Undergraduate Research Grants Distribution at the University Favors Science

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Social Impact

Undergraduate research is a challenging but rewarding experience that adds value to a student's education. In college, most students are introduced to cutting edge research for the first time and are presented with many opportunities for involvement. However, undergraduates do not always recognize or act on this opportunity due to the nature of their major's curriculum or career goals. This work achieves a better understanding of the distribution of undergraduate research involvement at the University of Virginia through analysis of University-wide research grant awardees. We discovered a skewed distribution towards a select few engineering and science majors that had significantly higher application and award rates year to year. The small number of these majors relative to the total number of majors at U.Va. is of interest, and individual departments should work to promote research among their undergraduates.

Abstract

Undergraduate research is critical to developing future leaders and experts in academia and public service, and, in theory, should be diverse and inclusive of all fields of study at the University of Virginia. University students may apply for competitive Harrison and the Double Hoo awards, which are awarded across the University to enable and promote undergraduate research in all fields of study. In this study, we analyzed information on applicants and awardees to uncover trends in the students who apply, and ultimately win, these awards. We determined that science majors, notably Neuroscience and Environmental Science, and some engineering majors, notably Biomedical Engineering, are more likely to apply for and receive a research award. This outcome is likely due to these majors' research focus and opportunity for collaboration with graduate students and tenure-track faculty.

Introduction

Undergraduate research is a defining quality of leading research universities, and tends to flourish in science and engineering fields. At the University of Virginia (U.Va.), "Faculty research projects also provide distinctive learning opportunities for undergraduate and graduate students"("Vice President for Research," 2012). Grants for undergraduate research enable every student at the University to pursue research, but is the group of students who pursue such research academically diverse? Are they sufficiently encouraged and prepared to be competitive for such University-wide grants? Ideally at a large research institution like U.Va., each student should have equal ability and opportunity to pursue research. Here we retrospectively analyze trends in the Harrison and Double Hoo applications and awarded grants, to investigate the distribution of applicants as well as the distribution of winners across majors and fields. We hypothesize that an applicant's major, proposal category, and the advisor rank affect the applicant's probability of earning funding.

Background

Design of Undergraduate Research Programs:

Undergraduate research (UR) has many benefits to students, faculty, and universities. UR increases student retention rates and graduate school attendance rates, particularly in underrepresented groups (Merkel, 2003; Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998) and student and faculty participants in UR frequently report high levels of satisfaction with learning achieved by undergraduates in their collaborative research with faculty (Fechheimer, Webber, & Kleiber, 2011; Healey & Jenkins, 2009). UR develops the student's ability to understand a research problem thoroughly enough to investigate it with the scientific method, and communicate the results (Kardash, 2000).

In large public institutions such as U.Va., UR flourishes in some areas but not others, often due to the efforts of individual departments to promote UR (Merkel, 2003). Among the many departments at U.Va., Biomedical Engineering and Neuroscience maintain dedicated lists of on grounds research opportunities for undergraduates; Environmental Sciences encourages students to partake in its four research areas at affiliated research centers or on grounds. UR projects vary across majors, from "examining the travel diaries of Joseph Cabell, soldier, politician and friend of University founder Thomas Jefferson, the feasibility of manufacturing medical devices in developing countries, estrogen's effect on cocaine addiction, [to] battery effectiveness at higher elevations"(Kelly, 2013)

The David A. Harrison Undergraduate Research Awards:

A part of David A. Harrison II's extraordinary gift to the University, the Harrison Undergraduate Research Awards enables outstanding UR. The program funds, on average, forty of eighty UR project proposals with $3,000 each. Eligible applicants are first-, second-, and third-year undergraduate students from fields of study across the University who obtain faculty sponsorship and mentorship ("Harrison Undergraduate Research Awards," 2012).

The Double 'Hoo Research Awards:

The student-run Undergraduate Research Network successfully campaigned in Spring 2004 for the creation of the Double 'Hoo program at the CUE. Funding ran out in 2006-2007, but returned in 2008 with funding sufficient to keep the program running until 2012—it was not available in 2013. Teams of one undergraduate student and one graduate student at the University apply to receive up to $5,000. The award encourages collaboration between graduate and undergraduate students, giving the undergraduate student a valuable research experience and graduate students mentoring experience (Kelly, 2011). The program funded eight out of an average forty teams per year ("The Double 'Hoo Research Grant," 2012).

