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WHY INVOLVE STUDENTS IN RESEARCH?

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ABSTRACT

This article addresses the benefits of undergraduate research to students, to faculty, and to universities. Research experiences are credited with increasing motivation for learning, helping undergraduate students decide on a career path, forming mentoring relationships between students and faculty, and improving student performance in writing, speaking, and working in teams. For many students, research experiences are their most memorable experiences as undergraduates. From the perspective of universities, students bring enthusiasm to research teams and often ask insightful questions—sometimes quite by accident—that can change the ways faculty approach research inquiries. Student researchers contribute to the world of knowledge. Research universities have distinct advantages in offering undergraduate research opportunities. For example, research and education strongly complement each other. Undergraduate students benefit from the libraries, laboratories, and computers that support faculty research and graduate education. Our experience at Penn State indicates that offering research opportunities to undergraduate students is an educational activity that doesn't cost large sums of money, although it does require substantial commitments of faculty time. Offering undergraduate research is a valuable recruiting tool, especially for academically gifted students. Several examples of undergraduate research at Penn State are included, for students in a variety of academic disciplines.

BENEFITS OF RESEARCH TO UNDERGRADUATE STUDENTS

I'm pleased to report on a significant component of undergraduate education at Penn State—the involvement of undergraduate students in research activities. Undergraduate research can be a transforming experience in shaping lives. Research introduces students to the joy of discovery and makes the process of learning an active rather than a passive one.

Most, if not all, of us here believe that participating in research helps students, but how does this happen? What are the benefits to students and what are the benefits to faculty and to universities? Let's begin with the benefits of research from the perspective of the undergraduate student.

"Research enables students to make better choices about graduate school." Rosalyn Millman, Penn State, 1983.

Research can help students decide on a career path. It helps them decide if graduate school is the right choice. Rosalyn Millman was an undergraduate student who was an essential member of my research group for more than two years. Her experience helped to shape her interests in public policy. She went on to earn a graduate degree at Princeton University and a subsequent career in Washington DC. Ros served as the Deputy Director of the National Highway Traffic Safety Administration during the Clinton Administration, and was named a Penn State Alumni Fellow last fall.

Generations of students have asked for relevance in their studies: “Why do I need to learn this? When will I use it?” Research offers students a concrete demonstration of the principles and concepts covered in textbooks and lab sections. The active learning element of research allows students to make connections to their own interests that may not ordinarily be made in passive learning environments.

Research experience has been credited with improving students’ motivation for learning. Students can pursue their individual interests. Intellectual curiosity is sparked, and research provides undergraduates with an opportunity to take greater ownership of their own learning process.

Research projects often provide badly needed financial support for undergraduates and better prepare them for paid off-campus jobs or internship opportunities. It may, at the same time, yield academic credits toward their degrees. The students’ work is excellent value for the faculty member, too. And undergraduates, as newcomers to the research process, rarely feel that any of the tasks related to the research are beneath their dignity.

Mentor relationships with faculty often evolve. Students develop a different type of relationship with faculty than is possible within the classroom. The interaction is usually more intense and takes place over a longer period of time. It often provides the basis for a lifetime of personal connections and career guidance. Faculty research mentors are a great source of references and advice when students apply for jobs or graduate school.

Research—as an active learning process—challenges students to frame questions, develop a strategy for testing their propositions, analyze information, and report the results. Students learn to support an argument, to tolerate ambiguity, and often to see the world as the more complex place that it usually is.

Students also learn to work as a member of a research team. Research often involves group work, more in-depth interactions with colleagues, and development of improved communication skills. Employers are increasingly concerned about these characteristics.

Writing and presentation skills improve as students present their work at conferences and poster sessions. Published research papers and research experiences strengthen students’ résumés and graduate school applications. Research begins the habit of sharing research with other scholars, as well as appreciating and regularly reading published research.

For many students, research experiences are some of their most memorable ones as undergraduates. My only experience certainly reflects this proposition. My most memorable recollections of my undergraduate years at the University of Minnesota are those when I was part of a small group of students—including graduate students—who spent Saturday mornings with a young professor doing field research. I still remember the field sites, the propositions we were testing, our findings—and such things as the stop at the café for a late morning breakfast of bacon, eggs, coffee—and more conversation—on our way back to campus.

BENEFITS OF RESEARCH TO UNIVERSITIES

Besides the benefits to students, universities also benefit when undergraduates are involved in research. Students bring energy and enthusiasm to research teams. They’re hungry to learn and they often keep asking for more to do.

