Undergraduate Research at Six Research Universities

A Pilot Study for the Association of American Universities

Carolyn Ash Merkel
Director, Student-Faculty Programs
California Institute of Technology
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Introduction

Students matriculating into American research universities enter a diverse, rich, and dynamic environment that promotes academic rigor and intellectual and personal growth. Students learn from professors who are engaged in forefront research in all fields, and a few students have always had the opportunity to work with faculty in their projects. Over the past fifteen years, a spate of articles, reports, and books have been written criticizing the research universities for emphasizing faculty research at the expense of teaching. These articles helped to reinvigorate undergraduate education and increase opportunities for students to engage in research. As a result, students have gained advantages, faculty have benefited, and institutions have profited. An ever-growing accumulation of anecdotes about the benefits of undergraduate research attests to the importance of the enterprise even as the criticism continues to push universities further into teaching and educational reform. The controversy piqued my interest in what makes the undergraduate research enterprise flourish within the culture of some institutions and not in others.

A Brief History of Undergraduate Research

In 1969, MIT established the country’s first campus-wide program, the Undergraduate Research Opportunities Program (UROP), founded by Dean Margaret MacVicar and President Paul Gray (http://web.mit.edu/urop/index.html). In institutionalizing undergraduate research, MIT declared that undergraduate students should have the benefit of the mentor-protégé relationship and that they should become recognized members of the scholarly community. Ten years later, then-professor of chemical engineering Fred Shair founded Caltech’s Summer Undergraduate Research Fellowships (SURF) program. The benefits to the students, the faculty, and the institution for both Caltech and MIT have extended far beyond what the founders of these programs initially envisioned. Both programs have served as models for programs at other institutions.
In the early ‘80s, the National Science Foundation (NSF) created its Research Experiences for Undergraduates (REU) program to provide support for students to participate in research with faculty. REU takes the form of site grants to support a number of students (8-10 or more) to work on projects within NSF’s areas of interest. In FY 2001, close to 32,000 students nationwide will be introduced to research. In addition, NSF REU supports undergraduate research through supplemental funds to faculty grants (http://www.nsf.gov). Through the REU program, NSF has promoted the undergraduate research enterprise and created a legacy that continues to benefit students and universities.

In 1987, the Carnegie Foundation published *The Undergraduate Experience in America*, which concluded that undergraduates at large research universities were less satisfied with their college experiences than peers at other kinds of institutions (Grassmuck, 1990). In *Scholarship Reconsidered*, Boyer challenged universities to “break out of the tired old teaching versus research debate and define in more creative ways what it means to be a scholar.” He went on to propose that universities strengthen research, integration, application, and teaching starting at the highest levels of university administration (xii). State legislatures took up the call and pressured their public universities to reform undergraduate education (“Transforming the State Role,” 13).

These articles and others created the perception among many groups that teaching and research are separate, even opposite, activities, and the increasing publicity stimulated and challenged the academic community. Stanford, Cornell, and Michigan were among the first research universities to advocate reforms ranging from the introduction of new criteria for the promotion and tenure of faculty members to the creation of more effective teaching methods and adoption of new approaches for managing and obtaining funds (Grassmuck). Supported by NSF and the Johnson Foundation, Sigma Xi held a national conference at Wingspread in Racine, Wisconsin, in 1989 on “An Exploration of the Nature and Quality of Undergraduate Education in Science, Mathematics, and Engineering.” The purposes of the conference were to “explore the nature and quality of undergraduate education” and to “identify significant topics and issues that should be
addressed in charting policy…” The conference urged reforms in the faculty reward structure for teaching; inclusion of undergraduates in research; curriculum reform in science, math, engineering, and technology (SMET) courses; and attention to the development of underrepresented groups (23-24).

In 1978, a group of chemists from liberal arts colleges, under the leadership of Professors Michael Doyle and Jerry Mohrig and Dr. Brian Andreen from Research Corporation, collaborated to form the Council on Undergraduate Research (CUR) to promote undergraduate research at the liberal arts colleges (www.cur.org/timeline.html). CUR has grown into an organization of 3,000 members from 850 institutions representing eight disciplines. CUR helps to strengthen the research programs of faculty in predominantly undergraduate institutions and promotes research by undergraduate students in all settings of science, mathematics, and engineering education. CUR believes that education is best served by faculty-student collaborative research combined with investigative teaching strategies. It provides avenues for faculty development and helps administrators to improve and assess the research environments of their institutions and generates awareness and national support for undergraduate research. CUR speaks on behalf of primarily undergraduate institutions. It works with federal agencies and private and local organizations to develop and maintain research-based educational opportunities (http://www.cur.org).

The first National Conference on Undergraduate Research (NCUR) was held at the University of North Carolina at Asheville in the spring of 1987. Professor of Chemistry John Stevens, who conceived and chaired the conference, expected perhaps 200 students from schools within a 500-mile radius of Asheville. Instead, the conference drew 500 students, faculty, and administrators from institutions nationwide. NCUR welcomes students’ presentations in all disciplines, and it provides an excellent opportunity for students to share information and ideas across academic fields. It is an opportunity for students to discover how research is carried out and reported in various disciplines. More than 2,000 students, mentors, and administrators attended the 2001 conference at the University of Kentucky. According to Werner, et al., NCUR governance has evolved into
a non-profit organization that, in addition to promoting the conference, awards grants for interdisciplinary undergraduate research through the NCUR/Lancy program.

Under the leadership of Jeanne Narum, Project Kaleidoscope (PKAL) was established in 1989 with support by the National Science Foundation to promote inquiry-based teaching of SMET courses. The initial challenge was to identify what works to bring successful policies and practices to the attention of the larger undergraduate community and to facilitate the adaptation of such programs in other settings. Among other things, PKAL encourages faculty to be leaders in reform with special attention to faculty at an early stage of their careers through the Faculty for the 21st Century program (http://www.pkal.org/history2.html).

Private foundations have played an important role in the promotion of undergraduate research. In 1987, the Howard Hughes Medical Institute (HHMI) announced that it would begin awarding grants for science education related to biomedical research. Two years later HHMI awarded $61 million to 51 universities to help strengthen undergraduate science education and to increase the number of students who pursue research and teaching careers in biomedical sciences and related disciplines, including chemistry, physics, and mathematics (http://www.hhmi.org/about/a330.html).

More recently the Arnold and Mabel Beckman Foundation established an invited grant program to stimulate, encourage, and support research activities by exceptionally talented undergraduate students in the fields of biology and chemistry (http://www.beckman-foundation.com). Grants provide generous stipends, travel, and supplies and encourage top students to engage in research over the course of two summers and the intervening academic year rather than the eight to ten weeks of funding provided by other programs. This model allows students to become more deeply involved in research.

Professional societies such as the American Physical Society and the American Chemical Society have promoted undergraduate research through inclusion of student poster
presenters in their meetings and conferences. The theme of the 1999 Sigma Xi annual meeting was undergraduate education, including undergraduate research.

In 1998, the Boyer Commission of the Carnegie Commission on Higher Education issued a report on undergraduate education in America. The report criticized the research universities for not providing “maximal opportunities for intellectual and creative development” through, among other things, “opportunities to learn through inquiry rather than simple transmission of knowledge.” To ameliorate these deficiencies, the Boyer report recommended that universities provide research-based learning, undergraduate research, and internships. It suggested starting students in inquiry during the freshman year. It put forth the idea of a mentor for every student and removing barriers to interdisciplinary education. It encouraged universities to cultivate a sense of community and recommended that all students develop better communication skills. (http://notes.cc.sunysb.edu/pres/boyer.nsf/webform/rights). Undergraduate research is one facet of the report, but the undergraduate research enterprise addresses many of the Commission’s concerns.

An outgrowth of the Boyer report was the creation of the Reinvention Center at the State University of New York at Stony Brook. According to the center’s brochure, it plans to sponsor programs to bring together creative thinkers from diverse backgrounds to examine issues central to undergraduate education and to prepare papers on specific topics that emerge from the programs. It will also carry out studies and surveys to identify particular problems in education and recommend strategies to address them. It will develop and maintain a web site (http://www.sunysb.edu/reinventioncenter) from which it will disseminate position papers and reports. It aims to develop networks of professionals in diverse fields.

What Is Undergraduate Research?
A discussion of undergraduate research should not proceed without defining the term. Henry Rosovsky (86) says, “The word ‘research’ is now used so commonly, has been so vulgarized, that any answer must be carefully defined.” The same is true of the term
“undergraduate research.” “Undergraduate research” has become an umbrella term that includes the collaborations of students and mentors in the sciences, engineering, arts, humanities, and social sciences. It also is used to describe the curricular activities in inquiry- or research-based courses. The term is used whether students serve as research assistants doing the “intellectual bottlewashing” in an ongoing project or design their own projects and publish the results. The confusion is further exacerbated by the semantic descriptions of original work used in different disciplines. While scientists do research, humanists do scholarly activities, and faculty in the arts call their work creative activities.

Undergraduate research started in the sciences. By nature, science is collaborative, and it is easy to bring students into a group. Scientific publications list all significant collaborators as authors, and sometimes students become co-authors. Undergraduate research in the humanities has been somewhat controversial. Humanities scholars have developed a culture of solitary work, and for some faculty it is difficult to imagine how they would work with students; they believe students cannot engage in humanities research until they are in graduate school. Other humanities faculty allow their undergraduates to choose an original topic and work in the solitary manner of the discipline but under the mentor’s close guidance.

This variety of activities creates confusion and misunderstanding for faculty and students. As one faculty member at University of Illinois at Urbana-Champaign said, “They have a research experience, they brush up and get research dust on them, but both for reasons of time and experience they seldom really do state of the art publishable research.” In an address to the 1999 Sigma Xi annual meeting, Melvin George said, “…when others talk about integrating research into the educational experience, they really mean doing things that engage the students in inquiry—whether it’s an original question or not, whether the answer is known or not. So it’s very important to be clear about what you mean by research…This is a call for clarity.” (1999 Sigma Xi Proceedings)

Wenzel (547 A) states in “Undergraduate Research: A Capstone Learning Experience” that CUR faculty and administrators have defined undergraduate research as “an inquiry
or investigation conducted by an undergraduate student that makes an original, intellectual, or creative contribution to the discipline.” The elements of the definition make it applicable to all disciplines, make no judgment on the value of the work allowing both student-faculty and student-student collaborations, and establish a high standard by maintaining that scholarship be original and contribute to the discipline.