Methods

Five years (2007-2012) of Harrison Award application data were studied and three years of Double 'Hoo application data were studied (2010-2012). University of Virginia's Center for Undergraduate Excellence provided limited applicant demographics. The data was categorized in Microsoft Excel. Faculty mentor rank was researched using Virginia People Search and reported as of August 2012. Applicants were evaluated by the following metrics: major (e.g. Political science, Foreign affairs, Psychology), category (Humanities, Science, Engineering, Social Science, other), and advisor rank (Assistant, Associate, or Full professor).

A

Major	Win (z-score)	No Win (z-score)
Anthropology	7 (0.98)	4 (-0.98)
Biochemistry	3 (-0.34)	4 (0.34)
Biology	17 (0.66)	14 (-0.66)
Biomedical Engineering	10 (-0.95)	15 (0.95)
Chemical Engineering (ChE)	12 (1.00)	8 (-1.00)
Chemistry	11 (1.61)	5 (-1.61)
Civil Engineering	0 (-2.21*)	5 (2.21*)
Cognitive Science	3 (0.49)	2 (-0.49)
Economics	2 (-2.66*)	12 (2.66*)
English	5 (1.69)	1 (-1.69)
Environmental Sciences	6 (1.96*)	1 (-1.96*)
Foreign Affairs	6 (-1.17)	11 (1.17)
Global Development (GDS)	3 (0.49)	2 (-0.49)
History	9 (-1.71)	18 (1.71)
Mathematics	3 (0.49)	2 (-0.49)
Neuroscience	21 (2.62*)	8 (-2.62*)
Political & Social Thought	13 (0.73)	10 (-0.73)
Psychology	6 (1.48)	2 (-1.48)
Religious Studies	5 (1.69)	1 (-1.69)
Sociology	4 (1.39)	1 (-1.39)
Spanish	3 (-0.34)	4 (0.34)
Systems Engineering	0 (-2.21*)	5 (2.21*)
Undeclared	3 (-2.12*)	11 (2.12*)

B

Category	Win (z-score)	No Win (z-score)
Humanities	28 (-0.82)	35 (0.82)
Engineering	27 (-1.49)	39 (1.49)
Science	75 (4.09*)	41 (-4.09*)
Social Science	40 (-1.49)	54 (1.49)
Other	2 (-2.09*)	9 (2.09*)
Total (%)	172 (0.49)	178 (0.51)

C

Major	Win (z-score)	No Win (z-score)
Biology	1 (-1.45)	16 (1.45)
Biomedical Engineering	5 (1.98*)	7 (-1.98*)
Chemistry	3 (1.07)	6 (-1.07)
Civil Engineering	1 (-0.88)	10 (0.88)
Cognitive Science	2 (1.17)	3 (-1.17)
Environmental Sciences	0 (-1.21)	6 (1.21)
Neuroscience	2 (-0.24)	10 (0.24)
Psychology	1 (-0.99)	11 (0.99)

D

Category	Win (z-score)	No Win (z-score)
Humanities	2 (0.07)	9 (-0.07)
Engineering	8 (0.71)	29 (-0.71)
Science	10 (0.09)	46 (-0.09)
Social Science	3 (-0.66)	21 (0.66)
Other	0 (-0.92)	4 (0.92)
Total (%)	23 (.17)	109 (.83)

Table 1: Chi-square results as the number of win and no-win outcomes for each subset. * = p <0.05 for the z-score resulting from each adjusted residual. Chi-square tests of no association were evaluated at p<0.05 and had chi-squared values as follows: A. Harrison Award by Major shows association, and df = 48 B. Harrison Award by Category shows association, and df = 4 C. Double 'Hoo Award by Major shows no association, and df = 35 D. Double 'Hoo Award by Category shows no association, and df = 4.

Chi-square test

The data was analyzed using a chi-square test of no association to evaluate the correlation of majors or category of study to application outcome. It tested to see if the combined deviation from the mean for all of the degrees of freedom was significant (if the overall distribution was skewed). Standardized residuals adjusted to the expected outcome frequency (average outcome frequency of the entire set) identified which majors or categories had a significant unexpected outcome correlation (identifying which options skewed the distribution, and in which way). We expected the majors and categories to fall within a normal distribution around the average.

