Impact of STEM Focus on Graduation Rates in Ranking Colleges

Craig E. Wills

Computer Science Department
Worcester Polytechnic Institute
Worcester, MA 01609

WPI-CS-TR-16-05
November, 2016

Abstract

Interest in Science, Technology, Engineering and Math (STEM) disciplines has been reflected in college rankings. In this work we do not seek to rank STEM-focused institutions, but rather examine how the STEM focus of an institution (the percentage of awarded STEM degrees) impacts its college ranking. In particular, we examine how STEM focus affects the U.S. News use of graduation rate performance in its ranking of colleges. U.S. News considers both the six-year graduate rate of a college as well as the predicted six-year graduation rate for the college based on characteristics of its students.

We use data available from the College Scorecard to determine the STEM focus of each institution ranked in the U.S. News National Universities list over the past five years (2013-2017) and examine if the STEM focus of the institution affects its graduation rate performance and subsequently its overall ranking.

The results show there is a statistically-significant difference between the graduation rate performance of STEM-focused institutions under-performing the predicted rate in comparison with all other institutions with a five-year net difference of 4%. The five-year net difference is even more pronounced at 5% of under-performance relative to the predicted rate when comparing the most-STEM-focused with all other institutions. Looking at the least-STEM-focused institutions these institutions out-perform their predicted graduation rate by a statistically-significant net difference of 2% compared to all other institutions over the five-year period.

While these discrepancies could be due to differences in performance of STEM-focused institutions, such a large and consistent "under-performance" across many STEM-focused institutions seems unlikely. Rather, these results suggest that the U.S. News prediction method for Graduation Rate under-estimates the difficulties of students in STEM disciplines to graduate at the same rate as students with comparable characteristics in non-STEM disciplines. Understanding why students in STEM disciplines are less likely to graduate at the same rate as students with similar characteristics in non-STEM disciplines is an important question to follow-up from this study.

1 Introduction

Interest in Science, Technology, Engineering and Math (STEM) disciplines has been reflected in college rankings. A report from U.S. News in 2013 examined the top-ranked national universities that granted the highest proportion of STEM degrees [3]. More recently, Forbes published the Top STEM Colleges in 2016 [1].

In this work we do not seek to rank such institutions, but rather examine how the *STEM focus* of an institution (the percentage of awarded STEM degrees) impacts its college ranking. In particular, we examine how STEM focus affects the U.S. News use of graduation rate performance in its ranking of colleges. U.S. News considers both the six-year graduate rate of a college as well as the predicted six-year graduation rate for the college based on characteristics of its students. In previous work we found that technological institutions consistently under-performed (or U.S. News over-predicted) their expected graduation rate [6]. In this work we examine if the STEM focus of an institution affects its graduation rate performance and subsequently its overall ranking.

An online article published with the 2017 U.S. News Best Colleges rankings describes the ranking criteria and weights used in the ranking [2]. Graduation Rate Performance, which accounts for 7.5% of the ranking for each institution, is described as:

> "A comparison between the actual six-year graduation rate for students entering in fall 2009 and the predicted graduation rate. The predicted graduation rate is based upon characteristics of the entering class, as well as characteristics of the institution.
>
> This indicator of added value shows the effect of the college's programs and policies on the six-year graduation rate of students after controlling for spending per student, the proportion of undergraduates receiving Pell Grants, standardized test scores and high school class standing.
>
> If the actual graduation rate is higher than the predicted rate, the college is enhancing achievement or is overperforming. If its actual graduation rate is lower than the predicted rate, then it's underperforming.
>
> A school with a higher ratio of its actual graduation rate compared with its U.S. News predicted graduation rate (actual graduation rate divided by predicted rate) scores better than a school with a lower ratio in the ranking model."