The Project

As director of the Summer Undergraduate Research Fellowships (SURF) program at Caltech over the past twelve years, my professional experience is steeped in undergraduate research. At Caltech undergraduate research is deeply imbedded in the academic experience of most students and faculty. I am concerned daily with providing excellent research opportunities for students. I have been associated with CUR, NCUR, and PKAL. I helped to start the Southern California Conference on Undergraduate Research (SCCUR), modeled on NCUR, to promote and celebrate undergraduate research in the region. The release of the Boyer Report was, in part, the genesis of this project. The report piqued my interest in why undergraduate research flourishes in some places, either broadly within an institution or within a college or department, and does not in others.

Over the past year and a half, I conducted a project to qualitatively review undergraduate research at six AAU institutions: Caltech, Emory, MIT, Rutgers, the University of Illinois at Urbana-Champaign, and the University of Washington. I submitted a proposal to the Association of American Universities in the summer of 1999 for this pilot project (Appendix I), and I met with the AAU K-16 Task Force in November 1999. I undertook the project during 2000.

The purpose of the project was to characterize undergraduate research at these institutions; to identify issues, questions, opportunities, and barriers affecting undergraduate research in the sciences and engineering and in the arts and humanities. The K-16 Task Force asked me to include the schools of education at these institutions in
my study to determine whether future elementary and high school teachers were involved in undergraduate research, gaining the benefits of working on open-ended questions, and better training them to introduce inquiry-based instruction in their classrooms. The project included analyzing and reporting on the resulting data. Ultimately, I aimed to determine the feasibility of carrying out a full exploration of undergraduate research at the AAU institutions or, more broadly, all research institutions.

The institutions were selected to provide a range of AAU institutions from small private to large public universities. The size and complexity of the public research universities present unique challenges to the promotion of undergraduate research. The environment at private research institutions may more easily promote the undergraduate research enterprise where there are fewer students per faculty member.

When I started the project, I expected to develop a compendium of undergraduate research programs and an outline of best practices at the selected institutions. I hoped to have an estimation of the numbers of students engaging in research and to know what counted as research for students. Part of my mission was to discover how institutions assess undergraduate research. The original purpose was to determine the common threads that could be pulled from these six disparate institutions that would provide a focus for a further study.

As the study progressed, the project changed significantly. I was not able to interview many individuals associated with the education schools, so the data in that area became spotty. In addition, when I spoke with faculty in the schools of education about research, it became clear that we were talking about different things. Therefore, I have not included a discussion of undergraduate research in the schools of education in this report.

At each institution I requested interviews with faculty and students who had participated in undergraduate research and with those who had not. Few who had not engaged in the enterprise spoke with me. The resulting picture is drawn by those most actively involved in undergraduate research.
I recognized that some institutions have taken steps to make undergraduate education in
general and undergraduate research in particular a component of the strategic plan or
central mission and have developed objectives to support the mission. A picture of a
culture of undergraduate research emerged from my interviews. Certain issues such as the
faculty reward structure and the definition of the term “undergraduate research” arose
repeatedly. I began to ask more questions about those issues. As I interviewed people and
as my knowledge of undergraduate research nationwide increased, I encountered other
individuals and groups working on projects to assess undergraduate research, develop the
history of the undergraduate research evolution, and determine academic outcomes for
students involved in research. The literature about the value undergraduate research adds
to education is just now being written.

**Methodology**

I developed a set of questions (see Appendix II) to guide the interviews with the key
constituencies within a university: administration, faculty, students, and faculty or staff
administrators involved in undergraduate research. The questions were formulated to
query the issues, challenges, costs, and benefits faced by each constituency.

The AAU provided the name of a contact person at each university, and I worked through
those individuals to set up interview schedules at each campus. I met with individuals and
groups in the sciences, engineering, humanities, and social sciences. Each meeting
typically lasted 45-60 minutes to allow full discussions. I audiotaped and transcribed the
interviews. In summarizing the interviews for each institution, I worked with the material
in the transcript without interpreting or commenting on the substance in order to create a
snapshot of undergraduate research at that university.

Altogether, I have interviewed 72 faculty, 35 administrators, and 74 students at Emory,
MIT, Rutgers, UIUC, and UW. The information on undergraduate research at Caltech
comes from my association of almost 25 years with the Institute and from daily
interactions with faculty, administration, and students. I formally interviewed five
Caltech faculty and ten students. My experience administering an undergraduate research program provided the frame for the project.

**Snapshot of Undergraduate Research at the Six Institutions**

*Rutgers*

The New Brunswick campus of Rutgers has an undergraduate student body of 28,000 students and about 7,000 graduate students. Ten colleges comprise the university. Over the last 30 years, through strong leadership by an administration with a vision of what a public research university ought to be, Rutgers has grown from a well-regarded undergraduate institution into a research university. Ten years ago the university’s new president built initiatives into the institution’s strategic plan to foster excellent educational experiences to permeate the academic life of its students. According to the latest survey of graduating seniors, 60% self reported having had an undergraduate research experience. The way in which students define a research experience is not clear.

Evidence of the institution’s commitment to improving undergraduate education and research opportunities is shown in the development of a Teaching Excellence Center created with institutional funds. The center helps faculty overcome the “sage on the stage” approach to lecturing, focuses on helping faculty use a variety of active learning methods in their classrooms and develop critical thinking skills in students, and provides training for faculty members regarding use of new instructional technology. An example of the move to inquiry-based courses may be seen in the genetics course that serves 1000 students. Beginning in Fall 2000, all students will have a gene to investigate. With funds from an NSF Institution-wide Reform Grant new science courses for non-science majors have been created that focus on inquiry-based learning. As one administrator said about these changes, “It will be different from lectures. It brings Rutgers closer to the new curriculum that will be commonplace in ten years.”

The office of the Vice President for Undergraduate Education was created as part of the President’s initiative. The VP has been innovative in enhancing the curriculum, including the development of an undergraduate research program. A crucial step has been to
educate students about the available opportunities and about the value and benefits they receive from getting involved in research. Every sophomore now receives a brochure describing undergraduate research and how to participate. Students often saw research and teaching as opposites. They did not see themselves as members of the community of scholars, able to participate in the creation of new knowledge. The university also encourages students through advising to start doing research.

The VP for Undergraduate Education has identified Rutgers’ strengths in these areas and has taken steps to build upon those activities already in place. For example, to showcase ongoing undergraduate research activities that have been housed in the various colleges, she created Research Weeks each spring to publicize over 60 undergraduate research events in all departments. Students and faculty like the smaller departmental or college events, but the small events get published as part of a larger activity and attract university-wide and community attention.

Undergraduate research is prominently featured on the Rutgers web site, and the Undergraduate Research at Rutgers University (URRU) may be found within one click of the front page. Directly linked to the front page is the following description: Creating knowledge and transmitting it to present and future generations is the very essence of a research university. At Rutgers, research programs take this one step further; our students, both undergraduate and graduate, are actively involved in research, which prepares them to become tomorrow’s innovators (www.rutgers.edu/news/science/science.html).

The university has emphasized undergraduate research opportunities to recruit a high quality student body that complements the caliber of the faculty, and it has been proactive in getting students involved in undergraduate research from the moment they arrive on campus. It happens most easily in the sciences where faculty and students traditionally work collaboratively.
The VP for Undergraduate Education created the University-wide Fellows Program as a centerpiece of the institution's effort to emphasize undergraduate research. The program provides funds for 50-60 student-faculty pairs each semester from an applicant pool of about 120. Awards are made on the basis of a faculty review of competitive proposals. All faculty and students receive the call for proposals. Faculty members apply for the funding, up to $1500, to support the student. The funds may be used for a student stipend, or the faculty might take the student to a conference, or use the money to purchase special materials the student will use in the research. Articles about the fellows and mentors appear in campus publications to disseminate information about the program and bring focus to the undergraduate research enterprise.

Several programs serve underrepresented students to prepare them to make contributions to faculty work and therefore make them attractive for research positions. The institution-wide McNair program funded by the Department of Education serves about 15 first-generation, low-income, underrepresented students each year. The goal is to help students gain admission to graduate school and ultimately to graduate from doctoral programs. The program is meeting its goals. Students are being admitted to graduate programs, but often their GRE scores are not high enough to help them win the fellowships that will pay for graduate school. The program has addressed this problem by teaching students skills and specialized applications so that when they get into graduate school they can support themselves as RA’s or TA’s.

Project L/EARN (Learn and Earn), funded by the National Institutes of Health and the National Institute of Mental Health, was created ten years ago in response to the Healthy People 2000 report that cited the dearth of underrepresented groups in the health-related professions. The purpose of the program is to train students in basic research skills so they can contribute to a faculty member’s research making students competitive for undergraduate research positions. It also seeks to develop a pipeline of students going into these professions. Ten students take an eight-week course, well supported by TA’s and tutors, followed by two weeks of research with a faculty member. Students receive stipends of $2800 for the ten-week summer period. In addition, the program pays for
room and board, fees, and books. Students get a tuition waiver; they earn three academic credits.

The colleges participate in the effort to increase undergraduate research experiences for students. The Honors program at Rutgers College, the largest of the ten colleges on the New Brunswick campus, is a four-year program serving about 200 students per class (of 2800). The critical requirements include undergraduate research in about 75% of the junior and senior Honors projects. Many Honors students do independent research in their junior year, sometimes earlier. The senior project has four options, three of which are thesis options. The Henry Rutgers thesis project is a 12-credit project available to students with a 3.4 or higher GPA (about 700 students per class). Ultimately over 130 students participate in this program.

Cook College revitalized its undergraduate curriculum in 1994, and the faculty decided that every student should be required to have a practical experience, often a research experience with a faculty member, as a graduation requirement. Some students do cooperative education programs. The George H. Cook program allows 60-70 students to take six credits of research during the senior year. Students define a topic, work with a faculty member in that definition, develop a hypothesis and methodology, and conduct research during the senior year. They then report on it in April. The college is committed to finding ways within its budget constraints to provide these opportunities for students.

The degree requirements for the Mason Gross School of the Arts mandate that all students have a research experience. Art and performance have scholarly dimensions as well as mathematical or hypothetical bases. A faculty member may send a student to do the final analysis for a set design for a Shakespeare play, and the student may go to the Rutgers archives, to the Library of Congress, or to London. “When we engage students we are not using them as go-fers, we are trying to get them excited about discovering something new,” said the Dean. “Students are doing research that is contextualized in the history and contemporary theory of their particular art.”
Douglass College, the nation’s largest women’s college, has the Douglass Project for Rutgers Women in Math, Science, and Engineering. It is part of a consortium of units within the college that focuses on research, teaching, and public service involving women. Some of these programs get women students involved in research. The Leadership Scholars program is an endowed program to support students for special projects, travel, and research. The women are mentored from beginning to end.

