Assessing the impact of undergraduate research experiences: a review of the literature
(5/07 under review for publication in the Council of Undergraduate Research Quarterly)

Dr. Mary Crowe, Director, Office of Undergraduate Research, University of North Carolina Greensboro, 1000 Spring Garden Street, Greensboro, NC 27455 mlcrowe@uncg.edu, 336 334 4622
Dr. David Brakke, Dean, College of Science and Mathematics, James Madison University, Harrisonburg, VA 22807, brakkedf@jmu.edu, 540 568 3508

Institutions of higher education have entered the 21st century under increased scrutiny. Students, their parents, taxpayers, and legislators are demanding greater accountability for the benefits derived from their undergraduate education. Because undergraduate research seems to hold some of the answers to increasing student learning, retention, graduation rates and entrance into graduate programs, campuses across the country are providing more undergraduate research experiences (URE) for students. The faculty members who mentor undergraduate researchers are becoming responsible for assessing the impact of these experiences on students, faculty members, and their institution. While it is not realistic to conduct assessments of all of the possible benefits or outcomes of UREs on all levels (students, faculty members, the institution), we encourage individuals to select a few pertinent issues (e.g., retention, the impact on a faculty member's scholarship) to focus on. The purpose of this article is to represent key articles related to the assessment of undergraduate research. It is not a primer on designing an effective assessment protocol. However, we remind individuals that it is essential to establish clear objectives and to select or design the appropriate assessment instruments in order to derive meaningful information from an assessment. Then, as individuals collect and analyze information they should use that information to improve their program and the learning experience and outcomes for their students.

In the remainder of this article, we provide our summaries of the current literature associated with assessing undergraduate research experiences.

Assessment of Institution/Programmatic Undergraduate Research programs

Alexander, B., Foertsch, J., Daffinrud, S. and Tapia, R. 2000. The spend a summer with a scientist (SaS) program at Rice University: a study of program outcomes and essential elements 1991-1997. *Council on Undergraduate Research Quarterly* 20(3): 127-133
This article describes a summer program in Computer Science at Rice where minority students worked with role models on research projects. Sixty-two students participated, 67% of which have gone on to graduate school while another 33% obtained their undergraduate degree and found employment in a STEM-related field. The author suggests that the essential features of a successful summer program include: a meaningful research experience, the opportunity to interact with role models and other undergraduate students forming a "community".

Bauer, K.W. and J.S. Bennett. 2003. Alumni perceptions used to assess undergraduate research experience. *Journal of Higher Education* 74: 210-230.
The article begins with a brief history of the conflict between teaching and research and talks about how the Boyer Commission recommended making research-based learning standard in the curriculum. It begs the question for empirical evidence to demonstrate that the costs of

undergraduate research are justified in terms of value added. Current assessment instruments include attitudinal surveys of summer research experiences, perceived research skills gained and acceptance into graduate school. In this study, researchers surveyed alumni of a research institution and divided respondents into one of three groups: those who participated in research experience as part of a "university organized" program, those who participated in research on their own with a faculty member or those who did not do research as part of their undergraduate experience. Students within the three groups were matched for major, GPA, and year of graduation. The results were based on 986 returned surveys: 418 students participated in the institution's research program, 213 worked on their own with faculty members, and 355 had no research experience. Alumni in the first two groups were more likely to go on to graduate school (80% and 71% versus 59%, respectively), reported a greater satisfaction in their undergraduate experience, and reported increases in intellectual curiosity, research skills and communication skills. The students from the first two groups also reported that being involved in research with a faculty member did not prohibit them from doing other things. The alumni involved in research also reported they had better time management skills.

Campbell, A. and Skoog, G. 2004. Preparing undergraduate women for science careers. Journal of College Science Teaching 33(5): 24-26.
Women may be underrepresented in the sciences because they have fewer opportunities or because they encounter obstacles, both internally and externally. Texas Tech's HHMI program began in 1992 and its purpose was to increase the number of women and minorities who had research experiences. The authors sent surveys to the 57 participants and interviewed seven past participants who were currently enrolled in STEM PhD programs. Seventy-five percent (43/57) participants responded to their survey. The surveys indicated that the increase in skills, confidence and motivation was a result of the research experiences, mentors, external presentations and the student's interactions with others in the program. The article also quotes some of the women with respect to what they got out of the experience and their mentors. There was no control group.

