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Impact of Initiatives for Helping First Year Students Start on Track in Mathematics Sequence

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Impact of Initiatives for Helping First Year Students Start on Track in Mathematics Sequence

Abstract

This is an evidence-based practice paper. New Jersey Institute of Technology, located in Newark, NJ, administers mathematics placement test to all incoming first time full-time first year students, except those with proof of advanced placement or transfer credits for calculus courses. Performance on this placement test determines students' starting point in the calculus sequence. Students will either be placed in Calculus-I, which is the preferred scenario, or one of the two pre-calculus courses. Students that are placed in pre-calculus courses start 1-2 courses behind as compared to those placed in Calculus-I. In addition, performance in the mathematics placement test also drives placement in physics and chemistry. All this put together means that students that do not do well on the mathematics placement test are looking at 1-2 added semester(s) to their graduation, at the least. As a common practice across most colleges and universities in the United States, mathematics and science courses serve as pre-requisites or co-requisites to most core engineering courses. This makes things even more difficult for some students placed in pre-calculus courses who may run out of course options if they do not make quick progress in their mathematics sequence. Understandably, this not only hurts students' motivation to continue but also their retention and graduation rates. Acknowledging the seriousness of this issue, our college started a series of programs and initiatives to help students start on track in mathematics sequence and/or to make quick progress in it. This paper presents an overview of three main initiatives: strong student outreach, engineering mathematics summer boot camp and practice placement tests with placement calculator to determine mathematics placement based on placement test scores. Although the practice placement test and placement calculator initiatives were first implemented only in 2017, the engineering mathematics summer boot camp has been continuously offered since summer of 2015. This paper presents data collected on student performance and through various surveys. It also presents results of data analysis and short-term and long-term impact of these initiatives.

Introduction

As a standard practice in many four-year colleges, new incoming first-year students are required to take a mathematics placement test before their orientation. The result of the placement test indicates a student's background and competency in various mathematics topics and determines the level of mathematics (calculus I or pre-calculus courses) the student will begin in his/her first semester. For students in the Newark College of Engineering (NCE) at NJIT, this is particularly crucial; as this math sequence is a prerequisite to courses in engineering topics. Any delay in the completion of the math sequence would have drastic impact on the student's overall time to graduate. Figure 1 shows the additional pre-calculus courses needed for NCE and other students

who do not start at the recommended starting point. Table 1 further highlights how the good or bad performance on the Mathematics Placement Test, impacts Science-Technology-Engineering-Mathematics (STEM) track students. Most of the incoming NCE students fall under the STEM track (only exceptions are a select few majors within the engineering technology department that follow the general sequence). Students who are placed in MATH108 may take up to a year or even more before they can take core courses in their major or any other engineering courses.