Rutgers has been successful in the steps it has taken so far to enhance undergraduate research opportunities for its students. The Commission on Higher Education of the Middle States Association of Schools and Colleges reaccredited Rutgers in 1998. The self study featured undergraduate education, including research and creative activity, as one of four topic areas for review. The accreditation report stated, “Two aspects of undergraduate education are particularly deserving of commendation: 1. the emphasis on providing undergraduate student research opportunities and 2. in a more general way, the attentiveness of faculty and administrators to developing student leadership skills” (http://www.rci.rutgers.edu/~oirap/msa/index.html, 10).

Rutgers has taken important steps over the past decade to develop a culture that promotes a vitality in undergraduate education and undergraduate research. The results of the effort may be seen in many ways including the development of new programs and the strengthening of existing programs. Faculty and administrators at Rutgers accept a broad definition of the term “undergraduate research.” Although aspects of the definition vary from discipline to discipline, faculty largely agree that students who participate substantively in the work of the faculty member are doing undergraduate research. This agreement arises from an institutional conversation led by the administration. The university has expressed its commitment to expanding opportunities and raising funds to support it will be one of the requests in an upcoming capital campaign. Important inroads have been made, but as one dean said, “The institution has just scratched the surface.”
University of Washington

With more than 25,000 undergraduate students and 10,000 graduate students, the University of Washington has developed a central mission to enhance undergraduate education in general and undergraduate research and experiential learning in particular over the past decade. The university has taken focused and bold steps to create a dynamic environment for its students.

The Office of Undergraduate Education was created in 1992 to bring campus-wide coordination of undergraduate programs. Through the efforts of this office and other departments across campus, the university began to offer more students unique opportunities and experiences, among them undergraduate research, with an emphasis on learning.

About the same time, the Carlson Office (later renamed the Carlson Center) was created as a result of a generous contribution to the university from Edward E. Carlson. The mission of the Carlson Center was, among other things, to promote, organize, and support opportunities for UW undergraduates to become actively engaged in community service work that enriches and invigorates undergraduate education, to enrich academic programs for students by bringing community resources to bear upon their educational experiences, and to enhance the quality of academic programs and intellectual debate related to public service (www.washington.edu/students/carlson/mission.html). Three years later, the scope of these activities was broadened to include undergraduate research with the creation of the Undergraduate Research Program.

In 1994, the Office of Educational Assessment conducted a survey of the faculty to determine what activity was occurring in the realm of undergraduate research. The survey results indicated that there was interest by the faculty in having more undergraduate research involvement, but that resources were limited. Some faculty in the medical and dental schools expressed interest in working with undergraduates, but since they did not
teach undergraduates, they did not know how to contact them to make their research opportunities known.

In 1995, the new President, Richard McCormick, reviewed existing programs to identify new initiatives, and undergraduate research rose as politically and educationally important. In a public address, he declared undergraduate research as one of the university’s high priorities. Although the mandate was unfunded, it stimulated institutional conversation about ways to shift the emphasis from teaching to learning and to develop research opportunities for students.

In autumn 1995, the Undergraduate Research Program (URP) was established as a separate entity, to support students seeking opportunities to do undergraduate research, and to assist faculty wishing to explore ways of including undergraduates in their work. The URP, with a part-time director and small staff, maintains a web site that includes an extensive list of research opportunities at the university and beyond, information for faculty on incorporating undergraduates into their work, advice for students on getting started in research, and recognition of students’ research accomplishments. The URP currently organizes the annual Undergraduate Research Symposium, and offers assistance to students preparing to present their work at the symposium or in other professional settings. A current focus of the URP office is to stimulate more student research opportunities in the humanities, arts, and social sciences.

Also in 1995, the Bill and Melinda Gates established the Mary Gates Endowment for Students in memory of Bill’s mother, the university’s longest serving regent. Following deep discussions on the needs of the university, the proposal to the Gates family requested funds to enhance undergraduate student learning and to foster the development of independent learners and community leaders. The initial $10 million gift was reinvested in 1999 with an additional $10 million from the Bill and Melinda Gates Foundation, and the annual proceeds are dedicated exclusively to students. The UW is proud of the Mary Gates Scholars program, which supports 100 students each year to do undergraduate research with faculty mentors. Students receive a $1500/quarter stipend to
alleviate the necessity of their working at outside jobs. Students apply for the Mary Gates Scholarships by writing an essay on what they expect to learn from the research experience. The deans and a faculty committee evaluate the essays and decide the awards.

As a Space Grant university, the UW started the Summer Undergraduate Research Program (SURP) in 1993 to enhance the undergraduate experience and especially challenge the bright students the UW recruited from high school on Space Grant scholarships. The SURP allowed these students to do research the summer before they matriculated into UW. The first year, they placed 20 incoming freshmen. The next year non-scholarship students began to inquire about undergraduate research opportunities, and about half of the 40 participants that year were non-scholarship students. For two years, the Provost provided funding to expand the program. In 1997, the Mary Gates Endowment for students began to co-fund the SURP awards, and that partnership has allowed the program to grow to include approximately 65 students each year. Another program, focused on Earth system science and separately funded by NASA as a grant to the SURP director, offers research opportunities to 14 additional students.

The annual Undergraduate Research Symposium gives students the chance to share what they have learned through their research experiences. It provides a forum where students are the teachers, showcasing research projects that build on and enrich faculty work across the disciplines. Students, faculty, and the community have the opportunity to discuss cutting edge research topics and to examine the connection between research and education. It promotes the undergraduate research enterprise by providing information and examples for students not yet involved in research. In 2001, 250 students presented their work in poster and oral presentation sessions.

Other undergraduate research programs at the UW include a program funded by a Packard grant to allow 12 students, a TA, and a faculty member to spend an intensive quarter doing research at Friday Harbor Laboratory. There are also NSF REU grants and
a Howard Hughes Medical Institute program. In addition, students work with faculty members on projects that they arrange outside the auspices of formal programs.

Many departments have established innovative programs to involve students in forefront research. The geography department has revamped its requirements to include a research course for majors. Students will work on problems or projects brought by local industry and agencies. These problems are linked to the students’ coursework. Students present their work at a department symposium attended by faculty, local industry, parents, and students.

The political science department has a small program for 6-8 students who receive independent study credit. Students develop their own projects, which culminate in presentations at the department’s undergraduate research symposium. In addition, they work on the ongoing Policy Agendas Project to collect data on national legislative activity since WWII. The purpose of the program is to get students to understand how the research process works, what a political scientist does, and the difference between theory and evidence. The faculty in the Policy Agendas Project are starting a development push to build an endowment for the center and for student support.

The chair of the English department has created many opportunities for students to do research. Students in his class Introduction to Asian American Studies reviewed 100-year old Immigration and Naturalization Service interrogation files of Chinese immigrants stored at the National Archives in Seattle. Students worked with archival material, some of it classified, and they learned to read the files and then tell the immigrants’ stories to the class. He also petitioned the Dean for funds for a group of seven undergraduates to act as a “research pool” to assist young faculty with their research. The research projects of young faculty may not be large enough for a student to take on a whole part of a project, but they often would have small projects that students could do. Students might look up documents in the library, work with primary materials, or transcribe interviews.
An aeronautics faculty member has a multidisciplinary student team working on the development of a satellite to be launched in 2002. The satellite will be flown in tandem with two other satellites being built by students at two other universities. The satellites will create a wireless network in space. Graduate and undergraduate students comprise the team that has developed the systems and subsystems. They have built a clean room. They participate in activities required by NASA and attend and present their work at critical design reviews.

The UW created the Tools for Transformation program in 1998 as an incentive for departments to apply for one-time funding of $50,000 to $100,000 to implement an activity to respond to new challenges and to remove impediments to change (http://www.washington.edu/change/proposals). Some of the funded proposals have been student-focused including research, curriculum transformation, and expansion of service learning experiences.

In October 1998 the UW reported to the state’s Higher Education Coordinating Board on state-mandated accountability targets that over 22% of its undergraduates report a research experience with a faculty member. It is not articulated specifically what constitutes a research experience. According to the Dean of Undergraduate Education, the UW would like to have as a goal that every student would have some kind of experiential learning. “It should be a hallmark of the place,” he said.

Success has engendered success at UW and the institution is changing its culture to better emphasize undergraduate education in general and undergraduate research and experiential learning in particular. Faculty and administrators are feeling upward pressure from students who now demand more of these opportunities. The institution has responded by taking simple, low cost steps, like creating a web site to advertise faculty projects to students. Because of increased student interest, the competition for available positions is greater, and, as a result, the quality of the experiences is improving. A faculty member commented, “The students are raising the bar for each other. They are seeing
what is possible and they are going for more. Faculty expectations are higher. We are all learning what can be done and it is impressive.”

The students are beginning to reflect the undergraduate research culture. A group has formed the Undergraduate Research Society (URS) to help promote opportunities and research positions among students, and to provide advice on applying for a research position. The URS meetings provide a forum for students to present their research, discuss current issues in research, and help each other refine their presentations and publications. The URS, barely a year old, has over 50 members and is one of the fastest growing student organizations on campus.

The UW has creatively marshaled its resources to increase emphasis on undergraduate education in general and in undergraduate research in particular.

**University of Illinois at Urbana-Champaign**
This large decentralized campus has an undergraduate population of almost 25,000 and about 10,000 graduate students. During the recession in the early ‘90s, public funding decreased, and the number of faculty declined as a result. At the same time, the number of students increased. Those were difficult years for the university, and it is just now recovering. The state recently increased its support, and the university expects that level of funding to continue, at least for this year. The Provost said that UIUC is now in a position to move forward.

In 1999, the Provost reconstituted a committee for Excellence in Undergraduate Education and charged it with assessing various activities including advising and research experiences. The committee’s report had little to say about undergraduate research. According to the Provost, “We need to understand where we are since it is a signature activity for research universities. It affects not just direct research experience but how, in fact, the research activity affects undergraduate education. We are having some difficulty benchmarking where we are and defining what we want.” The university has given consideration to the incorporation of undergraduate research opportunities in the realm of
undergraduate education and has articulated it in a Framework for the Future document, but the specific goals have not yet been determined.

