AC 2008-221: A SURVEY-BASED STUDY TO IDENTIFY METHODS FOR ACHIEVING POSITIVE OUTCOMES FOR UNDERGRADUATE RESEARCHERS

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A Survey-Based Study to Identify Methods for Achieving Positive Outcomes for Undergraduate Researchers

Abstract

This work describes the results of a survey administered to individuals involved in administrating and supervising undergraduate research. The purpose of the survey is to understand what factors lead to positive outcomes for undergraduate researchers. Positive outcomes include undergraduates pursuing graduate degrees, pursuing research careers and reporting their work at conferences and in journal publications. The factors investigated include various topics such as how candidates are identified, factors considered most important when selecting an undergraduate, defining a project for an undergraduate and assessing the undergraduate. Forty eight individuals, the majority of whom where professors (88%) at research institutions (56%), responded to the survey. Although there were not any statistically significant conclusions, the results suggest that (1) having a formal application procedure, (2) choosing undergraduates based on conceptual understanding and (3) assessing undergraduates based largely on critical thinking lead to more undergraduates attending graduate school.

Introduction

Conducting undergraduate research (UR) has been shown to have a number of positive outcomes for the undergraduate researcher including increasing confidence and understanding, clarifying interests in science, technology, engineering and math (STEM) careers and increasing the anticipation of a Ph.D[1]. Russell et al. recently performed an extensive survey for the National Science Foundation which included 3600 faculty, post doctoral and graduate student mentors of undergraduate research[1]. These mentors were identified because they were funded by one or more of the eight NSF programs with an undergraduate research focus. Although this study was comprehensive from the standpoint of NSF, mentors without funding from NSF may have been overlooked. This number could be significant given that many UR mentors (corporate) don't write proposals for funding and the funding levels of other organizations such as the National Institutes of Health, the Department of Energy, the Department of Defense, the Environmental Protection Agency and the United States Department of Agriculture are significant.

The inclusion of undergraduate researchers is a typical component of a successful research proposal. However, little guidance is given on how to ensure the best outcomes for undergraduate researchers. Given the importance of UR to the pipeline of graduate researchers, it is imperative that undergraduate research mentors are aware of the factors that lead to positive outcomes for undergraduate researchers.

Thus, the purpose of this work is two-fold. First, this study includes mentors that were contacted based on their affiliation with chemical engineering without regard to the agencies that fund their research. Consequently, this study should provide a different perspective than the Russell et al. study. Second, this study seeks to understand what factors from identification to assessment of undergraduate researchers effect positive outcomes.

Methodology

A web-based survey was formulated and administered to undergraduate research mentors affiliated with chemical engineering. The survey, consisting of ten questions listed in Table 1, was designed by the author with varying degrees of input from other chemical engineering UR mentors. Electronic messages were sent directly to over 150 chemical engineering undergraduate research mentors with a request to forward to applicable parties. The data were analyzed using primarily single variable statistics.[2] Forty eight mentors completed the survey.

Table 1: Survey Questions and Responses

Question	Example Responses
Please choose the option that best describes your institution.	Research, PUI, HBCU, Hispanic serving, Corporation, Government Lab, Other
Identify the undergraduate population at your institution.	Numbers ranging from 0-10,000
Identify the graduate population at your institution.	Numbers ranging from 0-10,000
What is your position?	Administrator, professor, post doc. etc.
With which of the following disciplines are you most closely affiliated?	Chemical engineering, environmental engineering, materials engineering, etc.
What is the primary mode by which you identify undergraduate researchers?	Word of mouth, formal application, informal application, from class, etc.
What factor do you consider most important when selecting an undergraduate researcher?	Enthusiasm for research, GPA, previous experience, academic level, etc.
Which of the following best describes the most important factor when defining a project for an undergraduate?	Ability of the student to perform tasks independently, opportunity to reinforce a class taken, etc.
On what primary basis do you assess undergraduate research?	Quality of results, critical thinking, enthusiasm, etc.
What has been the impact of the undergraduate research that you have supervised or been involved with? Please assess by identifying the approximate percentage of undergraduates that you supervised that are/were involved in the following activities:	Attending graduate school, pursuing careers in research, presenting at conferences for undergraduates, etc.

