

A Quantitative Investigation into whether the Publication of Engineering Pedagogical Material is an Indicator of Value in 'Rankings' when Assessing Instruction

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Abstract

Academic departments, colleges and universities are ranked by a variety of agencies, all utilizing different criteria. Arguments abound over how these rankings can and should be compiled. Because there are a variety of consumers who are impacted by these rankings and use them as a basis in their decision making processes, cries of foul play can usually be heard in the hollow halls of academia upon the latest release of such rankings; in fact, the more popular the ranking, the louder the cry. While there is a general consensus that academic numerical rankings are inherently flawed, they are used. Prospective students may use the rankings to inform their decision when selecting a school to attend; some faculty consult these guides when contemplating career moves, and administrators use these rankings for their institution's own self-promoting activities.

This paper will examine the practice of ranking undergraduate college and university engineering programs and document whether those rankings track with the pedagogical development of the discipline. On the one hand, one can successfully argue that overall research expenditures at the graduate level aid undergraduates by giving them access to cutting edge research in their chosen discipline. On the other hand, the availability of research funds does not guarantee undergraduates access to research opportunities. Therefore we make the claim that students in programs where the pedagogical development of the discipline is occurring will generally receive a better educational experience. It is our contention that faculty who drive the educational resource development in their disciplines are generally better educators than those that focus primarily on research.

We examine literature citations involving the pedagogical development of engineering and correlate those findings with engineering undergraduate school rankings using a popular magazine rating service. We find that the rankings of schools do not correlate with the number of educational development references, implying that the rankings are missing a key component in the undergraduate educational experience.

Introduction

An ongoing debate on college campuses is whether or not research and scholarly productivity is emphasized to the exclusion of teaching effectiveness. Often, ranking agencies rate institutions as if faculty prestige were synonymous with teaching effectiveness. The purpose of this research is to see if there is a correlation between the publication of pedagogical literature and the teaching faculty in consistently top ranked undergraduate engineering programs.

We contend that students benefit from being in departments where the pedagogical development of the discipline is occurring. The premise is that educators who drive the educational resource development in their disciplines are able to interact with students more skillfully than those whose primary focus is on engineering subject related research. The presumption is that instructors who care enough to research aspects of education are probably more proficient in incorporating effective instructional techniques into the classroom, and more knowledgeable of current cutting edge teaching practices.

The intent of this research is to determine if there is a statistical correlation between a school's standing in a particular ranking and the number of its faculty publications on engineering pedagogy. The implications of these results will be investigated so that ranking agencies may begin to focus on criteria that determine the quality of undergraduate education as opposed to using technical publications as a primary measure of faculty excellence. This paper begins with a brief overview of ranking services, those who use those rankings and the benefits they derive, followed by a short literature review discourse of similar research projects.

Ranking colleges and universities is a profitable business as indicated by the number of news magazines and publications that have jumped on the rankings bandwagon over the past several years.²⁻⁴ Some publications' interest in ranking colleges and universities has been openly suspected as being financially motivated. Most educators would agree that ranking academic units is a flawed complex process⁵⁻¹⁰ that will never be quantifiable to the point where the numerical scores rendered will accurately represent a list of "the best colleges and universities," nor should that be the goal. The real concern is the way these rankings are now being viewed by the public and the hype that accompanies their release.

Critics of the ranking process are quick to challenge the suggestion that an undergraduate education experience can be reduced to a statistical score.^{8,11} Even with their self cautionary admonishments to the contrary, some publications like U.S. News & World Report, Barron's Top 50, and Money Magazine appear to do just that by using a variety of evaluation criteria that in some cases fluctuate from year to year,^{10,12} which is why it is not unusual for these ranking agencies to show dramatic changes in their rankings from one year to the next.¹³ Unbelievably, a college ranked number one in one year could dive to tenth place the following year.¹⁰ In fact, U.S. News & World Report has changed its methodology every year since it began ranking schools. Some charge that the change in methodologies is artificial in intent and the resulting tinkering with the numbers may be mischievously done to increase sales.