In this work we compare the graduation rate performance with the STEM focus of institutions ranked in the U.S. News National Universities list over the past five years (2013-2017). This list has contained roughly 200 institutions each of the past many years, although the number jumped to 231 in 2017. As a baseline considering each ranking over the past five years, 55% of the National Universities have over-performed with a higher-than-predicted graduation rate. 36% underperformed with a lower-than-predicted graduation rate during this time. The remaining institutions performed as predicted. On average, institutions outperformed their predicted graduation rate by 1.2%. Thus the norm is that the U.S. News prediction method tends to under-predict the actual graduation rate.

2 STEM-Focused Institutions

We used data available from the College Scorecard [4] to determine the percentage of STEM degrees awarded by each institution. The data provide the percentage of degrees awarded in 38 disciplines. We used the U.S. Immigration and Customs Enforcement list of STEM-Designated Degree Programs [5] to determine which are STEM disciplines. We found 12 such disciplines: Agriculture (AG), Natural Resources (NR), Computer and Information Sciences (CI), Engineering (EN), Engineering Technologies (ET), Biological and Biomedical Sciences (BB), Mathematics and Statistics (MA), Military Technologies (MT), Physical Sciences (PH), Science Technologies (ST), Psychology (PS), and Homeland Security & Law Enforcement (HS).

We define a *STEM-focused institution* as awarding a majority of its degrees in a STEM discipline. Using the most recently available College Scorecard data from AY2014-15, Table 1 shows the 26 STEM-focused institutions that have appeared in the U.S. News National Universities list for each of the past five years (2013-2017). Other STEM-focused institutions have appeared in a subset of the five years, but for consistency of comparison we only consider the 26 that have appeared in each of the five years.

The table shows that Cal Tech awards the highest percentage of STEM degrees with the Colorado School of Mines close behind. The table also shows the percentage of degrees awarded in each of the 12 STEM disciplines to account for the total STEM percentage. The table is augmented to show the U.S. News 2017 ranking (in []'s) for each institution. STEM-focused institutions have better-than-expected representation with 19 (73%) of the 26 in the top half of the U.S. News rankings and 12 (46%) in the top quarter.

There is a distinction within Table 1 where the first 14 institutions award more than two-thirds of their degrees in STEM disciplines. These are the *most-STEM-focused institutions* and we separately analyze them as part of our study. These most-STEM-focused institutions are closer to their expected representation with 9 (64%) of the 14 in the top half of the rankings and 4 (28%) in the top quarter.

3 STEM-Focused Institution Results

We analyze the relative graduation rate performance of the 26 STEM-focused institutions from Table 1 in two ways. First we look at the percentage of rankings where an institution over-performs the predicted graduation rate, under-performs the predicted graduation rate and performs at the predicted rate. These results are shown on the left-hand side of Figure 1 for the STEM-focused institutions over each of the past five years as well as the summary results for all five years.

The results show relatively consistent results each year with a five-year average of 25% of STEM-focused institutions over-performing and 66% under-performing the predicted graduation rate. The right-hand side of Figure 1 shows yearly and total results for all other national universities. In contrast to the left-hand side results, the all other five-year results show 59% of institutions over-performing and 32% under-performing their predicted graduation rates. These are substantial differences between the two sets of results.

Second we analyze the size of the difference between predicted and actual graduation rate. This average difference (actual - predicted) is shown in Figure 2 for each year as well as for the cumulative five-year period. For each average the range representing a 95% confidence interval for