Results and Discussion

The focus of this study was chemical engineering UR mentors. Consequently, it was expected that the majority of the forty eight respondents would identify chemical engineering (73%) as the discipline with which they are most closely affiliated. Other disciplines with representation were chemistry (10%), materials engineering (4%), bioengineering (4%), other (4%), mechanical engineering (2%) and environmental engineering (2%). Table 2 shows the results for the institution type and position of the UR mentors. Over half of the respondents were from research institutions and greater than 80% are professors. Although corporate researchers were contacted, none participated in the survey. Similarly, although post doctoral associates and graduate students make up a significant fraction of UR mentors, none participated in the survey.

Table 3 shows the results for the undergraduate and graduate populations of the institutions. Half of the respondents are from institutions with more than 10,000 undergraduates. In contrast, most of the respondents have fewer than 3,000 graduate students at their institution.

Table 2: Responses for Institution Type and UR mentor position (% of 48)

Institution Type	%	Position	%
Research Institution	56	Administrator	4
PUI	17	Professor	88
HBCU	13	Post doctoral associate	0
Hispanic Serving	4	Graduate student	0
Corporation	0	Corporate researcher	0
Government Lab	6	Government research	6
Other	2	Other	2

Table 3: Responses for Undergraduate and Graduate Population (% of 48)

Undergraduate	Undergraduate (%)	Graduate (%)
Fewer than 1,000	6	29
1,000-1,999	4	17
2,000-2,999	10	6
3,000-4,999	8	25
5,000-10,000	21	13
More than 10,000	50	4
N/A	0	2

Table 4 lists the results for the methods that UR mentors use to identify undergraduate researchers. The most popular method is to choose students from undergraduate courses. Informal application and word of mouth were the next most popular methods. Interestingly, less than 20% of UR mentors use a formal application process. This process would include undergraduates from Research Education for Undergraduates (REU) programs and other structured programs. Table 4 also lists the selection criteria that UR mentors consider most important. Overwhelmingly, UR mentors consider enthusiasm for research the most important factor for selecting an undergraduate.

Table 4: Methods for Identifying URs and Criteria for Selection (% of 48)

ID Mode	%	Selection Criterion	%
Word of Mouth	23	Enthusiasm for research	73
Formal application	17	GPA	10
Informal application	27	Previous experience	2
From class	29	Academic level	4
Mining student transcripts	0	Conceptual understanding	6
Other	4	Other	4

Table 5 lists what UR mentors identified as the most important factor when defining a project for an undergraduate. Almost half of the respondents indicated that it is most important that the

undergraduate can perform the tasks independently. One explanation for this result is that there is no value added from the productivity standpoint if the undergraduate needs a significant amount of assistance beyond initial training. Another significant fraction indicated that the opportunity to learn something completely new is most important. Table 5 also lists the results for the primary basis that UR mentors use to assess undergraduate research. The most popular method was critical thinking and quality of results was second. Given the uncertainty of research, it seems reasonable that the most popular method of assessment is critical thinking. One avenue for further analysis would be to determine if there is a link between defining a project that the student can conduct independently and assessing the undergraduate based on the quality of the results.