In 1998, the university addressed some of the undergraduate education issues by creating the Discovery Program to provide freshmen with faculty-led small-group learning communities. Enrollment for available slots has increased and UIUC expects to hit the upper limits of available slots and interested students soon. One faculty member commented, “They are engaged, and the most subversive thing that happens is that they force learning to happen on other students.”

The Summer Research Opportunities Program (SROP) is a campus-wide program, sponsored by the Committee on Institutional Cooperation (CIC), a consortium of Midwest universities. The CIC’s goal is to increase minority recruitment for graduate school and improve retention. Each summer about 100 underrepresented students, half of them from UIUC, participate in SROP working with faculty mentors. Students receive stipends of $2,500 funded by the VP for Academic Affairs for the university system.

The Department of Education-funded McNair program provides an intensive eight-week summer research program with weekly workshops on topics such as the nature of academic life, standardized test preparation, writing and research skills, and the graduate school application process. The activities are designed to provide relevant experience and information to students who are strongly considering pursuing careers in academia. At the conclusion of the summer, students submit a research paper and give an oral presentation. Participants receive stipends of $2,400.

The Campus Honors Program (CHP) serves six undergraduate colleges and aims to enrich the undergraduate academic experience during the first two years. Students may elect to have a research experience, but it is not required, nor particularly encouraged. “When you talk about research on a campus like this, I think you will always be talking about a limited constituency that involves some of the students who have the energy, curiosity, and commitment,” said the CHP director.
The James Scholars Program is a university-wide program established to encourage undergraduate research and independent study. Students designated as James scholars are entitled to certain academic privileges, including access to the stacks in the library, priority assignment of earliest registration times, and official recognition on the University of Illinois transcript. The program gives a student a special opportunity to explore various topics and to receive recognition for those endeavors (<http://www.ed.uiuc.edu/ipo/undergrad/undergradhandbook/honors.html>).

*College of Liberal Arts and Sciences*

The humanities faculty raised the issue of the culture of the disciplines and one noted, “the work of the literary scholar is singular. That is how we have constructed our practice over the years, but I think I would be very open to seeing how it works using undergraduates.” Another faculty member said, “If you would call it research with a capital R, I don’t know...in my view it is research, but it is not research that can be done by students in solid state electronics.” The faculty in applied linguistics reported using students in their research because the work is more collaborative like science or social science than the work of the faculty who do literary studies, which is more solitary.

The history department requires all majors to take an undergraduate research and writing seminar, which is no larger than 15 students. Students do a one-semester research project where they work closely with the seminar group and with the instructor. History Honors students take a Historiography and Methodology course before they commence work on a senior Honors thesis project over the course of two semesters. In the fall of 2000, nine students were writing Honors theses out of 500 students in the department.

The Hughes Undergraduate Research Fellowships (HURF) program funded by the Howard Hughes Medical Institute offers a nine-week enriched research experience for 30 biology students selected from an applicant pool of about 300 to work with biology faculty. Target participants are women and minorities and students who attended small rural high schools. The minimum GPA requirement is 2.75. Participants receive a stipend
of $2,400 for the summer, five hours of graded credit, a tuition waiver, housing on campus, and a partial meal package. At the end of the summer, students present posters at a symposium attended by mentors and the students’ families. Many of the HURF students are preparing papers for publication.

One Life Sciences faculty member noted that in her department undergraduate research is actively promoted, and it is the exception for faculty not to incorporate students into their research programs. It was presented as a benefit when she was recruited. Students must have a research experience culminating in a research paper reviewed by a committee in order to graduate with Distinction.

A geology professor enthusiastically works with many undergraduates each term and incorporates all elements of the research process from proposal writing to oral and written communication, ethics, and politics into his interaction with the students. He requires all students to apply for outside funding to help support their research, and he maintains a spreadsheet on a lab computer containing a list of possible grants and their application deadlines. Each student brings in about $2,000-$5,000 during the time they work with him. In the fall 2000, he was working with six undergraduates in a department of 65 undergraduates and 13 faculty.

The math department has recently been awarded an NSF REU site grant. This grant has stimulated much discussion within the department about how to develop undergraduate research in math. The grant will support 18 students per year (6 projects during the academic year and 12 during the summer).

Two physics professors have a small program that allows six students to engage in high-level research that garners participants admission to top graduate programs. Students participate for three years, starting in their sophomore year. They become integral members of a collaborative team. They have much contact with the faculty mentors and work on substantive projects. Some have become authors of a paper in *Phys Rev B*. The
Faculty members expressed frustration that they have to seek funding every year for this program and wished that the department would make it a line item in the budget.

Another physics professor said there are things she would not dream of doing without student participation. Her concern is that there is no department infrastructure to support the effort. She pays students from her research funds. She views it as an add-on to her research program. She also said that students come in with no research experience, but they have the enthusiasm and open-mindedness to dive into a research project. She added, “Although they may not get to the point of independently publishing a paper, they have sometimes done enough to contribute and have their names on a published paper.”

College of Engineering
The College of Engineering has taken steps toward institutionalizing undergraduate research. The Dean hosted a faculty-student retreat last year. One outcome of the discussions was the realization that faculty needed students to help in their research, and students were looking for research opportunities. Efforts have been started to facilitate the matching of students with faculty opportunities.

A group of students has formed an engineering council to offer information on research positions. They are modeling their effort on MIT’s UROP program. The students said the motivation was “knowing how difficult and unorganized undergraduate research is. It is guesswork to find professors who will be involved. It takes luck and work.”

The conversation with the engineering faculty revealed that there are opportunities for students to work with faculty. In Electrical and Computer Engineering, the Honors program is a structured two-semester course that includes writing. Students do a project, present their work at an undergraduate research symposium. The department gives awards, and sometimes students submit their papers to conferences. Students work in groups with one student serving as team leader. Students also do a senior project. They may do independent study projects taking up to six credit hours over four years.
Another faculty member said that undergraduates help build lab infrastructure by writing software to make particular measurements. “These are backburner projects that would stay on the back burner if I had to have a graduate student do it, but the fact that the undergraduate is slow is not a problem because we might not do it otherwise,” he said. He stated that he was still using hardware and software that undergraduates had built eight or ten years ago.

The discussion frequently returned to the question of what is undergraduate research and what is the difference between research and engineering or design projects. One faculty member said, “As an undergraduate accumulates knowledge, he starts applying that knowledge to a design project.” Another participant in the discussion said that in her department every student has to do a senior project, but there is no research in the project. It was pointed out that students have to have design experience, but they don’t necessarily need research experience. A faculty member said, “Certainly all engineers ought to have some project experience, and our students get that. Research is an alternative career path and it requires an advanced degree. A student with a 2.5 GPA is not going to graduate school, so it would be a waste of time for him or her to do research. Students who should do research are those who want to go to graduate school, have the grades to do it, and who are potentially interested in a research career.”

Another faculty member observed that she doesn’t see many students doing real research and creating papers. But she does notice that graduate students who have done undergraduate research know how to read journals and analyze papers. “It is definitely beneficial for students and an educational experience,” she said.

*College of Agriculture, Consumer, and Environmental Science (ACES)*

The College of Agriculture has two undergraduate research programs, the Jonathan Baldwin Turner (JBT) program started in 1985 and the College Honors Program started in 1999.
The JBT program includes a $300-$500 scholarship to be used for tuition and fees; students also receive $1,000 to spend on supplies, travel, or anything else they need to do the research. The program, open to juniors and seniors with a GPA of 3.0 or higher, requires participants to do intensive research projects. At the conclusion of the program, students submit a report, and a small percentage become co-authors of published articles.

The ACES Honors program serves students beginning in the junior year. Participants have to develop an Honors contract, one element of which is an undergraduate research project. The Honors students present their research in a poster session at an ACES open house in the spring. The ACES Honors program does not require a senior thesis.

Apart from the JBT and Honors programs, it is up to ACES students to find research opportunities. In the animal science department, for example, there are 600 majors and 40 faculty. The faculty are overwhelmed, and they feel they cannot do research with many students, most of whom want to go to veterinary school. However, students are encouraged to do a research project to pad their resumes and to expose them to vet medicine so they can discover whether they are making the right career decisions. The department also requires an experiential component to the curriculum that includes special problems, internships, or a spring break trip to industries related to animal science.

Following a period of financial uncertainty that had broad impact on the university, the administration at UIUC is beginning to consider ways to invigorate undergraduate education in general and undergraduate research in particular. Students at UIUC have many opportunities to get involved in research through informal interactions with a faculty member or more formally through university, college, or departmental programs. The enterprise has not been institutionalized, and at this time there is no institution-wide culture of undergraduate research. Some colleges, departments, or individuals enthusiastically promote research for students while others have given it little thought. Many faculty question whether students can or should do research, and the definition of the term “undergraduate research” is not clear.
Emory

Emory University, with an undergraduate student body of 6,300 and 5,100 graduate students, has nine major academic divisions as well as centers for advanced study including schools of medicine, nursing, theology, law, business, arts and sciences, and public health. A host of prestigious affiliated institutions including the Yerkes Primate Center and the Center for Disease Control (www.emory.edu/welcome/glance.html) provides excellent research venues. Emory became an R-1 university about 15 years ago as the emphasis shifted from its liberal arts roots to a research-extensive institution. Undergraduate research has long been part of the academic life of some students, and within the last decade the opportunities have increased.

The Honors program has traditionally provided the primary mechanism for students to get involved in undergraduate research and creative activities, and in most departments, it is still the top students who have the opportunity. All Honors students are required to write a thesis. One hundred thirty-seven students in the 2000 graduating class of about 1000 received Honors. Many students who enroll at Emory are considering ultimately applying to medical school, and they seek undergraduate research experiences to enhance their resumes for their med school applications.

Only the best students are allowed to apply for research. They are required to have a 3.5 GPA to do research or to do Honors, although some departments ignore the restriction. One faculty member commented that many students start out in pre-med but they do poorly in one of the early science courses and it wrecks their GPA. They often switch majors after that, but even if they earn all A’s in the new major, they have a difficult time overcoming the poor grade. “I feel they are punished by this situation. We have wanted it to be the GPA in the major. There are enthusiastic and smart kids who are prevented from doing Honors. They can petition, but it almost never happens.”

Ten years ago, the Howard Hughes Medical Institute (HHMI) awarded Emory a large grant that allowed the university to expand and rebuild the biology department, provided
funds for equipment, and reinvigorated undergraduate inquiry-based laboratory courses. As part of the restructured curriculum, research was required of all majors, but that requirement strained resources, the department became overworked, understaffed, and overwhelmed. The requirement was subsequently dropped. Students now do research for elective credit that does not count toward the degree. The department has now been divided into two departments: biology and neuroscience and behavioral biology (NBB).

