, the changes appear to be successful at improving the program.

Summary and Conclusions

A residential summer bridge program in CEAS at UWM was held in the summer of 2009. Students used the ALEKS software package along with supplemental instruction to attempt to improve their math course placement. Of the participants, 67.6% improved their math course placement by at least one level, with 21.6% improving by two levels. While ideally this will accelerate the required math sequence for these students, the program will have little benefit if students are unable to succeed in their subsequent math courses.

While hindered somewhat by the small sample size of available students, it appears that the bridge program does help many students who advance one math course level through the program, and does not harm the remainder of those students. If students place one level higher, but then fail that course, they are at the same level as they likely would have been for the following semester, and in some cases may have still improved their ability to pass a difficult course (such as Math 116). In the future, with a larger number of students who have participated in the program, the impact of receiving a non-advancing grade on these students' persistence in the program can be studied.

For students who improve their placement by two levels, there again seems to be little immediate downside to the program, with many students benefiting substantially by potentially reducing the duration of their math sequence by one year. Again, as the number of these students increases, it will be of great interest to see the impact of advancing two levels on graduation rates.

Students in Math 105, even though many of them did not place up a level, still appear to have benefited from the bridge program. Only 1 of the 11 students failed to receive a C or better. While most of those students would have likely passed Math 105 without the bridge program, there is no indication that the bridge program harmed their math performance.

Many of these conclusions need to be considered preliminary. As more students participate in future bridge programs, the size of the population studied will expand and the influence of one or two students on the overall average performance will be reduced. Furthermore, study of the overall program goal of increasing retention and graduation rates from CEAS will need to be postponed until sufficient time has passed for students to graduate.

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