AC 2010-231: EVALUATION OF FACTORS AFFECTING THE SUCCESS OF IMPROVING MATH COURSE PLACEMENT FOR INCOMING FRESHMEN IN A SUMMER BRIDGE PROGRAM

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Abstract

A summer bridge program for incoming engineering and computer science freshmen has been used at the University of Wisconsin-Milwaukee from 2007-09. The primary purpose of this program has been to improve the mathematics course placement for incoming students who initially place into a course below Calculus I on our math placement examination. The students retake the math place examination after completing the bridge program to determine if they then place into a higher-level mathematics course. If the students improve their math placement, the program is considered successful for that student.

The math portion of the bridge program centers on using the ALEKS software package for targeted, self-guided learning. In the 2007 and 2008 versions of the program, both an on-line version and an on-campus version with additional instruction were offered. In 2009, the program was exclusively in an on-campus format, and also featured a required residential component and additional engineering activities for the students. From the results of these three programs, we are able to evaluate the success of the program in its different formats, and are able to judge the utility of the enhancements that have been added to the program.

In addition, data has been collected and analyzed regarding the impact of other factors on the program's success. The factors include student preparation before the beginning of the program (as measured by math ACT scores) and the amount of time the student spent working on the material during the program. Not surprisingly, better math preparation and the amount of time spent on the program are good indicators of success. Furthermore, the on campus version of the program is more effective than the on-line version.

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 lower than desired. While the number fluctuates a bit each year, based on incoming classes from 2003-2005, the graduation rate of incoming freshmen in CEAS is about 35%. Recognizing that this is an undesirably low graduation rate in that it does not advance

students to graduation in these STEM fields and that students who have shown interest in engineering and computer science have failed to achieve their goals, CEAS has sought to improve this by creating a bridge program for incoming freshmen who may not be academically prepared for college.

The bridge program has two components. One focus of the program is to provide students with exposure to activities in engineering so as to excite them about their future studies and provide motivation to the students 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 not uncommon.[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. It was found that students who place below Intermediate Algebra nearly never graduate from CEAS, 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, 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 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 delay taking Calculus I by a semester or a year or more, it is more difficult to maintain the students' interest in engineering or computer science. They quickly run out of technical courses that are of interest to them that they can take. The students are also looking at needing 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 ALEKS[8] software program. This has been used for three summers, with the first two summers being less intensive trials which helped to shape the new bridge program. By comparing different formats of the program, we have been able to reach some preliminary conclusions on what is needed for students to be successful in the math component of the bridge program. The variations of the summer programs, and the results, are discussed below.

Description of the Project

As mentioned above, the four-week summer bridge program instituted in 2009 at UWM 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 2009, the bridge program was designed as 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 program was 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. Some additional work was provided to the students for evening and weekends. The students retook the math placement exam on the second-to-last day of the bridge program. As a result, students had 17 days of formal work on math improvement during the program. The summer bridge program cost the students $25, and the students received a food allowance, housing, instruction, and all materials needed. If the students successfully improved their math course placement, the students received a $1,000 scholarship for the Fall 2009 semester.

Much of the format for the math portion of the summer bridge program was determined from experience gained in the summers of 2007 and 2008, during which a math-only improvement program for incoming students was offered. In both 2007 and 2008, two formats of an ALEKS-based instructional program were used. One format involved on-campus computer use with an additional instructor being present, and the second format involved a remote on-line version. In the on-line version, questions could be e-mailed to an instructor. But as students could work on the program at any time, immediate answers were not always available.

Table 1 contains the number of students who participated in the on-campus and on-line versions of the program in 2007 and 2008, and the number of students who participated in 2009. In 2008, there were two versions of the on-campus program, with one version containing more activities than just the math instruction. While this may eventually impact graduation rates between the two sets of students, for this paper the math placement results will be combined as the format of the math instruction was very similar. It is also noted that each year, one student received AP credit for Calculus while participating in the program. There was no need for these students to retake the placement exam, and so the number of students used in the analysis is changed accordingly.

Table 1: Number of participants in the Summer Math Instruction

	2007	2008	2009
On-Campus			
- Total	11	5 + 8 (2 programs)	37
- AP Credit	1	0	1
- Number in Study	**10**	**13**	**36**
On-Line			
- Total	29	31	No Program
- AP Credit	0	1	
- Number in Study	**29**	**30**	

Below, some trends noted from the results in the first two summers are presented, as is a discussion of how these trends influenced the form of the 2009 program. In addition, the overall results of the 2009 program are described.