Table 5: Defining Projects and Assessing Undergraduates (% of 48)

Defining a Project	%	Assessment	%
Ability of student to perform tasks independently	48	Quality of results	33
Opportunity to reinforce a class taken	4	Critical thinking	42
Opportunity to learn something completely new	25	Enthusiasm	13
Ability to be completed in a short time frame	13	Attendance	4
Likelihood of yielding good results	10	Other	8

The following outcomes were listed for UR mentors to evaluate: attending graduate school (Outcome 1), pursuing careers in research (Outcome 2), presenting at conferences for undergraduates (Outcome 3), presenting at general conferences (Outcome 4), authoring journal articles (Outcome 5) and authoring conference proceedings (Outcome 6). UR mentors were asked to indicate the percentage of undergraduates supervised who had participated in the activities listed as outcomes. The results are not weighted based on the number of students supervised. Figure 1 shows the averages for each response. There was no statistical difference for each of the outcomes. This is believed to be caused in part by the misinterpretation of the question. In particular, several responses were very low integers (1, 2, 3, etc.) suggesting that the question was answered in absolute terms rather than on a % basis. Based on the average alone, attending graduate school and presenting at conferences for undergraduates were the most popular outcomes at 44% and 46% respectively.

Going forward, the contribution of each factor to the percentage of undergraduates attending graduate school will be investigated. This outcome was chosen as the focus because it is assumed to be of more interest than undergraduates presenting at undergraduate conferences.

Figure 2 shows the relationship between the method of identifying undergraduates and the likelihood that they will attend graduate school. The number in parentheses refers to the number of respondents without the inclusion of the "other" category. The results suggest that undergraduates who formally apply are more likely to attend graduate school. Figure 3 shows the relationship between the method of choosing undergraduates and the likelihood that they will attend graduate school. Most respondents indicated enthusiasm for research as most important, but there may be a more positive relationship for indicating conceptual understanding as the most important factor. The number of respondents (3) is low which complicates that inference. Figure 4 shows the relationship between the method of defining a project and the likelihood that the undergraduate will attend graduate school. Defining a project that can be completed in a

short time frame appears to be the least effective method to ensure that an undergraduate researcher will attend graduate school. Finally, Figure 5 shows the relationship between the method of assessment and the likelihood that an undergraduate will attend graduate school. Assessing an undergraduate based on critical thinking appears to have the most favorable relationship to an undergraduate attending graduate school.

