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Using a Math Tutorial Program to Decrease the Number of Failed Grades the First Semester helping the College achieve a 91% First Year Retention Rate

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Abstract - **Universities are feeling the pressure to improve their first year retention rates and their graduation rates from their state legislators more than in past years. universities have improved retention rates by adding learning communities, increasing advisors, starting first year seminars and summer programs, along with making improvements in curriculum and teaching. However, students still struggle with the transition to college emotionally, academically, and socially. Many struggle with not having the level of preparedness and knowledge in mathematics. Many come to school overconfident and are surprised at the level of difficulty and the pace of college courses. The College piloted a new initiative to use the basic prep for calculus offered by ALEKS (Assessment and Learning in Knowledge Spaces) a web-based, artificially intelligent program for their incoming first year students. The purpose was not for math placement as many schools are using it for, but instead it was used to help students see how prepared they were in mathematics and to help tutor the students in the math subjects that they were weakest in. Those students who spent time in the ALEKS tutorial program did significantly better overall and in their first math course than those students who did not participate. The results from the year it was piloted saw dramatic decreases in C-, D, W and F grades and a 50% reduction in the number of students receiving less than a 2.00 GPA their first semester from the prior year. For the first time in the history of the College, 91% of the 2015 cohort of engineering first year students were retained to their second year.**

INTRODUCTION

Universities are receiving more mandates than ever before regarding student progression. In this state, the university can receive or lose millions of dollars based on what their retention and graduation rates are. As a result, this university invested in more advisors and support programs to try to improve their first year retention rate and their graduation rates.

Over the past five years, three new advisors were added in the college, tutoring resources were expanded and course-based learning teams were introduced. The learning teams in the College of Engineering were first started in the fall of 2012 and were continued and increased from the original ten in 2012 to 25 course-based teams by the fall of 2016. The teams would have about fifteen students each and they were linked with a math or chemistry class. The learning teams would meet one hour a week in a classroom with a peer mentor who was also an engineering student. Students are in the same section so they would see each other every day in class plus an hour outside of class when they meet with their learning team. The peer mentor would also hold study sessions outside of the one-hour class period. The learning teams helped to significantly retain the weaker first year students [1].

TABLE I
FIRST YEAR RETENTION RATES

Cohort	# Students	First Year Retention Rate
2011	496	83.5%
2012	632	89.4%
2013	623	87.6%
2014	658	86.8%

Note: Census date used is the 10th day of the semester

An addition, in 2012, a new "orientation" course for zero credits was introduced to help students adjust to college. All these improvements helped to raise the retention rates for the students starting in 2012. However, failure rates continued to be high for students in their first math course of either precalculus or calculus I. In 2014, the failure rates for the fall admitted students taking precalculus jumped to 23.5%. Students, especially the summer students, were still failing their first math course at a high rate (Table II, III).

TABLE II
FIRST SEMESTER FAILURE RATE FOR PRECALCULUS

	Summer Admits			Fall Admits		
Precalculus Grades	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Failed (C-, D, F, W grades)	32%	20%	24%	11%	12.3%	23.5%
N =	69	70	104	191	146	170

TABLE III
FIRST SEMESTER FAILURE RATE FOR CALCULUS

	Summer Admits			Fall Admits		
Calculus Grades	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Failed (C-, D, F, W grades)	26.9%	9.4%	20%	16.3%	16.7%	17.4%
N =	26	32	25	227	240	363

As a note, the academic profile of the students admitted in the fall is significantly better than for the students who are admitted in the summer only. The summer admitted students are only allowed to start in the summer due to their weaker academic background, yet they are still allowed to enter the engineering college. Table IV shows the significant differences (P<.001) in the high school grade point average (HSGPA), math SAT and ACT scores of summer admits versus the fall admits.