Chandra, U., Stoecklin, S. and Harmon, M. 1998. A successful model for introducing research in an undergraduate program. *Journal of College Science Teaching* 28(2): 116-118.
This paper discusses a program in computer information systems at Florida A&M University whose goal was to increase the number of African Americans who pursue graduate degrees in computer information systems. The program had four parts. The first was to provide re-assigned time for faculty to engage students in research during the academic year and summer. Second, the program helped faculty members develop new courses in their research areas. The third part of the program helped the department purchase needed hardware and software to support research and instructional activities. The last component of the program focused on students and included professional development activities, enrollment in special topics, and summer research. The department also added research elements to the introductory courses as well as adding programming assignments. The department built from one level to the next: to introduce students to research in introductory courses, encourage students to enroll in research orientated special topics courses and independent research, offer graduate education symposium as well as requiring students to take the GRE. The results show an increase in the number of student research abstracts, participation of students in research, and 23 students pursuing an advanced

degree (vs. 2 the year before the program began). The program also led the faculty members to develop a M.S. program in computer information systems.

Chaplin, S., Manske, J. and Cruise, J. 1998. Introducing freshman to investigative research: a course for biology majors at Minnesota's University of St. Thomas. *Journal of College Science Teaching* 27(5): 347-350.
Introductory courses that switch to investigative labs change the role of student from passive to creative and critical thinker. The article describes a one-month (January) interim course open to freshman and sophomore biology majors. By offering the course to students early in their college career they will realize that research is not restricted to the brightest students. Each year a different professor teaches the course so not only do the topics changes but so does the location of the research. In some cases, the research is done in a laboratory, while other times it is done in the field or at an international site. The overall schedule of the course, however, was consistent. In week one the students are introduced to the content of the course, basic techniques, how to read primary literature, and were introduced to statistics. During weeks two through four they worked on research projects, culminating in a presentation (poster or oral). At the time of article, the course was offered six times with 47 students (34 of whom were freshman and/sophomores). Fifty-four percent of students then worked as research or teaching assistants, increasing their interaction with the major. Only two of the 47 students subsequently changed majors. Eight of the 47 continued research and presented their research at a national meeting.

DiBiasio, D. and Mello, N. 2004. Multilevel assessment of program outcomes and assessing a nontraditional study abroad program in the engineering discipline. *Frontiers: the Interdisciplinary Journal of Study Abroad* 10: 237-252.
The article begins by describing projects that interdisciplinary teams of students undertook at various international sites: erosion of the canals in Venice, Thailand farming practices, Costa Rican fertilizer application, and in London the communication of new air quality regulations. The authors describe the philosophy and pedagogy of the program. In 1970 a project-based program emphasizing teamwork was adopted. Student outcomes are centered in analysis, synthesis and evaluation. Students are required to complete three projects before they graduate: one in the arts/humanities, something in their major and this interdisciplinary technology/society project. Students apply to complete their project abroad; if they are not selected they complete a project in the local community. Students receive nine credit hours (one semester) for the projects. If they go overseas, they are on-site for 8 weeks. Every week the students are evaluated by faculty mentors for both the process and the product of the project. Students submit final reports, which usually are longer than 100 pages in length. The authors describe how the overall program is evaluated (and include some good tables). Lastly the article considers a program-wide evaluation in which an independent team of faculty members read the final projects and rated them on a variety of scales, creating a rubric using a 1-5 Lickert scale. Overall, students that complete their project overseas scored higher than those that worked on projects on-campus. They have just begun to evaluate their faculty mentors with a 48 item instrument using the 1-5 Lickert-scale.

