

Findings of the Pilot Offering of an Application Oriented Course (ENGR101)

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Work in Progress – Findings of the Pilot Offering of an Application Oriented Course (ENGR 101)

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Abstract - Students' inability to easily apply concepts of mathematics to engineering problems and applications is detrimental to their success in pursuing an engineering degree. It has a direct impact on the retention and graduation numbers in engineering colleges. In addition, high failure rate in first year mathematics courses is also hurting students' chances to make satisfactory progress towards their degree and ultimately graduate within even six years. In order to address these serious issues, in Fall of 2016, New Jersey Institute of Technology offered ENGR 101 – an application oriented course based on Wright State University model to engineering students placed in pre-calculus courses. Although only one year worth of data has been collected thus far and there is much to be studied and analyzed on the effectiveness of the course, we can already see that this experiment has produced encouraging results and students taking this course performed better in their pre-calculus courses compared to students who did not take ENGR 101. This paper will present the results of our analysis, including performance in the mathematics course while taking ENGR 101 simultaneously, and performance in the mathematics course in the subsequent semester. With the lessons learned from last year, a few additions and changes will be made for Fall 2017.

Index Terms – First year introductory course, Application-driven, Increase student retention and motivation, Course analysis.

INTRODUCTION

Incoming first year students at mid-size STEM institutions like New Jersey Institute of Technology (NJIT) are required to take at least one year of calculus to advance to sophomore level core engineering courses. However, a large percentage of the first year students are placed into remedial pre-calculus courses and do not reach calculus until their second semester or second year. At NJIT, for each student placed in calculus-I there is another, who is placed in one of the two pre-calculus courses. This distribution has only slightly improved despite significant increase in average student profile in terms of SAT/ACT scores and high school GPA. Moreover, a good portion of those placed into calculus fail

to finish these pre-requisite mathematics requirements in their first year to progress ahead in a timely fashion due to high failure and withdrawal rate. A key detrimental factor contributing to this is that a majority of the incoming first year students are considered to be underprepared in mathematics. Another reason is students placed into Calculus I lose their drive to do well in the course as they find it difficult to establish a connection between mathematics and engineering [1-3]. Therefore, they struggle to keep up with the coursework. In addition to loss of motivation, any delay in entry to Calculus I or failure in Calculus I is almost automatically equivalent to an additional semester to couple of years of added stay at NJIT. More often than not, this leads to students switching to non-engineering majors or leaving NJIT. In pursuit of solving this problem, the Newark College of Engineering at NJIT decided to offer an “Engineering 101” introductory course starting in Fall 2016, loosely based on the Wright State University (WSU) engineering mathematics education model.

Wright State University (WSU) has developed a model with NSF funding to increase student retention and motivation and is currently being tried or adopted in 40+ engineering schools nationwide [1-2]. The idea is to teach mathematics to incoming first year students using an application-oriented, hands-on introductory course. This course provides an overview of relevant topics in engineering analytical methods that are most heavily used in the core sophomore-level engineering courses reinforced through extensive examples of their use in lab exercises. Topics include algebraic manipulation of engineering equations; use of trigonometry, vectors and complex numbers, sinusoids and harmonic signals, systems of equations and matrices in engineering applications; basics of differentiation, integration and differential equations in engineering applications.

The WSU model was first implemented in 2004 and has been used successfully since then. At WSU, every department requiring this course saw an increase in first-year retention in 2004-2005, as compared to baseline data averaged over the prior four years. Overall, WSU saw first-year retention increase from 68.0% to 78.3%. In addition to first-year retention, this model has had a significant impact

on student performance in calculus at WSU. Of the students ultimately enrolled in Calculus I, 89% of those who had formerly taken this course earned a “C” or better, compared to only 60% of those who had not [3].

The goal of this paper is to analyze the effectiveness of the pilot offering of ENGR 101, a similar course offered at NJIT. The following section discusses the analysis and results obtained in detail.

ENGR 101 – COURSE ANALYSIS

ENGR 101 is a 4-credit course meeting for 90 minutes of lecture two times a week, and 90 minutes of recitation and 90 minutes of lab meeting once a week. The total population of students will be divided into a group of 90 students per common lecture and 30 students for both recitation and lab. The structure of ENGR 101 is loosely based on the WSU model. The course was changed to cater specifically to students who are taking pre-calculus and are one-two terms behind the ideal student. More details about the course can be found in the authors’ previous paper [4].

