ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #20898

High School ACT Math Scores: Why and How Do We Use Them?

Dr. Sungwon Steven Kim, Minnesota State University, Mankato

Dr. Sungwon S. Kim joined the Mechanical Engineering faculty at MSU Mankato in January of 2011. He received his Ph.D. degree in Mechanical Engineering from Purdue University (2008), working in the area of synthesizing carbon nanotubes, his M.S. degree in Mechanical Engineering from Korea Advanced Institute of Science and Technology (KAIST), working in the area of designing and analyzing double spiral heat exchangers, and his B.S. degree in Mechanical Engineering from Korea University (2000).

Before joining MSU Mankato, Dr. Kim was a Visiting Assistant Professor in the School of Engineering at Purdue University, teaching courses in the thermal fluid sciences, and conducting research in nanotechnology. His research expertise and interests lie in the controlled synthesis of CNTs for thermal and biological applications. While at Purdue, he was actively involved in research sponsored by DARPA (Defense Advanced Research Projects Agency) in the development of carbon nanotube (CNT) enhanced wicks for vapor chambers (Thermal Ground Plane Program), and in enhancement of thermal interfaces using CNTs (Nano Thermal Interface Program).

Currently, his research activities are concentrated in the area of engineering education, with the purpose of promoting interest in engineering and fostering the next generation of engineers.

High School ACT Math Scores: Why and How Do We Use Them?

Sungwon S. Kim, Ph.D.
Department of Mechanical and Civil Engineering, Minnesota State University, Mankato, sungwon.kim@mnsu.edu

Abstract - **This paper summarizes the continued study of trying to correlate ACT Math scores of students enrolled in a university freshman level "Introduction to Engineering" course and their level of success. Voluntary survey data collected initially during Fall semester 2015 was compared with results of the same survey conducted during Fall semester 2016. The survey, which consisted of questions asking students 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 for the survey conducted during Fall semester 2015 suggested that students making good progress towards their engineering degree had ACT Math scores of 28 and above. Results from the follow up survey conducted during Fall semester 2016 largely reinforces the results from the previous year.**

In addition to ACT Math score results being used for university admissions and math course placement cutoffs, the possibility of using ACT Math score to identify a group of "marginally prepared" students for engineering study is explored. The question of how we can provide academic and advising support to the group of students who are identified to be "marginally prepared" is raised and discussed. Effective strategies of using ACT Math scores to identify this group of "marginally prepared" students so that their probability of success in the freshman and sophomore year calculus and calculus based physics courses are suggested.

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

INTRODUCTION

At Minnesota State University, Mankato, students who declare an engineering major are placed into appropriate math classes based off of their ACT Math scores. Nominally, students are expected to be ready to enroll for Calculus I (MATH 121) to make good progress towards graduation. An ACT Math score of 24 is the minimum score to be placed into Calculus I. Students who declare their major as "Mechanical Engineering" enroll for the "Introduction to Engineering – Mechanical" (ME 101) class during the first semester of their freshman year. Enrollment in ME 101 has held steady at approximately 100 students in recent years. The number of students moving on to the second semester of their freshman year in to the next introductory engineering course "Introduction to Problem Solving and Engineering Design" (ME 201) drops down to approximately 60 students and the number of students moving on to their sophomore year, as indicated by enrollment numbers for subsequent engineering courses such as Statics (ME 212) or Dynamics (ME 214) drops down even further to approximately 30 students. In a previous paper [1], the author attempted to correlate freshman engineering students' ACT Math scores with students' academic performance in the Mechanical Engineering program by conducting a voluntary student survey in Fall 2015 which asked students in the ME 101 class several questions and their high school ACT Math score. This paper compares the results of the same survey given to the ME 101 class of Fall 2016, with further interpretation of the survey results.

BACKGROUND

The motivation behind the previous study of attempting to correlate ACT Math scores with student success largely stemmed from the author's personal conversation and interaction with graduating senior students that spanned throughout the students' entire academic career at MSU, Mankato. The number graduating senior students has held steady at approximately 25 students, while the number of students registering for the ME 101 course has held steady at approximately 100 students. The underlying question has been, "What traits did the successfully graduating students have compared to their peers? What did they look like academically as entering freshman?" This question has been especially interesting to the author, since the vast majority of the students (~90%) registering for ME 101 has been comprised of students registered for Calculus I (MATH 121), whose ACT Math score was at least 24 (maximum score of 36). Within the large group of students whose ACT Math score was greater than 24, it was reasoned that several sub groups of students existed, based off of the gradual and incremental decrease of the number of students in a class of students, eventually leading to the approximately 25 students in a graduating class. A survey consisting of several questions and their high school ACT Math score was given with the hope that the results would reveal a pattern that would distinguish the differing groups.