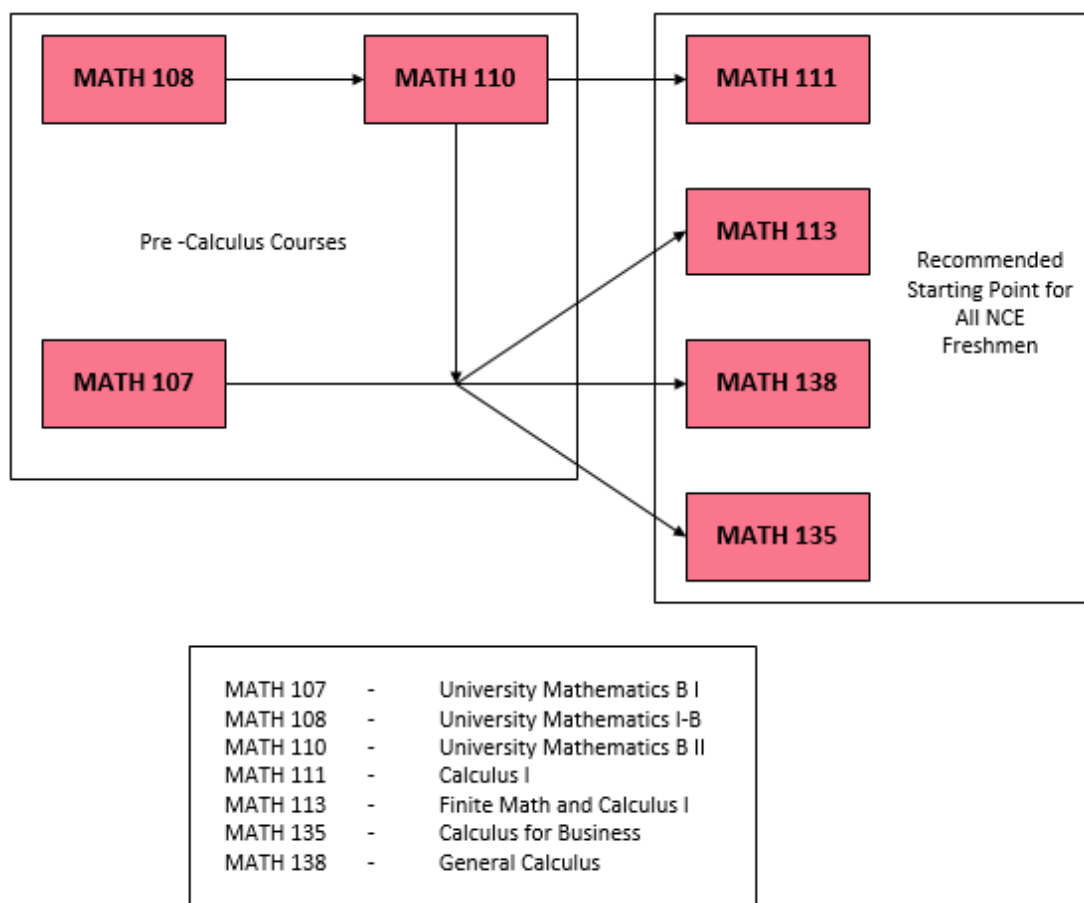


Figure 1: Pre-calculus Course Sequence

Table 1: Impact of Performance in the Mathematics Placement Test for STEM Track Students

2 semesters behind	1 semester behind	On track	1 semester ahead (AP Credits)
MATH-108	MATH-110	MATH-111	MATH-112

A thorough analysis of placement test results, and results of retakes was performed. Table 2 shows the placement numbers from 2015 until 2017. Please note that SAT average score for the incoming student population rose every year since 2015. Up until 2015, for every student placed

in MATH111 there was at least one student that got placed in one of the two pre-calculus courses (MATH108 and MATH110). This meant that about half of the students entering NCE were starting at least a course behind in the math sequence. This was clearly an alarming statistic and most likely has the strongest impact on the four and six-year graduation rates within NCE.

Table 2: Students Placed in Various Mathematics Courses from 2015-2017

Year	Mathematics Placement		
	MATH108	MATH110	MATH111
2015	203	171	232
2016	113	130	269
2017	91	102	279

The placement test is often harder than expected for many students because they did not take time to visit the placement-testing website for additional information and did not prepare seriously, thinking that the test would be similar to ones they have taken in their high schools. For starters, calculators are not allowed during the placement test. Secondly, students often did not read their emails fully and did not take advantage of practice questions and other material. Students are allowed one retake attempt of the placement test if they are not satisfied with their performance on the first attempt. They must wait at least two weeks after their first attempt before then can take test for the second time. A look at the retake performance indicated that, about 1/3 of the students retaking the placement test performed better in their second attempt.

As an aid to preparation for the test, our university has been offering pre-calculus courses and supplemental instruction as part of summer boot camp, since Summer 2015. However, several students are not able to take advantage of such boot camps due to financial or personal reasons. One common reason is that, after high school, many students also feel that they are on their last summer break before they enter college and ‘hard-work’ phase of their lives. The outcomes of this pilot offering and its subsequent updates were presented at the First Year Engineering Education conferences [1-2]. In order to take maximum advantage of the students spending six summer weeks at the university before their first semester, along with the mathematics courses offered, the boot camp also offered interesting activities to get students motivated towards pursuing engineering as well other academic support activities [1-2]. Some activities were designed to get students adjusted to the college environment and spread awareness about academic support that is available to them as well as help with time management, learning style, self-advocacy among other things [1-2]. Educational researchers have looked at ‘Bridge to Success’ programs and shown their importance in preparing students for the academic rigors of college [3-4]. Many universities have reported successful implementation of summer boot camps [3-5] and studies [6-12] have shown positive impact on student retention and persistence.