Results

Table 2 summarizes the results for the 2007 program. In Table 2, a breakdown of the number of students who did and did not improve their math course placement for both the on-campus and on-line versions of the program is provided. In addition, information on the average math ACT scores of students in each category and the average total amount of time spent using the ALEKS software for each category is provided. The math ACT score is used as an indicator of student preparation entering the program, as most students in the program had similar math backgrounds in high school. The math ACT score gives a measure as to how well the students mastered their mathematics studies entering the program. It should be noted that 9 of the students who participated in the on-line version of the program did not retake the math placement exam. This indicates that the students did not stay dedicated enough to the program to feel that they had learned enough to improve their math placement.

Table 2: Program Results and Potential Influencing Factors for 2007 Program Participants

	On Campus - Improvement	On Campus- No Improvement	On-line - Improvement	On-line – No Improvement
Number of Students	9	1	14	15
Average math ACT	24.9	26	23.8	23.7
Average time spent on ALEKS (hours)	32.7	14.5	20.9	8.5

Table 3 contains the same data for the 2008 program, with the exception of the lack of data for the time spent on the ALEKS software for the on-campus version of the program. However, this lack of data should not significantly impact the conclusions.

Table 3: Program Results and Potential Influencing Factors for 2008 Program Participants

	On Campus - Improve	**On Campus- No improvement**	**On-line - Improve**	**On-line – No Improvement**
Number of Students	8	5	13	17
Average math ACT	26.4	24	25.4	24.2
Average time spent on ALEKS (hours)	--	--	20.7	13.9

From Tables 2 and 3, it can be seen that certain factors do appear to influence the likelihood of a student improving their math course placement. Clearly, students who attend a program on campus are more likely to improve their math course placement than those who attempt to do the work at home in an on-line program. This does not mean that students can not succeed in an on-line program. But between the two years, 74% succeeded in an on-campus program, while 46% succeeded in an on-line program. This is likely a result of the maturity level of the students, as incoming college freshmen will probably benefit by being in a structured setting rather than relying upon themselves to work on their own. In addition, the immediate presence of instructors to provide additional help is likely beneficial.

A second clear indicator of potential success is the amount of time the students spend on the ALEKS program. As seen in Tables 2 and 3, the groups who improve their math placement, on average, spent significantly more time working in the program. Furthermore, the campus group spent more time than the on-line group. This feature reinforces the idea of the benefit of a structured setting.

In the past, CEAS has found that math ACT scores correlate well with math course placement, and as such, we expected that the math ACT score may also be a good indicator of student success in the program. Yet, the data in Tables 2 and 3, coupled with the sample sizes involved, do not show a clear indication that that is the case. To further explore the math ACT score impact, the data for the on-line students from 2007 and 2008 were combined, with the results of improvement vs. no improvement in math course placement being analyzed with respect to the math ACT score. The results of this are shown in Table 4.

Not surprisingly, students at the high end of the scale (27 or above on the Math ACT) generally succeed in improving their math placement in this program. As we have found that a Math ACT score of 28 is usually a good indicator that a student will place into Calculus I, and that most of

Table 4: Math Course Placement Improvement Based on Math ACT Scores for 2007 and 2008 On-line Program Participants.

Math ACT Score	< 21	21	22	23	24	25	26	27	> 27
Improvement	0	0	3	6	8	2	3	4	2
No Improvement	1	5	2	5	3	7	6	1	1

these students placed into Math 105 (Intermediate Algebra), it is reasonable to expect that such students will place into at least College Algebra after participating in the program. Similarly, students with an ACT of 21 or below do not appear to benefit much from this program, at least in its on-line version. Again, we have found that this type of Math ACT score often leads to a math placement at or below Math 105, so it isn't likely that these students would improve above Math 105. The results for the intermediate Math ACT scores are more interesting and may warrant further study. Scores of 25 or 26 correlate to students who generally place into College Algebra, yet these students placed, in general, into Intermediate Algebra. On the other hand, students with scores of 22 or 23 usually place into Intermediate Algebra. Nearly all of the students in the on-line program placed initially into Intermediate Algebra. So, one would expect the students with the higher Math ACT scores to be more likely to improve their math placement to at least College Algebra, the course into which many of their peers with the same math ACT score initially placed. Instead, students who had Math ACT scores of 22-24 were more likely to improve their placement, while students with scores of 25 and 26 were more likely to not improve. One possible explanation for this is that students who had lower ACT scores may be more apt to recognize that they needed more work on their math skills, and may have taken the on-line program more seriously. Conversely, students with the higher scores may not take the program as seriously, and as a result do not put in enough effort to master the material to move to the next math course level. This is something that is difficult to determine; the average time spent on the ALEKS program is slightly higher for the students with the lower ACT scores, but does not gauge how determined the students were to learning the material and does not include any information on additional self-study while off-line. However, this piece of information could be useful in determining how to motivate students to work through the program.

