

Work-in-Progress – Are Students Properly Placed into their First-Year Engineering Course?

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Abstract – Currently at Michigan Technological University, there are two pathways through the common first-year engineering program based on math placement. There is a two-semester sequence for students starting in Calculus I or higher and a three-semester sequence for students starting in Pre-Calculus. Traditionally, math placement was based on a student's math-ACT score. Beginning fall 2014, students have been placed using Assessment and LEarning in Knowledge Spaces (ALEKS) an online system that customizes each student's assessment and learning experience based on their knowledge and readiness to learn topics. The changes in the method used to place students into their beginning math course have provided both challenges and opportunities. The challenges include getting students to take the ALEKS assessment seriously and accommodating an upward shift in the number of students going through the two-semester sequence. This shift has provided an opportunity to begin to examine if two paths through the first-year engineering courses are necessary. If two paths are needed, can math placement be used for engineering course placement?

Index Terms – first-year placement, engineering, ALEKS

INTRODUCTION

Michigan Technological University has a common First-Year Engineering Program (FYEP) that is housed in the Engineering Fundamentals Department within the College of Engineering. This program currently has two pathways based on math placement. One path is for students who are calculus-ready and the other for students beginning in pre-calculus. The calculus-ready students are enrolled in ENG1101: Engineering Analysis and Problem Solving, while the pre-calculus-ready students take ENG1001: Engineering Analysis, followed by ENG1100: Engineering Problem Solving (two semester sequence). Students in both paths complete the first-year engineering program by taking ENG1102: Engineering Modeling and Design.

The Michigan Tech FYEP began in the fall of 2000 and had a single path for calculus-ready students [1]. A second path was developed in 2002 for students starting in Pre-Calculus to enable them to engage in their major and have

contact with engineering faculty during their first semester [2].

The first-year engineering program at Michigan Tech is currently undergoing revision. One item being investigated is whether two pathways are necessary based on beginning math placement. A cursory review of other first-year engineering programs suggest that if there is more than one path, it is an "honors" track (e.g. Colorado School of Mines, Iowa State, Ohio State, and Purdue). Some programs with a single track require students to be calc-ready to take their first-year engineering courses (e.g. Texas A&M and Virginia Tech).

Since placement into the two paths of the first-year engineering program at Michigan Tech is based on math placement, changes made to math placement allow us to examine how students that would have traditionally been admitted to the pre-calculus path perform in the calculus-ready path.

MATH PLACEMENT

Historically, math placement, and by default their path through the FYEP, was determined by the student's ACT/SAT math score for students without Advanced Placement (AP) or transfer credit. The intent of these standardized tests is to measure a student's readiness or preparedness for college calculus [3, 4]. Table I lists math placement guidelines for students at Michigan Tech prior to fall 2014 and the corresponding engineering course the students were enrolled in. Note that there are two Calculus I courses: Calculus I+ covers the same core material as the standard Calculus I course, but includes an additional class period per week to emphasize both prerequisite material and skill development.

TABLE I
MATH AND ENGINEERING PLACEMENT GUIDELINES PRIOR TO FALL 2014

ACT Mathematics Score	SAT Mathematics Score	Math Placement	ENG Placement*
<19	<500	College Algebra 1	no ENG course until 2 nd year
19 to 25	500 to 599	Pre-Calculus	ENG1001
26-28	600-649	Calculus 1+	ENG1101
≥29	≥650	Calculus 1	ENG1101

* ENG course placement since 2002

In 2014, incoming students were placed into their math courses based on their ALEKS (Assessment and Learning in Knowledge Spaces) test scores. This online testing method is adaptive and targets individual knowledge gaps [5]. This allows student placement into math courses that match students' individual skills. Starting in 2014, Michigan Tech used the ALEKS test scores shown in Table II to place students into their math and corresponding engineering course. The recommendations from ALEKS for math course placement are included for comparison. The ALEKS scores for math placement used at Michigan are lower than the recommended cut scores and were based on pilot studies at Michigan Tech and in consultation with ALEKS representatives. Students may retake the ALEKS assessment two additional times (three total attempts) after spending time in the ALEKS Learn and Prep modules.