A faculty member serves as the director of undergraduate research for biology. He has developed a web site (http://www.emory.edu/biology) to help students identify potential mentors. The site includes pages that advise students on the process for getting involved in research. To recruit mentors, he also has a page that highlights the benefits to faculty who work with students. And he meets individually with faculty and students to ensure good mentor-protégé matches. The NBB department is just establishing an infrastructure for undergraduate research. Undergraduate education and undergraduate research are often topics in formal and informal faculty discussions.

The Summer Undergraduate Research Experience (SURE) program for biology students also was developed from the HHMI grant. The program now supports 80-100 students each summer, about half of them non-Emory students. During the summer, students can become immersed in their research without the responsibilities and distractions of simultaneous coursework. They often work at the research venues near the campus. One aim of the program is to foster cross-institutional research and to provide opportunities for underrepresented students, particularly those from the Atlanta consortium of Historically Black Colleges and Universities. The SURE program includes enrichment activities and social events. Students receive a stipend of $2,500 plus housing on the campus for the ten-week summer period.

I interviewed several faculty in humanities, social sciences, and performing arts, many of whom incorporate undergraduates, most of them Honors students, into their scholarly activities. A faculty member in the performing arts questioned what is research for students in those areas. He said, “We have performers and composers and people who
create things. Performance is temporal. You don’t have a paper product to circulate and have critiqued. What is research for someone in the performing arts?”

A Science and Society program provides funding for faculty projects that sometimes includes students. An art history faculty member received the first grant to collaborate with her science colleagues to test the composition of ancient containers and to analyze what the contents of the containers had been. She went on to say, “All these programs are faculty initiatives. They are not coming from above. It is the faculty who organize it because of a commitment to undergraduate education. I find that heartening.” She also curates a collection of antiquities in the museum and has included students in the development of a catalog of 2000-year old objects. Students did much of the photography, moved objects, and arranged the photos.

An English professor described his work that includes undergraduate and graduate students and faculty in building an archive of 20\textsuperscript{th} century poets. Undergraduates do first-hand work with manuscripts, letters, and unpublished documents, and they publish out of the archive. It is a living collection, and other faculty send their students to work in it. An undergrad was cataloging the collection of Ted Hughes, an English poet, when she discovered a missing manuscript by Sylvia Plath. Another student has published a book of interviews with Irish poets. The professor said, “I try to use every opportunity I can to make undergraduates feel that the scholarly community is ready to welcome them.”

Another English professor said that it is much harder to quantify what counts as research if you compare collaborative work in the sciences with solitary humanistic work. He said that English students have to learn the vocabulary and the methodology before they can participate. “Research is at the outer edges of all that and it takes a long time to get there,” he said. “I am a strong believer in the liberal arts ideal where specialization too soon should be avoided. If you are serious, go to graduate school. That is what it is for.”

A history professor said that some students do research on aspects of local history at the Atlanta History Center. Students also work with advocacy groups like the Anti-
Defamation League, American Civil Liberties Union, and the Poverty Law Center. Students have placed their research in briefs that have been used in court, and one student who had done research on the Fleet financing scandal appeared on “60 Minutes.” Four years ago the same history professor developed an interdisciplinary Violence Studies program that brings together faculty from 16 programs and departments from the schools of Public Health and the Law School. Students work on internships and research grants in public health, the Yerkes Center, and the Carter Center. Students have collaborated to produce a desktop-published book of their research. Other students have returned following graduation to make presentations to the Violence Studies class.

Although the administration is supportive of undergraduate research, it has not included it in Emory’s strategic plan. A faculty member noted that a few years ago the Provost asked all the senior administrators to read Boyer’s Scholarship Reconsidered and then held a symposium in April 1994 to discuss the issues raised in the book. Ernest Boyer was a featured speaker at the symposium, and the text of his talk was included in a book of his selected speeches (69-80).

The faculty member also stated that the faculty talks about the issues, and there is some recognition of the value and importance of an interdisciplinary focus. She suggested that the administration should consider the issues that affect undergraduate research in all disciplines, and she added that there is no recognition of how difficult it will be to expand faculty mentoring of undergraduates in research if the faculty reward structure is not changed.

Asked if Emory is supportive of undergraduate research, the history professor said, “A big yes!” The university administration had doubled the amount of funding he had requested to start the Violence Studies Program. A music professor commented that some of his students do research abroad and that students have been able to get travel funding from the university, another demonstration of institutional commitment.
Although the administration appears to support undergraduate research at Emory, its support seems somewhat benign. It initiated a conversation among faculty a decade ago about reinvigorating undergraduate education including undergraduate research; however, it did not formalize a commitment by building an institutional infrastructure to support the enterprise. It has provided or helped to raise funds in targeted areas for these activities. The effort largely has been supported by the enthusiasm and energetic investment of several biology faculty who have promoted the enterprise among their colleagues in other disciplines, and the administration has in no way hampered their efforts.

Massachusetts Institute of Technology

At MIT, with an undergraduate student body of close to 4,400, a graduate student body of over 5,500, and more than 900 faculty, undergraduate research plays a featured role in undergraduate education. Students are encouraged to do research from the very start. In 1969, stimulated by a speech by Edwin Land, head of Polaroid, Dean Margaret MacVicar with the support and encouragement of President Paul Gray, founded the Undergraduate Research Opportunities Program (UROP). Any MIT student can do research through UROP, and students often begin to seek research experiences in the first term of their freshman year. About 1,800 MIT students annually participate in the program, and approximately 80% of its graduates have done at least one UROP project. According to the 1998 senior survey, 48% of respondents reported that they did more than one UROP; 35% stated they did only one UROP. One faculty member commented, “Nobody at MIT has not heard about UROP, that it is great, and that it is unique. The point is to bring students into the apprenticeship role.”

Almost all faculty I interviewed were extremely enthusiastic about and proud of UROP. They stated that students doing research is the essence of MIT. Faculty enjoy working with bright and talented students, and several faculty commented on the undergraduate focus of MIT. About 46% of faculty participate in UROP. I talked with three assistant professors all of whom had done research in their own undergraduate careers. They were
enthusiastic proponents of involving students, even under pressure from their senior colleagues to avoid working with students at this point in their careers.

UROP supports student-faculty collaborations in all the research efforts represented at MIT. Students usually join a faculty member’s project, but they also may design their own projects and recruit faculty to advise them. Students identify mentors and write proposals that include a description of the research and a budget. They work during academic terms as well as summer. Students and faculty mentors agree at the outset about the remuneration the students will receive. Students may receive pay or academic credit. Occasionally students volunteer to work in a research group receiving neither pay nor credit. Students work on campus or at other MIT venues such as Lincoln Lab.

According to the Assistant Dean, Academic and Research Initiatives, of all UROP projects done for pay, 84% are funded from faculty grants and departmental resources. Faculty choosing to pay students from their own funds often pay more than UROP’s minimum hourly rate of $8.00. When agreeing to support student wages, faculty do so in full; they do not supplement wages paid to students from UROP program funds. The remaining 16% of students participating in UROP for pay are covered by UROP program funds. These students are paid an hourly rate of $8.00. The largest portion of UROP program funding comes from gifts and endowment income. The remaining portion of UROP’s budget comes from Institute general funds.

Many students do multiple UROPs, starting out by doing routine tasks in support of the work of faculty and graduate students. If they continue, students often take on increasingly sophisticated and challenging projects, and in the end many achieve something significant. About 20% become authors or co-authors of articles in the refereed literature.

The UROP staff, 2.5 FTEs, provides infrastructure for the program under the direction of the Dean for Undergraduate Research. It is part of the Academic Resource Center which also houses Freshman Advising, Freshman Orientation, the Committee on Academic
Performance, the Freshman Seminars Program, and Learning Strategies Program. The UROP staff manages the application process, communicates program guidelines and goals to the students and faculty, reviews student proposals, sets hourly wage levels (with approval by the Dean), and awards funding when appropriate. They also evaluate the program and student and faculty experiences through feedback from participants. The Dean makes UROP policy. Because of the small number of staff, in recent years the program has not sponsored a symposium or poster session, but some departments coordinate such events. The UROP office is beginning to collaborate with other areas of the Institute to create an event (or events) to showcase student research through UROP.

UROP developed a Research Mentor Program in 1993 to take advantage of the Independent Activities Period (IAP) held in January. The program links undergraduates who have never done UROP with experienced UROP students who serve as peer mentors. The purpose of the program is to help prepare students to do research and to give upperclass students mentoring experience.

An example of undergraduate research as part of the curriculum may be seen in the year-long undergraduate projects laboratory developed in 1960 in the Aeronautics/Astronautics department. In the first term students pick a subject and devise a research plan; in the second semester they do the research in teams of two, each team working with a faculty supervisor.

Undergraduate research is ubiquitous at MIT. It permeates the culture, and a new generation of faculty who were undergraduate researchers themselves is beginning to deepen the culture even more.

**California Institute of Technology**

Caltech is a small private research institute with an undergraduate student body of about 900; graduate students number 1,000; and faculty number about 350. The Institute has six academic divisions, and it manages NASA’s Jet Propulsion Laboratory. Caltech’s educational mission has not changed since it was stated by the original trustees in 1921:
“To train the creative type of scientist or engineer urgently needed in our educational, governmental, and industrial development.” (2000 Catalog, 9)

At Caltech undergraduate research has been deeply imbedded in the academic life of the Institute since the earliest days. Ernest Swift, Professor of Analytical Chemistry, Emeritus said: "Undergraduate research was introduced into the curriculum at Caltech by Arthur A. Noyes after his arrival in 1920 as first chairman of the Division of Chemistry. This was probably the first extended use of undergraduates in scientific research anywhere. About a dozen students would spend a summer conducting chemical research at the Marine Biology Station at Corona del Mar. One of these investigations led to a publication by Edwin McMillan and Linus Pauling: 'An X-ray Study of the Alloys of Lead and Thallium,' *Journal of the American Chemical Society*, Vol. 49, p 666, 1927. Both authors continued their research careers and both later won Nobel Prizes in Chemistry" (SURF Newsletter, February 21, 1983).

