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An Engineering Mathematics Course to Improve Success of Students in Algebra II

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Introduction

Since the number of incoming first-year students to our College who are placed into Algebra II by the ACT-MATH sub-score to begin their first semester is a significant portion of the first-year population, we implemented the CEAS-EXEP Cohort program in 2013 to improve their success. This paper will describe the details of the CEAS-EXEP Cohort program, an engineering mathematics course that supports Algebra II learning, as well as other strategies to successfully help more of the Algebra II students to begin Pre-Calculus in their first semester. The paper will also describe the preliminary results of the CEAS-EXEP Cohort program and the engineering math course, based on student performance in Algebra II and in Pre-Calculus, and retention to CEAS and to our university.

About Our University and Our College

Western Michigan University (WMU), located in Kalamazoo, MI was founded in 1903 as a normal school for teachers, and it is now a state-assisted university in the western part of the state. It is one of 139 public institutions of higher learning that are classified by The Carnegie Foundation for the Advancement for Teaching as “research universities.” Our institution is designated by the Consortium for Student Retention Data Exchange (CSRDE) at the University of Oklahoma[1] as “Moderately Selective” in its classification of four-year universities. The other categories in the classification are “Highly Selective,” “Selective,” and “Less Selective.” Total Fall 2015 enrollment at our institution consisted of 18,567 undergraduates and 4,989 graduate students. In 2013-14, a total of 3,823 bachelor’s, 1,313 master and 126 doctoral degrees were conferred by WMU.

The College of Engineering and Applied Sciences (CEAS) has nine EAC-ABET accredited engineering programs (aerospace, chemical, civil, computer, construction, electrical, industrial & entrepreneurial, mechanical, and paper), three ETAC-ABET accredited engineering technology programs (engineering design, engineering management, and manufacturing engineering) and a CAC-ABET accredited computer science program. Our graphics and printing science program is accredited by the Accreditation Council for Collegiate Graphic Communications (ACCGC). In addition, CEAS offers 11 master and six doctoral programs. Fall 2015 enrollment consists of 2,431 undergraduate, 450 master and 142 doctoral students. In 2013-14, CEAS awarded 312 bachelor, 125 master, and 8 doctoral degrees.

As a “Moderately Selective” institution, about 20-30% of the incoming first-year CEAS students for the past 10 years were placed into Algebra II or Algebra I during their first semester. Table 1 below shows the percent of the first-year CEAS students’ enrollment in mathematics courses in their first-semester at WMU from 2006 to 2015.

Table 1. Percent of First-Year CEAS Students and First-Semester Mathematics Enrollment from 2006 to 2015

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Calculus II or Higher	5.4	5.1	5.2	7.9	7.5	3.4	4.5	8.0	7.0	13.8
Calculus I	35.3	42.7	39.2	34.3	40.7	38.0	37.2	35.1	35.0	38.1
Pre-Calculus	31.0	31.1	29.8	27.9	25.2	34.0	31.7	33.4	31.9	27.5
Algebra II	17.7	13.7	18.9	22.0	19.1	16.8	24.2	20.8	25.6	19.7
Algebra I*	10.3	7.2	5.9	7.6	6.8	8.4	---	---	---	--
No Math Data	0.3	0.3	1.0	0.3	0.7	0	2.4	2.6	0.4	0.9

*Beginning in Fall 2012, students with ACT-MATH sub-score of 18 or less, are not admitted to a CEAS major and instead admitted into the university's Exploratory Advising program. Hence no data has been kept for 2012 and forward.

To better inform students of the academic pathways in engineering, engineering technology and applied sciences, the admissions requirement into CEAS was revised in Fall 2012. In CEAS Exploratory (CEAS-EXEP), students must achieve a grade of B or better in Algebra II in no more than two attempts before they can advance into Pre-Engineering, Pre-Engineering Technology, or Computer Science. The Pre-Engineering and Pre-Engineering Technology curricula consist of a set of courses normally taken by students during the first four semesters of the curricula. When students complete the pre-programs with a grade of C or higher in all the course work, they can apply and be admitted into the professional programs. There are currently no established enrollment limits for admission to CEAS professional programs.

This paper should be of interest to other engineering, engineering technology, and applied science programs with similar student demographics as WMU, because the engineering mathematics course, the CEAS-EXEP Cohorts program and other strategies can be implemented at relatively low cost to support the success of the Algebra II students.

A Different Approach to Enhance the Success of the Algebra II Students

Traditionally, students with ACT-MATH sub-score of 19 to 23 and who are placed into Algebra II in their first semester in college are considered to be under-prepared in science, technology, engineering and mathematics (STEM) studies, and their success as measured by second-year retention to STEM has been low. [In fall 2015, the ACT-MATH sub-score was revised to 20 to 24 for Algebra II.] Summer Bridge[2, 3, 4] and Peer[5, 6, 7] and Alumni Mentor[8] programs have been implemented by many engineering schools to support the success of this student population.

These support programs are often successful but have significant costs. A potential drawback of Summer Bridge could be the cost of the program, which might involve housing and meals for the participating students. The students might also lose an opportunity to earn incomes through summer jobs at their hometowns. A hurdle in scaling up Peer or Alumni Mentor is the intensive human resource costs of matching one-mentor-to-one-mentee. The intensive human resource costs could also be a hurdle in sustaining the program to broaden participation.

CEAS implemented a Summer Bridge day program in summers 2011 and 2012 with mixed results in student participation and in performance in a math placement examination at the conclusion of the 3-week, day program. Our findings showed that students and their parents viewed student's placement in Algebra II in the first-semester based on ACT-MATH sub-score unfavorably, because they expected to begin in either Calculus I or Pre-Calculus. Participation was low because students were reluctant to forego earning opportunities of a summer job in their hometowns. Finally, there was no significant difference in student performance in a math placement test conducted at the conclusion of the Summer Bridge day program, with about the same number of students who were promoted to Pre-Calculus as students who remained in Algebra II, and for those "bumped up" to Pre-Calculus, about equal success (grade ≥C) and failure in Pre-Calculus. Based on this formative assessment, we changed strategies in supporting the Algebra II student population.