In an effort to help students improve their performance in placement test, the Office of the Dean of NCE developed several initiatives. These initiatives include 1) establishing a strong and precise outreach to educate students about the benefits and impact of mathematics placement test on their engineering curriculum and motivating them to do better in the placement test or to take action to catch up during summer, 2) developing sample placement tests for students to practice under the same environment as the original test, 3) making a placement calculator for students to input the scores from the practice placement tests to determine their likely mathematics placement, and 4) engineering mathematics summer boot camp. This paper presents the outcomes of first three of these initiatives and an analysis of engineering mathematics summer boot camp performance for the past three years. Together, these initiatives have addressed some of the major reasons for poor performance of students on the mathematics placement test and has helped them get back on track and catch up to the appropriate mathematics level they should begin their studies with.

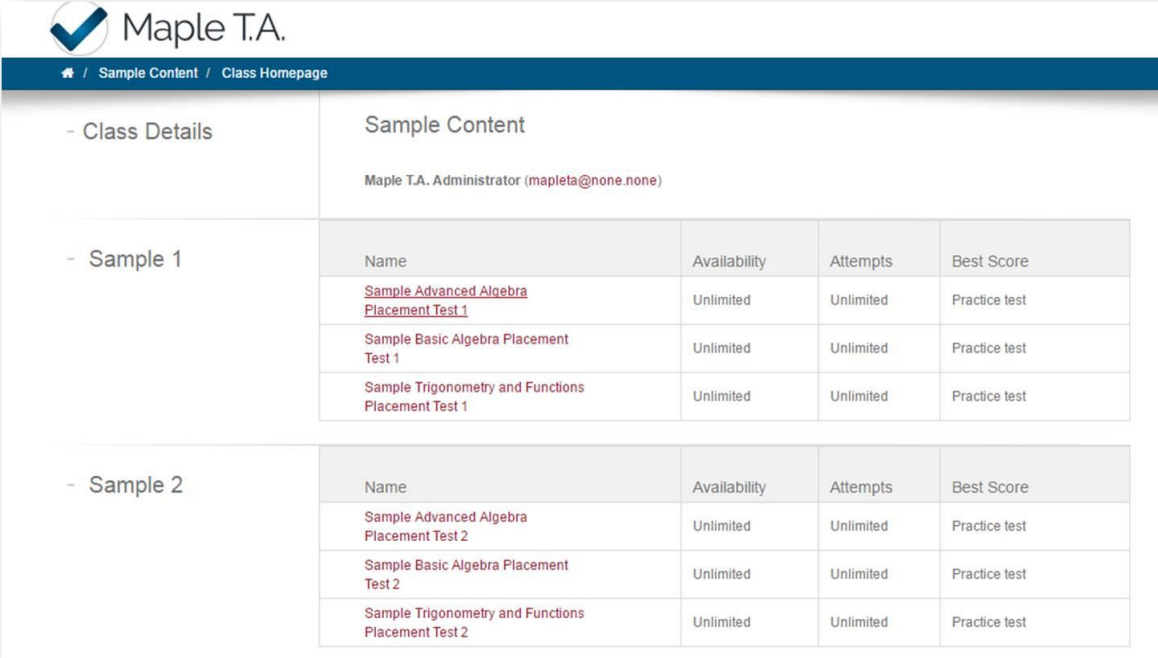
Strong Student Outreach

In order to help first year students placed into either MATH108 or MATH110 better understand what their placement test means for their respective degree plans, our university spent a great deal of time and effort developing and implementing marketing strategies. On receipt of the student's deposit, an electronic and regular mail outreach campaign was triggered informing the student about the placement test, how to register for it, if they did not already have advance placement or transfer credits. At open house events and admitted student day, advisors presented the importance of mathematics for STEM majors, the impact on graduation timeline and what options are available to students to prepare and/or catch up during the summer before their first full time semester. In addition to this, a student who received placement into MATH108 or MATH110 would immediately see information about their summer options (retake the placement test, attend a community college course equivalent, or attend the pre-calculus summer boot camp) in a placement email, followed by a letter sent to the home address on file. During summer orientation programs, an additional layer of follow up and education during breakout sessions were offered that directly explained what their placement means for their mathematics at our institute, their degree, and their graduation time line.