Other criticisms leveled against these ranking agencies are that they often lack objective

sources for gathering information to use in their evaluations, and that the data being reported is not independently verified. Then there is the mystique surrounding the criteria some agencies like the Gourman Report use to measure quality. This really begs the question, how reliable can the data be if the authors refuse to disclose their methodology so that their findings can be replicated?

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In addition, some question the validity of numerical scores used to rank academic institutions¹⁵ when the differences in scores between the schools are statistically insignificant. Oftentimes, two schools are separated by a tenth of a point on an arbitrarily weighted scale, and forcing them to be placed on a scale can then exaggerate those minute differences¹⁶ so that the scores themselves become significant. The difference between 4.6 and 4.5 on the weighted scale is much less than a difference between a ranking of 1 and 2 suggests.

One has to wonder if the American public really believes that universities vary significantly from year to year with respect to the quality of their faculty, their funding levels, etc. Additionally, in some cases, the shift in ranking may be due to the incorrect usage of the reported data.¹⁷ Other problems that contribute to an inherently flawed system include the arbitrary weighting scheme of all methods.¹⁸ There is no way to prove that one weighting scheme is better than another because there is no one way to definitively quantify educational excellence. For instance, one study showed that changing from one weighting system to another equally valid one led to completely different rankings with schools moving places into a different ranking quartile.¹² The bottom line is that what is important to one college applicant may be meaningless to another.¹⁹

Yet, even if the methodologies did not change every year much of the data in school ranking reports should still be suspect because the information is self-reported by the schools themselves.²⁰ Whether through commonplace mistakes or through unscrupulous manipulation, some schools often misreport or misrepresent information to ranking services.^{17, 21-22} For example, research on the reporting of SAT scores showed that there are numerous ways to skew the data by ignoring or excluding certain data sets from a subject pool.¹⁶ In addition, when U.S. News & World Report stopped independently calculating student to faculty ratios in 1996 and schools began self-reporting this information, ratios dropped from 12:1 to 10:1 in one year.¹⁰ This meant that an institution of Harvard's size with approximately 7000 undergraduate students would have had to hire 100 more faculty in just one year to have their student-to-faculty ratios change that much. The actual numbers at most schools do not reflect that large of an increase in either faculty hiring or such a dramatic drop in student enrollment, which seems to be implied in the 1996-1997 self-reported data on student to faculty ratios.

Besides the inherent flaws that have already been mentioned in relying on self-reported information, there are still other problems with aggregating information to measure the quality of an education experience. Certain aspects of the college experience can be readily quantified, such as grade point averages, standardized test scores, and rank in a graduating class.^{18,23} Yet, other tangible experiences are more appropriately expressed qualitatively, such as the reputation of the school, alumna experiences, the quality of the teaching faculty and other intangible aspects that form the college experience, which makes quantifying many aspects of the educational experience

difficult.²⁴

Uses of Rankings

Now that we have highlighted some of the problems with ranking services that rank undergraduate colleges, we will take a closer look at who uses the rankings so we can identify the importance of maintaining quality rankings. In this section of the paper we look at rankings from the point of view of prospective students, faculty, and school administrators.

Prospective Students

Due to the perceived lack of other easily obtainable comparative information on schools, parents and students often rely on school rankings as they contemplate which institutions to apply to. One study revealed that up to sixty percent of some student populations cited a school's ratings as being an important selection criteria.²⁵ Graduating high school students from upper middle and upper class families tend to rely more heavily on these types of rankings in selecting where they will apply^{16,26} and which schools they will visit. In addition, researchers have found that the number of applications to a school increases when a school moves up in a ranking, showing that parents and students are affected by the rankings.²⁷

Some claim that the proliferation of "early-decision plans" whereby students must indicate their commitment by early fall to attend a school they have been accepted to is caused in part by the ranking systems.¹⁰ So, students not only use the rankings, but they allow their actions to be manipulated by them as well. Students and parents are not the only users of rankings; faculty use them as well.

Faculty

Faculty often use the rankings to justify moves from one university to another, while granting agencies or their pools of grant referees may use them to justify research expenditures at those institutions.²⁸ In fact, it was the perception by faculty in physics departments that high rankings did affect faculty recruitment and funding opportunities,²⁹ and these perceptions probably spread to other disciplines as well. If rankings are perceived as affecting departmental mechanisms, then it is important that they do truly measure excellence.