SURVEY CONTENTS

The survey consisted of the following three Likert scale (1=lowest, 5=highest) questions, two GPA related questions and a final ACT Math score question.

- Do you feel the Mechanical Engineering program/curriculum is engaging?
- Do you feel the Mechanical Engineering program/curriculum is relevant?
- How likely is it you will continue in the Mechanical Engineering program?
- What do you expect your grade in ME101 to be?
- What do you expect your overall GPA this semester to be?
- What was your ACT Math score from high school?

The survey, which augmented a previous survey [2] with the ACT Math score question, was approved by the campus Institutional Review Board (IRB) and was conducted in a voluntary and anonymous manner near the end of the semester. The same survey was used for both Fall 2015 and Fall 2016.

SURVEY RESULTS

The results of the survey have been summarized in the following three tables. The number of responses for Fall 2015 was 74 and the number of responses for Fall 2016 was also 74. The results for all responses can be found in Table 1.

TABLE I. SUMMARY OF SURVEY RESULTS FOR ALL RESPONSES.

	Fall 2015		Fall 2016	
	Avg.	S.D.	Avg.	S.D.
Do you feel the Mechanical Engineering program/curriculum is engaging?	4.07	0.69	4.16	0.72
Do you feel the Mechanical Engineering program/curriculum is relevant?	4.32	0.76	4.54	0.60
Do you feel the mechanical Engineering program/curriculum is welcoming?	3.66	1.04	3.74	0.97
How likely is it you will continue in the Mechanical Engineering program?	3.85	1.36	4.16	1.11
What do you expect your grade in ME101 to be?	2.87	0.88	2.86	0.74
What do you expect your overall GPA this semester to be?	2.83	0.58	3.13	0.56
What was your ACT Math score from high school?	27.4	4.52	27.5	3.63

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

	Fall 2015		Fall 2016	
	Avg.	S.D.	Avg.	S.D.
Do you feel the Mechanical Engineering program/curriculum is engaging?	4.43	0.57	4.24	0.60
Do you feel the Mechanical Engineering program/curriculum is relevant?	4.50	0.69	4.60	0.58
Do you feel the mechanical Engineering program/curriculum is welcoming?	3.82	0.98	3.92	0.91
How likely is it you will continue in the Mechanical Engineering program?	4.00	1.31	4.28	1.10
What do you expect your grade in ME101 to be?	3.02	0.90	3.14	0.76
What do you expect your overall GPA this semester to be?	3.06	0.51	3.14	0.49
What was your ACT Math score from high school?	30.89	2.74	30.80	2.20

The students were divided into two groups; one group of students having responded that their ACT Math score was above 28 and the other group consisting of responses of 27 and below. The second group included students who responded that they did not take the ACT Math test, due to the fact that they were international students, or the took the Accuplacer Test. The number of students in the first group in Fall 2015 was 28 and that in Fall 2016 was 25. The results for the students in the first group are shown in Table 2. The results for the students in the second group are shown in Table 3.

The two groups were divided largely based on the author's retroactive assessment of senior class students' past performance in their ME 101 class. All of the senior class students that the author has interacted with were in the top 25% of their respective ME 101 classes in terms of the final grade that they earned. The minimum ACT Math score of roughly the top 25% responses was identified to be 28, both in the Fall 2015 surveys and the Fall 2016 surveys. Results of the average ACT Math scores for all responses, the top 25% scoring group and the lower 75% as shown in Table 1 through Table 3. The average for all responses was 27.4 and 27.5, respectively for Fall 2015 and Fall 2016. The average for the top 25% scoring group was 30.89 and 30.80, respectively. The average for the lower 75% scoring group was 23.78 and 24.72, respectively.

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

	Fall 2015		Fall 2016	
	Avg.	S.D.	Avg.	S.D.
Do you feel the Mechanical Engineering program/curriculum is engaging?	3.85	0.67	4.12	0.78
Do you feel the Mechanical Engineering program/curriculum is relevant?	4.22	0.79	4.51	0.62
Do you feel the mechanical Engineering program/curriculum is welcoming?	3.57	1.07	3.65	0.99
How likely is it you will continue in the Mechanical Engineering program?	3.76	1.40	4.10	1.12
What do you expect your grade in ME101 to be?	2.78	0.87	2.72	0.70
What do you expect your overall GPA this semester to be?	2.69	0.58	3.12	0.60
What was your ACT Math score from high school?	23.78	2.81	24.72	1.77