TABLE II
MATH AND ENGINEERING PLACEMENT GUIDELINES BEGINNING FALL 2014

Michigan Tech ALEKS Score	ALEKS Recommended Cut Score	Math Placement	ENG Placement
<56	<60	College Algebra 1	no ENG course until 2 nd yr
56 to 69	61 to 75	Pre-Calc	ENG1001
70-79		Calc 1+	ENG1101
≥80	≥76	Calc 1	ENG1101

At Michigan Tech, first-year engineering students are scheduled into cohorts by the registrar's office in mid-July. In July 2014, it appeared that students did not understand the impact of the ALEKS placement. There were a large number of students who either did not take the test at all or did not complete the Learn and Prep modules and therefore did not retake the assessment to improve their placement. This resulted in a much higher number of students being placed into college algebra than in the past. Therefore, the math placement process was modified for fall 2014 to use a combination of ALEKS and Math ACT scores.

During the spring and summer of 2015, Michigan Tech had a more comprehensive ALEKS placement campaign, educating fall 2015 incoming students and their families on the importance of taking ALEKS early and taking it more than once after completing the learning modules to improve placement. As a result, more students completed the ALEKS assessment by mid-July and a larger number of students, 59%, took the ALEKS assessment two or three times. This produced a shift in math placement with a larger number of students beginning in a higher math course than they would have if they had been placed using their Math ACT score.

EFFECT ON ENGINEERING COURSE PLACEMENT

The changes in math placement methods have had an impact on enrollment in the first-year engineering courses, as shown in Table III. Fall 2013 was the last year of using Math ACT scores for math placement and serves as a baseline for enrollment in the two paths of the first-year engineering courses (ENG1001 for pre-calculus-ready students; ENG1101 for calculus-ready students). Due to the

modifications made to the math placement in fall 2014 (using both ALEKS and Math ACT scores), the number of students in the first-year engineering classes was approximately the same as fall 2013. As a result of improved communication regarding math placement, there was a much larger percent of students in fall 2015 that began in ENG1101 and fewer students beginning in ENG1001. There were also a number of fall 2015 first-year students that were not able to enroll in any first-year engineering course due to their placement into College Algebra. To encourage these 16 students placed in College Algebra to stay in engineering, they were placed into ENG1001 in fall 2015 and will be allowed to progress into the subsequent first-year engineering courses.

TABLE III
NUMBER OF STUDENTS ENROLLED IN FIRST-YEAR ENGINEERING COURSES DURING MATH PLACEMENT TRANSITION

Term	Math Placement	ENG1001	ENG1101	Total
Fall 2013	Math ACT	211 (21.4%)	775 (78.6%)	986
Fall 2014	ALEKS and Math ACT	180 (18.5%)	792 (81.5%)	972
Fall 2015	ALEKS	87* (8.5%)	932 (91.5%)	1019

* Includes 16 students that were concurrently enrolled in college algebra

Since it appears that the ALEKS assessment was used in the recommended manner by most students beginning in fall 2015 (i.e., a large percent of students completed the assessment on time and took it more than once), these students form the study group. A comparison in placement was performed for these students between the traditional math placement (Math ACT score) and ALEKS. Only students who had both an ACT and ALEKS score were included in this analysis; this does not include students with AP or transfer credit. As shown in Figure 1, only 37% of students would have been placed in the same course using their ALEKS score as using their Math ACT score (agree). Surprisingly, almost half of the students (n = 248, 48%) were placed in a higher math course (placed up). Only 15% of the students were placed in a lower math course (placed down). The effect on the FYEP was to increase our ENG1101 enrollment to approximately 900 students, and to decrease our ENG1001 enrollment to under 100 students: a swing for the FYEP program of approximately 10%.

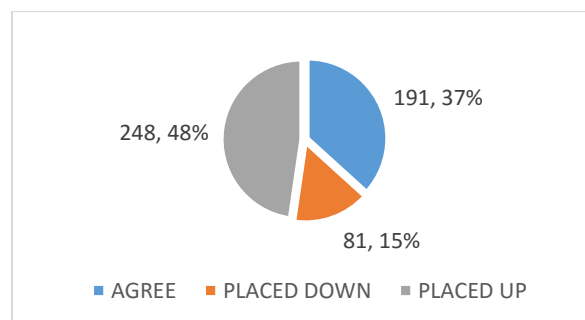


FIGURE 1
COMPARISON OF MATH PLACEMENT (ALEKS VS. MATH ACT) FOR FALL 2015 ENGINEERING STUDENTS (N=520)

A comparison of the number of fall 2015 ENG1101 students whose placement is the same or different using the two placement methods is shown in Table IV. There were 157 students whose ALEKS and Math ACT scores agreed ($n=56$ Calculus I, $n=101$ Calculus I+). A number of students that would have traditionally been placed in pre-calculus and ENG1001, were moved up to ENG1101 based on their ALEKS score. Of the 143 students that were moved up, 64 students were placed into Calculus I and 79 were placed into Calculus I+. There were 37 students who were placed down in math, but it did not affect their engineering placement.