Many researchers have used the institutional ranking results of colleges as a correlative parameter in their research models. These usages range from correlating the size of PhD programs in various disciplines,³⁰ to justifying whether it is financially beneficial for students to attend schools with highly ranked reputations.³¹⁻³⁵ While individual faculty may use ranking results from multiple services in many ways, institutions also use these same rankings in strategic ways.

Institutions

Arguably, the biggest use of school rankings for educational institutions is in self-

promotion.^{3,5} Colleges and universities aggressively use the rankings to promote themselves in their brochures and in other communications to prospective students, and their alumni.¹⁶ Schools also use these rankings when they recruit for graduates to enter as assistant faculty. Other institutional uses appear to be tied to compensation of high-level administrators since salaries correlate well with institutional ranking.³⁶

The media also use school rankings as a yardstick to justify their focus on certain schools when covering college related topics. There is a growing perception by the public that it is extremely difficult for high school students to get into college, a belief fostered by the media's exclusive focus on only the highly ranked schools. Claims have been made that the media tend to ignore all but the top ranked schools when choosing what to report in the news.¹⁶

Other institutions and individuals may be affected by the rankings too. Foundations and other non-tuition based revenue sources can change where their dollars go depending on the perceived quality of colleges and universities.² The positive correlation between school reputation and interactions with major corporations is shown by the fact that recruiting dollars by companies are allocated to institutions with high academic rankings while lower ranked schools are dismissed from consideration.²⁹

Literature Review and Hypothesis Formulation

A study similar to this one was done in 1999 on publication and school ranking, but took a different approach where they used total number of publications to correlate with a school's ranking.¹ One implication from that study is that one must be a fine scholar engaged in research appropriate to a specific field before one can become an excellent teacher.¹ A common argument supporting this claim is that faculty engaged in high level research will bring the results of that work into the classroom, making their classes more interesting and cutting edge.

In "College Rankings and Faculty Publications" Baughman and Goldman reported on an exploratory study they conducted that looked at whether or not there was an association between faculty scholarship and academic prosperity¹—understood here as an ability to attract a wide pool of applicants from which to choose. The core question asked was "is there a positive association between an institution's ranking and the degree to which its faculty produce scholarship?" The study used Barron's Profiles of American Colleges, which places all accredited four-year colleges and universities in the United States into one of six competitive rankings on a continuum from (1) non-competitive to (6) most competitive, and then compared it to data extracted from the Institute for Scientific Information (ISI) database.

The findings reveal a strong and positive association between scholarship and institutional ranking. However, this research didn't look at specific disciplines. The study showed that both scholarly productivity and Barron's ranking are closely correlated with the percentage of faculty members who hold a PhD degree. The article concludes by saying that more data are needed to further explore this relationship to see if the relationship holds true over time. The authors exhaustively documented an empirical relationship between faculty publication activity and

admissions selectivity across the full range of the American academy. A rebuttal article³⁷ that followed the original research pointed out, though, that faculty responsibilities are a "zero-sum game" - one must reduce workload on teaching if one is to do more on research. This argument has been supported by data from other studies.³⁸⁻⁴³ Faculty publications on either topical research or overall publications are but one of many indicators of value in assessing the quality of higher education.

For the purposes of our study, instead of using the total number of all publications, we have focused instead on the number of publications on educational issues related to the development of teaching in the engineering discipline. The argument could be made that faculty who concentrate heavily on technical research in their areas do not have as much time to spend on quality teaching. However, faculty that are involved with the pedagogical development of instruction are expending energy and time on improving teaching techniques, potentially leading to improved learning experiences for the students in their courses.

In this study, we conducted a comprehensive search of engineering education related information contained in non-monograph publications. We did not include textbooks since textbooks are normally content specific as opposed to being focused on teaching excellence. Therefore, since few engineering textbooks deal specifically with how to teach or learn better, our focus was on publications in journals and conference proceedings.

Methodology

In this section, we detail the methodology behind the data collection effort for determining the number of pedagogical references for each school. The major obstacle we encountered while testing our hypothesis was the inability to easily gather author affiliation information in an aggregated format we could use.