Table 1: STEM-Focused National Universities

STEM Pct Rank. University [2017 US News Rank]	STEM Pct	STEM Degree Pcts											
		AG	NR	CI	EN	ET	BB	MA	MT	PH	ST	PS	HS
1. California Inst. of Tech. [12]	99.5	0	0	18	36	0	13	11	0	22	0	0	0
2. Colorado School of Mines [82]	99.2	0	0	4	87	0	0	5	0	3	0	0	0
3. Missouri U. of Sci. and Tech. [164]	92.8	0	0	9	66	4	4	1	0	6	0	3	0
4. Worcester Poly. Inst. [60]	91.7	0	0	5	72	0	8	3	0	2	0	0	0
5. SUNY C. Env. Sci. & Forestry [99]	87.5	0	38	0	7	3	36	0	0	3	0	0	0
6. Massachusetts Inst. of Tech. [7]	87.3	0	0	23	39	0	10	7	0	8	0	0	0
7. Stevens Inst. of Tech. [71]	86.5	0	0	7	68	5	4	2	0	1	0	0	0
8. Clarkson U. [129]	83.6	0	1	2	55	10	8	2	0	2	0	4	0
9. Rensselaer Poly. Inst. [39]	82.2	0	0	11	53	3	6	4	0	6	0	1	0
10. Michigan Tech. U. [118]	80.9	0	3	6	58	4	4	1	0	3	0	1	0
11. New Jersey Inst. of Tech. [135]	78.4	0	0	14	41	14	5	2	0	1	0	0	0
12. Georgia Inst. of Tech. [34]	77.7	0	0	8	61	0	5	1	0	2	0	1	0
13. Florida Inst. of Tech. [171]	75.8	0	0	4	41	1	9	3	0	9	0	8	0
14. Illinois Inst. of Tech. [103]	75.5	0	0	10	51	3	4	1	0	4	0	3	0
15. Case Western Reserve U. [37]	62.1	0	0	5	31	0	13	2	0	6	0	5	0
16. Rice U. [15]	58.1	0	0	5	25	0	13	5	0	6	0	5	0
17. Carnegie Mellon U. [24]	57.1	0	0	12	26	0	3	6	0	7	0	3	0
18. Cornell U. [15]	56.9	14	2	4	18	0	14	1	0	2	0	2	0
19. U. of Maryland-Baltimore Cty [159]	56.9	0	2	17	6	0	15	3	0	1	0	12	0
20. North Carolina St. U. [92]	56.7	10	3	3	23	1	10	2	0	2	0	4	0
21. U. of Massachusetts-Lowell [152]	56.1	0	0	13	14	2	4	1	0	2	0	8	12
22. Lehigh U. [44]	54.9	0	0	6	32	0	8	1	0	4	0	4	0
23. U. of California-Davis [44]	54.3	5	3	2	10	0	21	1	0	2	0	11	0
24. U. of California-San Diego [44]	53.5	0	2	4	13	0	18	2	0	6	0	8	0
25. Virginia Poly. Inst. and St. U. [74]	51.6	5	4	3	23	0	8	2	0	2	0	5	0
26. Stanford U. [5]	50.3	0	0	13	17	4	6	3	0	5	0	3	0

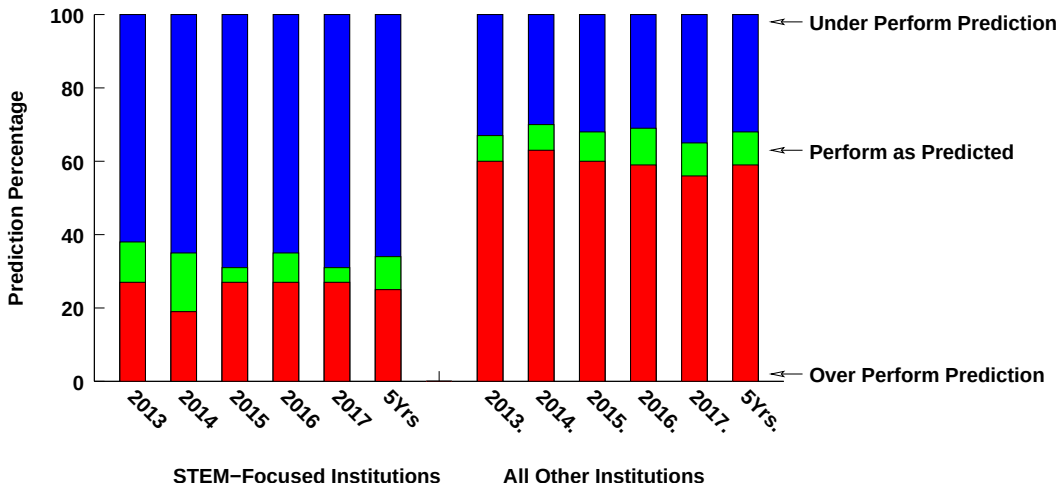

Figure 1: Over and Under Percentages for Graduation Rate Performance of STEM-Focused Vs. All Other Institutions

the true value is also shown. The figure shows that the STEM-focused institutions tend to underperform their predicted rate with a five-year average performance of -2.4%. In contrast, all other institutions have a five-year average performance of +1.7% leading to a net difference of 4.2%. This difference is statistically significant both on a yearly and a five-year basis as the confidence interval ranges do not overlap.