TABLE IV
FALL 2015 ENG1101 COURSE GRADES FOR VARIOUS PLACEMENT GROUPS

Placement based on Math ACT	Placement based on ALEKS	Placement Comparison	N	Mean (Std. Dev.)	Median
Calc I ENG1101	Calc I ENG1101	Agree	56	3.31 (0.76)	3.5
Calc I+ ENG1101	Calc I ENG1101	Placed up in math, Agree in ENG	99	3.05 (0.60)	3.0
Pre-Calc ENG1001	Calc I ENG1101	Placed up in math and up in ENG	64	2.72* (0.83)	3.0
Calc I ENG1101	Calc I+ ENG1101	Placed down in math, Agree in ENG	37	3.04 (0.67)	3.0
Calc I+ ENG1101	Calc I+ ENG1101	Agree	101	2.91 (0.69)	3.0
Pre-Calc ENG1001	Calc I+ ENG1101	Placed up in math and up in ENG	79	2.55* (0.84)	3.0

* Differences are statistically significant.

A comparison of ENG1101 course grades for students in these different placement groups are also shown in Table IV. A one-way ANOVA with a Bonferroni Post-Hoc test was used to determine the effect of math placement group on ENG1101 course grade. Statistically significant differences were found between the groups. In comparison to the students placed into Calculus I by both math placement methods, there are two groups which have a statistically lower significant difference, 1) students who placed up to Calculus I from Pre-Calculus ($p=0.002$) and 2) students who placed up to Calculus I+ from Pre-Calculus ($p=0.000$). While those students that were placed into ENG1101 based on their ALEKS score who would have traditionally been placed into the Pre-Calculus path (ENG1001) had significantly lower average ENG1101 course grade, their medians were the same.

A comparison of the number of fall 2015 ENG1001 students and their course grades are shown in Table V for different placement groups. There were 26 students who would have traditionally been placed into Calculus I or Calculus I+ who were placed by ALEKS into Pre-Calculus and subsequently ENG1001. There were four students placed into Pre-Calculus from College Algebra and another 16 who were placed into College Algebra that were enrolled into ENG1001. While the students placed into College Algebra had a lower average course grade than those students that

were placed into Pre-Calculus by both math placement methods, their difference was not statistically significant.

TABLE V
ENG1001 COURSE GRADES FOR MATH PLACEMENT GROUPS

Placement based on Math ACT	Placement based on ALEKS	Placement Comparison	N	Mean (Std. Dev.)	Median
Calc I or Calc I+ ENG1101	Pre-Calc ENG1001	Placed down in math and down in ENG	26	2.58 (1.09)	3.0
Pre-Calc ENG1001	Pre-Calc ENG1001	Agree	32	2.50 (1.15)	2.5
College Algebra, No ENG 1 st yr	Pre-Calc ENG1001	Placed up in math and ENG	4	2.50 (0.58)	2.8
	College Algebra	Placed down in math	16	2.40 (1.39)	3.0

CONCLUSIONS AND FUTURE WORK

This study is the beginning of an investigation into whether two paths through the first-year engineering courses are needed, and if they are, what metric should be used for placement into the different paths. Initial results indicate:

1. There are statistically significant differences in ENG1101 course grades that are lower for students that traditionally would have been placed by Math ACT score into the Pre-Calculus engineering path, but were placed into the calculus-ready path by ALEKS.
2. There is no statistically significant difference in ENG1001 course grades for students that were placed into college algebra by ALEKS and allowed to take ENG1001 in fall 2015.

The impact of engineering placement on student performance, attitudes, and retention is complex. The students that began in ENG1101 or ENG1001 in fall 2015 will continue to be monitored longitudinally and their course grades will be compared when they are available for other common first- and some second-year courses. Metrics such as retention, academic performance, etc. will also be evaluated for use in analyzing these data.

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