AC 2009-2436: A ONE-WEEK INTENSIVE SHORT COURSE FOR INTRODUCING LOWER-DIVISION STUDENTS TO UNDERGRADUATE RESEARCH

David Bahr, Washington State University

David Bahr is a professor in Mechanical and Materials Engineering at Washington State University. He serves as the campus-wide Director of Undergraduate Research for the Washington State University Office of Undergraduate Education.
A One Week Intensive Short Course for Introducing Lower Division Students to Undergraduate Research

Abstract

This paper describes a short course used to introduce students to an undergraduate research environment at Washington State University, a rural residential land grant university. The course runs the week after classes end, and consists of nine topics presented in half day module formats. The program has run since the summer of 2007, and has served 32 students as of fall 2008. Students from engineering and science majors from across campus were selected from applications solicited from primarily first year students, though the program also included first year transfer students. The paper will describe the modules, ranging from gaining library skills to research based career options to finding an advisor and best practices for poster presentations. Students were provided a stipend for housing during that week, and a stipend for research expenses during the subsequent semesters. The paper will also discuss the retention rates and motivation surveys from the program. The students selected for the program had a GPA average similar to the college as a whole, and over 90% have been retained in STEM fields. Survey results suggest that one critical aspect of involving students in this program was a modest stipend to ensure financial concerns do not preclude participation for the students.

Introduction

Campus-wide undergraduate research programs at schools around the country support activities for a wide range of students. Many of these students have had little or no prior experience working in a laboratory research environment. Consequently, many university faculty, undergraduate research directors, and others involved in organizing college- and campus-wide activities anecdotally comment on the challenge of integrating these students into undergraduate research programs. This occurs both in providing the students with fundamental information about the process of research, as well as helping students understand the types of roles undergraduate researchers play in engineering research activities. Many of the ideas and plans in place or in progress at the nation’s research institutions are based on ideas laid out in the Boyer Commission report.

Many of the larger public research schools struggle with low retention rates in STEM fields; for instance, at Washington State University (WSU) freshman to senior retention in engineering fluctuates year by year between 45% and 48%. As noted in the literature, the independent aspect of research in STEM fields is often a capstone, held until the end of the curriculum as a culminating experience. However, it has been found that the retention rate of students in STEM increases with participation in undergraduate research; at WSU we have found that retention rates can double for students participating in research activities. Undergraduate research is regularly noted in the National Survey of Student Engagement as a significant way to improve student learning. Thus, undergraduate research programs, including those that incorporate coursework and/or peer mentorship, should increase student engagement and retention, particularly if they occur in the first two years of the college experience. It should be noted here that addressing community college transfer students, a source of almost 50% of the
It is important to identify the locally perceived challenges to including freshmen, sophomore, and initial transfer students in research activities. Anecdotal evidence from faculty members noted that the lack of skills and experiences are some of the barriers to including undergraduates in their research projects, particularly at the underclassman level. In particular, one of the major problems is misunderstanding of the role of independent research projects within a larger research organization, and disconnected expectations of workloads and faculty – mentor roles. However, faculty members that have mentored students from the freshman year onward report outstanding relationships and successes occur by the junior year. Another key factor noted by faculty participating on campus was that there is an initial “incubation” period for each student where their research productivity is relatively low, while their requirements for faculty time are high. While this is true for all students, there was a perception that this might be a larger challenge for younger students. These early stages of research activity are an impediment to both students and faculty participation, as they input significant effort and do not see a quick payoff. Hence, many faculty members hesitate to work with students younger than the senior year because “they don’t have enough experience”. However, most faculty surveyed informally also agree that even the senior students require substantial mentoring and time commitment from the faculty to have them fully participate in research endeavors on campus.

Our solution to this perceived lack of experience issue is to give students, particularly at the freshman and sophomore levels, the tools and training needed to become more effective researchers to reduce the “incubation” time required. By providing students skills and realistic expectations of the responsibilities entailed in successful undergraduate research projects we hope to dramatically increase the number and success rate of WSU students that participate in undergraduate research. This paper will describe a new undergraduate research experience on campus, based on our background information driving our choice of mechanisms, and a brief assessment of the initial pilot program.