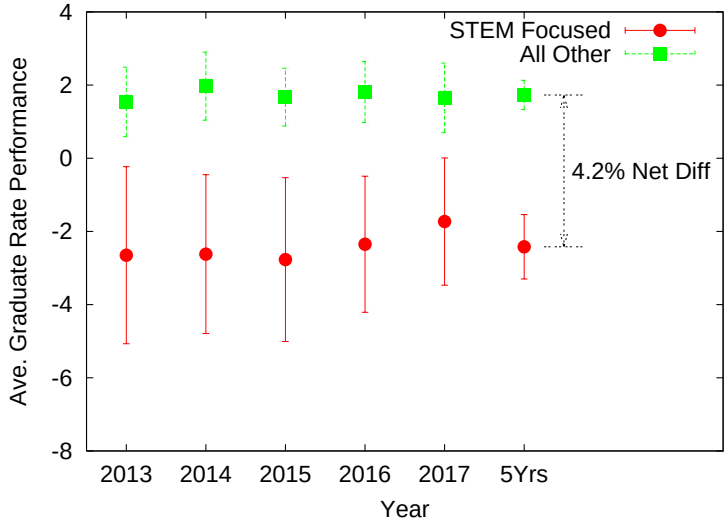

Figure 2: Average Graduation Rate Performance of STEM-Focused Vs. All Other Institutions

4 Most-STEM-Focused Institution Results

We next examine the same results for the 14 most-STEM-focused institutions shown in Table 1. Figure 3 shows even more pronounced differences between the most-STEM-focused and all other institutions than found in Figure 1. These five-year results show 21% of most-STEM-focused institutions over-perform and 74% under-perform their prediction in comparison to 58% and 34% for other institutions.

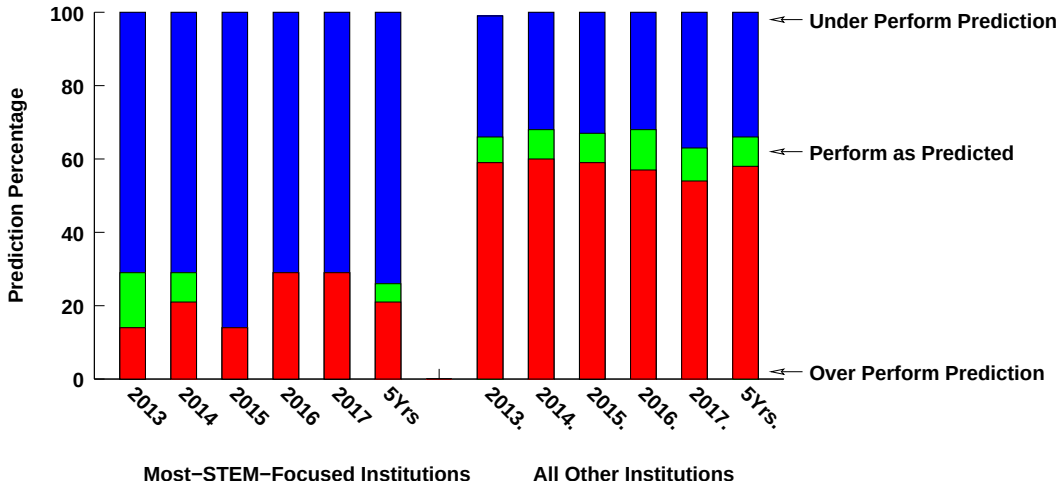

Figure 3: Over and Under Percentages for Graduation Rate Performance of Most-STEM-Focused Vs. All Other Institutions

Figure 4 shows the average graduation rate performance of these two groups of institutions for each year as well as for the five-year period. Again, the results show a more pronounced difference with the most-STEM-focused institutions under-performing their predicted rate with a five-year average performance of -3.8% and all other institutions over-performing during this time with an average difference of +1.6% leading to a net difference between the two groups of 5.3%. Again this difference is statistically significant both on a yearly and a five-year basis.