Our CEAS-EXEP Cohort program is based on the highly successful CEAS-STEP (STEM Talent Expansion Program), which was implemented in 2005. Annually, the CEAS-STEP program involves approximately 350-400 first-time first-year students, who have diverse academic preparation backgrounds. In CEAS-STEP, students are placed in cohorts of ~24 during Summer Orientation in which they are enrolled in the same section of 3-to-5 courses in the Fall semester and the same 2-to-4 courses in the Spring semester. Progressing through the first-year of college as a cohort gives CEAS students an opportunity to build social and academic connections with each other, thus easing the transition from high school to college and helping students form study groups[9]. The STEP retention project has resulted in an increase in 2nd-year retention rate to CEAS from a baseline of 57.4% (averaged 2000-2004) to 67.6% (averaged 2005-2009), and 5-year graduation and 6-year continuation rate in CEAS from a baseline of 32.3% to 42.4%. Details on how the CEAS-STEP cohorts are constructed for first-year students can be found elsewhere[10, 11].

In Fall 2013, the CEAS-EXEP Cohort program was created. Students in CEAS-EXEP Cohort were enrolled in the same section of Algebra II, and a First-Year Experience (FYE 2100) seminar taught by a CEAS academic advisor. Depending on a student's intended CEAS major, a third course – Engineering Graphics – was added to the CEAS-EXEP Cohort schedule. In addition, students take a General Education course or two to meet full-time enrollment status (12 credit hours).

Beginning in Fall 2014, we added an engineering mathematics course to the CEAS-EXEP Cohort schedule, ENGR 1002, "Introduction to Engineering Analysis." ENGR 1002 is adopted from the National Model of Engineering Mathematics Education supported by the National Science Foundation[12] and focuses on engineering applications. ENGR 1002 is one credit hour, and together with FYE 2100 add to three (3) credit hours. The addition of ENGR 1002 to the CEAS-EXEP Cohort schedule was made with the recognition that it would not add to a student's tuition, because our institution has a flat tuition rate covering 12-15 credit hours (essentially four or five 3-credit-hour courses a semester).

Another enhancement to CEAS-EXEP Cohort in Fall 2014 was adding the textbook, *Studying Engineering: A Road Map to a Rewarding Career* by Raymond B. Landis[13], to give the student development aspect of FYE 2100 an engineering focus. We searched the internet for used copies of *Studying Engineering,* which can sometimes be obtained for much less than $10 (sometimes as low as $3 or $4), and provide the textbook free of charge to students in the CEAS-EXEP Cohort. We collect the textbooks at the end of the semester to use again the following year.

FYE 2100 is a university-wide transition course for first-year students that was begun in Fall 2005. It is listed in the university's undergraduate catalog as "a two-credit hour course [that] gives first-year students a shared opportunity to successfully make the academic and social transition to university life. Seminar activities and programs are designed to prepare students for their first year and beyond. Students receive instruction in the course from a faculty/staff member and an upper-level student instructor who both facilitate this unique university experience"[14].

Though an optional course, approximately 50% of first-year WMU students take either a general or themed FYE 2100. The "classic" sections and the "themed" sections of FYE 2100 all share a common syllabus and course objectives, including an introduction to college-level research, extra-curricular activities and assignments, and participation in the University Common Read project. WMU's FYE 2100 program is based on models of similar seminars at other comparable institutions[15]. The CEAS-EXEP Cohort population takes an engineering-theme section of FYE 2100 that is taught by a CEAS academic advisor. The advisors, together with current CEAS students who serve as student assistants (with preference given to those who successfully completed the CEAS-EXEP Cohort program themselves), mentor the students in CEAS-EXEP Cohort.

Details of FYE 2100 and ENGR 1002, which include learning objectives and course format, will be described in the following two sections. The phased-in implementation of ENGR 1002 allows us to better manage the CEAS-EXEP Cohort program, use formative assessment for continuous improvement, and discern the impact on student success and retention of the different aspects of CEAS-EXEP Cohort.

FYE 2100, First-Year Seminar

As noted previously, FYE 2100 is a course offered by the university to assist first-year students with the transition to college. Students in CEAS-EXEP Cohort are specifically registered for engineering-themed sections of FYE 2100. Each section meets twice per week for a total of 150 minutes. The goal of the FYE 2100 engineering sections is to provide support for students under-prepared in mathematics and currently enrolled in Algebra II. The course learning objectives are to help students develop life management skills, effective academic strategies, and understanding of STEM studies.

Life management skills are addressed in FYE 2100 to encourage students to recognize and develop mechanisms to effectively manage their college experience. Time management is the semester's first topic. Discussions and activities focus on use of a time management tool and understanding individual course expectations to prepare daily schedules that accommodate effective study time and healthy life practices. Students learn the concepts by using their current course syllabi and personal calendars. In mid-semester, diversity is discussed as a topic for personal challenge and growth. Diversity topics are led by trained campus facilitators, and they explore topics relevant to local and global issues.

Academic strategies are immersed throughout the semester. Early on, students take a personal assessment that identifies strengths and weaknesses related to academic skills. Students are encouraged to focus on strengthening the weak areas in order to be more effective when studying and in the classroom. Additionally, Saundra McGuire's Study Cycle[16] is discussed as a method by which students can be engaged in their learning process and seek continual improvement. Communication skills—written and oral—are also addressed during the semester via a research project and paper, and an oral presentation sharing research findings with the class. Throughout the semester, informal discussions are held regularly to discuss students' experiences in Algebra II and to highlight connections among coursework (particularly, Algebra II and ENGR 1002). Students share their successes and challenges, providing opportunities to encourage use of resources such as tutoring and study groups.

Throughout the semester, all topics are connected to STEM fields and the pursuit of a career in engineering, engineering technology and applied sciences. Near the beginning of the semester, students are introduced to CEAS student organizations and encouraged to become engaged in order to develop connections within the college and their chosen fields. Additionally, students are required to attend the engineering career fair and senior design presentation days held during the semester. These events allow CEAS-EXEP students to learn of the opportunities available in STEM fields.

ENGR 1002, Introduction to Engineering Analysis

ENGR 1002, "Introduction to Engineering Analysis," is a one-credit hour recitation course that meets once a week for 150 minutes. The goal of ENGR 1002 is to enhance students' Algebra II knowledge and skills so they will achieve a grade of B or better. The learning objectives of ENGR 1002 are: 1) Demonstrate how Algebra II is applied to solve a variety of engineering problems to connect mathematics to engineering practices in students' first semester; 2) Provide students with additional opportunities to practice algebraic operations and manipulations to gain mastery of Algebra II knowledge and skills, and develop academic habits crucial to student's future success; and 3) Help students develop the proper method, procedure, habit and mindset to apply mathematics to solve problems in engineering, engineering technology or applied sciences.