DISCUSSION

The survey results comparison for Fall 2015 and Fall 2016 show that the numbers across the various responses to questions are quite similar, meaning that the general academic aptitude of the incoming freshman students were fairly consistent across the two years in question. Answers to questions were more positive for the ACT Math score 28 and above group compared to that given by the ACT Math score 27 and below group. Students who understand the material are able to enjoy the material. In delivering the core message of the answer to the question of "What is engineering?", various activities of utilizing science and math as fundamental tools to understand a problem and to find a solution to a problem were conducted in the ME 101 course. An example would be a group project called the "Penny Boat Challenge" where groups of four students were initially given a 6 inch by 6 inch aluminum foil and were asked to calculate the dimensions of a box like boat that would maximize the number of pennies that it could accommodate before sinking. This activity required the groups to make the connection between buoyancy force, the volume of the water displaced by the structure. Furthermore the ability to mathematically express the volume of the boat as a function of the height of the boat (a variable) as a polynomial, differentiate that polynomial and to find the root (both graphically and algebraically) were critical points of understanding that the students would have needed to solve the problem. The students who understood how to use the calculus (mainly differentiation) that they were learning in their Calculus I course, expressed how interesting it was to be able to utilize the math that they had learned in solving an engineering problem.

The above is an example of why Calculus I is the math course that all engineering programs start with for their freshman students. The implication is that the students that enter their freshman year in an engineering program are "calculus ready", to be successful. The natural question is who can be deemed to be "calculus ready"? Many universities use the SAT Math score or the ACT Math score to make this decision, so that students can be placed in the appropriate course so that they can be successful [3]. From the several searches that the author has conducted, most universities with engineering programs have minimum ACT Math score requirements of 28 or higher for Calculus I placement. Coincidentally, the score of 28 is the score same that the author has identified in terms of the group of students whose chance for success as engineering students is high at Minnesota State University, Mankato. At the national level, the ACT Math score of 28 is the 91st percentile [4,5] based off of scores from national distributions of high school graduates from 2013, 2014 and 2015 (sample size of 5,569,466). For context, the minimum ACT Math score of 24 at Minnesota State University, Mankato for Calculus I (Math 121) placement corresponds to the 73rd percentile from the same data set.

For the students identified in the 73rd percentile (ACT Math score 24) and the 88th percentile (ACT Math score 27), a more rigorous and systematic math readiness program should be implemented to increase their chances of success in engineering majors. This is the "marginally prepared" group of students who will more than likely have difficulty comprehending and more importantly have difficulty utilizing the various concepts of differentiation and integration covered in calculus. It is the author's assertion that it is morally irresponsible to give them a path that will lead them to a high probability of failure.

How to help these "marginally prepared" students become "calculus ready" students is the big question. From high school graduation to the beginning of the freshman semester, bridge summer math camp seems to be a good model to implement. How these bridge programs are implemented is a matter of having the right combination of resources, both financial and human resources, in place. Often times the "marginally prepared" students come from humble social and economic backgrounds who may not be able to afford these summer bridge programs even if they are offered. Therefore, creation of these summer bridge math camps require the financial and man power support from the university administration, who should view these initiatives as investments that will help students who need it the most.

For institutions such as Minnesota State University, Mankato, increasing its ACT Math score requirement for Calculus I placement from the current 24 to the national "going rate" of 28 would have several implications, mostly which would have consequences for enrollment numbers. However, to reflect current issues of many students having to repeat Calculus I in their second semester of their freshman year, because they received a D, F grade or they voluntarily withdrew (W) during their first semester, this seems to be the first step in solving the problem. Concepts of mathematics and engineering are not easy to comprehend and the standards of engineering professional societies do not bend based on which school the engineering student graduated from. It would be interesting to continue this study after making such curriculum change and comparing the before and after.

The author would like to thank the Minnesota State University, Mankato Institutional Research Board (IRB) members for reviewing and approving the IRB application (MSU IRBNet ID# 835683) for this study.

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.

REFERENCES

[1] Kim, S., S., "Engineering Retention and Student Math Preparedness", Title", *Proceedings of 6th FYEE Conference, 2014*.

[2] Kim, S., S., "Engineering Student Success and High School ACT Math Scores," *Proceedings of 8th FYEE Conference, 2016.*

[3] Fuller, E.J., and Deshler, J.M., "The Effect of a New Placement Process on Student Success in First Semester Calculus*", Creative Education, Vol. 4, No. 9, 18-21, 2013.*

[4] Dorans, N., J., "Correspondance Between ACT and SAT I Scores", *https://www.ets.org/Media/Research/pdf/RR-99-02-Dorans.pdf*, 1999.

[5] College Board, "ACT and SAT Correspondance Tables", *https://research.collegeboard.org/sites/default/files/publications/2012/7/researchnote-2009-40-act-sat-concordance-tables.pdf,* 2009.