

Engineering Student Success and High School ACT Math Scores

Sungwon S. Kim, Ph.D.

Department of Mechanical and Civil Engineering, Minnesota State University, Mankato, sungwon.kim@mnsu.edu

Abstract - Engineering student retention related issues are receiving more and more attention as the nation tries to prepare for shortage of students graduating with engineering degrees. Much of the attention has been focused on making adjustments to the undergraduate curricula or providing alternative methods of content delivery. Although many of these adjustments are warranted and effective, these efforts are being made with the assumption that the students come to college ready to understand and receive a college level education. While this assumption may be true for certain institutions, it may not be for others. Calculus and calculus based physics courses that provide a foundation for all engineering fields of study are perhaps the most difficult courses that engineering freshman and sophomore students experience during the initial stages of their academic careers. Students who are able to understand and pass these courses generally tend to continue with their engineering studies.

This paper attempts to create a correlation between high school ACT Math scores of students enrolled in a university freshman level “Introduction to Engineering” course and their level of success. A voluntary survey was conducted asking students enrolled in a university freshman level “Introduction to Engineering” course their anticipated grade in the course, their anticipated GPA in the semester, the current math course that they were registered for, the math course that they were planning to register for in the following semester, and their high school ACT Math score. Preliminary results show that students making good progress towards their engineering degree had ACT Math scores above 28. Continued research, both in terms of longitudinal tracking of students and in terms of giving the survey to incoming students enrolled in the same class year after year, is expected to give more data points that should provide higher confidence in these preliminary results.

Index Terms – ACT Math scores, freshman engineering, retention, student success.

INTRODUCTION

At Minnesota State University, Mankato, incoming freshman engineering students are placed into an

appropriate math course, based off of their ACT Math scores. The most ideal case is for students who have a minimum of ACT Math score of 24 to be placed into Calculus I (MATH 121) and for these students to continue over the duration of a total four semesters the subsequent courses of Calculus II (MATH 122), Calculus III (MATH 223) and Differential Equations (MATH 321). Freshman students who have declared their major to be “Mechanical Engineering” are expected to enroll for “Introduction to Engineering-Mechanical (ME 101)” during their first semester. Enrollment in ME 101 has held steady at approximately 100 students per year and the number of senior students who complete the Mechanical Engineering program has also held steady at around 25 students per year. Of particular interest has been understanding the so called “retention” problem with the purpose of trying to understand why the large number of starting freshman students has not been resulting in a larger number of graduates. A survey was conducted at the end of the fall semester of 2015 in ME 101 that asked several questions about the students’ experience in the program, the math courses that they were enrolled in and their high school ACT Math score. The ACT Math score question was asked with the idea that there would be an observable correlation between the students’ ACT Math score and the students’ academic performance in the program. This paper attempts to share initial results of this survey such that the information can be used by a variety of stakeholders, including prospective students, parents, advising centers and other engineering programs.

BACKGROUND

Observations of the freshman students enrolled in ME 101 and how these students are doing academically has been the focus of attention by the author, who has been the instructor for ME 101 since the fall semester of 2011. Initial survey studies since fall semester of 2012 have been conducted in terms of gauging student math preparedness by asking students which math course they started the program in, and by asking which math course they planned to take in the following semester. Results from the previous study of survey results from fall semester of 2012 [1] showed that the group of students who registered for Calculus I (MATH 121) in the fall semester and who had plans of registering

for Calculus II (MATH 122) in the following spring semester were identified to have an adequate level of math preparedness to move on in the Mechanical Engineering curriculum. Groups of students of who registered for Calculus II (MATH 122) in the fall and had plans of registering for Calculus III or Differential Equations (MATH 223 or MATH 321) in the spring and groups of students of who had completed their four semester math sequence showed positive responses to survey questions. The survey consisted of questions of whether the student felt that the Mechanical Engineering program/curriculum was engaging, relevant and welcoming, and whether the student felt that he or she would likely continue in the program. The survey also asked what grade in the course they were expecting and what they expected their overall GPA to be that semester. The survey concluded by asking which math course the student was enrolled in the current semester and which math course the student plans to take in the following semester.