The engineering analysis course is conducted in a hybrid format in which students view video lectures and examples prior to class; take a quiz on the video lecture materials at the start of the class period; and spend the class period working problems under the guidance of the student assistants and the instructor when he is available. (The instructor is an associate dean and he has administrative duties that may prevent presence in every class period.) The topics of the course are organized according to how Algebra II is taught in a 14-week course at WMU, such that each week's ENGR 1002 topic is aligned with topics in Algebra II. The engineering topics in ENGR 1002 are by no means exhaustive, and they reflect the academic training of one of this paper's authors, which included a B.S. degree in mechanical engineering, a Ph.D. in metallurgy, and post-doctoral experience in solid state physics. Table 2 shows a week-by-week class schedule of ENGR 1002 and the engineering topics:

Table 2. A Weekly Class Schedule of ENGR 1002 and Engineering Topics

Week	Class Schedule	Engineering Topics	Comments
Week 1	Course Overview and Units	Engineering units and unit Conversion	Address a common student mistake: $(ab)^x \neq ab^x$ or a^xb but $= a^xb^x$
Week 2	Algebraic Expression	Definition and algebraic expressions for Density, Avagadro's Number, Atomic Weight, Number of Moles, Mass Fraction, Volume Fraction and Molar Fraction	Practice algebraic manipulations of the form a = b/c and a = (b/c)/(d/e)
Week 3	Algebraic Relations	The functional relations between mass fraction, volume fraction and molar fraction	Learn to derive the algebraic equations relating mass fraction to volume fraction, and vice versa, etc.
Week 4	Review and Hour Exam 1	Review engineering topics in Weeks 1-3	First 90 minutes on review and the last 60 minutes on Hour Exam 1
Week 5	Algebraic Function	Linear coefficient of thermal expansion	Inputs versus outputs; independent variable versus dependable variable; continue to practice algebraic operations and manipulations
Week 6	Algebraic Function	Ohm's law and Hooke's Law; parallel and series arrangement of resistors or mechanical springs	Same as Week 5
Week 7	Review and Hour Exam 2	Review engineering topics in Weeks 5-6	First 90 minutes on review and the last 60 minutes on Hour Exam 2
Week 8	Equation of a Straight Line	Linear interpolation and linear extrapolation; superheated steam table	Practice algebraic manipulation involving an equation of a straight line; slope and intercept
Week 9	Equation of a Straight Line	Position, speed, and acceleration of a particle	Rate of change; slope and intercept of a straight line
Week 10	Quadratic Equation	Projectiles	Practice solutions to quadratic equations; interpret solutions with negative values
Week 11	Review and Hour Exam 3	Review engineering topics in Weeks 8-10	First 90 minutes on review and the last 60 minutes on Hour Exam 3
Week 12	Exponential and	PV^n = constant; pressure and	Practice exponential and

	Logarithm Functions	volume properties of a gas in an internal combustion engine; present and future value of money	logarithm functions and how to make an exponential equation into an equation of a straight line
Week 13	Natural Exponential and Logarithm Functions	Diffusion coefficients	Practice natural exponential and logarithm functions and how to make a natural exponential equation into an equation of a straight line
Week 14	Review of Final Exam		

The video lectures, which are 10-to-15 minutes long, are created using Microsoft Office PowerPoint and TechSmith/Camtasia Relay. Videos of problem solving and engineering examples, which are 5-to-10 minutes each, are created using an Intuit tablet and SmoothDraw, and TechSmith/Camtasia Relay, and model how the instructor approaches the problem in a thinking-out-loud manner. A similar approach is used to create videos for solutions to homework problems and hour examinations. Just-in-time supplemental videos are similarly created to address student questions. The videos, together with course notes and homework assignments, are posted online on the university *eLearning* platform. Thus, they are accessible to students 24/7 and for multiple viewings. The course does not require a textbook. In Fall 2015, Microsoft One Note replaced SmoothDraw in creating the videos of engineering problem-solving.

Preliminary Results and Discussions

Since the admissions revision began in Fall 2012 and the implementation of CEAS-EXEP cohorts began in Fall 2013 and ENGR 1002 in Fall 2014, we can treat the Fall 2012 group as the baseline. The preliminary results of the CEAS-EXEP Cohort as evidenced in performance in Algebra II and in Pre-Calculus the semester following Algebra II, and retention to CEAS and to WMU, are presented in the figures and tables below.

Figure 1 below shows the number of CEAS-EXEP Cohort students from 2012 to 2015 and their mean ACT-MATH sub-scores. The numbers above the bars are number of CEAS-EXEP Cohort students.

As shown in Figure 1, there were 62 total students in the Fall 2012 baseline group; 79 students in the Fall 2013 CEAS-EXEP Cohort; 90 in the Fall 2014 Cohort; and 82 in the Fall 2015 Cohort. Based on the average ACT-MATH sub-scores and the standard deviations, there is no difference in math preparation between the baseline and the CEAS-EXEP Cohort.