There are several mechanisms by which students can do research. They may do research for academic credit or faculty may hire them to work in their labs. All students are required to take Ch3a, Fundamental Techniques of Experimental Chemistry, as part of the core curriculum. This course teaches basic methods and procedures of experimental science. Several majors hold introductory research seminars in which faculty present their research to recruit majors and to provide a broad perspective on the research carried out at Caltech. The students themselves publish the Undergraduate Research Opportunities Handbook to allow faculty, research fellows and postdocs, and graduate students to advertise projects on which undergraduates might work. Opportunities for off-campus research are readily available on the web sites of the Student-Faculty Programs Office and the Career Development Center.

The opportunities for students to do research are widely publicized in materials published by the public relations department and by the admissions office. High school students visiting the campus tour laboratories, and incoming freshmen are encouraged to visit labs as part of freshman orientation.
The Student-Faculty Programs Office (SFPO) provides infrastructure for several undergraduate research programs. SURF is the primary program. About 350 students receive SURF awards each year. More than one third of the eligible (rising sophomores, juniors, and seniors) Caltech students participate as well as non-Caltech students from colleges and universities worldwide.

Founded in 1979 by then-professor of chemical engineering Fred Shair, SURF is a microcosm of the grant-seeking process. Students collaborate with potential mentors to write research proposals, which are reviewed by a faculty committee that recommends awards. Students carry out the work during a ten-week summer period. Since science not reported is essentially science not done, SURF places strong emphasis on communication. Students are required to submit technical papers at the conclusion of the program. They also give oral presentations at SURF seminar day, a symposium modeled on a professional technical meeting. Students compete for cash prizes for outstanding technical papers and oral presentations. Donors endowed these prizes as incentives for students to develop excellent communication skills. As with any fellowship, students receive a stipend. In 2001 the stipend will be $5,000. The total stipend budget amounts to $1.8 million.

The benchmark for a SURF project is the potential for publication, and about 20% of SURF students become co-authors of articles in the refereed literature, present at conferences, or contribute to significant reports. Nearly 60% of Caltech science and engineering faculty participate in SURF each year. Any student who wants to do research can find an opportunity in a variety of fields.

To enhance and enrich their research experiences, SURF students may attend weekly seminars presented by faculty. A series of professional development workshops helps students make short-term career decisions in the context of longer-term life and career goals. The series addresses issues students will face as they move into the next phase of their careers; topics include decision making, networking, intellectual property issues, a
discussion of alternative careers (other than becoming a professor!), and importance of developing excellent communication skills. Each week small groups of students have dinner with two or three mentors at local restaurants to promote informal interaction. Students balance research with social and cultural activities as well as field trips.

The SFPO administers other undergraduate research programs. The Axline program offers SURF opportunities to about 40 top freshman applicants to Caltech, making undergraduate research an important incentive for students interested in pursuing science and engineering to choose Caltech. The Beckman Scholars program funds three biology and chemistry students to engage more deeply in research over two summers and the intervening academic year and provides money for students to travel to conferences and purchase supplies. The Minority Undergraduate Research Fellowships program brings about 30 underrepresented students from colleges and universities nationwide to do forefront research with faculty at the campus. The SFPO publishes an annual report on the year’s program and listing all projects; students and mentors; social, cultural, and professional activities, and sources of funding.

The administration cites undergraduate research as a jewel in Caltech’s crown. The admissions office promotes the undergraduate research opportunities, and most students choose Caltech because of the opportunity to do research. Alumni frequently report that SURF was their best experience in their undergraduate careers. In addition to incorporating students into their research, faculty volunteer to help review proposals, read final reports, and evaluate oral presentations. SURF depends upon the participation of the campus community, and faculty’s willingness to support the program in this way is a strong testimony to the value they place on it.

The Western Association of Schools and Colleges reaccredited Caltech in 1998. The self study addressed four specific areas, one of them was undergraduate research. In their final report to the Institute, the visiting team stated, “By all indications the SURF program has been tremendously successful” (73).
Caltech pays the administrative costs of the SFPO, which includes 3.5 FTE’s. The SFPO staff raises funds from private external sources to match faculty contributions to student stipends. An endowment has been established and currently supports 20% of stipend funding.

Three committees support the SURF program. The SURF Board is a group of alumni and other friends of Caltech who help raise funds for the program. The SURF Administrative Committee reviews student proposals and sets academic policy for the program. The SURF Student Advisory Council provides student input into program planning.

The Culture of Undergraduate Research

A picture of the culture of undergraduate research emerged from my conversations at each university. To frame my thinking about this culture, I considered the basic elements of culture within a society or an organization. Components of culture include shared norms, values, customs, and beliefs within a community. There are celebrations, rituals, and traditions. New members of a community are introduced to the culture and assume the existing standards. Culture spreads through the communication of important experiences from individuals to groups of individuals.

It takes time and intention to develop or change culture. A well-established culture provides a foundation that anchors the community and (for better or worse) prevents rapid change. Academic cultures are well known for being entrenched and immovable. Creating or shifting a culture within an organization is an extremely challenging endeavor because the shared elements have been deeply ingrained over a long period.

An institution that has developed a culture of undergraduate research exhibits certain characteristics. Within the administration, these elements include some of the following: undergraduate research as a component of the university’s strategic plan or central mission for undergraduate education; an articulation of an overarching vision for
undergraduate education and the role of undergraduate research within it; and allocation of resources to encourage the activity. Some of the university administrations have addressed the issue of faculty rewards for working with students. The administration has led an institutional conversation about undergraduate research. Administrators and faculty know the goals and objectives for programs currently in place and those that might be developed in the future. The administration can articulate the costs and benefits of undergraduate research to the institution.

Faculty are able to articulate the institution’s commitment to undergraduate research. They understand what undergraduate research means within their university. Faculty within the university use common language to talk about mentoring students. They share expectations about what students can and should do. They identify benefits to themselves, to the students, and to the institution. The faculty know what programs are in place and how to get involved. They are often aware of how their colleagues work with students. It is clear that there has been an institutional conversation about where undergraduate research fits in the teaching-research continuum, usually on the teaching side.

In institutions that have cultivated a culture of undergraduate participation in research, students know that opportunities are available and that they are encouraged to get involved. They know how to find out about such opportunities, whether or not they choose to avail themselves of the chance to do research. They know why they want to have an undergraduate research experience and have expectations of what they will derive from it. They talk with each other about their research. The undergraduate research community takes on a welcoming air for students and faculty.

Universities can take steps to create a culture supportive and encouraging of undergraduate research. It requires a commitment to develop the components of the undergraduate research culture over the long term. It requires promotion of the enterprise, a regular communication of the importance and value of the activity, and a celebration of success and achievement. Creation of culture is a long process that requires sustained effort. It might employ marketing (a disagreeable word, but a good concept) techniques
such as identification of the strengths, weaknesses, opportunities, and threats or barriers to the organization, and targeting efforts and communications toward those elements.

Developing an undergraduate research culture also requires human and monetary resources. It may demand line-item budget funding to establish an infrastructure. An institution committed to undergraduate research has addressed these resource issues and has taken steps to assure that necessary funding is available.

Each university in this study has developed its own culture of undergraduate research. As culture evolves, it begins to permeate the institution and frame the discourse around this topic. At Caltech and MIT, the culture of undergraduate research has been in place for decades and is so deeply imbedded into the life of students and faculty. The topic is not in any way controversial. The administration, faculty, and students assume that undergraduate research opportunities will be available. They know the mechanisms for getting involved. Information about undergraduate research is ubiquitous; it appears on web sites (sometimes on the Institutes’ front pages, and always within three clicks of the home page) and in public relations and admissions materials. Anyone can ask anyone to get information.

Emory, Rutgers, and the University of Washington have been shifting toward a culture of undergraduate research over the past ten years. These institutions have generated campus-wide discussions about how to promote undergraduate research, and they have taken steps to intentionally create a culture that is supportive and encouraging of faculty and students who want to engage in research together. They have identified the costs, benefits, and challenges to the institution. The discourse may be different from institution to institution, but the language within these institutions is remarkably similar.

The University of Illinois at Urbana-Champaign is just now beginning the institutional dialogue, and I observed some confusion about the nature and definition of undergraduate research. The administration is beginning a review of undergraduate research programs as a prelude to possibly including it in the strategic plan. Some faculty had not given any
thought to how it might be done, while others enthusiastically have worked with students for years.

**Costs and Benefits**

Time is the cost mentioned by virtually everyone with whom I spoke. For faculty who are already busy with research, teaching, graduate students, and proposal writing, mentoring undergraduates adds another layer of activity and responsibility. Students also commented on the time commitment for doing research in addition to their coursework and extracurricular activities.

Monetary costs to undergraduate research include the administrative costs of an undergraduate research program, and funds for stipends or wages for students paid to do research. These funds are often provided by faculty research grants. As the Vice Provost at UW said, “There are costs on both sides, but they are costs that, within reasonable limits, should be expended.” Most faculty and all administrators said that they felt they got a good return on the time and monetary investments.

The undergraduate research enterprise benefits the institution, its faculty, and the students. Students and faculty discussed the benefits that accrue to students academically, personally, and professionally as they become members of the community of scholars in a significant way. The research universities offer students opportunities to work at the forefront of knowledge in all fields. The experience helps them develop critical thinking skills, the ability to work with the ambiguity of open-ended questions, an ability to apply skepticism to the daily flow of information, and an appreciation of what it takes to create new knowledge. They gain confidence and as they enter the next phase of their lives, whether job or graduate school, they have significant advantage over students who have not had the research experience. Students move seamlessly from undergraduate to graduate programs or professional school. “This part of the experience is absolutely critical,” said a faculty member at Rutgers. Nearly everyone involved in undergraduate research at the six universities in this study cites the benefits to students.
Faculty cited the advantages of working with students. Some said they bring enthusiasm, energy, and good ideas to projects. A faculty member at UW said, “The underads add a new dimension. Intellectually many of them are not different from faculty, and they have much to add. They raise as interesting a question as anyone.” A faculty member at UIUC said that he put students on his wild ideas that he could not give a graduate student because if the project did not produce results, the grad students would sacrifice their degrees while there is no risk to the undergraduate. Another UIUC faculty member said that the quality of research contributes to the general good of a laboratory. A faculty member at MIT commented that undergraduate research ties the institution together including undergraduate and graduate students and faculty and increases the connections these constituencies have with one another. An administrator at Rutgers said, “It is the only way to ensure that faculty continue to be involved in important research and that research is passed on to the next generation of scholars. My sense is that it is the strong guarantee of the quality of the institution.” He continued, “It is about bright undergraduates, graduate students, and faculty involved in a single enterprise. Without research it can’t happen.” A faculty member at MIT said, “I think that students, particularly freshmen, come in here and they don’t think anything is impossible. It is really nice to have a group of energetic, unjaded young people who are asking ‘why’ all the time.” Several junior faculty said that undergraduates had helped them launch their research programs, adding that their own undergraduate research had influenced their decisions to become professors and strengthened their commitment to mentoring undergraduates.