TABLE IV
INCOMING CHARACTERISTICS OF SUMMER ADMITS COMPARED WITH FALL ADMITS

Mean	**2014 Summer Admits**	**2014 Fall Admits**	**2015 Summer Admit**	**2015 Fall Admit**
HS GPA	3.45	**3.93**	3.56	**3.97**
SAT Math	588.4	**629.4**	591.5	**635.8**
ACT Math	25.2	**27.7**	25.4	**27.4**

In addition, students who do poorly their first semester tend not to come back for their second year and many leave after their first semester. The first year retention rate for students who received less than a 2.00 GPA their first semester in school was under 40% (See Table V) for the 2014 cohort.

TABLE V
1ST YEAR RETENTION RATE BASED ON 1ST SEMESTER GPA WHEN GPA IS LESS THAN A 2.00

Cohort	**#Students with<2.00 GPA**	**Total Admits**	**% Retained University**
2011	75	555	32.0%
2012	64	632	43.8%
2013	65	623	35.4%
2014	86	658	39.5%

Therefore, in an effort to increase students' performance in their first math course and improve the students' overall success their first fall semester, a pilot was run on the 2015 cohort which involved having students participate in an online math tutorial program the summer prior to the students entering their first fall semester of school. The idea behind the program was to give students a chance to see where their math skills lined up to what would be expected of them in college and then to give students an opportunity to work on their weak areas in math so that they could be better prepared for their first math course in the fall.

BACKGROUND

Much research has been done documenting how having a good high school preparation in science and math increases a student's chances for success in engineering in college [2]-[4]. For those students with strong math skills their transition to college and the likelihood of graduation from college is much higher than students who enter college without the advantages of having advanced math courses in their high schools. Many students are not even ready to take calculus when they attend college and must begin in algebra or precalculus instead. Students disadvantaged economically tend to live in poor school districts where the schools lack the resources to provide advance math and science courses, qualified teachers, or a wide range of educational support such as workshops, and tutoring [5]. Summer bridge programs have been created to help students close the knowledge gap in math and be prepared for their first math course in college [6]-[8]. While these have been very successful, they demonstrate how so many students are coming to college without the math preparation needed to be successful. These programs are very expensive and cause students to leave home for six to eight weeks in the summer, taking away opportunities for the students to work and earn money for school during the summer months. The costs alone keep many students from attending these programs and prevent many colleges from being able to afford offering the programs to students.

TUTORIAL PROGRAM

The tutorial program used for the pilot was offered by the company called ALEKS (ALEKS.com). ALEKS stood for **A**ssessment and **LE**arning in **K**nowledge **S**paces. It is a Web-based, artificially intelligent assessment and learning system. From its website, ALEKS.com; "ALEKS uses adaptive questioning to quickly and accurately determine exactly what a student knows and doesn't know in a course." The program used was called the "Basic Prep For Calculus I". Some of the material covered includes trigonometry so students who had not taken precalculus in high school would not be expected to know 10% of the material.

A Canvas (Canvas is an open-source learning management system) site was created for all incoming students. At this university all students have to attend orientation prior to registering for classes. To prepare the students for orientation, the students were sent the link to the Canvas site where there would be orientation material to review. In addition, at the site there were instructions asking the students to take the initial assessment on ALEKS, and then they were asked to work through the tutorial in the areas that they were the weakest on and then take the post-test. Students were to try to obtain at least an 80% proficiency level. Students who had tested out of calculus I were exempted from participating.

As mentioned earlier, students who come poorly prepared for college academically, have a higher failure and dropout rate than better prepared students [9]-[11]. Many students do not know that they may be underprepared for

college level courses. The idea behind the tutorial is for students to take the initial pre-knowledge assessments to find the areas of math that they are weak in (see Figure 1 as an example) work through the problems, and then take the post-knowledge assessment.

By going through this tutorial it was hoped that students would learn or relearn critical math topics and thereby be better prepared for their first math course in college. In addition, some students come in overconfident in their preparation for college, so it was hoped that this would help students to set more realistic expectations. While all students were asked to take part in this tutorial program though communications at summer orientation and follow-up emails, less than half actually logged on and took the pre- and post-knowledge assessments.