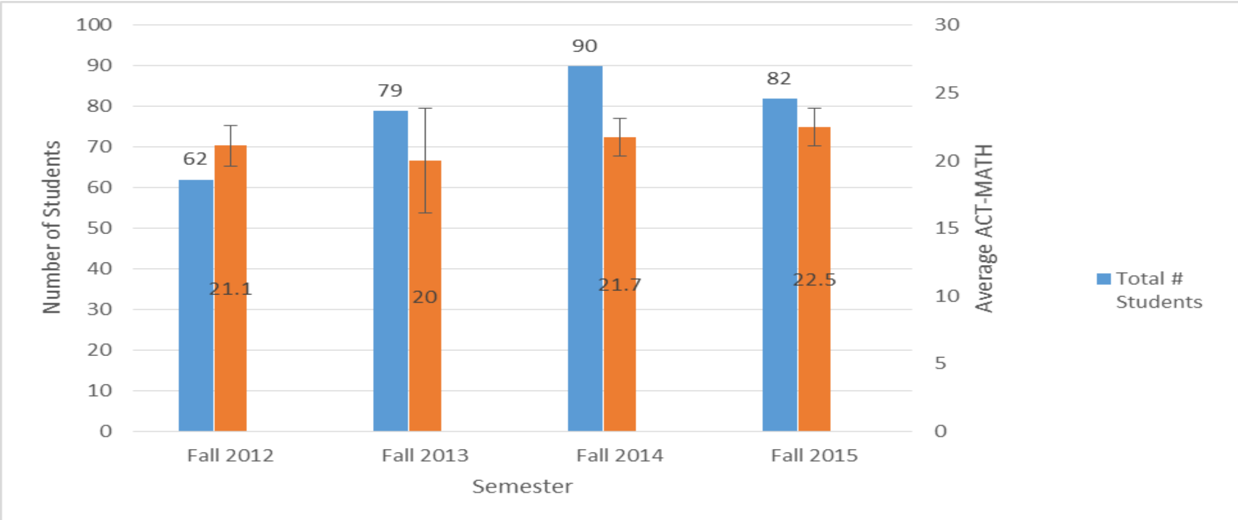

Figure 1. Number of CEAS-EXEP Students and the Mean ACT=MATH Sub-Scores

Figure 2 below shows the percent of CEAS-EXEP students who achieved a grade of B or better in Algebra II in their first attempt and two combined attempts. The numbers above the bars represent the number of CEAS-EXEP Cohort students.

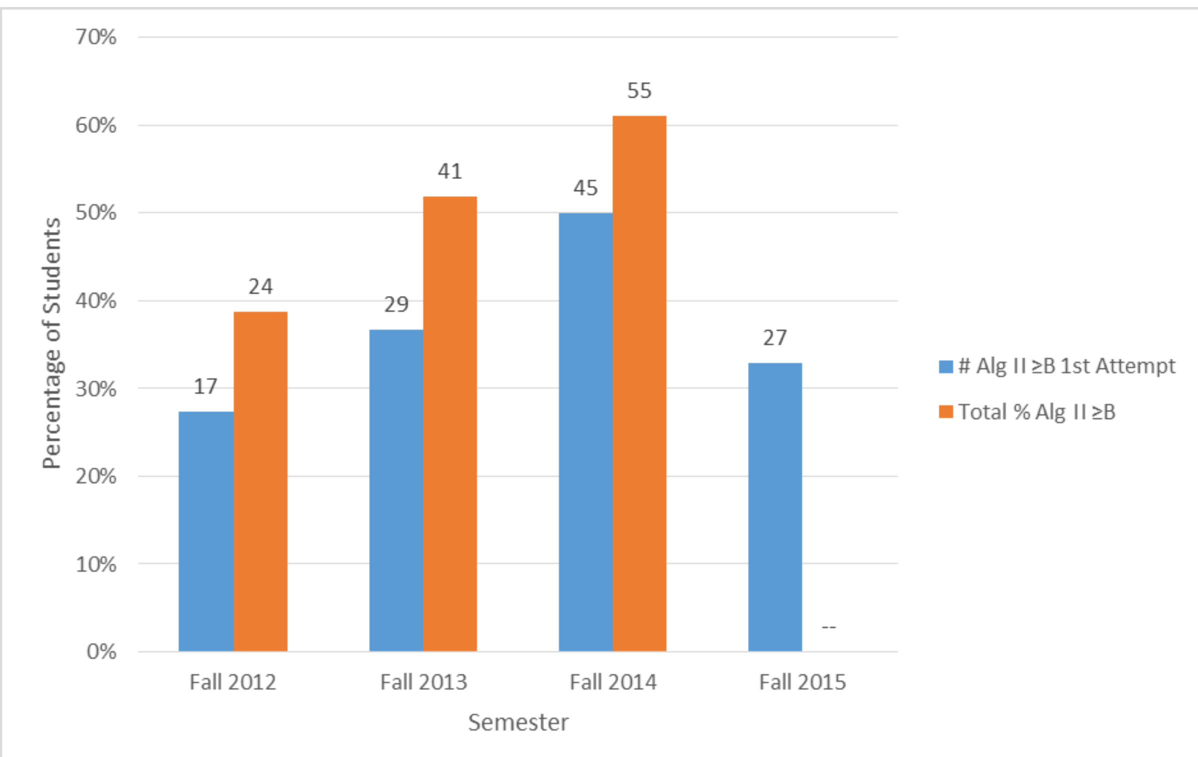

Figure 2. Percent of CEAS-EXEP Students with Grades ≥B in Algebra II

As shown in Figure 2, 27.4% of students (17 students) in the 2012 baseline group passed Algebra II with a grade ≥B in their first attempt, and 38.7% of students (24 students) passed Algebra II with a grade ≥B in two attempts. For the 2013 CEAS-EXEP Cohort, 36.7% (29 students) passed

Algebra II with a grade ≥B in their first attempt, and 51.9% of students (41 students) passed Algebra II with a grade ≥B in two attempts. For the 2014 CEAS-EXEP Cohort, 50.0% (45 students) passed Algebra II with a grade ≥B in their first attempt, and 61.1% of students (55 students) passed Algebra II with a grade ≥B in two attempts. For the 2015 CEAS-EXEP Cohort, 32.9% of the students (27 students) passed Algebra II with a grade ≥B in their first attempt. We will present the results of two-attempts of the Fall 2015 Cohort at the ASEE conference.

We test the difference in performance of the 2013-2015 Cohorts *versus* the baseline in Algebra II as measured by the percent of students with a grade ≥B, by carrying out chi-square test with one-way classification. The results are summarized in Table 3 below.

Table 3. Chi-Square Test of CEAS-EXEP Cohorts versus Baseline in Performance in Algebra II

Fall 2012 (baseline)		Fall 2013			Fall 2012 (baseline)	Fall 2013	
Total # Students	#≥B, 1st Attempt	Total # Students	#≥B, 1st Attempt	α value	#≥B, 1st+2nd Attempts	≥B, 1st + 2nd Attempts	α value
62	17 (27.4%)	79	29 (36.7%)	0.07	24 (38.7%)	41 (51.9%)	≤0.05
Fall 2012 (baseline)		Fall 2014			Fall 2012 (baseline)	Fall 2014	
Total # Students	#≥B, 1st Attempt	Total # Students	#≥B, 1st Attempt	α value	#≥B, 1st + 2nd Attempts	≥B, 1st + 2nd Attempts	α value
62	17 (27.4%)	90	45 (50.0%)	≤0.05	24 (38.7%)	55 (61.1%)	≤0.05
Fall 2012 (baseline)		Fall 2015					
Total # Students	#≥B, 1st Attempt	Total # Students	#≥B, 1st Attempt	α value			
62	17 (27.4%)	82	27 (32.9%)	0.11			

As shown in Table 3, the difference in performance in Algebra II between the CEAS-EXEP cohorts and the baseline as measured by a grade ≥ B is statistically significant with a confidence level of 95% for the Fall 2014 Cohort in both one or two attempts. For the Fall 2013 CEAS-EXEP Cohort compared to the baseline group, the two-attempts result is statistically significant but not the one-attempt. For the Fall 2015 CEAS-EXEP Cohort compared to baseline group, the results are not statistically significant for first attempt of Algebra II. We will include the results for two attempts at the ASEE annual conference.