5 Least-STEM-Focused Institution Results

As another means to understand the impact of STEM focus, we used the College Scorecard Data to determine the National Universities with the least STEM focus. In looking at the data, we chose a threshold of 20% with those awarding a smaller percentage of STEM degrees put into a *least-STEM-focused institutions* group. Using the same methodology as for STEM-focused institutions, we selected all institutions below this threshold appearing in the U.S. News National Universities list each of the past five years. A total of 20 such institutions were found and are shown in Table 2 again with total percentage of STEM degrees awarded and augmented to show the U.S. News 2017 ranking for each institution. Again other institutions qualified based on level of STEM focus, but did not appear in the list each of the past five years.

The New School is the national university awarding the lowest percentage of STEM degrees with American University the next lowest. The set of least-STEM-focused institutions are a bit

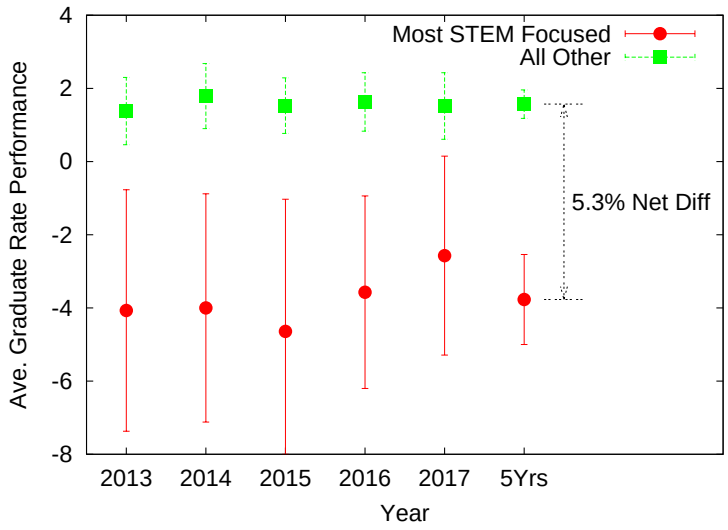

Figure 4: Average Graduation Rate Performance of Most-STEM-Focused Vs. All Other Institutions

Table 2: Least STEM-Focused National Universities

STEM Pct Rank. University [2017 US News Rank]	STEM Pct	STEM Degree Pcts											
		AG	NR	CI	EN	ET	BB	MA	MT	PH	ST	PS	HS
1. The New School (NY) [129]	2.3	0	1	0	0	0	0	0	0	0	0	2	0
2. American U. [74]	9.6	0	1	1	0	0	2	1	0	0	0	3	2
3. Ohio U. [146]	11.1	0	0	2	2	1	2	0	0	1	0	3	0
4. Azusa Pacific U. (CA) [183]	12.9	0	0	1	0	0	2	1	0	1	0	8	0
5. U. of La Verne (CA) [152]	13.0	0	0	1	0	1	2	0	0	1	0	8	0
6. Georgetown U. [20]	13.7	0	0	1	0	0	6	2	0	1	0	4	0
7. Pepperdine U. [50]	13.9	0	0	0	0	0	4	1	0	1	0	8	0
8. Ball St. U. [176]	16.5	0	1	1	0	3	3	0	0	1	0	4	4
9. U. of South Dakota [202]	16.6	0	0	1	0	0	4	0	0	1	0	6	4
10. Biola U. (CA) [164]	16.6	0	0	1	0	0	6	1	0	0	0	9	0
11. Fordham U. [60]	16.7	0	0	2	1	0	4	2	0	1	0	7	0
12. DePaul U. [124]	16.7	0	1	5	0	0	2	1	0	1	0	7	0
13. Maryville U. St. Louis [164]	17.1	0	0	0	0	0	4	1	0	0	0	11	0
14. George Washington U. [50]	17.2	0	1	1	4	0	3	1	0	1	0	5	2
15. Hofstra U. [133]	17.4	0	0	1	2	0	4	1	0	1	0	8	0
16. New York U. [36]	17.5	0	0	2	4	0	3	2	0	1	0	5	0
17. U. of San Francisco [107]	17.5	0	2	2	0	0	4	1	0	2	0	7	0
18. Seton Hall U. [118]	19.2	0	1	0	0	0	9	1	0	2	0	3	4
19. U. of Mississippi [135]	19.4	0	0	0	4	0	5	0	0	1	0	5	4
20. U. of Alabama [103]	19.9	0	0	1	8	0	3	1	0	1	0	4	3