For the Fall 2016 and Spring 2017 semesters, first-year Newark College of Engineering (NCE) students from biomedical engineering, chemical engineering, civil engineering, computer engineering, electrical engineering (henceforth referred to as NCE except engineering science) and engineering science (ESC) programs, who are not placed into Calculus I were enrolled in ENGR 101. Engineering science at NJIT is for (i) still-deciding freshmen engineering students and (ii) students who need more attention and supervision especially in the first year of education at NJIT. The mechanical engineering and industrial engineering programs (MIE) opted not to participate in the program during its pilot offering and hence allowed us to use their students as a control group. In addition, there were several students, who were eligible to be enrolled in ENGR101, but could not be accommodated due to schedule conflicts. They also served as part of control group and helped with comparison of results. Broadly speaking, the control group is similar to the treatment group as both populations are first time full time freshmen students who were underprepared in mathematics and were placed in a pre-calculus course using a standardized placement test.

As mentioned before, primary objectives of this pilot program was to help students make a connection between concepts of mathematics and their common engineering applications as well as to help them do well in pre-calculus and subsequent mathematics courses. Therefore, for analysis, comparison of passing percentages in pre-calculus classes was done for students taking ENGR101 and those who didn’t take the course in Fall 2016. ENGR101 course material includes topics from all MATH 108, MATH 110 and MATH 111 courses which are taught in an application

based setting. Taking the course in Fall should help students understand these topics better in the later mathematics course. Thus, a comparative analysis was also done to track the performance of students in their mathematics course in Spring 2017 who took ENGR101 in Fall 2016.

Passing percentage in mathematics was chosen as the criterion for comparison as high failure rate in first year mathematics is a key detrimental factor in low retention and graduation rates. At NJIT, a C or a better grade is considered to be a passing grade in all pre-calculus and calculus courses. To recap, incoming NJIT engineering students are assigned to MATH 111 Calculus I (the desired "normal path"); or to MATH 110 University Mathematics B II (pre-calculus, one course away from the "normal path"); or to MATH 108 University Mathematics B II (pre-calculus, two courses away from the "normal path"). MATH 108 engineering students who took ENGR 101 were compared to those who didn’t take ENGR 101. Similarly, MATH 110 engineering students who took ENGR 101 were compared to those who didn’t take ENGR 101. The results for Fall semester are given in the figures 1 and 2 below.

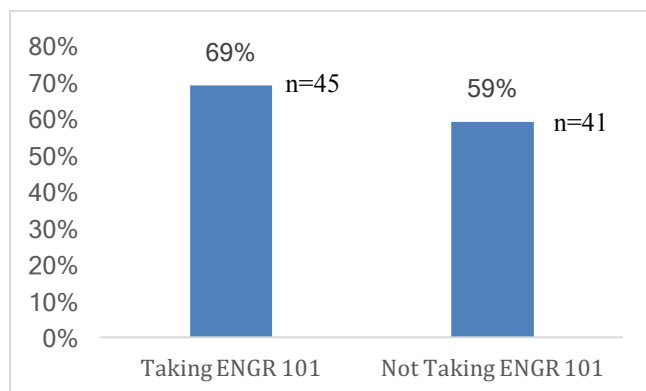


FIGURE 1
PASSING PERCENTAGE COMPARISON IN MATH 108

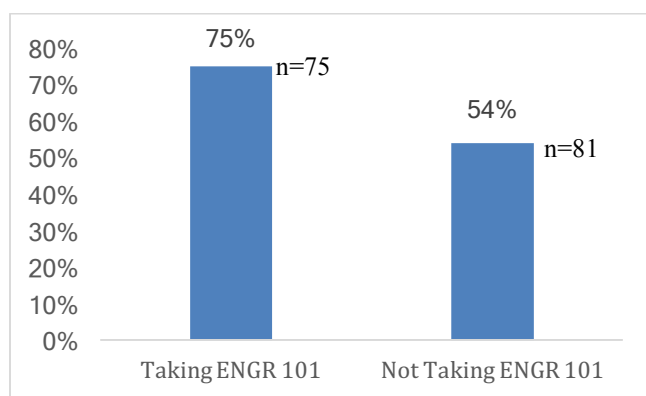


FIGURE 2
PASSING PERCENTAGE COMPARISON IN MATH 110

Other comparisons were also done with different groups – MATH 108 NCE except ESC vs. MATH 108 MIE control group, MATH 108 ESC students taking ENGR101 vs. MATH 108 ESC students who haven’t taken ENGR101.

Similar analysis was done for MATH 110 for the same populations. In all cases but one (ESC students who took MATH 108, where the results were alike) pre-calculus engineering students who took ENGR 101 have done better than students who did not take ENGR 101. Most notably 75% of NCE students in MATH 110 who also took ENGR 101 passed MATH 110, while NCE students in MATH 110 who did not take ENGR 101 had a passing rate of only 54%. Similar results were observed for the Spring semester, but since the majority of freshmen students take it during Fall, the results for the Fall semester are shown.