Undergraduate students ask questions that can be very insightful—sometimes quite by accident—and can change the ways faculty approach research questions. They’re not yet afraid to make mistakes. They force us to respond to questions in different ways and on different terms

than we often do with graduate students and other faculty members. Faculty learn from students, just as students learn from faculty.

Student researchers contribute significantly to the world of knowledge. One of the joys of my job is learning about the contributions of our faculty and students to scientific discovery and creative accomplishment. I'm thinking, for example, of Nicholas Bond, our undergraduate student in Astronomy and Astrophysics who recently discovered—in collaboration with other astronomers—giant “superbubbles” in a very distant galaxy. Superbubbles are huge spherical regions where thousands of exploding stars have blown holes in the gaseous medium between the stars. Nicholas has received substantial professional acclaim and major national media coverage.

Undergraduate research breaks down the divisions between undergraduates and grad students and between faculty and students. And, it's a great factor in building maturity among young people as they interact with more seasoned professionals.

Offering strong programs supporting undergraduate research strengthens our requests for research funds. There are an increasing number of federal research grants that now require evidence of undergraduate student involvement in research as a condition of the award of funding.

Offering undergraduate research is also a valuable recruiting tool, especially for academically gifted students. After all, the potential involvement of undergraduates in research is one of the most important assets that research universities such as Penn State have to offer prospective students.

ADVANTAGES OF RESEARCH UNIVERSITIES

The Committee on Institutional Cooperation (CIC) prepared a report some years ago called *Values Added* about the advantages of an undergraduate education at a major research university (Committee on Institutional Cooperation, 1989). Several of the advantages cited relate to research; for example,

1. Teaching and research support one another. Advancing the state of knowledge through research strengthens teaching. Teaching the material and discussing it with others may stimulate new lines of research or application of the findings.
2. The undergraduate experience benefits from the resources maintained to support faculty research and graduate education, for example, libraries, laboratories, computers, other facilities and equipment.
3. Personal interaction between undergraduate students and active scholars benefits both. Role model and mentor relationships motivate students. Faculty will be motivated by the increased success and drive of their students.
4. Research universities offer their undergraduates a vast range of options for specialized study. The many and diverse specialized research interests of our faculties create wide opportunities from which students can select.

5. Research activity brings to campus a constant flow of people from outside the university—leaders from business, industry, government, and other universities. These guests visit classrooms and public forums, contributing to an enriched educational experience.

COSTS/TRADEOFFS OF A RESEARCH-BASED APPROACH TO TEACHING

Applying a research-based model to teaching is easier to implement in small classes, rather than large classes, although Penn State is implementing this in some large classes. One example is the recent changes in Economics 002 and 004, in which students write joint research papers on economic topics, combining writing and active learning in a large class.

Research-based teaching may require slightly more time on the part of the faculty, at least initially. There is certainly truth to this statement, as there is always more time spent on laying the groundwork for effective research contributions with undergraduates.

Switching from lecture-based to research-based courses requires some real adjustments on the part of faculty and students. Some students object to taking more responsibility for their own learning, and prefer the more passive non-research-oriented environment of their previous experiences in both high school and college.

In some instances, universities may be trading some breadth of content coverage for greater depth. This has been one of the constant concerns in Problem-Based Learning. But we also know that material covered in a research-based course will be better understood, better retained, and more easily applied by students. Evidence that I have seen related to medical education, for example, indicates that students in PBL perform equally well on standardized tests covering a wide range of material. Of course, we need to remember that undergraduate research—or most other approaches to learning for that matter—isn't necessarily the best for all students or all knowledge acquisition.

ADMINISTRATIVE SUPPORT FOR UNDERGRADUATE RESEARCH

With the cooperation of the academic deans at Penn State, we have been able to increase the number of students who are engaged in undergraduate research opportunities. Our experience indicates that this is not a costly venture in monetary terms, although it does require substantial commitments of faculty time.

Let me give you an example. For nearly a decade, Penn State had a small fund administered from my office called the "President's Fund for Research." This fund was used to support faculty research. It was customary for faculty to write lengthy proposals to get a few hundred or, at best, a few thousand dollars for their projects.