Win percentage

The win percentage (equation below) was calculated for each metric by the ratio of the sum the total number of wins, N_{win}, (e.g. the number of philosophy major awardees) to the sum of the total applicants, N_{total} (e.g the total number of philosophy major applicants). It identifies the probability of success for each major, but is highly sensitive to low numbers of total applicants.

$$win\% = \frac{N_{win}}{N_{total}}$$

Area plots

Area plots (reference Figure 1) graphically represent the relationship between win percentages and the number of applicants from a major or categories of study. They display the win percentage on the vertical axis, and the width of the bar along the horizontal axis represents the relative number of applicants. They provide a visual way of comparing the win-rates and the correlated number of students seeking awards. The chi-square test provides measures of significance for the win-rates, taking the size of each sub-group into account and removing the win-rate sensitivity to low numbers.

Harrison award

The Harrison award shows an overall win percentage of 49 percent (Table 1), and the chi-square test revealed a significant association between win-outcomes and major or category. Science shows a significantly higher number of win-outcomes, 65 percent, 16 percent higher than the population average (p<0.05), indicating a correlation between science applicants and awardees. Science also accounts for the large bulk of the applicants at 33 percent of the total applicants (Figure 1). Humanities nearly matched the expected win outcome, and Social Science and Engineering both show fewer win-outcomes than expected. Neuroscience and Environmental Sciences show significantly more win-outcomes than expected (p<0.05). Environmental Sciences

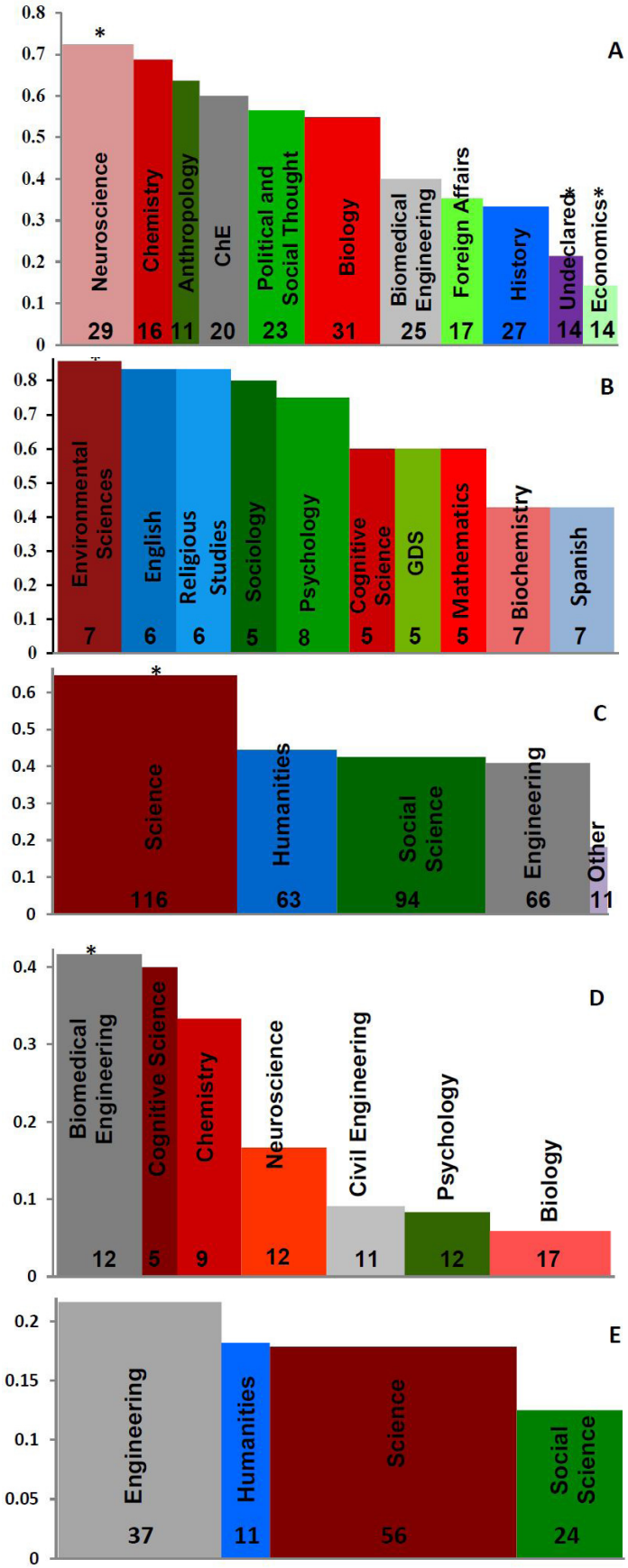

Figure 1: Area plots of table 1, * = p <0.05. A. and B. Harrison Award by Major. C. Harrison Award by Category. D. Double 'Hoo Award by Major. E. Double 'Hoo Award by Category. Generally Blues = Humanities, Reds = Science, Greys = Engineering, Greens = Social Science.