We now compare the CEAS-EXEP Cohort students with a comparison group consisting of all other students taking Algebra II in the same semester. Figure 3 below shows the performance in Algebra II of CEAS-EXEP Cohort with a comparison group of students taking Algebra II in the same semester as measured by the percent of students with a grade ≥B (number above the bars represent the number of students):

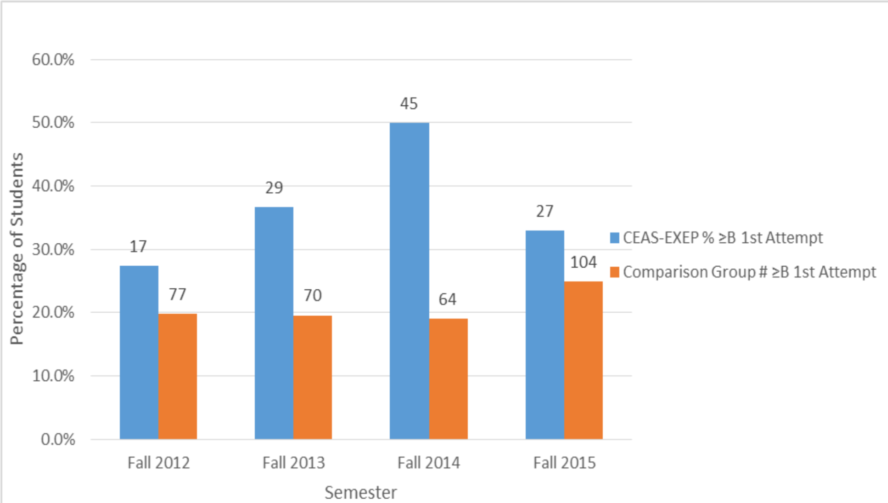

Figure 3. Percent (and Number) of CEAS-EXEP Cohort Students with Grade ≥B in Algebra II and Comparison Group

Figure 3 shows 27.4% of the 2012 baseline (17 students) passed Algebra II with a grade ≥B, compared to 19.8% of a comparison group of 389 students (77 students) who took Algebra II at the same semester. For Fall 2013, 36.7% of the CEAS-EXEP Cohort students (29 students) passed Algebra II with a grade ≥B, compared to 19.6% of a comparison group of 357 students (70 students). For Fall 2014, 50.0% of the CEAS-EXEP Cohort students (45 students) passed Algebra II with a grade ≥B, compared to 19.0% of a comparison group of 337 students (64 students). For Fall 2015, 32.9% of the CEAS-EXEP Cohort (27 students) passed Algebra II with a grade ≥B, compared to 24.9% of a comparison group of 417 students (104 students).

We test for the statistical significance in the difference in performance in Algebra II as measured by the percent of students with a grade ≥B between the CEAS-EXEP Cohort and a comparison group of other students taking Algebra II in the same semester, and the results are summarized in Table 4 below. The difference is statistically significant at confidence level ≥95% for the 2013 and 2014 cohorts but not for the baseline group and the 2015 EXEP cohort.

Table 4. Performance in Algebra II of CEAS-EXEP and Comparison Group

Semester	Total # CEAS-EXEP Students	# ≥B 1st Attempt	Total # Comparison	# ≥B	α value
Fall 2012	62	17 (27.4%)	389	77 (19.8%)	0.50
Fall 2013	79	29 (36.7%)	357	70 (19.6%)	<0.05
Fall 2014	90	45 (50.0%)	337	64 (19.0%)	<0.05
Fall 2015	82	27 (32.9%)	417	104 (24.9%)	0.35

Figure 4 below shows the performance of the EXEP cohorts in Pre-Calculus as measured by percent with grade ≥C as well as 2nd-year retention to CEAS and to WMU of the baseline group and the 2013 and 2014 cohorts.

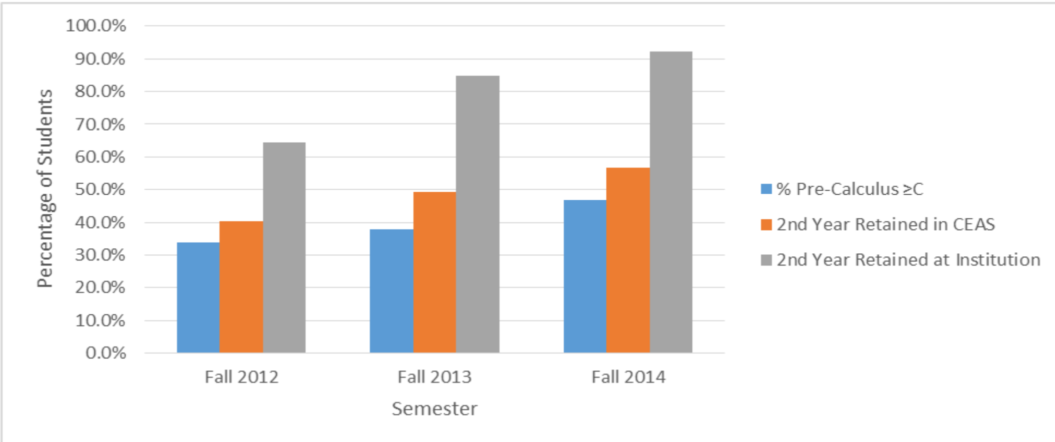

Figure 4. Percent of CEAS-EXEP Students in Pre-Calculus with Grade ≥C and 2nd Year Retention to CEAS and WMU

We performed chi-square test with one-way classification to compare the Fall 2013 and Fall 2014 CEAS-EXEP Cohort against the baseline group in performance in Pre-Calculus, and the results are summarized in Table 5 below.