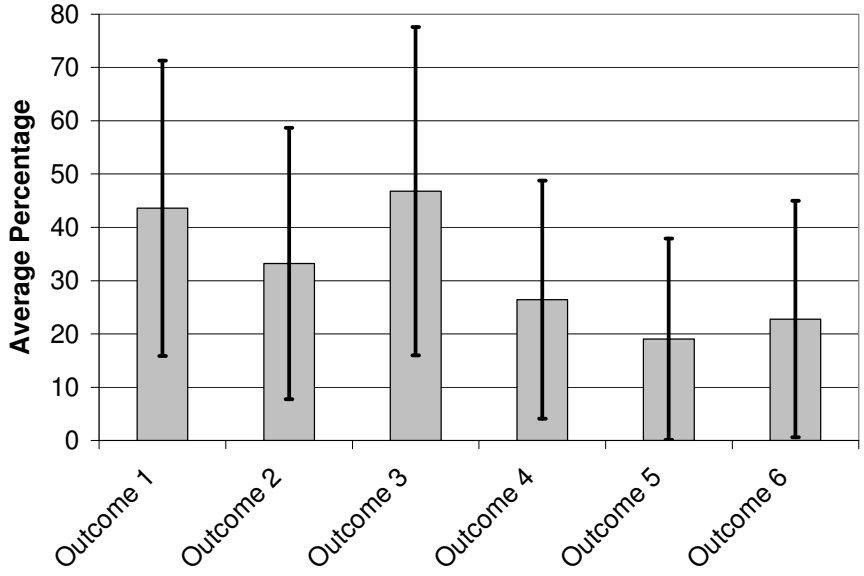

Figure 1: Outcomes Reported for Undergraduate Research

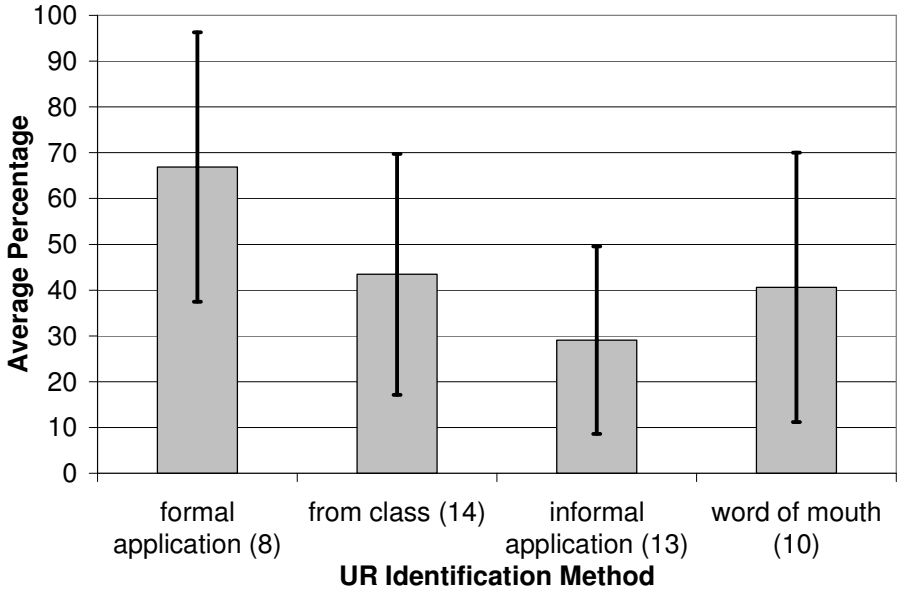

Figure 2: Relationship Between Method of Identifying Undergraduates and Attending Graduate School

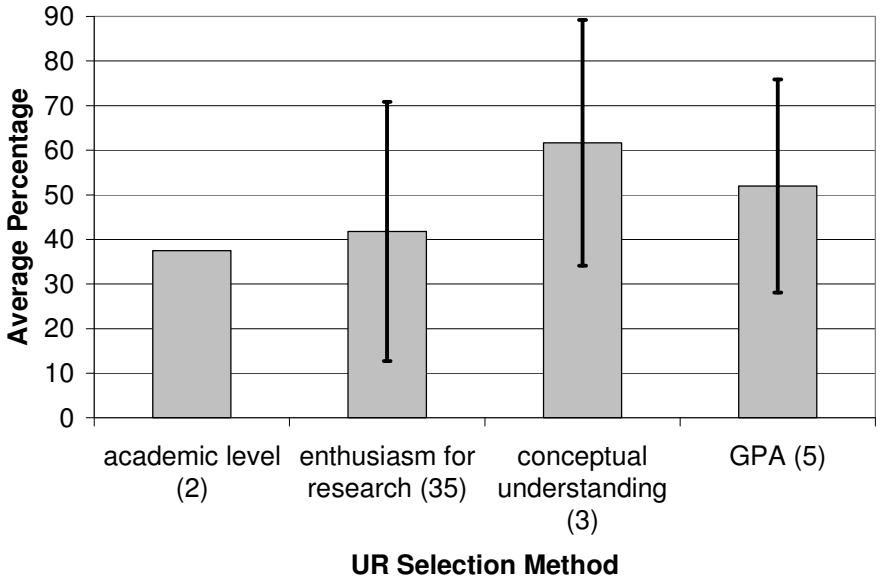

Figure 3: Relationship Between Method of Choosing Undergraduates and Attending Graduate School