Practice Placement Test Portal

Looking at the data for student performance on mathematics placement test between 2013-2015, it was observed that in general, approximately for every student placed in Calculus-I, there is one student who is placed in one of the pre-calculus courses. This is an interesting observation because the overall student profile at NCE and in general at the university has been improving every year. This should have resulted in more students being placed directly in Calculus-I. Although this number is growing, it is not growing in accordance with growth in students' SAT scores and high-school GPA. It was therefore concluded that students are caught off guard when they show up to take the mathematics placement test. There are several possible reasons for this.

A few being- students' lack of preparation, the fact that students are not familiar with placement test portal, and that they are not allowed use of calculators. NCE Dean's office and Placement Testing office reached out to MapleSoft – the company that offers placement tests based on pre-set criteria at our institute. Two sets of practice placement tests were developed for Fall 2017 incoming class and have since been expanded to four sets for Fall 2018 incoming class. Each of the practice tests were offered in the same three categories as the actual placement test: basic algebra, advanced algebra, and trigonometry & functions. MapleSoft made sure that the look and feel of the practice tests matched that of the actual placement test. It is very likely that taking the practice tests will not only prepare students better, but also will boost their confidence when then appear for their actual placement test. Figure 2 and 3 show front page of the practice test portal and one of the sample questions. Students are given unlimited attempts and shown correct answers at the end of each test. In addition, several other sample questions have been developed by the Mathematics department and are available on the home page of the Placement Testing Office's website as well on the Mathematics department website.



Maple T.A.		Sample Content		
Maple T.A. Administrator (mapleta@none.none)				
- Sample 1	Name	Availability	Attempts	Best Score
	Sample Advanced Algebra Placement Test 1	Unlimited	Unlimited	Practice test
	Sample Basic Algebra Placement Test 1	Unlimited	Unlimited	Practice test
	Sample Trigonometry and Functions Placement Test 1	Unlimited	Unlimited	Practice test
- Sample 2	Name	Availability	Attempts	Best Score
	Sample Advanced Algebra Placement Test 2	Unlimited	Unlimited	Practice test
	Sample Basic Algebra Placement Test 2	Unlimited	Unlimited	Practice test
	Sample Trigonometry and Functions Placement Test 2	Unlimited	Unlimited	Practice test