Foertsch, J., Alexander, B. and Penberthy, D. 2000. Summer research opportunity programs (SROPs) for minority undergraduates: a longitudinal study of program outcomes 1986-1996. *Council of Undergraduate Research Quarterly* 20 (3): 114-119

This article reports on the Committee on Institutional Cooperation's summer research program. The CIC involves 15 Midwest R1 institutions that run summer research programs for minority students. Over 5400 students have participated during the 10 year period, 63% of which were African American. The students, from a variety of majors, worked on a research project, gained experience writing reports and giving presentations and attended GRE preparation workshops. This qualitative report of structured, open-ended questions posed to participants and alumni of the program, directors of Summer Research Opportunity Programs (SROP) and representatives from the minority institutions the students came from. Fifty-two percent of SROP graduates have gone on to graduate school with 35% of them completing their degrees. Another 23% elected to attend a professional school, whereas only 8% of minority students not involved in the program attended either graduate or professional school. Minority students from a given campus that were involved in SROP were more likely to attend graduate school at their given school than minority students from other campuses. Students felt the experience was a necessary and important step in getting into graduate school and the relationship with a mentor was critical to their success.

Nagda, B., Gregerman, S., Jonides, J., von Hippel, W., and Lerner, J.S. 1998. Undergraduate student-faculty research partnerships affect student retention. *Review of Higher Education* 22: 55-72.
This study examined a research program targeting freshman and sophomore students at a research university. Students involved in the program worked with faculty members to conduct bibliographic research, literature reviews and lab experiments. The program took place during the academic year. It involved monthly meetings, peer mentoring, and some skills workshops. The authors had a well conceived control group in which they could compare with participants of the program. They found that students involved in the program had a lower attrition rate than those not involved in the program, with African American students that had lower entry scores lower achieving African American students receiving the greatest benefit. The program had a greater impact on sophomore students versus freshmen students and found that peer advising helped to bridge the gap between intellectual and social lives.

Nnadozie, E., Ishimaya, J. and Chon, N. 2001. Undergraduate research internships and graduate school success. *Journal of College Student Development* 42(2): 145-156.
The article begins with an explanation of why and when the McNair Program began. Interestingly the program was authorized in 1965 but not funded until 1986. The components of a McNair Program include: undergraduate research, workshops, counseling, help applying for financial aid, and graduate school and GRE preparation. Success in this article is defined not only in getting into graduate school but completing an advanced degree. The authors sought to ascertain which characteristics of the McNair research program are most important; specifically the examined the frequency of workshops, the rigor of the research experience, and GRE preparation. They hypothesized the more rigorous of experience the better the success of the program. A 12 item Lickert questionnaire was distributed to 157 program directors in which the directors were asked to supply the number and types of workshops their program offers and the requirements of the research project. They asked for the directors to provide their institution's programmatic history with respect to McNair student's admission into graduate school, whether the student got funding and their completion rates. The authors got a response rate of only 22% (35 surveys were completed). They computed an overall rating of the program and recorded the number of students who went onto graduate school versus the total number of students that were

involved in the program. The authors also developed a scale for the rigor of the research experience with each of the following worth 1 point: research proposal, research design, final report, final presentation and submission for publication. Most of the research projects undertaken by students required a proposal and a final report. Many did not require a presentation or submission for publication. The results show that program directors reported that the most important components of the McNair program were: seminars, faculty mentored research projects and visits to graduate schools. They reported that GRE preparation workshops were the least effective. Additionally they thought the more rigorous the research project the higher the success rate of their students in graduate school and felt that if students attended too many workshops it was detrimental to student growth. The authors also interviewed McNair students at Truman State University. These students were in agreement with the program directors in citing the importance of undergraduate research in getting into and securing funding for graduate school, as well as in resulting in a higher success rate in graduate school.