Table 5. Chi-Square Test with One-Way Classification for CEAS-EXEP Cohort *versus* Baseline for Performance in Pre-Calculus

Fall 2012 (baseline)		Fall 2013		
Total # EXEP Students	# ≥ C	Total # EXEP Students	# ≥ C	α value
62	21 (33.9%)	79	30 (38.0%)	0.24
Fall 2012 (baseline)		Fall 2014		
Total # EXEP Students	# ≥ C	Total # EXEP Students	# ≥ C	α value
62	21 (33.9%)	90	42 (46.7%)	≤0.05

As shown in Table 5 above, the difference in performance in Pre-Calculus between the Fall 2014 CEAS-EXEP Cohort and the baseline is statistically significant at a confidence level greater than 95%, while the difference between the Fall 2013 cohort and the baseline is not.

We compare the results of CEAS-EXEP Cohort students in Pre-Calculus as measured by percent of students with a grade ≥C, with a comparison group of other students taking Pre-Calculus in the same semester. The comparisons are summarized in Figure 5 below, in which the number above the bars represent number of students with a grade ≥C:

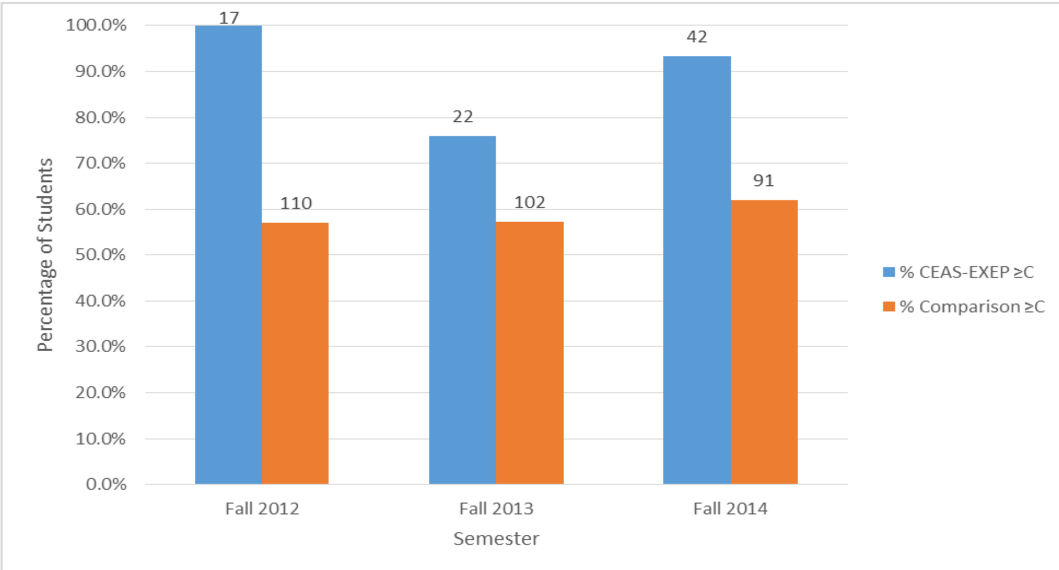

Figure 5. Percent of Students with Grade ≥C in Pre-Calculus

Figure 5 shows 100% of the 2012 baseline group passed Pre-Calculus with a grade ≥C, compared to 57.0% of a comparison group of 193 total students (110 students) taking Pre-Calculus in the same semester. For Fall 2013, 75.9% of the CEAS-EXEP Cohort (22 students) passed Pre-Calculus with a grade ≥C, compared to 57.3% of a comparison group of 178 students (102 students) taking Pre-Calculus in the same semester. For Fall 2014, 93.3% of the CEAS-EXEP Cohort (42 students) passed Pre-Calculus with a grade ≥C, compared to 61.9% of a comparison group of 147 students (91 students) taking Pre-Calculus in the same semester.

We performed chi-square test with one-way classification to test the observed difference between the baseline and CEAS-EXEP Cohort with a comparison group of all other students taking Pre-Calculus in the same semester. The results are summarized in Table 6 below:

Table 6. Performance in Pre-Calculus (the Following Spring Semester) of CEAS-EXEP and Comparison Group, and Alpha Value

Semester	Total # CEAS-EXEP in Pre-Calculus	# ≥C	Total # Comparison in Pre-Calculus	# ≥C	α value
Fall 2012	17	17 (100%)	193	110 (57.0%)	≤0.05
Fall 2013	29	22 (75.9%)	178	102 (57.3%)	0.20
Fall 2014	45	42 (93.3%)	147	91 (61.9%)	≤0.05

As shown in Table 6, the difference in the performance in Pre-Calculus between the CEAS-EXEP Cohort students and a comparison group as measured by a grade ≥C are statistically significant at a confidence level ≥95% for Fall 2012 and Fall 2014 but not Fall 2013.

We next test the statistical significance of the difference in retention to CEAS and to WMU of the CEAS-EXEP Cohort against the baseline. The results are summarized in Tables 7 and 8 below.

Table 7. Chi-Square Test of CEAS-EXEP Retention to CEAS *versus* Baseline

Fall 2012		Fall 2013		
Total # EXEP	2^{nd} Year Return to CEAS	Total # EXEP	2^{nd} Year Return to CEAS	α value
62	25 (40.3%)	79	39 (49.4%)	0.06
Fall 2012		Fall 2014		
Total # EXEP	2^{nd} Year Return to CEAS	Total # EXEP	2^{nd} Year Return to CEAS	α value
62	25 (40.3%)	90	51 (56.6%)	$\leq$0.05

Table 8. Chi-Square Test of CEAS-EXEP Retention to WMU versus Baseline

Fall 2012		Fall 2013		
Total # EXEP	2^{nd} Year Return to Institution	Total # EXEP	2^{nd} Year Return to Institution	α value
62	40 (64.5%)	79	67 (84.8%)	$\leq$0.05
Fall 2012		Fall 2014		
Total # EXEP	2^{nd} Year Return to Institution	Total # EXEP	2^{nd} Year Return to Institution	α value
62	40 (64.5%)	90	83 (92.2%)	$\leq$0.05

Tables 7 shows the difference in the retention rate to CEAS of the 2014 CEAS-EXEP Cohort versus the baseline is statistically significant at a confidence level ≥95%, but it is not for the 2013 CEAS-EXEP Cohort. The difference in retention to WMU between the 2013 and 2014 CEAS-EXEP Cohort and the baseline are statistically significant at a confidence level ≥95%.

Next, we delved into the population of CEAS-EXEP students who completed (total enrollment minus those who withdrew from course) and who passed ENGR 1002 (grade ≥C), and examine their performance in Algebra II. Figure 6 shows the percent of students who completed ENGR 1002 and their performance in Algebra II.