We used the Ei Compendex Web database to identify engineering pedagogical citations because it is the most comprehensive interdisciplinary engineering information source in the world. Ei Compendex Web is the machine-readable version of Engineering Index. However, the web version is more comprehensive for a variety of reasons, such as ongoing data clean up and filtering in missing issues when they become available. The primary reason, though, is because electronic databases do not have to have a cut off point like their print companions. Unfortunately, because of this variability, it makes it somewhat difficult for one to duplicate the exact research being presented here since publications from previous years are being abstracted and added to the database upon identification. Therefore, identical searches from the same time period may produce different results as was the case in this research.

Flawed as the U.S. News & World Report's methodologies are, we choose to correlate the publication of pedagogical materials with their rankings because of their popularity with college incoming freshmen and their parents. This will also highlight and document what critics have been saying all along, which is that the criteria these rankings are based on do not have a lot to do with attributes that significantly contribute to the overall student learning experience in a way that enhances positive learning outcomes.

To expedite our search we selected the Expert Search option in Ei Compendex because it allows for precision searching using a single search box. To execute a search within a specific field you simply use the “within” command (wn) and a field code. The field codes we initially selected for this search were the Main Heading (MH), and the Author Affiliation (AF). Each Compendex record is assigned a Main Heading that serves to represent the major subject aspect of the document. We utilized the truncation feature in the Main Heading because this allowed our search to include all of the derivatives of ‘education’.

Using the author affiliation field code to search proved to be problematic. Prior to 2001, the official Compendex policy regarding the Author Affiliation field was to provide only the institutional affiliation of the first author or editor, if it could be determined from the source document. However, in 2001 this policy changed to include only the affiliation of the corresponding author. Searching the author affiliation field yields only the corresponding author of the article. In Compendex, there is no easy way to identify the institutional affiliation of each author listed on a given article. To locate the other author affiliations would necessitate clicking on the author's name, and if the author was either the first or corresponding author on another publication, then the affiliation information could be retrieved. Another method would have involved first ascertaining the names of all the authors, then looking up those individuals in another database to determine what institute they are affiliated with, and then to determine if they were affiliated with said institute at the time of the institute's ranking.

Upon realizing that the database could not provide author affiliation information for all the authors in a given article, it no longer made sense to use the author affiliation as a search strategy. Instead, we conducted a search in the Main Heading field looking for variants of the word education in specific years. The individual results of that search were printed and the author affiliation in each citation was examined to identify the names of institutions in the author affiliation field for the time period of 2000 to 2002.

We truncated the word "education" using the following search string “education* wn mh” in the expert search mode, to search for derivatives of the word education in the Main Heading field of Compendex between 2000 and 2002. Our inquiry produced 1, 579 records. Out of those 1, 579 records, a much smaller number have been identified through the Author Affiliation field as being written or co-written about engineering pedagogy by individuals from institutions which were ranked in the top 25 US News and World Report Best Undergraduate Engineering for either programs with Ph.D. Programs or those without Ph.D. programs whose highest awarded degree is either a bachelor's or master's degree. In the results and discussion section, we summarize the number of pedagogical articles that were published between 2000 and 2002 from the top ranked schools.

As has already been mentioned, we chose to use the rankings published by U.S. News & World Report primarily because it is the most widely read publication for college rankings.^{2,14} It is also one of the few ranking services which ranks graduate and undergraduate-engineering schools separately, as opposed to those who combine graduate and undergraduate programs in one overall ranking. The category “Best Undergraduate Engineering Programs” was first featured

in the 2000 edition of “American’s Best Colleges.” This is a critical distinction because one would expect that graduate rankings should be closely tied to the number of technical publications since graduate degrees heavily emphasize research as a major component of educational development. In fact, most ranking services did not begin separating undergraduate from graduate programs until recently so it would not be possible to do a longitudinal time study for these other categories.

For the purposes of our research we focused on both the schools whose highest awarded degree is the Ph.D., and those whose highest awarded degree is the bachelor's or master's degree. Initially we suspected that the number of schools whose highest awarded degree was a bachelor’s or master’s degree would have too few ranked schools to be statistically significant. However, since the information was easily gatherable we decided to collect and report it.