Russell, S.H., Hancock, M.P. and McCullough J. 2007. Benefits of Undergraduate Research Experiences. Science 316: 548-549.
This short two page article summarizes a nation-wide assessment of undergraduate research experiences in STEM fields. The study involved four groups: 4,500 undergraduate student researchers funded by the National Science Foundation (NSF), the 3,600 research mentors of these students, 3,400 individuals who received STEM degrees but did not participate in a NSF funded URE and 3,200 individuals who received degrees in social, behavioral or economic sciences (SBES) but did not participate in a NSF funded URE. In 2005 the authors re-surveyed the undergraduate student researchers funded by NSF. Each group answered a web-based survey (available online at www.sri.com/policy/csted/reports/university/index.html#urosynthesis). The authors found that undergraduate student researchers said that the research experience clarified their career interests, increased their understanding and their confidence. Close to 70% of those surveyed said their interest in a STEM career increased as a result of their experience and 29% of students who had never considered getting a PhD now expected to. There appears to be a positive effect of the duration of the research experience on how students view the experience. The surveys did not detect significant differences between genders, racial/ethnic groups and that all students benefited from having a mix of mentors (with respect to the gender and ethnicity of the mentor). The authors conclude that earlier involvement in URE (freshman, sophomores) would be very beneficial.

Shellito, C., Shea, K., Weissmann, G., Mueller-Solger, A. and Davis, W. 2001. Successful mentoring of undergraduate researchers: tips for creating positive student research experiences. *Journal of College Science Teaching* 30: 460-465.
In 1997 the authors of this study conducted a mail survey of the 250 STEM undergraduate researchers at the University of California- Davis. They also conducted oral interviews with the faculty mentors. One hundred and seven students returned the survey, 2/3 of whom were seniors, 61% were female and 2/3 of them had previous research experiences. Of the respondents, 57% that reported they were satisfied with their experience said that their mentor was helpful. Sixty-four percent of respondents who were unsatisfied or somewhat satisfied were mentored by someone other than a faculty mentor (grad student or post doc). Students said it was important for mentors to be approachable and encouraging. The amount of time a mentor/mentee were together was an important criterion determining satisfaction. The most satisfied students spent

2.5 hrs a week with their mentors, while those that were somewhat satisfied reported only spending 1.1 hrs a week in contact with their mentors. Of the three models of mentors (project, career and individual), 54% of the students felt the ideal mentor would emphasize project guidance, while 34% felt the ideal mentor would provide individual guidance. The 13 tips from the faculty interviews include: develop well defined projects, recognize student constraints outside of the laboratory, commit ample supplies and equipment, understand and communicate expectations, spend time with your students, know your students as individuals, give positive constructive feedback, be approachable, respect students, progress toward student independence, encourage presentation, offer career advice and provide continued mentorship.

Summers, M. and Hrabowski, F. 2006. Preparing minority scientists and engineers. Science 311 (5769): 1870-1871.
In 2005, 45% of college bound students intend to major in science and/or engineering field when at college. Many leave the field, but women and minorities are more likely to leave than others. They leave because of academic and cultural isolation, non-supportive peers, discrimination and motivational and performance expectations. Majority serving institutions award 75% of the Bachelor degrees to African Americans. This article describes a program at UMBC to improve the number of underrepresented students who graduate with a STEM degree. In 1989,five of the eighteen African Americans students who graduated with a science and/or engineering degree had a GPA higher than 3.0. In the same year, UMBC began offering four-year scholarships to African American students intending to major in S&E fields and encouraged them to do research as part of their undergraduate experience. . From 1989-2006 they supported almost 800 students, 86% of which graduated with a S or E degree. Students in the program were twice as likely to graduate and five times more likely to go on to graduate school than control students (students who applied to the program but were not accepted). Five tips for success discussed in the article include: recruit high achieving students, give merit based financial aid, have a freshman orientation program, recruit research active faculty members, involve students early in research and have group activities (support network peer mentors, tutoring etc).