The same survey has been given to ME 101 students in following years of fall 2013 and fall 2014, and results have shown similar trends. Based off of the results obtained in fall 2012, a curriculum change has been implemented to limit enrollment of freshman students in ME 101 to those who are concurrently enrolled for nominally Calculus I (MATH 121), Pre-Calculus (MATH 115) or Trigonometry (MATH 113). Since this curriculum change, most students (~90%) registering for ME 101 have been students registered for MATH 121. However, the number of freshman students moving on the Mechanical Engineering curriculum to the sophomore level has remained relatively constant at around 50 students and the number of junior students in the Mechanical Engineering curriculum has remained constant at around 25 students. This observation has been interesting to the author in that the curriculum change (MATH 113, MATH 115, MATH 121 or higher) seems to have had little impact on the student enrollment numbers in the sophomore, junior and senior levels. Considering that most students in ME 101 were concurrently enrolled in at least Calculus I (MATH 121), which had a university minimum requirement of ACT Math score of 24 or higher, it was surmised that the freshman class enrolled in ME 101 was a mixture of a wide variety of ACT Math scores, and that the ACT Math scores could give some correlation between the students' level of preparedness and their academic performance in the program. This is the main reason why an updated survey, which included the question of "What was your ACT Math score from high school?" in addition to all other questions included in the previous survey, was conducted in fall 2015.

The idea to investigate ACT Math scores came from informal conversations with graduating senior students during the past few years, in which many of them expressed how they were one of the top students from their high school graduating class, and that their ACT Math scores were in the mid 30's (maximum ACT Math score of 36). Although asking the graduating senior students what their

ACT Math scores was as entering freshman students is possible, the results could most probably be used for only internal purposes and would most likely not be suitable for dissemination. This is the motivation for this study – to collect data about ACT Math scores of incoming freshman students in the Mechanical Engineering program and to interpret the results and to disseminate the results to prospective high school students who are considering pursuing an Mechanical Engineering degree, to their parents and counselors, and the staff who work in the university admissions office. The information would be used the answer the question of "What ACT Math score do you need to succeed in the Mechanical Engineering program at Minnesota State University, Mankato?".

SURVEY CONTENTS

The voluntary and anonymous survey used for this study was an updated version of the "Post-Semester Questionnaire" used for ME 101 since fall 2012. The previous version of the survey included questions of whether the student felt that the Mechanical Engineering program/curriculum was engaging, relevant and welcoming, and whether the student felt that he or she would likely continue in the program. It also asked what grade in the course they were expecting and what they expected their overall GPA to be that semester. The survey concluded by asking which math course the student was enrolled in the current semester and which math course the student plans to take in the following semester. The questions to most questions were based off of the Likert scale (1=lowest, 5=highest). One additional question was asked in the updated version of the survey. This one additional question was "What was your ACT Math score from high school?". The survey was conducted at the end of the semester, immediately after the course evaluations were conducted. An Institutional Review Board (IRB) approved consent form was read to the students not by the instructor but by a department colleague and only students who wanted to volunteer for the study participated by filling out the IRB approved survey form. A total of 74 responses were collected out of a total of 81 students who received a final grade in the course.

SURVEY RESULTS

Survey results were retrieved by the author from the department colleagues in the subsequent spring semester and analyzed. Of particular interest were the answers to the ACT Math score question. Most answers were a direct answer to in the ACT score format, but some SAT Math or SAT Composite scores were also reported. Some students indicated that they did not know, or left the question blank, which would have been the case for international students who did not take the ACT Math Test. In cases where SAT

scores were reported, a conversion table [2, 3] was used to convert the SAT score to an ACT Math score.

Based off of the authors’ observation in the ME 101 course, roughly the top 50% of students in the ME 101 course continue their studies in the ME curriculum in their sophomore year and approximately the top 25% of students in the ME 101 course are formally admitted to the ME Program to successfully continue their studies the ME curriculum in to the junior and senior years. Focusing on the percentage of students who successfully finish, an ACT Math score of 28 was identified as the minimum score of 28 students with the highest ACT Math score. That is, the top 28 ACT Math scores of the respondents from the survey had a minimum ACT Math score of 28. As a comparison, the top 15 ACT Math scores of the respondents from the survey had a minimum ACT Math score of 30. The top 15 students were considered based off of the authors’ observation in the ME 101 course of students who thrive and excel in the ME program throughout their entire time in the curriculum. The average of all reported ACT Math scores was calculated to be 27.4. The results of the survey for all 74 responses are summarized in Table 1.

TABLE 1. SUMMARY OF SURVEY RESULTS FOR ALL 74 RESPONSES.