below their expected representation with 8 (40%) of the 20 in the top half of the U.S. News National University rankings and 4 (20%) in the top quarter.

We then examined the performance results for these least-STEM-focused institutions. Figure 3 shows less-pronounced differences between the least-STEM-focused and other institutions than found for STEM-focused institutions. These five-year results show 68% of least-STEM-focused institutions over-perform and 25% under-perform their prediction in comparison to 54% and 38% for all other institutions.

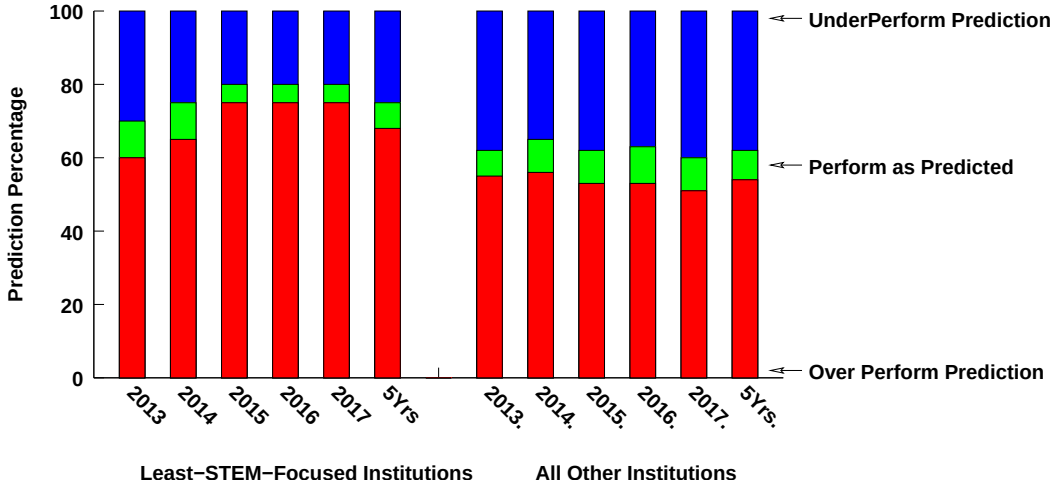

Figure 5: Over and Under Percentages for Graduation Rate Performance of Least-STEM-Focused Vs. All Other Institutions

Figure 6 shows the average graduation rate performance of these two groups of institutions for each year as well as for the five-year period. Again, the results show a less pronounced difference with the least-STEM-focused institutions over-performing their predicted rate with a five-year average performance of +2.8% and all other institutions over-performing during this time with an average difference of +1.0% leading to a net difference between the two groups of 1.8%. While not statistically significant for any individual years, the five-year results are statistically significant between the two groups indicating the least-STEM-focused institutions do perform better than all other institutions.

6 Summary and Future Work

The overall results show there is a significant difference between the graduation rate performance of STEM-focused institutions under-performing the predicted rate in comparison with all other institutions with a five-year net difference of 4%. The five-year net difference is even more pronounced at 5% of under-performance relative to the predicted rate in when comparing the most-STEM-focused with all other institutions. Looking at the least-STEM-focused institutions these institutions out-perform their predicted graduation rate by a significant net difference of 2% compared to all other institutions.