Ward, C., Bauer, K. and Bennet, J. Undated. 2004. Content analysis of Undergraduate Student Research Evaluations. http://www.udel.edu/RAIRE/Content.pdf (accessed January 14, 2005).
The authors examined free-form evaluations of 183 rising junior science majors who completed research projects during the ten year period 1985-1995. No specific questions were posed to the students rather the authors coded existing evaluation forms collected after the end of a 10 week summer experience. To compare the research experience to course work, comments were scored as equal in value to course work, less valuable than course work or more valuable than course work. Eighty-four percent (154/183) had written a comment on this overall question. Seventy-three percent (73%) of the students felt they experienced greater learning and 25% of the students felt they experienced equal learning to completed course work. Thirty-nine percent (39%) of respondents felts that their learning was as valuable as course work but was of a different kind. Ninety-five percent (95%) of the students felt they had increased their technical skills as a result of the undergraduate research experience while 28% had increased self-confidence. Over thirty percent (30%) of the students thought they increased their ability to think creatively while 57% cited an improved ability to act independently. About half of the students said that research had given them insight into what graduate school would be like while nearly a

third reported an increased desire to learn. No control group was identified and no input was received from faculty mentors.

<u>Assessment of the student experience in undergraduate research</u>

Cole, F. 1995. Implementation and evaluation of undergraduate research practicum. ***Journal of Professional Nursing 11(3): 154-160.***
From 1977, accrediting nursing organizations have required a research component for baccalaureate degree earning students. For the most part, schools meet this requirement by didactic means in the form of a lecture. The author designed an eight hour research practicum in which 35 nursing students carried out an experiment in which they measured the effect of ice water and circadian rhythms on temperature. The students worked in groups to measure temperatures at regular intervals, beginning early in the morning until late in the afternoon. Students were involved in all aspects of the research process except deciding on the research question. One important aspect was learning about the IRB process and patient information. At the end of the experiment students were given two Lickert-scaled surveys, one of which examined their attitude while the other asked what they learned. The students stated they gained a greater appreciation and understanding of what research was and were more positive about research. There was no control group and the statistical methods used to analyze the data (principle component analysis) do not appear to be appropriate.

Ferrari, J. and Jason, L. 1996. Integrating research and community service: incorporating research skills into service learning experiences. *College Student Journal* 30 (4): 444-451.
This article describes a class in which service learning was tied to research. Twenty-four undergraduates at DePaul University carried out research/service projects related to smoking cessation, chronic fatigue and self-help for substance abuse. Three teams of eight students carried out the projects, answered Lickert-scaled questions about how much they learned, and listed the pros and cons of the experience. Participants thought the experience resulted in personal growth, enriched their education and influenced their career goals. They liked working in teams and collecting data with real world implications. They found it difficult to schedule group meeting times and that, sometimes, there were personality conflicts between group members. However, most said they would repeat the experience and would recommend it to others.

Gafney, L. 2005. The role of the research mentor/teacher: student and faculty views. *Journal of College Science Teaching* 34(4): 52-57.
The author of this article has been an independent evaluator of many undergraduate research programs. The narrative results from examining qualitative evaluations of the programs and from over 250 individual interviews with student participants and faculty mentors. Five themes emerge from the qualitative evaluations: image of scientists, classroom vs. laboratory, mentoring and teaching styles, varied expectations, and multiple mentoring. When students work with faculty members on a research project, it is the first time that they realize that scientists are human and that many are passionate about their work, often coming in on weekends and at night. The biggest difference between the classroom and the lab is that the classroom setting provides answers while the lab is focused on answering a question. Students were also surprised at how long it took to complete a project. Mentors and students recognized that there are two levels of research; there are times when students need quite a bit of supervision and the times when a

student's skills are such that the student can function more independently from the mentor. Both students and faculty stressed that mentors need to be aware of the transition from the first to the second level and adjust their actions accordingly. Both students and faculty had varied expectations about how much personal and professional development might occur during the research project. Lastly, it was noted that mentors play more than one role, often coaching students in the lab, in preparation for a career or graduate study, and on some personal matters.

Hakim, T. 1998. Soft assessment of undergraduate research: reactions and student perceptions. *Council of Undergraduate Research Quarterly* 18 : 189-1192.
The article serves as a call to others that anecdotal information is was longer enough to document the benefits of undergraduate research. The author suggests that undergraduate research has four components: mentorship, originality, acceptability and dissemination. The article discusses qualitative assessment the experience of 25 undergraduate research students at Jacksonville University. The students were asked about their relationship with mentors, the challenges and rewards of undergraduate research, their gains in their academic discipline, their feelings and personal changes. The foremost conclusion that students state was that their research started out as directed but then proceeded to self-driven and motivated. Students felt more connected to their discipline, felts as though they contributed new information, and the experience allowed them to improve their problem solving skills.