Results and Discussion

In Figure 1, we show a breakdown of the total number of articles found and the categories they fit within.

Out of the 1579 records that listed ‘education’ as a main heading in Ei Compendex Web between 2000 and 2002, 191 of those publications listed no affiliation in the author affiliation field so they were excluded from the research pool, leaving a remaining 1335 publications. Three articles had an affiliation listed, but it was not clear which category they belonged in and they were similarly excluded from our study. Out of the remaining 1385 publications, 455 were

excluded because they were from schools outside the United States while 44 were from companies and therefore not under the purview of U.S. News & World Report. Our findings therefore are based on a pool of 886 publications written by faculty at engineering schools in the United States.

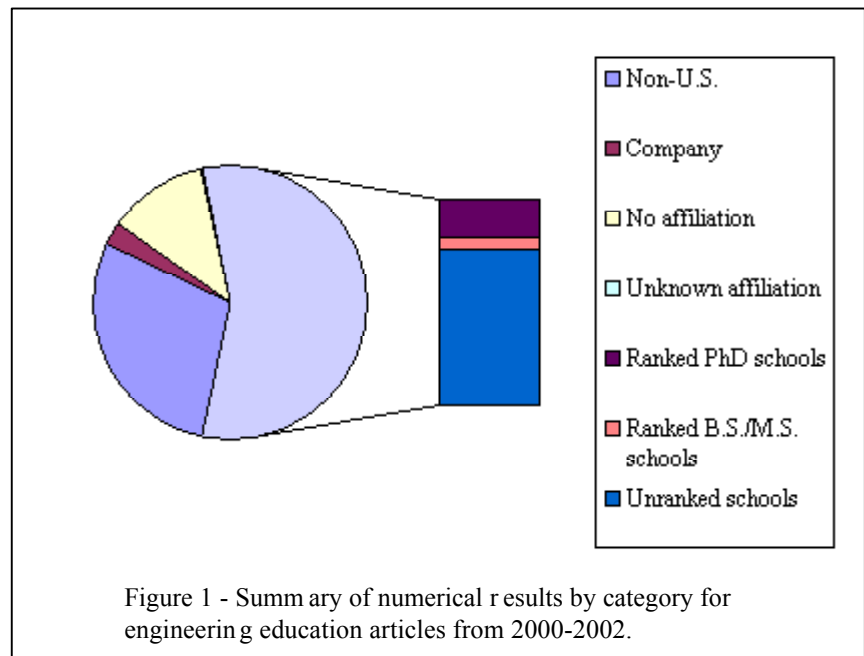


Figure 1 - Summary of numerical results by category for engineering education articles from 2000-2002.

The bar chart to the right of the pie graph shows the breakdown of the 886 articles into the subcategories of ranked Ph.D. granting institutions, ranked B.S./M.S. granting institutions, and unranked institutions. These groups are distinguished from one another because they are the classifications listed by U.S. News & World Report since 2000. Listing a school as ranked means that it was in the top 25 for one of the three years under study in this work. It is clear that the majority of articles are written by faculty at schools that were not ranked.

The results of the literature survey for the ranked Ph.D. granting schools are shown in Figure 2 by plotting the number of pedagogical publications in engineering from 2000 through 2002. When the top 25 engineering undergraduate schools from 2000 to 2002 according to U.S. News & World Report that grant Ph.D.'s were examined, there were only 28 unique schools. Two schools only showed up in a single year during the time frame looked at, and one school showed up in two out of the three year periods. Therefore, all 28 of the unique schools identified in the three-year time frame with the pedagogical publications from that same time period were compared in this analysis. The total number of publications by schools ranked at each position were used in the plot so that the data could be aggregated easily.

Note that there is no correlation between a school's ranking and the number of pedagogical publications during the time frame considered in this work. Similarly, Figure 3 shows the number of publications by ranked schools that grant B.S. or M.S. degrees as their highest degrees. We again see that there is no correlation with school rank. So, the bulk of pedagogical development within engineering as evidenced by publications is being done at schools that are not ranked highly by U.S. News & World Report.