Program description of the CURE

To address the problems noted above, WSU faculty have developed the “Cougar Undergraduate Research Experience”, targeted for students at Washington State University (the “Cougars”) that were either rising sophomores, early transfer students from community college, or other underclassmen that were interested in identifying research options on campus. The CURE is divided into a one-week summer portion and a mentor matching program during the school year, and started in the summer of 2007. The intensive one-week program, which runs at the start of the summer after courses have just ended, has so far included 32 students from most engineering disciplines on the WSU campus. Students were provided a $500 stipend to cover the costs of being on campus for that week, and were responsible for their own housing. During this one-week “boot camp” the students participate in a series of hands on group activities geared at teaching the skills they need to become productive researchers. After the successful completion of the intensive program, students are considered “certified” as having a jump start on research, and provided with access to $1000 in matching funds for a mentoring professor to cover student stipends and materials usage. This “stamp of approval”, and the financial incentive, has proven

graduating BS degrees in some engineering majors at WSU, is also a possible target group for this improvement in retention and engagement.
to be a marketable skill on campus, demonstrating to faculty that the student will have a certain set of tools which makes them an appealing candidate for undergraduate research programs during the school year and minimizing the initial financial risk.

**Summer Program**

The summer schedule rotates short lectures with active learning activities over the span of one week. There are two topics covered each day, with small group activities after each lecture, such as identifying resources on a specific research topic, separating popular sources from peer reviewed literature, writing a 1-page essay surveying faculty research opportunities, or carrying out a “Rube Goldberg-esque” task to develop lab notebook skills. A team of five faculty and two staff members act as instructors for the course; the staff include a full time librarian and a member of the Washington State Research Foundation’s Technology Transfer unit. Each topic, listed below, began with a short lecture, and then breaks for active learning activities. An active learning activity consisted of a short group or individual homework assignment, such as identifying several sources on a specific research topic, separating popular sources from peer reviewed literature, writing a one page essay surveying faculty research opportunities, scheduling a “Rube Goldberg-esque” task to develop organization practice, or other suitable 1.5-2 hour activities. After the activity, the group reviews the activity, usually with short presentations with the instructor.

After running this program for two years, the following topics seem to meet the needs of both the students and the participating faculty:

1. Finding an advisor, interviewing with faculty and creating a résumé geared at research and selection of a research project (this is a morning and afternoon session, and is tied in with presentations from faculty around campus on their research activities)
2. Discussions of intellectual property, scientific integrity and ethics in research
3. Understanding the difference between popular, textbook, and peer reviewed literature
4. Selection of information sources and use of library resources
5. Making and presenting posters for research symposia
6. Improving technical writing skills
7. Improving laboratory notebook techniques
8. Developing time management skills
9. Long term career options for research, including how federal and state funding options impact research activities

In the interests of providing a snapshot of the activities carried out it is instructive to describe two of them in more detail. The half-day session on the differences between popular, textbook and peer reviewed literature began with a power point discussion and lecture on the different types of information from a faculty member, and why it is important to carry out a literature review. Different sources of information were covered, ranging from the student selected Wikipedia to peer reviewed journals. After showing examples of all these on a topic of interest to the faculty presenter, the students were given an assignment that involved selecting a paper from a trade journal. Groups of 4 students were formed, and the students picked a paper from a selection of approximately 10 possible papers provided by the instructor. They had to find two different sources of information on their topic, including one peer reviewed paper, and then...
prepare a 5-10 minute presentation comparing and contrasting the differences in the information provided based on the source type.

The second half-day session that has definitely been embraced by the students and faculty, and is being adapted to other courses and student groups, is also related to references using library resources. The students were given a 30 minute presentation by the library staff on using peer reviewed search engine tools (such as Web of Science and EI Compendex). After this presentation, the students were grouped in randomly selected teams of 4, and were given a common paper published in 2002. They were then given an hour to find the earliest paper cited by papers cited by this paper in six steps or less, and they had to be able to print or copy the first page of the cited paper. They also had to find the most recent paper that cited the common paper. The groups competed to see who had the earliest and most recent papers. We developed a scoring method for the students to have a competition feel to the activity, with the points being awarded for the oldest paper as the number of steps taken times the age of the last paper found, and the points for the newest paper awarded as the number of steps taken times twelve minus the number of months ago the paper was published.

Using a focused, short, and intensive summer program has had several benefits. First, by positioning the program at the start of the summer the students were able to begin next semester ready to seek out research projects. Secondly, students were able to focus and experience the type of concentration and dedication required for carrying out research with faculty. Third, a short summer program does not dramatically interfere with summer jobs that are not on campus; an additional week after finals was not viewed as breaking up a large portion of the summer over which many students work to provide financial resources during the school year. Fourth, because we are not aiming to replace credits usually allotted to ABET organized curricula, the short course means students did not have an initial expectation of “getting out of” another course, or try and substitute this for a more traditional elective. Finally, by opening the application procedures to all interested students we did effectively allow self selection, students who could not dedicate a week to a program to advance their options probably are not good candidates or at a level of maturity required for long term research.

Providing the $500 stipend for housing, food, and incidental costs for the week-long program is a significant cost of the program. This incentive, approximately what students would make at an entry level internship, was given as a lump sum at the end of the week to ensure successful participation. We did not want students to decline participation due to costs, providing a stipend ensured broad participation regardless of economic background.