was an average source of applicants at 2 percent, while Neuroscience was one of the largest sources of applicants with 8 percent of total applicants. Economics, Civil Engineering, Systems Engineering, and Undeclared show significantly fewer win-outcomes than expected. Non-tenure track faculty have approximately half the win-rate of tenure track (data not shown).

Double 'Hoo Award

Chi-square test of no association show no association between category and win-outcomes. Similarly, there was no general observed association between the major of an applicant and his or her outcome, with one notable outlier: Biomedical Engineering shows higher than expected number of win-outcomes, with a win percentage of 42 percent, which is unusual given the average win percent of 17 percent (Figure 1D). Biology and Environmental Sciences both have fewer win-outcomes than expected. Biology is the leading source of applicants to the award.

Discussion

Because the ability to 'do science'—namely to develop, ask, and answer meaningful questions to further knowledge—is one of the largest takeaways from UR, it is not surprising that Science and its associated majors dominate both awards. The varieties of majors which have unexpectedly low win outcomes for the Harrison award are mostly Social Sciences and Engineering (e.g. Economics, Systems Engineering, Civil Engineering). Perhaps these majors primarily produce students more prepared to work in their field rather than to 'do science.' Majors from the Humanities also showed fewer win-outcomes than expected (e.g. Foreign Affairs, History). These material-heavy majors may tend to develop students' base knowledge in their field rather than their ability to discover new knowledge.

Neuroscience shows significantly higher than expected win-outcomes, given both the number of applicants and the size of the major—15 percent of the major applies for the Harrison award each cycle and 10 percent of the major wins a Harrison award each cycle. This result may be due to the faculty teaching the major encouraging and enabling students to pursue UR, which might be easily facilitated by the relatively small size of the major. In the Double 'Hoo, Biomedical Engineering's higher than expected number of win-outcomes is likely related to the strong graduate-undergraduate relationships in the department and the strong research focus of the major. Environmental Sciences students win significantly more often than the average in the Harrison, but have never won a Double 'Hoo—perhaps the nature of the research the graduate students in that field does not create attractive team projects.

In general, there is a strong correlation between the majors that are successful for each of the awards—Neuroscience, Biomedical Engineering, Chemistry, Psychology, and Cognitive Science are well represented in both awards—

indicating there is a set of majors whose undergraduates are better prepared to pursue undergraduate research. This set suggests that those majors, through coursework, curriculum, faculty, or department resources, effectively prepare students to compete for UR grants.

Non-tenure track faculty in the Harrison award show significantly less than expected win outcomes, which may correlate to the nature of their job position. No non-tenure track faculty advised Double 'Hoo applicants, likely because non-tenure track faculty do not have graduate students, which is central to the Double 'Hoo award. The ability of a student to find a faculty mentor may be a significant factor in the ability of students from any given major to apply. Matching undergraduates to faculty is a difficult process, and doing so successfully is even more difficult (Lee, Yam, & Guilford, 2011). It depends on both the culture of the faculty in each major and the type of students that major tends to attract—both of which are not analyzed here.

Conclusion

Overall, both the Harrison and Double Hoo awards show an academically diverse body of students applying and winning, but with a set of majors that routinely apply and win more often. Broadly speaking, areas which have a research focus as part of their curriculum or strong research groups among the faculty, such as Science, win more often than others. Certain majors—Biomedical Engineering, Neuroscience, and Environmental Sciences—also win awards significantly more often than expected. This correlation could be due to faculty involvement and the nature of the major. Undergraduate students from across the University apply for these awards successfully, and work to further the research mission of U.Va., yet clearly there are numerous departments and majors that have yet to engage fully in these two grant opportunities for undergraduates. Further research looks to investigate whether these trends prevail at other leading public research universities.

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