The institution as a whole benefits in many ways as students garner excellent undergraduate education of which research is a part. As undergraduates gain rich academic experiences, they become enthusiastic alumni who retain contact with the university through personal involvement and financial contributions. The institution attracts top faculty who enjoy working with bright and curious students. The institution is able to attract excellent freshmen seeking significant experiences in this time when students have become critical consumers of education and choose universities that
provide, promote, and encourage students to participate in excellent opportunities. Undergraduate research provides great stories of achievement and success that universities can tell to the public and to state legislatures to counter negative publicity about the undergraduate experience. The benefits to the institution have a multiplier effect. As the academic constituencies reap advantages from undergraduate research and relate their experiences, the culture deepens, more people and groups become involved, understanding of the experience expands, and the movement takes another turn up the helix.

**Issues and Challenges**

Significant issues and challenges face universities as they shift emphasis toward undergraduate education including undergraduate research. These include, but are not limited to, the problem of expanding undergraduate research opportunities to most students; the faculty reward system; and assessment.

**Expansion of Undergraduate Research Opportunities**

At Caltech and MIT, any student who wants to do research can have the opportunity. The faculty at both institutions have long included students in their research; working with students is part of the culture. The student-faculty ratio allows any student desiring the one-on-one mentoring experience to have it.

At Emory, Rutgers, UIUC, and UW, it is primarily the top students, the Honors students, who have access to research opportunities. Faculty at all institutions comment on the pleasure they find in working with these bright young minds. Students who demonstrate drive and initiative in seeking research opportunities with faculty are the students who get involved. Faculty welcome students who step out of the crowd and put themselves forward with an interest in the mentor’s research. But the students with less-than-stellar GPAs, or those who are shy or lack the confidence to approach a potential mentor, may not get research opportunities.
Can these universities expand opportunities to more, or even most, students? Rutgers has set a goal of every undergraduate engaging in research. The administration acknowledges that the target cannot be reached through one-on-one research experiences but will be accomplished through research-based course work or other one-to-several experiences. At the UW, the administration noted that it would take a different way of working to expand the research experience much more broadly and has taken steps through its Tools for Transformation program and through its budget process to encourage departments to think creatively about problems like this one. Several departments at UW have taken innovative steps to revamp the way they teach students and get them into investigation and inquiry.

Significant obstacles preclude undergraduate research experiences for all students. The ratio of students to faculty makes one-on-one mentoring impossible in the large public universities. Mentoring an undergraduate costs time, especially when the student has no research skills or experience, and many faculty members resist adding the activity to their over-busy schedules. Many students hold full-time jobs to earn money for their education and do not have time to take on research. Some faculty do not want to work with undergraduates, and some students are not interested in the research experience.

Antidotes exist for some of the obstacles that prevent students from doing research. A faculty member at Rutgers described her program to train students in basic research techniques to make them more competitive for positions in faculty projects. The Caltech SURF program and the UW Mary Gates Scholars program pay students sufficiently generous stipends to allow them to do research without the necessity of holding outside jobs. Students who would not seek independent research experiences may be introduced to research through required courses that lead students into inquiry. Rutgers and UIUC look to local corporations and agencies to provide research opportunities, thus expanding the pool of possible mentors. Medical and/or vet schools at UIUC, UW, and Emory expand the number of faculty who can work with undergraduates and broaden the kinds of research experiences students get. These opportunities are particularly important for students aiming to go to medical or veterinary school. The UW has expanded the
umbrella to include both undergraduate research and experiential learning opportunities. Students taking advantage of experiential learning opportunities often gain similar advantages to those students who do research. Emory’s biology department has established undergraduate laboratories, open 24-hours a day, to allow students to work at any time on real research questions. These labs give students the chance to work on open-ended problems under the course structure. New technologies offer opportunities. The use of technology has just begun, and no doubt, it will be used far more creatively in education in the future than one can imagine at the present.

Bringing every student into a research experience is a worthy and important goal which may never be fully reached, but with innovation and creativity, institutions can close the gap between those students who now get to do research and those who do not.

**Faculty Reward System**

At every institution I visited some faculty and administrators cited the faculty reward system as a barrier to faculty mentoring more undergraduate students. Faculty are stretched with their teaching and research responsibilities, the need to write proposals for research funding, and service to the institution and the community. Faculty generally do not receive credit for mentoring students in undergraduate research. Several faculty members at UIUC said that mentoring is pure overload layered on top of everything else. A faculty member at Emory commented that there is no formal way that mentoring is evaluated, and for young faculty who are building portfolios there is no standard way to assess his or her effectiveness in mentoring students. The time commitment for faculty mentoring students doing Honors theses is significant, but the effort is not counted as teaching credit. Faculty at Caltech, MIT, and Rutgers regard mentoring undergraduates as part of their teaching responsibilities; a few regard it as part of their research activities. The reward structure leans heavily toward research. It has been noted that faculty get pay raises for their research; they get prizes for teaching. Rutgers has started to shift the emphasis more toward teaching, and as one dean commented, “The absence of mentoring would give a distorted view of what teaching is.” Others emphasized that the biggest
reward for faculty is getting research done, and the undergraduate student is often a valuable contributor.

Several people commented that the issue of faculty rewards is greater than the structure at a single institution. It is a national issue. As the research universities compete for human and financial resources, the pressure increases for institutions to improve their research reputations to attract top faculty and students. The system rewards research productivity and innovation, and it is deeply imbedded in the national academic culture. A faculty member at UIUC said, “Unless the national reward system for universities changes, then it is naïve in the extreme to expect that any single institution, no matter how well intentioned, will move the ball very far from where it is now.”

Assessment

Another significant challenge is that of assessment. Those of us who work with students in the undergraduate research enterprise can recite anecdote after anecdote about the value and importance of the activity. The students say it is important to them. Administrators want to see hard data about how resources are used, and they want cost-benefit analysis. Donors and funding agencies want to know specifically what the returns are on their investments in students. At the Sigma Xi meeting in 1999, Melvin George stated that one of the categories lacking in the *Shaping the Future* document was assessment. He also said that one of the barriers to carrying education reform further is the focus on teaching particular material rather than assessing what students have learned.

According to Mabrouk there is little information in the sciences education literature regarding efforts to assess the undergraduate research experience. The University of Michigan has studied the effect of undergraduate research on retention and academic performance of students of color (Nagda, et al). A study of student evaluation of their research experiences has been reported by Mabrouk and Peters at Northeastern University. The LEAD Center at the University of Wisconsin at Madison has published three assessment studies (Alexander, et al.).
Several other assessment studies are currently underway. The University of Delaware is completing a longitudinal study and will soon publish reports on alumni perceptions of undergraduate research, content analysis of undergraduate research student evaluations (1985-1995), faculty perceptions of undergraduate research, and cognitive and psychosocial growth of undergraduate research (Bennett). Elaine Seymour at the University of Colorado, Boulder, and David Lopatto at Grinnell College, are collaborating on an NSF-funded “Pilot Study to Establish the Nature and Impact of Effective Undergraduate Research Experiences on Learning, Attitude, and Career Choice.” The project is being carried out at four liberal arts colleges.

A consortium of five foundations including Research Corporation, Keck Foundation, Camille and Henry Dreyfus Foundation, Robert Welch Foundation, and the Murdock Charitable Trust, is completing the first phase of a study to evaluate funding patterns for undergraduate research grants. The initial report will be issued in June to the presidents of 136 liberal arts colleges and comprehensive universities that participated in the study.

**Funding**

Funding undergraduate research is the good news and the bad news. The good news is that undergraduate research does not cost much relative to the costs of other initiatives, programs, and facilities at a university. The bad news is that because it does not require large sums of money, it may not get on the priority list for institutional fund raising. Students receive a big bang for a modest amount of money through undergraduate research. Faculty in most science disciplines can support students through supplements to their NSF, NIH, or other grants, but either they have to request it in the budget proposal or they have to write annual letters requesting supplemental support. The humanities and math faculty seldom have grant or departmental funds to support students even though research is relatively inexpensive. As a philosophy professor at UIUC said, “Philosophers are cheap to keep.”

The Howard Hughes Medical Institute has given institutions very large grants over five year periods to enhance research, facilities, and education in biology-related fields. Such
a grant launched undergraduate research in biology at Emory about ten years ago through support for program infrastructure and the restructuring of lab courses. An additional result was that undergraduate research began to spread into other disciplines at the university.

The need for funding brings opportunities with the challenges. Undergraduate research presents the opportunity to cultivate individual, corporate, and foundation donors who want to benefit students at a modest level of giving. The SURF program at Caltech raises close to 20% of its annual stipend funding of $1.8 million from these sources. It has also established an endowment that currently provides about 20% of annual stipend funds. The need to raise money has benefited the SURF program in many ways as a large cohort of stakeholders become interested in and committed to the students, the program, and the institution.

Conclusion

Fifteen years ago a series of reports and articles challenged the research universities to enhance and improve undergraduate education by, among other things, creating opportunities for students to do research with faculty. These reports also added to public pressure to address what was perceived as a research-versus-teaching emphasis at the universities. Students began to demand more opportunities to participate in the wealth of offerings available at a research university. Institutions began to struggle with ways to respond to growing popular and political pressure.

Response to this pressure among the six institutions in this study varied according to the state of undergraduate education at the institution, the priorities set by university leadership, and available human and financial resources. Caltech and MIT, with their smaller, more homogenous science and engineering focused environments, have provided undergraduate research for decades. About ten years ago, Rutgers, UW, and Emory began the arduous process of shifting emphasis to undergraduate education and creating a culture of undergraduate research. UIUC, faced with difficult financial problems during the ‘90s, is just now beginning the campus dialogue to address these matters.
Over the last decade Rutgers, UW, and Emory have taken steps to create a culture of undergraduate research. The administrations of these universities have acknowledged the value and importance of the enterprise and have committed resources to it. Faculty include students in their research programs and scholarly activities because they enjoy the mentoring process, and they are stimulated by working with bright minds. Faculty support institutional efforts to engage students in research and they concur that undergraduate research is a valuable part of the teaching mission. Students are invited into the community of researchers and scholars. They know how to find opportunities to engage in research, scholarship, and creative activities. In the institutions where there has been a university-wide conversation, the administration and the faculty deliver similar messages about the importance and value of undergraduate research. There is an institutional understanding of the definition of undergraduate research. Influencing the culture is the most difficult aspect of making change within an organization, and these institutions have been successful in that regard.