Believing that faculty time could be put to better use, I changed the format for the President's Fund. We granted block funds to the colleges and told the deans to pass on the funds to faculty for the exclusive use of supporting undergraduates involved in research. We also required the colleges to match my funding at least one-for-one, and we specifically stipulated that faculty should not write more than a paragraph or two supporting their request. The results have been positive far beyond our hopes.

Information as to the exact number of students involved in these block grants is difficult to pin down. But our data from the 1999-2000 academic year—which is admittedly conservative—

show that total funding of \$241,000 supported at least 295 projects involving 200 faculty and over 470 undergraduates.

In addition, a recent survey of Penn State's colleges reveals that over 5,200 undergraduates participated in some form of research this year. We know that about 500 undergraduate students complete a formal research thesis each year, working one-on-one with a faculty member. Our payroll data scans indicate that nearly 600 undergraduates each year are financially supported by faculty members' sponsored research projects. And many other students simply volunteer for a chance to participate on faculty research projects.

EXAMPLES OF UNDERGRADUATE RESEARCH PROGRAMS AT PENN STATE

Let me share just a few of the first-rate examples of undergraduate research at Penn State.

The Learning Factory Showcase displays the results of senior capstone design courses in engineering. Students work in teams on industrially sponsored engineering design projects. The projects include both written and oral presentations. Students, industry sponsors, faculty, and parents attend a Project Showcase, and a panel of industry judges give awards for Best Product Design and Best Process Design.

The Schreyer Honors College and the Office of Undergraduate Education host an Undergraduate Exhibition every March. This event provides an opportunity for **all** undergraduates at Penn State to share their research and creative accomplishments—from art and anthropology to astrophysics and engineering. The number of participating students is increasing each year.

WISER (or Women in Science and Engineering Research) is a program for first-year women students in science-related fields—science here broadly defined. Students are matched with a lab or faculty member and agree to work at least five hours a week. The purpose is to retain women students in science and engineering fields.

The Eberly College of Science offers a Summer Research Program, funded by the John and Elizabeth Holmes Teas Scholarship. Its goal is to support every interested chemistry major for one summer of research; 80-90 percent of undergraduates in chemistry will do research at some point in their undergraduate careers, and many graduate with one or more publications. Undergraduate chemistry major Morgan Mihock, for example, uses a laser to break apart molecules; Morgan and faculty member Tom Mallouk are trying to create a clean, renewable alternative to fossil fuels.

Research sometimes involves international study—often a first for our students. Students from Geosciences, Art History, Arts, and Landscape Architecture have participated in archeological fieldwork in southern Egypt under the direction of several Penn State faculty. Students studied groundwater levels and geologic strata and identified buried monuments and structures.

Closer to home, Dr. Lakshman Yapa, known as Lucky to his friends and students, leads a student service-learning project which researches urban poverty in West Philadelphia. Students undertake research-based thesis projects looking at different aspects of urban life, living for several weeks in a Quaker work camp located in the midst of the community.

Besides promoting undergraduate research, Lucky Yapa and his students are changing the way we look at poverty. For example, students examined the transportation system and learned how the emphasis on cars and the lack of public transportation, carpooling, or safe routes for

bicycles helps to create poverty. Other students studied the potential of urban gardens to increase food production and supply fresh produce to city restaurants, and investigated nutrition and food prices in the West Philadelphia neighborhood.

CONCLUSION

The offices of the Vice President for Research and the Vice Provost and Dean for Undergraduate Education in cooperation with the Schreyer Honors College are now regularly devoting an issue of *Research/Penn State* to undergraduate research. Students in each of Penn State's colleges have contributed lively accounts of their research, including their reactions to the experience and thoughts about its potential impact. Dana Bauer, editor of the September 1998 issue, said this of the experience:

Undergraduates are willing to try anything, a professor told me when I was working on my thesis, a magazine about undergraduate research. He was right. My staff of undergraduate writers and I, the editor, interviewed researchers who traveled to Australia to study zoos, spent hours sitting in lab sifting through dirt to find bits of dinosaur teeth, and designed a project to help community leaders understand the ecological effects of over-development. The students that we wrote about were more interested in the process of exploration than the outcome and that's what undergraduate research should be about: learning to discover.

Research universities are discovering (once again) that research and undergraduate education are not in conflict but complement each other. Through research, we are able to offer personal attention and hands-on experiences to our undergraduate students. We want to increase the number of research opportunities that we can offer to students and encourage more students to take advantage of these opportunities. Students tell us that these experiences are making a real difference in their lives.

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