Fall 2016 ENGR101 students' performance in the subsequent mathematics course in the Spring semester was also looked at. Figure 3 gives the passing percentage in MATH 110 in the Spring semester, of students who took ENGR101 and MATH 108 in the Fall semester. Figure 4 gives the passing percentage in MATH 111 in the Spring semester, of students who took ENGR101 and MATH 110 in the Fall semester.

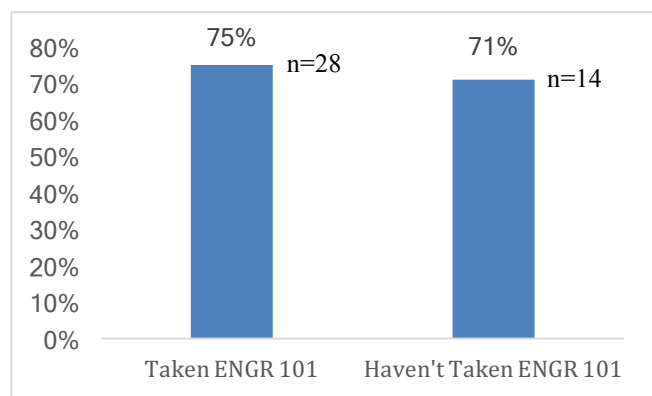


FIGURE 3

PASSING PERCENTAGE COMPARISON FOR MATH 108 STUDENTS IN THE SUBSEQUENT SEMESTER IN MATH 110

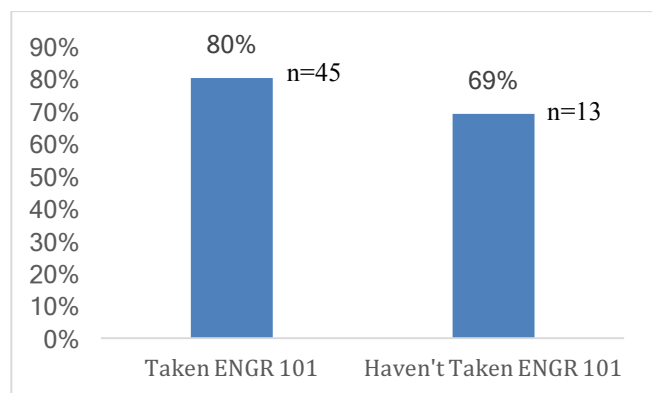


FIGURE 4

PASSING PERCENTAGE COMPARISON FOR MATH 110 STUDENTS IN THE SUBSEQUENT SEMESTER IN MATH 111

The above figures represent the complete NCE population including all engineering streams except MIE control group and the ESC students. In addition, performance of NCE

except ESC students were also looked at in comparison to the MIE control group for both MATH 108 and MATH 110 students. Similarly, ESC students' performance in mathematics courses was also tracked. The results look quite promising with students who have taken ENGR 101 doing better than those who haven't taken ENGR 101. The pass percentage for ESC students, which is a weaker group of students, in both MATH 110 and MATH 111 was surprisingly even better than the performance of MIE control group students. Another observation from figures 2 and 4 is that MATH 110 students showed better results as compared to the MATH 108 student population.

The authors have not conducted a test to confirm statistical significance at this stage as the data collected is only for one course offering with small sample sizes in some cases. With more data available in the subsequent semesters, a detailed statistical analysis would be done to determine the impact of this study.

ADDITIONS AND CHANGES FOR NEXT OFFERING

With the lessons learned from two semesters, there will be some new additions and changes made for the next offering of ENGR 101. (i) With the success of the first year of ENGR 101, Fall 2017 offering will also have mechanical and industrial engineering students also taking the course. (ii) Feedback from students and instructors recommended separate sections for MATH 108 and MATH 110 students. For Fall 2017, MATH 108 students will be offered a different version of ENGR 101 with fewer topics and more in-depth study of pre-calculus topics. Newer topics such as Complex Numbers would also be added. (iii) Lastly, some labs will now be changed from virtual (on computer) to physical hands-on lab to provide a better understanding of the course material.

SUMMARY

The objective of this paper is to report the findings of offering ENGR 101, a course to increase student retention, motivation, and success in engineering through an application-oriented, hands-on introduction to engineering analytical methods. The course was run for the first time at NJIT during Fall 2016. An analysis was done to evaluate the effectiveness of such a course. The results look very promising and students who took ENGR 101 did better in the mathematics course in the same semester as well as the subsequent semester as compared to students who did not take ENGR 101. The authors will analyze the outcomes further, collect data from the next iterations of ENGR 101 and make further suggestions and recommendations.

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