Taking what was learned from these 2007 and 2008 programs, a new bridge program was designed for 2009. Considering the benefits of having students on campus in terms of keeping them motivated in the program and the benefits of spending additional time working on the material, it was decided to have a resident-only program. Other features described previously were incorporated to improve overall retention and eventual graduation, but not specifically to influence the math placement results. It was also determined to have instructors present to immediately answer questions as needed by the students during the time dedicated to working with ALEKS. The results for the math placement improvement in the 2009 program are shown in Table 5. Note that the format of the program, considering time spent on other activities in-class, would have led to a minimum of approximately 35 hours of time spent on ALEKS by a student attending the program every day.

Table 5: Program Results and Potential Influencing Factors for 2009 Program Participants

	Improvement	**No improvement**
Number of Students	23	13
Average math ACT	24.7	23.2
Average time spent on ALEKS (hours)	46.3	39.1

Another item to note about the 2009 program is that not all students initially placed into Intermediate Algebra. In this program, 5 of the students initially placed into College Algebra (3 of whom improved their placement) and 3 placed below Math 105 (all of whom improved their placement).

From Table 5, it is clear that time spent on the ALEKS program is again a strong indicator of likely success. The results also suggest that a higher ACT score may be a good indicator in this on-campus program. A further breakdown of the results by ACT score is presented in Table 6. These results are more expected than those seen for the 2007 and 2008 on-line programs. These results show that students with a math ACT score of 23 or below succeeded at a 50% rate, while students at 24 or above succeeded at a 75% rate (and students at 27 or above succeeded at an 80% rate). Such information may be very helpful for recruiting more students who have a score in the mid-20s on their math ACT into the program.

Table 6: Math Course Placement Improvement Impact Based on Math ACT scores for 2009 Program.

Math ACT Score	< 21	21	22	23	24	25	26	27	> 27
Improvement	1	3	1	3	2	2	3	5	3
No Improvement	1	2	2	3	1	1	1	2	0

Summary and Conclusions

A program designed to improve the math course placement of incoming freshman has been conducted in various formats. This program is centered on using the ALEKS software to target and track individual students' needs and to provide tutoring. Students also had access to instructors to provide additional teaching and guidance. This program was studied for 2 years, with the results from different versions being used to create a formal summer bridge program beginning in 2009 of which the math improvement was an integral part.

Based on the results, it was found that the success rate of participants with regards to improving math course placement at the University of Wisconsin-Milwaukee was positively impacted by using an on-campus model rather than an on-line version. The on-campus version provided the students with a set structure for working on the program, and also provided the students with an instructor who could provide immediate assistance and feedback. In addition, there was a clear relation in the amount of time spent by participants on the software and the likelihood of success.

The use of math ACT scores as a predictor of success in the program is not yet clear and needs further study in future years. A math ACT score of 27 or above is generally a good indicator of success for students in the program, particularly if these students are working to place out of Math 105 (Intermediate Algebra) and into College Algebra or Calculus I. Students with a math ACT score of 21 or lower tend to struggle with the program, although progress is still possible in the on-campus version used in 2009. The on-campus version appears to be very helpful in keeping students with math ACT scores of 25 and 26 focused on the program, thereby increasing their likelihood of success.

This project is to be continued over at least the next few years and additional data will be gathered on factors impacting the success of the students. The data presented here provided a basis for developing and modifying the program, and future modifications will continue to be made as the program develops. For example, one planned modification for the 2010 program is to use student mentors, who will be employed to not only help with the engineering projects portion of the bridge program, but to also go into the residence hall in the evenings to provide additional math tutoring. This is being attempted in response to desires from the students in the program to have more structure in the evenings as well as more hands-on math tutoring, and the mentors' desire to have more impact in the program.

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