Although the environment at the universities has become more supportive of undergraduate research as part of undergraduate education, the largest undergraduate research programs I discovered at UW, Rutgers, Emory, and UIUC serve about 100 students; it is more common for programs to serve 30-50 students. The faculty with whom I spoke often work with one or two students at a time, some of them under formal programs, some through independent study, and others as employees or volunteers. It appears that a small fraction of the tens of thousands of students actually get a research experience.

Changing culture is a difficult process. It takes a long time. Change has begun to occur within the institutions in this study. Administrations and faculties are thinking creatively about how to address the shortcomings identified in various media. Students, now more sophisticated consumers of their educational experiences, are demanding increased educational opportunities including undergraduate research and experiential learning. The key to ultimate success will be in continuing the conversation, communicating success
within the academic community and to the public, and enlarging the vision of how research enhances the education of the nation’s undergraduates.

**Recommendations**

This report concludes with two recommendations of actions that can bolster the undergraduate research culture in the research universities. The recommendations are not intended to provide the silver bullet that will reform undergraduate education for the next century. They are made to encourage the next step in the process of changing the culture, pushing the conversation and action another turn up the helix. I leave it to others to paint the overarching vision of the ideal educational environment for our students. My intention here is to encourage modest steps that can be undertaken rather easily but which would make an impact in promoting undergraduate research.

**Keep the Conversation Going**

The AAU with its communication channels to the leaders of the top American universities is in a position to encourage the institutions to continue the conversations already started on their campuses. The undergraduate research enterprise competes with large and important issues that demand the attention of those who make policy on any campus. The AAU should encourage constituent universities to continue the conversation about undergraduate education reform and the development of undergraduate research on their campuses.

The administrators charged with responsibility for creating, managing, and running research programs for students often find themselves reinventing practices that have been established at other institutions. Several administrators with whom I spoke in my visits said that they wished there were a network of colleagues to share information, ideas, and best practices. Such a network would encourage the development of undergraduate research programs and would help foster the undergraduate research culture in participating universities through annual meetings, a web site, electronic newsletters or list servers. Such an organization would also encourage the dissemination of information...
and best practices through publication of articles. The organization and management of such a network would require minimal monetary and human resources.

**Funding for Undergraduate Research**

The AAU should use its influence to lobby federal agencies to expand their program portfolios to adopt a new funding paradigm for undergraduate research programs. Currently the NSF funds undergraduate research through its REU program providing grants that support 8-10 or more students at university sites or through supplements to ongoing faculty research grants. Proposals often must be written every year; sometimes grants are awarded for three years. The model used by the agencies makes undergraduate research funding uncertain; an award may be given one year, but not the next. Faculty and administrators scramble to launch a program one year, and just when they begin to understand what to do and how to do it, they have to apply for funding again which may not be awarded.

Institutions striving to develop undergraduate research programs would benefit from having significant funding over a long period of time, five years or longer, to develop infrastructure. They would have time to seek additional funding from other sources to maintain a program. This model alleviates the annual search for funding and allows administrators to concentrate on building programs to meet the needs of the students, the faculty, and the institution. A robust program can (and should) in time attract funding from other sources, but establishing the infrastructure is a critical factor that must be addressed early. This model could provide administrative salaries and expenses, student stipends, or research or travel funds for faculty to use for students. Developing a proposal to create an infrastructure for undergraduate research would induce institutional discussion about the costs, benefits, issues, and challenges to building a program. The university should be able to apply for funds that would best match its needs and its environment rather than an agency prescribing the nature of a new program.
NSF and other agencies use this funding model for large research programs, and using the paradigm to further promote undergraduate research would greatly benefit the universities, faculties, and students.

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I began this pilot project with a purpose of determining the focus of a larger study of undergraduate research at the research universities. I do not believe that further study of this type is necessary. As I interviewed faculty, administrators, and students over the past year, I began to hear themes repeated on each campus. The costs, benefits, issues, and challenges have been restated at each campus without adding new questions. I believe that this project has adequately described the state of undergraduate research in the research universities. I do not think that qualitatively reviewing another set of institutions using any focus of this study would reveal new information.
References


Bennett, Joan, e-mail communication, March 23, 2001.


Seymour, Elaine and David Lopatto, e-mail communication, February 2, 2000.


Western Association of Colleges and Schools Accrediting Commission for Senior Colleges and Universities, Visiting Committee Report to the California Institute of Technology, 12-15 October 1998.
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Appendix I

Pilot Project to Study Undergraduate Research in Six AAU Institutions

Purpose of the Pilot Project
- To characterize undergraduate research at six AAU institutions
- To identify issues, questions, opportunities, and barriers affecting undergraduate research
- To analyze data gathered from the project
- To write a report for the AAU
- To determine feasibility of carrying out a full exploration of undergraduate research at the AAU institutions or, more broadly, of the R-I institutions with funding from an agency or foundation

Scope of the Project
- Universities included
  - Caltech
  - University of Washington
  - University of Illinois, Urbana-Champaign
  - MIT
  - Rutgers
  - Emory
- Disciplines to be reviewed
  - SMET
  - Education
  - Humanities
- Individuals to interview at institutions
  - VP for Research/Deans (undergraduate and graduate)/Provosts as appropriate for the particular institutions
  - Faculty who involve students in their research and those who do not
  - Students who have and who have not done undergraduate research
  - Staff with responsibility for undergraduate research programs

Methodology
- Review reports of NSF REU or other agency/foundations and review the literature to gain broader view of undergraduate research at the research universities
- Develop set of questions to ask the various constituencies at the six universities; these questions will evolve during the course of the project
- Visit the six campuses and interview individuals and groups identified
- Establish database of responses and analyze data
- Write and submit report to AAU

Timeline
- December, 1999 – Search literature, set up travel schedules and appointments
- January-March, 2000 – visit campuses and conduct interviews
- April, 2000 – analyze data and write report
- Spring/Summer, 2000 – meet with AAU Deans and Provosts to present report
- Early fall, 2000 – Determine feasibility of expanding study and, if further study is desirable, draft plan for the broader study
Appendix II

Pilot Project on Undergraduate Research
at the Research Universities

Interview Questions

Questions to ask Administration:

What is the institutional commitment to undergraduate research?

What benefits does the institution gain from having undergraduate research opportunities or programs?

What are the costs to the institution for having undergraduate research?

What might the costs be of not having undergraduate research?

What are the motivations for having undergraduate research?

What has been the most important contribution that undergraduate research program has made to your university/scholarly community?

How did undergraduate research get started on your campus?

What are the unique benefits the research universities in general can offer undergraduate students? What about this institution in particular?

How can universities have more students involved in undergraduate research and experiential learning? What do all the students who don’t do UGR do? What are their opportunities?

Questions to ask Program Directors:

Describe the program. How do students apply to the program? How are they matched with the mentors? What are the requirements for participation? Eligibility? Are students paid? How much?

What is the motivation for the program? Recruitment? Retention? Enhanced academic experience for students? Support for underrepresented students?

Do students work in teams? How are teams formed? How do students learn how to work together?

How many students apply? How many participate? Who decides on who gets into the program? What fraction of students (relative to student body in college/department/etc.) participate? Do they get paid? Credit? Pay and credit?

Are there costs to the student for doing research? Does it change time to graduation? Are there benefits?

How many faculty mentors participate? What fraction of faculty in the institution/college/department participate? What are the incentives for faculty to participate (or not)? What are the costs to faculty for participating? What fraction of the faculty have participated? What fraction of the faculty have never participated?

Who initiates interaction between students and faculty?

How is the program supported? Sources of funds? Size of support staff?

Has the program grown over the past 5 years? How much? When did the program start? Why did it start?

What is the publication rate for students in research?

Have you assessed your undergraduate research students? If so, for what were you assessing? How did you do it? Have you tracked students beyond their bachelors degrees? Do you know how undergraduate research influenced students’ attitudes towards academics? Do you know how undergraduate research experiences influenced career decisions? Grad school?

How can universities have more students involved in UGR and experiential learning? What do all the students who don’t do UGR do? What are their opportunities?

What would help you do your job better? What has been most difficult for you in developing your program?

Do students receive pay or credit? How much credit? How much pay?

Do students majoring in one field conduct research in another field?

How is undergraduate research funded? Do faculty contribute to the undergraduate researchers? If so, typically how much of the stipend is contributed via faculty resources (internal and/or external)?

What has been the most important contribution that undergraduate research program has made to your university/scholarly community?
Questions to ask faculty who have served as mentors to undergrads:

How did you get involved with mentoring students?

What are the costs and the benefits to you? Your research?

What observations have you made about students who do research vs. those who do not?

What kind of projects do students do? Independent research projects? Class assignments? Web searching? What is the benchmark for a good research project?

Are students supervised on a day-to-day basis by grad students or postdocs? How do you prepare the grad students/postdocs for the mentoring responsibility?

What do you do to help integrate undergraduates into your lab group? Do you expect/invite them to participate in lab meetings?

Do undergraduates become colleagues with other members of your group?

Do students need special preparation/skills/techniques before doing research?

Do you discuss the culture of your discipline with the students? Research ethics? Research funding? Work ethics? Tenure hurdle? Publication issues? Other? Lab notetaking?

How often does the topic of undergraduate research surface in periodic faculty meetings? Typically what about the undergraduate research program is discussed?

What has been the most important contribution that undergraduate research program has made to your university/scholarly community?

How can universities have more students involved in UGR and experiential learning? What do all the students who don’t do UGR do? What are their opportunities?

Questions to ask students who have done research:

Tell me about your research.

Why did you do a research project? How did you get involved?

How did you find a faculty member to work with?

Was it easy to get a research project?
Do you believe that your institution is committed to this experience for its students? Do your friends do research? Do you like research?

Is your rapport different between friends who have done research and those who have not?

Has your research project changed, confirmed, or enhanced your ideas about your career?

What were the most important things you gained from your research?


Are there costs to you?

Are you comfortable with your faculty mentor? Do you ask questions? If problems arise, how do you handle them? Can you talk with your mentor about them? Are you more or less comfortable participating in class since your research experience? (or no change)?

How would you describe the environment at your school?

What has been the most important contribution that the undergraduate research program has made to the undergraduate student experience and community?