Results of student participation in the CURE

Of the 32 students that have participated in the program, 31% are women. This is significantly higher than the percentage than the general engineering pool at WSU for a similar cohort of students, which fluctuates between 13 and 18% women. Most students are still either engineering majors or in a STEM related discipline, of the 32 students 28 are currently enrolled in engineering majors; one is currently Pre-Med, one Psychology, one Cell Biology, and one Neuroscience. The average GPA of participants for summer 2007 was 3.46 (ranging from 1.8 to 4.0), and the summer 2008 participants had an average GPA of 3.27. After one semester there was no statistically significant difference in student GPAs (most changed less than 0.05), a
Wilcoxon-Mann-Whitney analysis produced a p value of greater than 0.05 for both cohorts. This demonstrates that the participation in this program has little impact on GPA on average.

Sixteen (50%) are fully ensconced in a research group: they attend meetings with faculty, graduate students, and post docs and are regularly pursuing research in those groups. One of the students in civil engineering has recently won a nationally competitive fellowship (further details are being withheld for confidentiality purposes); she was originally considering transferring out of engineering before the summer program and wasn’t sure she’d find engineering research work interesting. Through the CURE program she found an advisor in Agriculture, who was interested in taking a student from a very different discipline to help him in a project that required some water systems design and construction planning. This student is an example of the interdisciplinary work fostered by the CURE program, and her faculty research advisor has continued to support her on other research grants for over a year. The remaining students have worked sporadically with faculty, but not “found a home” or have slowed participation in research. Interviews with these students have found that in almost all cases they have decided that the work needed to participate in research during the school year may adversely impact their performance in the classroom. They have commented that the level of participation expected by faculty is greater than they feel they can currently commit to during the semester. Most are looking for REU programs in the summer to augment their CURE experience.

We have surveyed the student’s motivation for participating in the program, and find their preferences of the summer boot camp activities. The initial motivation survey examined their motivation for participating (i.e. rank your reason for participating from 1-4, and the students were provided a list of reasons previously noted by REU participants at WSU), their estimates of the hours a full time researcher would spend on various tasks per week, and their responses to the boot camp activities. The motivations grouped into three levels. The prime motivation factors were to “find out what it’s like to be a researcher” and to “gain hands on experience to go with class”. Students listed moderate motivators that included “find out if I want to continue in engineering”, “rather do research than non-research job”, “to improve analytical abilities”, and that it “sounded fun”. Finally, students were not concerned with “future travel to other universities” and “getting references from faculty for later career options”.

Students all said that they would like to get academic credit for this program (but that they would obviously do it without credit). The majority of students said that a stipend was nice but not mandatory, when asked what a one week stipend should be the average response was $238; 6 students said they would participate without a stipend. However, we note here that several of the students said that without a stipend they could not participate, and so to ensure broad participation from students in diverse economic backgrounds some stipend is probably needed, or an option to provide a scholarship to offset costs for lower income students.

Finally, in the surveys we examined the engagement level of the topics covered in the boot camp activities. The students selected their favorite sessions of the week; these were in order the sessions on keeping lab notebooks, using library search methods, and the presentation tips session. In the first year we included a session on critical thinking skills. This was the least favorite topic in the first year, and we have removed that and replaced it with the extended version of finding an advisor.
Summary

This paper has summarized the first two years of a pilot program consisting of a one-
week intensive short course format to provide research skills to first year undergraduates in
engineering. Our initial results suggest that a short course in the summer is a viable mechanism
to introduce undergraduates to research on campus. Of the 32 students that participated, over
90% noted that a one week, 40 hour program in the summer was much easier to participate in
over a school year course. The main motivation for participating was to gain experience and
determine if they want to participate in research activities. Most students would be able to
participate with a smaller stipend to cover housing expenses, though if no stipend were offered it
would have precluded 6 students from participating. Finally, the applicant and participant
demographics included a higher fraction of women than the general engineering population at
Washington State University.

Acknowledgements

This work was supported through the National Science Foundation’s Division of Undergraduate
Education under grant number DUE0633678.

Bibliography

1. Kenny, S.S., Chair of the Boyer Commission on Educating Undergraduates in the Research University.
Reinventing Undergraduate Education: A Blueprint For America’s Research Universities, (1998)
http://naples.cc.sunysb.edu/Pres/boyer.nsf/.

Undergraduate Education: Three Years After the Boyer Report, Stony Brook University (2001)
http://hdl.handle.net/1951/26013


Student Learning and Success, Indiana University (2007)
http://nsse.iub.edu/NSSE%5F2007%5FAbstract%5FReport/