Figure 2: Practice Placement Test Portal – Front Page

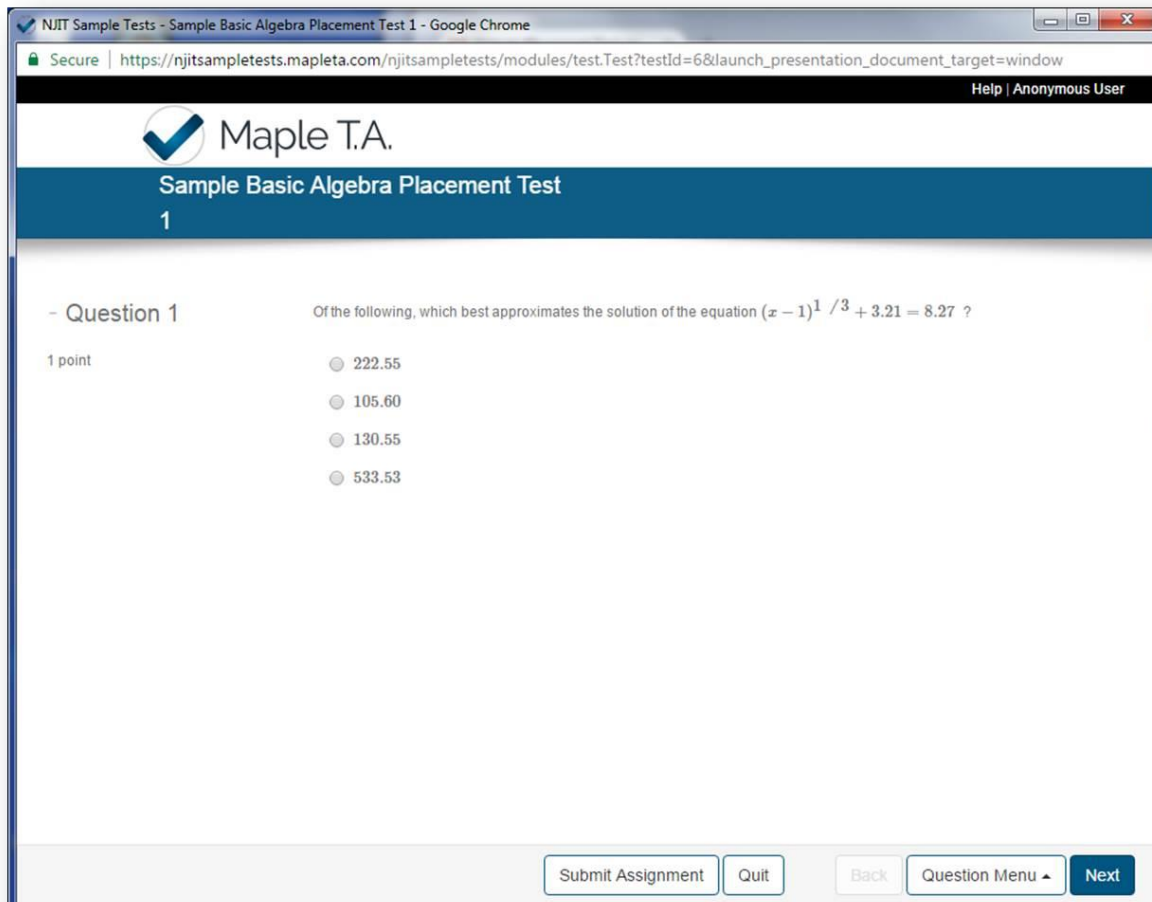


Figure 3: Practice Placement Test Portal – Sample Question

In order to allow students to access the practice tests without having to create a log-in and for granting them unlimited attempts, we had to give up on the ability to automatically track number of students taking these practice tests. However, with strong outreach and consistent message through all student-staff interactions, our hope is that most students will come better prepared for the placement test and will be placed higher. We did develop a small survey to be administered during New Student Orientation in June 2017 (Appendix-I). Similar survey will also be administered during summer 2018 orientation. Results of the 2017 survey related to the knowledge and use of the practice placement tests are presented below:

Practice Placement Test

- 80% of the respondents knew about the availability of Practice Placement Test.
- 64% of the respondents actually took at least one of the Practice Tests.
- 94% of test takers found the test useful or very useful.

Another indicator to the success of the practice placement tests can be seen in table 1. 2017 cohort saw the lowest number of students placed in pre-calculus courses. It is important to note that 2017 cohort is also the brightest incoming class in terms of SAT scores, so practice placement tests cannot be given full credit for the improvement in students' placements. We will continue to develop additional practice tests and improve the outreach to educate students on what their placement means and how they can make up for it by taking advantage of various initiatives developed by NCE as well as other options in front of them. Some of our other initiatives (not covered in the scope of this paper) such as math help sessions and offering an application oriented mathematics course for underprepared students based on the wright state model (separate paper submitted at the ASEE2018 conference), have shown that several students benefit from these efforts in the short run, but not all of them are able to maintain this advantage in the long run. It is likely that the students, who take advantage of the practice tests and practice problems, will be placed higher. However, it will be interesting to see how many of these students are able to maintain this advantage in their subsequent mathematics courses.