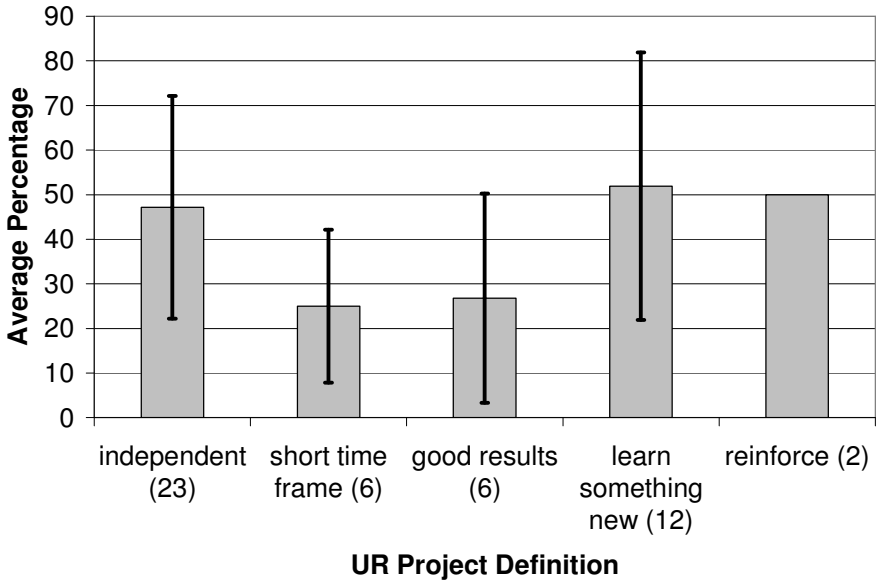

Figure 4: Relationship Between Method of Defining a Project and Attending Graduate School

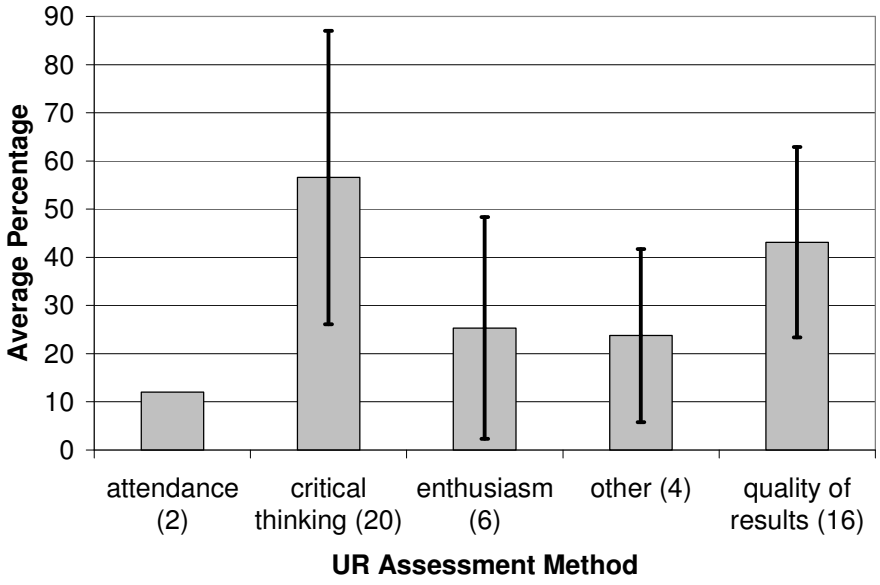

Figure 5: Relationship Between Method of Assessment and Attending Graduate School

Conclusions

A survey was conducted to identify factors that lead to positive outcomes for undergraduate researchers. Forty eight respondents, the majority of whom were professors from research institutions, completed the survey. Although there were not any statistically significant conclusions, the results suggest that (1) having a formal application procedure, (2) choosing undergraduates based on conceptual understanding and (3) assessing undergraduates based largely on critical thinking lead to more undergraduates attending graduate school.

Acknowledgements

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References

1. Russell, S. H., Hancock, M. P. and McCullough, J., "Benefits of Undergraduate Research Experiences," *Science*, Vol. 316, 2007, pp. 548-549.
2. Weisberg, H. F., Krosnick, J. A., Bowen, B.D., *An Introduction to Survey Research, Polling and Data Analysis*, 3rd *ed*., London: Sage Publications, 1996.