A large number of publications, almost fifteen percent, are from outside academia or have no school affiliation. One would hypothesize that schools should be the ones driving the development of their disciplines since they have the closest contact with students but this does not appear to be the case. These results lead to some interesting ideas for further research on the topic of excellence in undergraduate engineering education and quantifiable ways of measuring it.

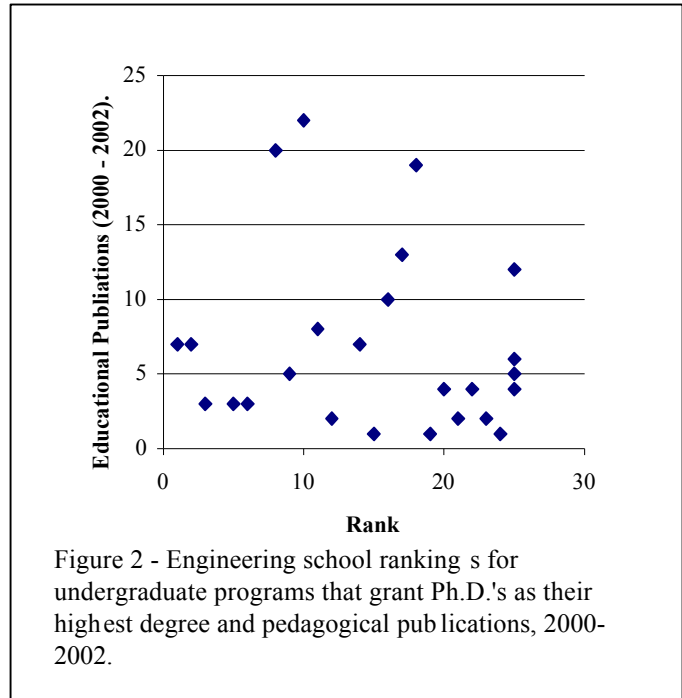
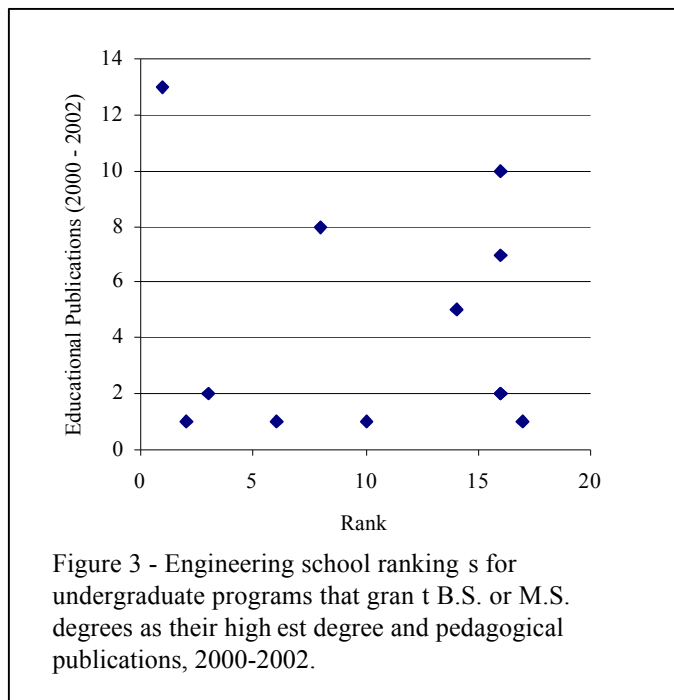


Figure 2 - Engineering school ranking s for undergraduate programs that grant Ph.D.'s as their highest degree and pedagogical publications, 2000-2002.



For example, the examination of the schools whose highest degree is a bachelor's or master's degrees showed that publication patterns did not correlate with school rank. One would have expected that the number of pedagogical publications would increase for these schools that do not have a large research component, i.e. schools that grant B.S. degrees as their highest degree, since professional development requirements would be met through these types of publications. This issue should be studied further to reveal if the number of pedagogical publications is a good correlating parameter for focus on education. Institutions that only grant B.S. degrees and that do little topical research would be expected to contribute more to the educational development of

the undergraduate students since their efforts would not be diffused by other demands.