Estimated Placement Calculator

Since its implementation, the mathematics Placement Test performance has been a very good indicator of preparedness in mathematics of incoming freshmen. Students are tested in three areas on the placement test: basic algebra, advanced algebra, and trigonometry & functions. Performing well on the placement test will place students in Calculus-I, the recommended starting point for engineering programs. Poor performance will land them in one of the two pre-calculus courses. Although, students were always made aware of this general information; they were not familiar with exact cut-off scores for these placements. Even when these cut off scores were communicated to students, they found it difficult to follow and to convert their mathematics placement test scores into their actual course placement. The cut off scores for Fall 2017 entering class, who were tested in Spring and Summer 2017, are:

- For placement in MATH111 (Calculus-I):
Adv. Alg. + Trig. ≥ 35
- For placement in MATH110:
Bas. Alg. + Adv. Alg. ≥ 30
AND
Bas. Alg + Adv. Alg. + Trig. ≥ 45
- For placement in MATH108
If neither of the above criteria are met.

Some students and advisors found these criteria a little complicated to use and asked for a simple tool that will translate placement scores into estimated placement. In response to this request, NCE Dean's Office in collaboration with University Information Systems department developed

a web-tool where students can input their practice or placement test scores and the output will be their estimated placement. The first iteration of the tool catered primarily to STEM track students. Although, it should be noted that over 85% of the incoming class at the university and over 95% of the incoming NCE students fall under STEM track classification. Figure 4 shows the 2017 version of the web-tool in action.

Google Analytics is being used to track usage of this website. This data will help us find out how useful this tool has been. By June 30 2017, the website was accessed more than 500 times and by over 200 unique users. This tool became popular within the university among advisors and other members interacting with incoming student class. An updated version of the tool is currently being developed that will allow course placement determination for all majors and all mathematics sequences for incoming first-year students. The updated calculator will be launched by April 30, 2018.

NJIT Math Placement Calculator for Practice Placement Exams

Welcome to the Math Placement Calculator for Practice Placement Exams

Since the math placement test is used to determine your first semester math course, we strongly recommend that you prepare for the math placement test by reviewing the subject areas on the test and practicing the sample placement tests on this ([attach Maplesoft link here](#)) website. This calculator can then be used to input scores on the sample tests to determine what Math course you will likely be placed in to give you a fair idea of where you stand. Please be advised that this calculator is designed specifically for math placement of Newark College of Engineering (NCE) freshmen students and won't give you the correct course otherwise. The practice placement tests, though, can be used by all freshmen students.

Math Placement Calculator: Enter your grades in the Sample Placement Tests

Basic Algebra (out of 25): *	<input type="text" value="19"/>	✓
Advanced Algebra (out of 25): *	<input type="text" value="15"/>	✓
Trigonometry and Functions (out of 30): *	<input type="text" value="14"/>	✓

Estimated Placement:

Based on your scores, your likely placement is - **MATH 110**

If placed in MATH110 in the original placement test, you will be starting one term behind in Math. Please work harder and practice more using the resources available [here](#) to do better on the actual placement test.

Please note that this is only likely placement based on scores you have entered. Your actual placement will be sent to you shortly after you take the placement test with the Office of Placement Testing at NJIT. Email placementtesting@njit.edu to schedule a test if you haven't done so already.

Figure 4: Estimated Placement Calculator Showing Results for MATH110 Placement

The mathematics placement calculator page takes in the score input scores and displays the MATH course the respective students are likely to be placed. The page also spreads a word about the mathematics placement test and consists of a link to the sample placement test website.

Summer 2017 orientation survey results for the estimated placement calculator:

- Only 45% of the respondents knew about the availability of Placement Calculator
- All of these students said that they used the Placement Calculator and found it useful or very useful
- Google Analytics tracked 500+ visitors by June 30th since the launch of Placement Calculator.

Based on this feedback, outreach and messaging on incoming student website has been improved to try and inform all incoming students about the availability of the upgraded placement calculator.

Engineering Mathematics Summer Boot Camp

Engineering Mathematics Summer Boot Camp is being offered since Summer 2015. Each year, one section each for both the pre-calculus courses MATH108 and MATH110 are offered. These sections are reserved for the incoming first year students so that targeted support can be offered to them. Although the numbers vary a little from year to year, students typically received discount on tuition fees, free tutoring, meals (breakfast and lunch) and various opportunities to participate in activities designed to increase their interest in and enthusiasm for engineering.