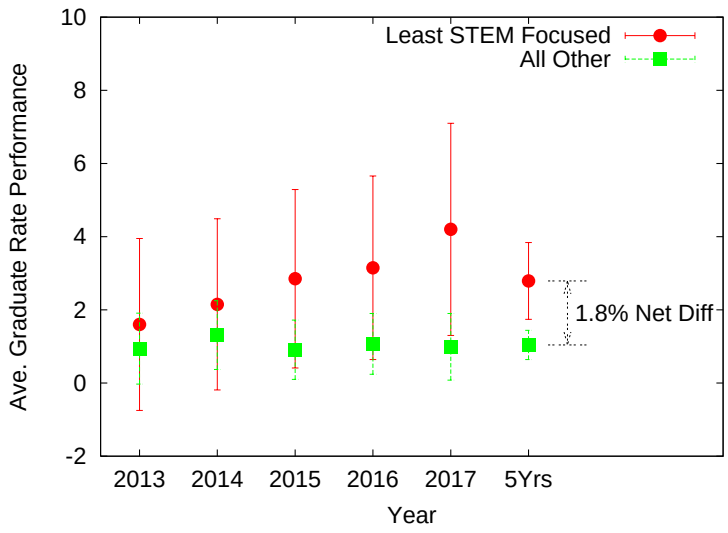

Figure 6: Average Graduation Rate Performance of Least-STEM-Focused Vs. All Other Institutions

As suggested in [6], there are two possible explanations for this significant discrepancy in predicted and actual graduation rate performance depending on the level of STEM focus. It is possible that STEM-focused institutions are indeed under-performing in the value that these institutions add in enhancing student achievement. Similarly least-STEM-focused could be over-performing in the value that these institutions add. However, such a large and consistent "under-performance" across many STEM-focused institutions seems unlikely. Rather, these results suggest that the U.S. News prediction method for Graduation Rate under-estimates the difficulties of students in STEM disciplines to graduate at the same rate as students with comparable characteristics in non-STEM disciplines.

The results from this work raise a number of questions for future work. One question raised by the results is whether the actual graduation rates, which themselves have an 18% weight in determining an institution's U.S. News Ranking, can even be directly compared in an accurate manner for STEM-focused and other institutions. Another question is whether similar predicted vs. actual graduation rate discrepancies between STEM-focused and other institutions exist in other groups such as National Liberal Arts Colleges or regional-based institutions.

Finally beyond college rankings themselves, the results raise the question of understanding why students in STEM disciplines are less likely to graduate at the same rate as students with similar characteristics in non-STEM disciplines. Given the interest in STEM disciplines this is an important question to follow-up from this study.

References

[1] Carter Coudriet. Top 21 STEM colleges of 2016. *Forbes*, July 2016. http://www.forbes.com/sites/cartercoudriet/2016/07/07/top-stem-colleges-of-2016/.

[2] Robert Morse and Eric Brooks. Best colleges ranking criteria and weights. *U.S. News*, September 2016. http://www.usnews.com/education/best-colleges/articles/ranking-criteria-and-weights.

[3] Robert Morse and Diane Tolis. Top-ranked universities that grant the most STEM degrees. *U.S. News*, June 2013. http://www.usnews.com/education/blogs/college-rankings-blog/2013/06/18/top-ranked-universities-that-grant-the-most-stem-degrees.

[4] U.S. Department of Education. College Scorecard Data, September 2016. https://collegescorecard.ed.gov/data/.

[5] U.S. Immigration and Customs Enforcement. STEM designated degree program list, May 2016. https://www.ice.gov/sites/default/files/documents/Document/2016/stem-list.pdf.

[6] Craig E. Wills. Analysis of U.S. News graduation rate performance for technological institutions. Technical Report WPI-CS-TR-14-05, Computer Science Department, Worcester Polytechnic Institute, September 2014. http://www.cs.wpi.edu/~cew/papers/gradperf14.pdf.