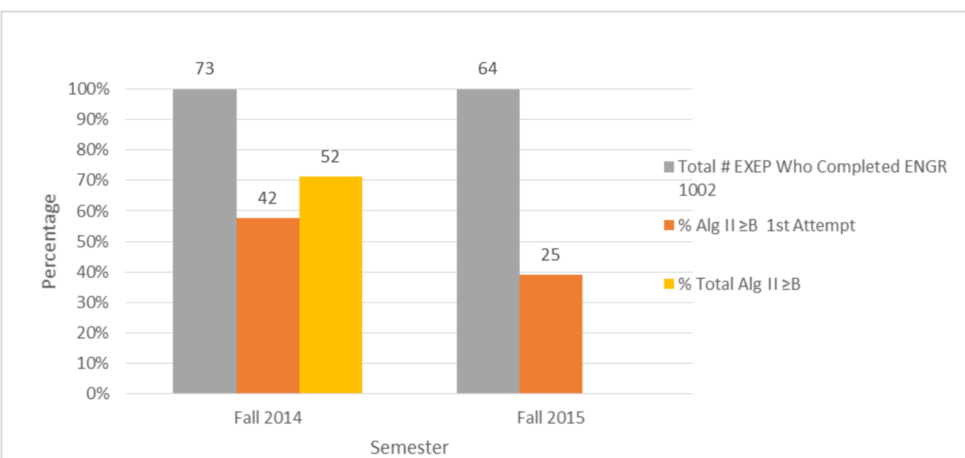

Figure 6. Percent of Students Who Completed ENGR 1002 and Their Performance in Algebra II

Since ENGR 1002 was implemented in Fall 2014, we compare the performance in Algebra II of students in the 2014 CEAS-EXEP Cohort who completed ENGR 1002 with the Fall 2013 CEAS-EXEP Cohort, which did not include ENGR 1002. This comparison is summarized in Table 9 below:

Table 9. Chi Squared Test of CEAS-EXEP Who Completed ENGR 1002 *versus* Comparison Group without ENGR 1002, in Algebra II

Fall 2013		Fall 2014			Fall 2013	Fall 2014	
Total # CEAS-EXEP Students	# Alg II ≥B, 1st attempt	Total # Students Who Completed ENGR 1002	# Alg II ≥B 1st Attempt	Alpha Value	# Alg II ≥B, 1st + 2nd attempts	#Alg II ≥B 1st + 2nd attempts	Alpha Value
79	29 (36.7%)	73	42(57.5%)	≤0.05	41 (51.9%)	52 (71.2%)	0.09
Fall 2013		Fall 2015			Fall 2013	Fall 2015	
Total # Students	# Alg II ≥B, 1st attempt	Total # Students Who Completed ENGR 1002	# Alg II ≥B 1st Attempt	Alpha Value	# Alg II ≥B, 1st + 2nd attempts	Total # Alg II ≥B With ENGR 1002	Alpha Value
79	29 (36.7%)	64	25(39.1%)	0.57	--	--	--

Based on Table 9, only the difference in performance in first attempt of Algebra II of the Fall 2014 CEAS-EXEP cohort is statistically significant with a confidence level of ≥95. All other differences are not statistically significant.

Finally, we compare the performance in Algebra II of those students in the 2014 and 2015 CEAS-EXEP Cohort who passed ENGR 1002 to the Fall 2013 CEAS-EXEP Cohort which did not include ENGR 1002. The comparison is shown in Figure 7, which shows the percent of students who passed ENGR 1002 and who received a grade in Algebra II ≥B.
≥

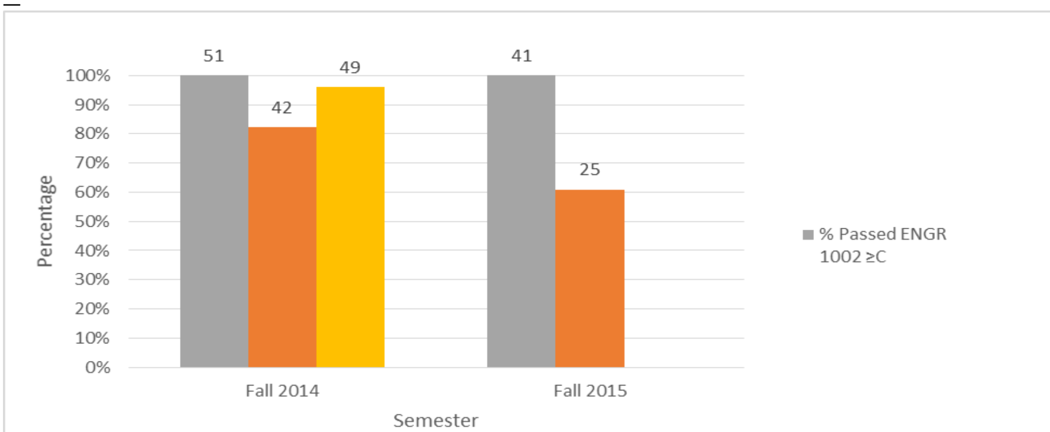

Figure 7. Percent of Students Who Passed ENGR 1002 and Who Passed Algebra II with Grade ≥B

We test the difference in performance in Algebra II between the 2012 baseline group with those in CEAS-EXEP Cohort who passed ENGR 1002 by carrying out chi square test with on way classification. Table 10 summarizes the results:

Table 10. Chi Squared Test of CEAS-EXEP Who Passed ENGR 1002 with Comparison Group

Fall 2013		Fall 2014			Fall 2013	Fall 2014	
Total # Students	# Alg II ≥B, 1st attempt	Total # Students Passed ENGR 1002 (≥C)	# Alg II ≥B 1st Attempt	Alpha Value	# Alg II ≥B, 1st + 2nd attempts	Total # Alg II ≥B With ENGR 1002	Alpha Value
79	29 (36.7%)	51	42 (82.4%)	≤0.05	41 (51.9%)	49 (96.1%)	0≤0.05
Fall 2013		Fall 2015			Fall 2013	Fall 2015	
Total # Students	# Alg II ≥B, 1st attempt	Total # Students Passed ENGR 1002 (≥C)	# Alg II ≥B 1st Attempt	Alpha Value	# Alg II ≥B, 1st + 2nd attempts	Total # Alg II ≥B With ENGR 1002	Alpha Value
79	29 (36.7%)	41	25 (61.0%)	≤0.05		-	

Based on Table 10, the differences in performance in passing Algebra II with a grade ≥B between the 2014 and 2015 CEAS-EXEP Cohorts of students who passed ENGR 1002, from the 2013 EXEP Cohorts, are statistically significant at ≥95 confidence level.