Another research avenue based on this work could pursue the hypothesis that instructors that publish pedagogical articles are indeed better instructors. One could correlate student teaching evaluations for instructors who publish pedagogical papers versus those that do not over a period of time. Although teaching evaluations done by students are viewed by some as nothing more than a popularity contest as opposed to being a true measure of educational excellence, they are still one of the few quantifiable measurements of instructional effectiveness.²⁴ This line of inquiry would indicate whether pedagogical papers would be a good addition to undergraduate ranking criteria.

We touched on the argument that higher education is a "zero-sum game", meaning that if one concentrates more on research, one must necessarily reduce instructional efforts. Even the National Science Foundation expresses concern about this Zero-Sum situation in their guidelines for submission of their prestigious CAREER proposals that emphasize both technical and educational excellence. They say that proposals may not assume extraordinary time expenditures in order to reach their goals. Proposals must detail realistic time expenditures. Quantifying the numbers of publications in both pedagogy and technical areas would show if this zero-sum game does hold with more technical papers leading to fewer pedagogical papers. One could check this hypothesis by correlating these publication categories over a period of time. This data set could also then be used to see if the total number of publications, not just pedagogical publications, did correlate well with school rankings. One would expect that the higher number of publications correlates with higher rankings because many of the criteria used in rankings correlate with each other,¹⁸ i.e., the criteria are not statistically independent.

We have seen that several ranking systems use the total number of publications as one of their weighted measures that factor into the aggregated undergraduate engineering school ranking. However, the zero-sum affect would imply that technical publications should NOT be used in compiling undergraduate education rankings. The first argument would be that faculty who spend a large percentage of their time doing research or writing technical papers are forced to spend less time focused on their educational duties like lectures, office hours, and grading. The zero-sum situation shows that an increase in time spent on research leads to less time on other activities like education and service.

Many schools try to avoid the faculty zero-sum situation by buying out of classes. This would mean that professors who are very successful at research would be able to use research monies to hire replacement adjunct faculty to teach their courses for them. However, the ranking services often use the number of faculty with a certain academic rank or the number of faculty with the highest degree, or both, as criteria in their numerical evaluations. So, more research monies could lead to higher numbers of lower ranked instructors if faculty are buying out of classes. The perception of the ranking services is that adjunct faculty may be less experienced or have lower qualifications because they would be working as full time faculty for higher salaries if they could. However, the impact of adjunct faculty on student experiences is not clear because no research has been conducted on this issue. This could be evaluated with more data as well.

Another argument against using the number of technical papers published as a correlating paramant with ranking criteria for undergraduate education is that very few undergraduate researchers are included as authors on technical papers in engineering. This means that undergraduate contributions to these technical works are not viewed as being very important to the overall work. Students then are doing minor tasks that may not be enhancing their educational experiences.

Summary

We live in a society that stratifies us from the cradle to the grave, being constantly rated and placed in strata's of all types, sometimes for good reasons, and sometimes for not so good reasons. Yet, while most educators contend that it is impossible to place a meaningful numerical value on the quality of an education experience, college admissions boards across the country do just that every day when they set about quantifying perspective students' backgrounds, which is admittedly a less convoluted process. Nevertheless, most of the players in academia will readily acknowledge that there is a place for academic ratings. However, the discussion digresses when the talk moves to how some of these lists are paraded and viewed as being definitive when they can never be that. Institutions of higher education are not, nor are they intended to be, a "one size fits all" model.

The practice of quantifying qualitative aspects of an educational experience is a lucrative business marred in controversy in academia. The controversy surrounding these college rankings and rating systems stems from attempts to quantify quality. Most educators contend that it is impossible to place a meaningful numerical value on the quality of an education; nevertheless, many college ranking systems purport to do just that, often to the dismay of college admissions

officers. As much as critics of ranking systems complain about their unfairness and unreliability, practically everyone uses them for different purposes in one form or another and they are here to stay. With those sentiments in mind we would like to make the case for a more inclusive process in these ranking endeavors that include more attributes, which specifically measure teaching effectiveness. One measure would be to use the number of pedagogical publications in a field, but clearly more research on these topics are needed to resolve the issues raised in this work.

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