Analysis of the performance of students is presented in tables 3, 4, 5 and figure 5 below. In general, students did quite well and most of them were able to reach one mathematics course higher than their original placement.

Table 3: MATH108 and MATH110 Grades Breakdown 2015-2017

	2015	2016	2017
Pass (A/B/C)	37	28	24
Not Passing (D/F)	7	2	10
Total Students	44	30	34

Table 4: MATH108 Grades Breakdown 2015-2017

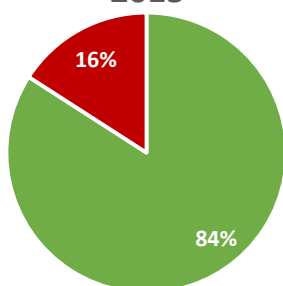
	2015	2016	2017
Pass (A/B/C)	16	16	8
Not Passing (D/F)	4	0	5

Total Students	20	16	13
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Table 5: MATH110 Grades Breakdown 2015-2017

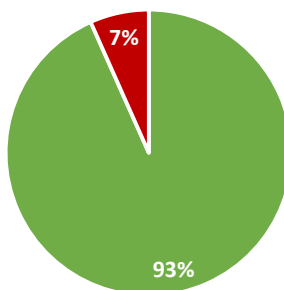
	2015	2016	2017
Pass (A/B/C)	21	12	16
Not Passing (D/F)	2	2	5
Total Students	23	14	21

**Boot Camp Grades
2015**



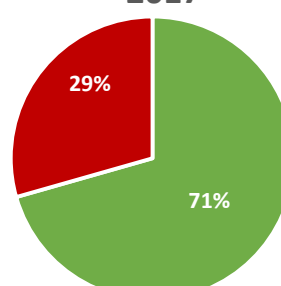
■ Passing ■ Not Passing

**Boot Camp
Grades 2016**



■ Passing ■ Not Passing

**Boot Camp Grades
2017**



■ Passing Grade ■ Not Passing

Figure 5: MATH108 and MATH110 Grades Breakdown 2015-2017

Table 3 and Figure 5 show the overall impact of the boot camp from 2015 through 2017. It can be observed that 84%, 91% and 71% of the students received a C or better grade and were able to take the next course in their mathematics sequence during the subsequent fall semester. In the three years that the boot camp has been offered, a total of 91 students caught up in their mathematics sequence by one course. Tables 4 and 5 show a further break-down of the performance by each of the two pre-calculus courses. There is not much difference that separates the results for MATH108 and MATH110.

In the summer of 2015 the Pre-Calculus Summer Boot Camp completed its first program cycle. An assessment plan was designed and students were tagged in order to carefully assess whether and to what extent the boot camp was successful in helping students. In the 2015 program, 48 students enrolled in one of the pre-calculus courses with 4 of those students later withdrawing from the program. In total there were 24 students originally enrolled in what NJIT calls Math 108 and another 24 in MATH110. Of the MATH108 population, approximately 76% of students passed the course with a C grade or higher. Of the MATH110 population, approximately 91% of students passed the course with a C grade or higher.

In the summer of 2016 the Engineering Mathematics Summer Boot Camp completed its second program cycle. In the 2016 program, a total of 38 students enrolled in three pre-calculus courses: MATH107 (University Mathematics B I), MATH108 (University Mathematics I-B), and MATH 110 (University Mathematics B II - Trigonometry and Differential Calculus). 35 students moved to next course in mathematics sequence by securing C or better grade, 1 student withdrew and 2 received D or F grades and were unable to move to next course.

In Summer 2017, 24 out of 34 students received sufficient grades to move on to the next course in mathematics sequence. As has been the trend, total number of students signing up for the courses continues to decline. The passing percentage of the students overall is also lower in 2017 than in the past years.

It can be generally seen that boot camp helped several students save one semester and make up for their less than ideal mathematics placement. However, it is also important to see whether this positive impact lasts and students continue to make progress in mathematics and in their major of study at the university. We recently looked back at the 2015 and 2016 boot camp students to find out where they were at in Fall 2017. The findings are presented below:

Where are they now?