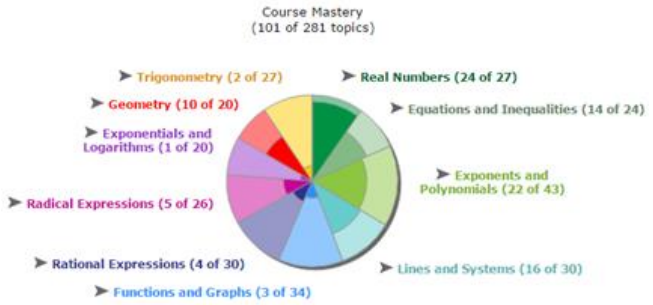

FIGURE I
EXAMPLE SHOWING THE RESULTS OF THE PRE-KNOWLEDGE ASSESSMENT

RESULTS

Of the 667 students who initially were considering engineering 342 students logged on and 252 students actually took the pre-knowledge assessments, worked on the tutorials, and then took the post-knowledge assessment (Table VI).

TABLE VI
NUMBER OF STUDENTS PARTICIPATING IN ALEKS

Cohorts	**#**
Students in the initial cohort	667
Students who opened ALEKS	342
Students who took both the pre-test and post test	252

There were no significant differences between the group of students who used ALEKS and the group that did not, in regards to HSGPA, math ACT and SAT math scores (Table VII). There was a significant effect for students who participated in using the ALEKS $t(100)=2.60$, $p<.0001$ on their calculus grade as those students had a significantly higher course grades and first semester GPAs, $t(100)=3.32$, $p<.0001$ (Table VIII) as compared to those who did not use ALEKS.

TABLE VII
COMPARISON BETWEEN STUDENTS IN CALCULUS WHO DID AND DID NOT TAKE ALEKS

	HSGPA		**ACT Math**		**SAT Math**	
	ALEK	NonA	ALEK	NonA	ALEK	NonA
Average	3.92	3.92	27.8	27.8	648.2	649.1
Median	4.02	4.02	28	28	650	650
N=	158	158	66	98	88	132

Note: ALEK: Students who used ALEKS. NonA: Students who did not use ALEKS

TABLE VIII
COMPARISON BETWEEN STUDENTS IN CALCULUS WHO DID AND DID NOT TAKE ALEKS ON GPA

	Calculus Grade		**Fall Sem. GPA**	
	ALEK	NonA	ALEK	NonA
Average	**3.13**	2.73	**3.46**	3.16
Median	**3.67**	3.00	**3.68**	3.37
N=	100	158	100	158

Note: ALEK: Students who used ALEKS. NonA: Students who did not use ALEKS

The same result held for the precalculus students. While the HSGPA and math ACT/SAT test scores did not differ significantly between the two groups (Table IX), there was a significant effect for students who used ALEKS $t(123)= -4.98$, $p<.0001$ on their precalculus grade and their first semester GPAs, $t(123)= -5.47$, $p<.0001$) than those who did not use ALEKS (Table X).

TABLE IX
COMPARISON BETWEEN PRECALCULUS STUDENTS WHO DID AND DID NOT TAKE ALEKS

	HSGPA		**ACT Math**		**SAT Math**	
	ALEK	NonA	ALEK	NonA	ALEK	NonA
Average	3.77	3.64	25	24.9	580	589.8
Median	3.85	3.72	25	25	590	590
N=	112	123	79	82	93	100

Note: ALEK: Students who used ALEKS. NonA: Students who did not use ALEKS

TABLE X
COMPARISON BETWEEN PRECALCULUS STUDENTS WHO DID AND DID NOT TAKE ALEKS ON GPA

	Precalculus Grade		**First Fall Sem. GPA**	
	ALEK	NonA	ALEK	NonA
Average	**3.29**	2.64	**3.3**	2.79
Median	**3.33**	3	**3.42**	2.90
N=	113	123	113	123

Note: ALEK: Students who used ALEKS. NonA: Students who did not use ALEKS

Tables VIII and X show there were significant differences between course grades and the first semester GPA for students who participated in the ALEKS pilot and those who did not. For those students who did not, the GPAs in both the class and for their first semester were significantly lower. This may have contributed to reducing, by half, the number of students who received less than a 2.00 compared to the 2014 cohort (Table XI).