Other Strategies to Support Success of the CEAS-EXEP Student Population

In the current economic conditions where cost of higher education is increasing and student college debt is a national concern, we are sensitive to the need for incoming students to earn an income through summer jobs. Therefore, we implemented another strategy to get more students who are placed into Algebra II based on ACT-MATH sub-score, to begin in Pre-Calculus in Fall semester. The strategy is described in a letter to the student's parent or guardian, who most likely is helping with the tuition costs. In the letter, which is sent in mid-February, the importance of mathematics in studying engineering, engineering technology or the applied sciences and the need for students to get a grade of B or higher in Algebra II in no more than two attempts are emphasized. Then the letter identifies a community college near the student's hometown, and the name and course number of an Algebra II course that will transfer to our institution. Also included in the letter is the last day to register for the course at the community college.

In 2014, such a letter was sent in February to the parents of 302 admitted students who were placed in Algebra II. Of the total contacted, 217 did not attend our institution in Fall semester. Of those who attended our institution, 25 completed an Algebra II course at a community college with a grade of B or higher and they were therefore "bumped" to Pre-Calculus in Fall semester. Also in 2014, we found 69 enrolled students who either did not take an Algebra II course at a community college or did not pass with a grade of B or higher. This is correlated to 29.4% of incoming students who were placed by ACT-MATH sub-score into Algebra II, but now moved to Pre-Calculus as their first-semester math course. [The actual enrollment of the Algebra II was higher because there were other students admitted after February and therefore were not contacted. We pick the February date to send the letter to allow students sufficient time to better make plan for their summer and to register in time for the Algebra II course at a community college.]

In 2015, such a letter was sent to the parents of 400 admitted students that were placed in Algebra II. Of the total contacted, 333 did not attend our institution in Fall semester. Of those who attended our institution, 20 were “bumped” into Pre-Calculus in Fall semester because they passed Algebra II at a community college with a grade of B or higher. There were 47 enrolled students who either did not take an Algebra II course at a community college or passed with a grade of B or higher. This is correlated to 29.9% of incoming students who were placed by ACT-MATH sub-score into Algebra II, but now moved to Pre-Calculus as their first-semester math course.

We feel the success rates of 29.4% for 2014 and 29.9% for 2015 demonstrate that sending a letter to parents or guardians is a cost effective strategy in getting more students who are placed into Algebra II by ACT-MATH sub-scores, to begin Pre-Calculus in Fall semester.

Another strategy to support the success of the CEAS-EXEP students was implemented in 2013. The CEAS Dean's Office instituted a $1,000 scholarship for CEAS-EXEP students who met the following criteria: (1) passed Algebra II with a B or better on their first attempt; (2) passed Pre-Calculus the following semester with a CB or better on their first attempt; and (3) enrolled in Calculus I and other engineering classes related to their major to start their second year. There is no application/essay required, and the $1,000 is remitted directly into the student's account after census is taken in the Fall semester of their second year. This money effectively covers the tuition dollars spent on the Algebra II course. All students who earned a B or better in Algebra II are invited to a celebration banquet at the start of their second semester, attended by Dean's Office staff and academic advising staff. At this dinner, students are reminded of the scholarship criteria. The event is also utilized as an open forum and feedback session for students to share best practices learned over their first semester, including study habits and test taking skills. Anecdotal evidence suggests that these students, who share a spring learning community set of classes that includes the same section of Pre-Calculus, form study groups as a direct result of the celebration banquet.

Future Work

Since the CEAS-EXEP Cohort program, ENGR 1002, and the FYE 2100 supplemental textbook *Studying Engineering* are relatively recent initiatives, we will continue to collect student performance and retention data. We will survey the parents of students who took Algebra II at a community college on the impact of the letter that we sent to them. Another future work involves a more formal assessment of the $1,000 scholarships, including a projection of the costs required to sustain the scholarship program.

In Fall 2015, our institution discontinued funding the themed sections of FYE 2100 due to budget constraints. The CEAS Dean has indicated support of the engineering-specific FYE 2100 by funding it with Differential Tuition beginning in Fall 2016. Therefore, a future work in FYE

2100 will be a review to make more use of *Study Engineering* in the student development aspects of the first-year seminar.

Conclusions and Lessons Learned

In Fall 2013, we implemented the CEAS-EXEP Cohort program to support the Algebra II students as a result of revision to admissions to our College implemented in Fall 2012. In Fall 2014, we phased in ENGR 1002, an engineering math course focused on engineering applications. Based on the results so far, the following findings are statistically significant at ≥95% confidence level:

- Students who passed ENGR 1002 with a grade ≥C have a higher chance of passing Algebra II with a grade ≥B
- The EXEP Cohorts program has resulted in improving 2nd-year retention to WMU because one of the goals of FYE 2100 is to help students find a major within WMU that they can be successful.

However, the impacts of the engineering math course (ENGR 1002) and of the CEAS-EXEP Cohorts programs on performance in Algebra II and in Pre-Calculus, and on the retention to CEAS are mixed, with some of the observed difference statistically significant and some not significant.

We feel the strategy of sending a letter to parents and directing their students to take Algebra II at a community college to be cost effective and mentally satisfying to students, in moving more students from Algebra II to Pre-Calculus as the first semester math course.

While some of the results of CEAS-EXEP Cohort and ENGR 1002 are mixed from a statistical standpoint, there are many important lessons learned, including

1. Creating the online video lectures, problem solving, and solutions to homework and hour exam are relatively effortless using TechSmith and an Intuit tablet;
2. We learned student attendance in the Friday afternoon section of ENGR 1002 was lower than another section held on a weekday. Consequently, we plan to move the Friday section of ENGR 1002 to a weekday beginning Fall 2016.
3. CEAS will be funding the engineering-specific section of FYE 2100 beginning 2016, thus allowing us more flexibility with its content. This provides an opportunity to incorporate more materials from the textbook, *Studying Engineering* by Raymond Landis, to give the student development aspects of the first-year seminar an engineering focus.

Finally, the CEAS-EXEP Cohort program and the engineering math course are relatively inexpensive to implement, and they could be used to support the Algebra II students alongside with or even in place of Summer Bridge, Peer Mentor or Alumni Mentor programs.

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