Summer 2015 Cohort:

These students have had 2 academic years at the university and are entering their 5th semester. Only CoE students were factored into the breakdown below:

- MATH108 – 20 students (14 CoE)
 - On Track (Math 211/213 or above): 3
 - Behind 1 semester: 1
 - Behind 2 or more semesters: 7
 - No Longer at the university: 3
- MATH110 – 23 students (21 CoE)
 - On Track (above Math 211/213): 5
 - Behind 1 semester: 7
 - Behind 2 or more semesters: 5
 - No Longer at the university: 4

Summer 2016 Cohort:

These students have had 1 academic year at the university and are entering their 3rd semester. Only CoE students were factored into the breakdown below:

- MATH108 – 16 students (14 CoE)
 - On Track (Math 112): 6
 - Behind 1 semester: 1
 - Behind 2 or more semesters: 5
 - No Longer at the university: 2
- MATH110 – 14 students (13 CoE)
 - On Track (above Math 112): 7
 - Behind 1 semester: 3
 - Behind 2 or more semesters: 1
 - No Longer at the university: 2

Boot camp students were also asked to rate their experience with the course, workshops and supplemental instruction the overall feedback from respondents was very positive. Of the students who participated in the Engineering Mathematics Summer Boot Camp 88% rated the supplemental instruction “good” to “great” and 87% of the students rated the program overall as “good” or “great”. Qualitative feedback included the following themes:

- Gaining insight into academic life
- Learned how to manage college workload
- Learned better study habits
- Sense of being prepared
- Confidence in mathematics education

As mentioned before, one of the concerns is that the total number students enrolled is much lower than the number of CoE students placed in pre-calculus courses. Students are offered a number of options to address their placement in pre-calculus courses and the boot camp is only one of them. As mentioned earlier, a lot of students are unable to take the boot camp because of financial or personal reasons, but do choose to retake the placement test and/or take an equivalent course at a community college near their residence.

In looking at student’s academic performance combined with student satisfaction and qualitative feedback the program appears to have strong initial impact on students’ academic performance. However, not all of the students are unable to maintain this advantage and fall behind in their mathematics sequence in subsequent semester.

Summary

In summary, NJIT is continuously improving its outreach initiatives in the hope of doing a better job at making incoming students understand the importance of doing well in the mathematics placement test and their mathematics courses in general. Several targeted initiatives have helped students start on track in their mathematics sequence or to catch up during summer. All of these initiatives have shown positive results and a strong impact on the short-term success of the students. Some initiatives like the Engineering Mathematics summer boot camp have been offered for the last three years and indicate that they are helping some students in the long term as well. Although, the number of students benefiting in the long term are not as high as they should be. Some other initiatives will require further analysis after they have been offered for at least two and hopefully more consecutive years.

The university has decided to continue to offer the pre-calculus courses in summer 2018, but with some rebranding. All the best parts of the boot camp will be kept including tuition discount and free tutoring. However, the package will not be marketed as Engineering Mathematics Boot Camp, but as a tutoring program. Despite our sincere efforts, we have not been able to attract more students to sign up for the boot camp. In fact, the number of students taking these courses in the summer has been declining for the last 3 years. Our goal is to lower the number of students placed in pre-calculus courses by aggressively marketing the practice test portal and placement calculator. We are committed to continue to offer these initiatives in one form or another and to help students as much as possible. We look forward to receiving feedback on the data we have so far and to see how we can further polish these initiatives and offer any additional ones that have found success at similar institutions.

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APPENDIX - I

CoE – New Student Orientation Survey

1. Did you know about the practice placement tests before attending this session?

☐ YES

☐ NO

2. Have you taken at least one of the available practice tests?

☐ YES

☐ NO

3. If you answered yes to question 2, please rate the helpfulness of the practice tests on a scale of 1-5 (1 being least helpful and 5 being most helpful)

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

4. Did you know about the placement calculator before attending this session?

☐ YES

☐ NO

5. Have you used the placement calculator to calculate your estimated placement?

☐ YES

☐ NO

6. If you answered yes to question 5, please rate the helpfulness of the placement calculator on a scale of 1-5 (1 being least helpful and 5 being most helpful)

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

7. Do you have any suggestions to improve the practice placement tests and/or the placement calculator?