	Avg.	S.D.
Do you feel the Mechanical Engineering program/curriculum is engaging?	4.07	0.69
Do you feel the Mechanical Engineering program/curriculum is relevant?	4.32	0.76
Do you feel the mechanical Engineering program/curriculum is welcoming?	3.66	1.04
How likely is it you will continue in the Mechanical Engineering program?	3.85	1.36
What do you expect your grade in ME101 to be?	2.87	0.88
What do you expect your overall GPA this semester to be?	2.83	0.58
What was your ACT Math score from high school?	27.4	4.52

The same analysis was done by dividing the responses into two groups – one group with ACT Math scores of 28 and above and another group with ACT Math scores of 27 and below. The second group included responses that did not include a response to the ACT Math score question. The results of the survey for the first group with ACT Math scores of 28 and above are summarized in Table 2, and the results of the second group with ACT Math scores of 27 and below are summarized in Table 3.

TABLE 2. SUMMARY OF SURVEY RESULTS FOR THE GROUP WITH ACT MATH SCORES OF 28 AND ABOVE.

	Avg.	S.D.
Do you feel the Mechanical Engineering program/curriculum is engaging?	4.43	0.57
Do you feel the Mechanical Engineering program/curriculum is relevant?	4.50	0.69
Do you feel the mechanical Engineering program/curriculum is welcoming?	3.82	0.98
How likely is it you will continue in the Mechanical Engineering program?	4.00	1.31
What do you expect your grade in ME101 to be?	3.02	0.90
What do you expect your overall GPA this semester to be?	3.06	0.51
What was your ACT Math score from high school?	30.89	2.74

TABLE 3. TABLE 3. SUMMARY OF SURVEY RESULTS FOR THE GROUP WITH ACT MATH SCORES OF 27 AND BELOW.

	Avg.	S.D.
Do you feel the Mechanical Engineering program/curriculum is engaging?	3.85	0.67
Do you feel the Mechanical Engineering program/curriculum is relevant?	4.22	0.79
Do you feel the mechanical Engineering program/curriculum is welcoming?	3.57	1.07
How likely is it you will continue in the Mechanical Engineering program?	3.76	1.40
What do you expect your grade in ME101 to be?	2.78	0.87
What do you expect your overall GPA this semester to be?	2.69	0.58
What was your ACT Math score from high school?	23.78	2.81

DISCUSSION

The two groups of students who were divided based off of a threshold ACT Math score of 28 exhibit discernable differences of their responses to survey questions. The first group with ACT Math scores of 28 or higher seems to be a much happier crowd in terms of their responses. Their expected grade in the ME 101 course and their expected overall GPA is much healthier. Contrastingly, the second group with ACT Math scores of 27 or lower seems to somewhat happy in terms of their interaction with the ME program, but do not seem as sure in continuing with the ME program/curriculum. Their expected grade in the ME 101 course and their expected overall GPA is not as healthy. As can be seen from the results of the survey summarized in Table 2 and Table 3, respectively, the first group exhibits an

average ACT Math score of 30.89, while the second group exhibits an average ACT Math score of 24.78. The number of students in the first group was 28, while the number of students in the second group was 56 with 27 students who actually gave a response to the ACT Math score question. 29 students out of the 56 students in this group did not respond.

While it is not unthinkable to have a student with an ACT Math score of 26 or 27 to end up completing the ME program or a student with an ACT Math score of 30 or 31 to end up not completing the ME program, these results provide a guideline for generally what can be expected. It is difficult to say that a student with an ACT Math score of 24 or below has a good chance of making it through the ME program with success. Based off of this survey result, it would be fair to say that a student with an ACT Math score of 28 has a good chance of moving along in the ME program. While discussing minimum ACT Math scores runs the potential of receiving criticism of being elitist, the value of these results are found in giving prospective students, their parents, counselors and the university admission office of being realistic in defining scopes of expectation. To better guide high school graduates who are considering pursuing a degree in engineering, it would be beneficial for the student, their parents, and receiving institutions to have some sort of idea of whether the student is actually prepared to pursue a degree in engineering. The broad issue of engineering student retention would also benefit by being able to better define the group of students who actually have the capacity to understand engineering related concepts, so that students who are not prepared are not counted in calculations related to engineering student retention. The final objective of this work is to generate a guideline of ACT Math scores that could be used to predict whether the high school graduate considering pursuing an engineering degree would be academically successful or not, so that the student and their parents can make appropriate decisions when the time comes to select universities and majors.

These results would be especially valuable for universities whose mission is not to be highly selective in admitting students but to be serving of the broader state population, which would be true for institutions like Minnesota State University, Mankato or comparable state institutions. This study will be continued in the coming semesters so that more data points can be collected and more meaningful information with higher levels of confidence can be extracted.

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AUTHOR INFORMATION

Dr. Sungwon S. Kim is an assistant professor at the Minnesota State University, Mankato. He is the instructor for the ME 101 course, in which he is trying to better understand issues related with retention and student success.

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