TABLE XI

1ST YEAR RETENTION BASED ON FIRST SEMESTER GPA WHEN THE GPA IS LESS THAN A 2.00

Cohort	# Students with < 2.00 GPA	Total Admits	% Retained University
2012	64	632	43.8%
2013	65	623	35.4%
2014	86	658	39.5%
2015	43	665	34.9%

Having many fewer students with less than a 2.00 GPA their first semester, in this case just 43 compared to 86 in 2014, helped the College reach the 91% retention rate (Table XII) since these students have the lowest first year retention rate of all new students.

TABLE XII
FIRST YEAR RETENTION RATES

Cohort	# Students	First Year Retention Rate
2011	496	83.5%
2012	632	89.4%
2013	623	87.6%
2014	658	86.8%
2015	665	91.0%

Note: Census date used is the 10th day of the semester

At the end of the fall 2015 semester, overall grades improved in key math courses. The College was able to reduce the failure rate in precalculus and calculus classes significantly. The precalculus failure rate (C-, D, F, W grades) dropped from 24% in 2014 to 11.4% for 2015 summer admits and from 11% to 3.9% for the 2015 fall admits (Table XIII). A drop of 52.5% and 65% respectively.

TABLE XIII
FIRST SEMESTER FAILED GRADES FOR PRECALCULUS AND CALCULUS

	Summer Admits			Fall Admits		
Precalculus Grades	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
Failed (C-, D, F, W grades)	24%	11.4%	18.9%	11%	**3.9%**	9.9%
N =	104	107	111	191	168	172
Calculus Grades	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
Failed (C-, D, F, W grades)	41%	31%	48.3%	16.6%	**12.6%**	17.8
N =	25	41	29	363	215	202

The calculus I failure rate dropped from 41% in 2014 to 31% for 2015 summer admits and from 16.6% to 12.6% for the 2015 fall admits. This was a reduction of 24% for both the summer and fall admits in their failure rates.

Even though the fall admitted students were much stronger students than the summer admits (refer back to Table IV) there were still significant improvement in their performance from 2014 to 2015. ALEKS was not used in 2016, due to the author being moved to other projects that year, and the failure rates went back to levels similar to the 2014 levels.

CONCLUSIONS

Initial finding suggest that the pilot was successful and should be continued. While the high school GPA, math ACT and math SAT scores were not significantly different between the two groups, the outcomes were significantly better for those who participated in the ALEKS pilot compared to those who did not. This then lends itself to the idea that the difference in performance could be due to self-selection bias. Students who chose to participate in ALEKS may have had personality characteristics such as conscientiousness, one of the "Big Five" factors of personality where students strong in this trait [12]-[14] are more likely to follow through with obligations and care about doing them well (i.e., complete the ALEKS tutorial when asked to by the College). The students may have better emotional regulatory behaviors, higher levels of intrinsic motivation or other types of personal characteristics that were not measured for this pilot. Since the failure rates went back up for the 2016 cohorts, however, while all the other support programs stayed the same, it could be assumed that the pilot program helped some students enough to result in the lowering of the overall failure rates in precalculus and calculus. In other words, for some students knowing what they did not know and having the opportunity to brush up and either relearn or learn the material for the first time, improved the passing rates for precalculus and calculus and benefited the students by resulting in higher grades for both their math class and their first semester in college. A future pilot will be run requiring all summer students to take both the pre- and post-knowledge assessments and require all the students to achieve a minimum score to continue on in engineering. In summary, having the students participate in this type of exercise in the summer prior to starting their first fall semester in college seems to have a good impact on their grades during the fall semester and it contributed to helping the College achieve its highest first year retention rate in its history.

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