Houlden, R., Raja, J., Collier, C., Clark, A. and Waugh, J. 2004. Medical students' perceptions of an undergraduate research elective. *Medical Teacher* 26(7): 659-661.
Queen's University in Ontario, Canada requires second year medical students to enroll in a critical inquiry elective during their second year. The authors administered an anonymous survey to the 2002 cohort of students. Sixty-six of the 71 students returned the survey, of which 60% of the students were male and 96% were between the ages of 22-27. Most of them had a research experience prior to medical school but this research experience prompted 47% of respondents to say they were more interested in medical research than prior to the experience. However, about half of the total respondents said the experience did not change their attitude about pursuing research as a career. Students reported skills that improved as a result of research include: literature search, critically reading the literature, designing a study, statistical analysis, and manuscript preparation. The article ends with a list of questions about the students' perception of factors influencing their decision to pursue a medical research career.

Hunter, A.B., Laursen, S.L. and Seymour, E. 2006. Becoming a scientist: the role of undergraduate research in students' cognitive, personal, and professional development. Science Education 91(1): 36-74.
This article is a continuation of the work described in Seymour et al. (2003). This ethnographic study summarizes the opinions of students and faculty members who engaged in an 'apprenticeship model" undergraduate research experience. The participants all hailed from four prestigious liberal arts colleges and were involved in a short-term (summer) undergraduate research experience. The article begins by outlines how undergraduate research fits within the constructivist learning paradigm and then describes the characteristics of the apprenticeship model of undergraduate research. The authors then describe the research design, interview protocols, transcription coding and analysis. The authors found that both students and their faculty mentors agreed on what students gained from their research experiences (such as gains in

understanding on what it means to work like a scientist, enhanced preparation for graduate school). There were differences between students and faculty mentors opinions about gains in higher order thinking skills and how each group "classified" their gains. The article includes a number of quotes from students and their faculty mentors in the sections: thinking and working like a scientist, becoming a scientist, personal-professional gains, clarification of career/graduate school intentions, enhanced career/graduate school preparation, and gains in skills. As with the Seymour et al. (2003) paper, there is a lot of good information to be teased out of the long narrative.

Ishiyama, J. 2001. Undergraduate research and the success of first generation, low income college students. *Council on Undergraduate Research Quarterly* 22: 36-41.
This article describes a program in which first-generation college and/or low income students are involved in research program that begins their sophomore year and continues until their senior year. The authors compared this group of students with a control group of students that had similar ACT scores and graduate school ambitions. They found that the students involved in research were more likely to stay enrolled as an undergraduate student and a greater percentage of these students went onto graduate school than the control group. In a self-reported survey, 71% of the students felt that the research experience was important, while 95% of them indicated that mentoring that accompanied the research experience was important.

Ishiyama, I. 2002. Does early participation in undergraduate students benefit social science and humanities students? Journal of College Students 36(3): 380-386.
This study examined whether humanities and social science students that engaged in undergraduate research as freshman indicate a higher self reported intellectual gains (thinking analytically, finding relationships and independent learning). The population consisted of 156 students attending a highly selective public university in the Midwest, 27 of who completed a research project early in their college career. The author compared the self-reported score of freshman with research experience with that of freshman students without research experiences on the College Student Experiences Questions (CSEQ). The results show that 47% of non-research students reported a score of 2.75 or higher vs. 72% of those students that did research. In a separate analysis of the data, the author indicates that a higher proportion of first generation low income students (88.9%) report a score of 2.75 or higher. There is no indication whether the author controlled for other variables. He concludes that early involvement in research promotes intellectual development.

Kardash, C.M. 2000. Evaluation of an undergraduate research experience: perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology* 92(1) 191-201.
Previous assessment of undergraduate research experiences has concentrated on the number of students that graduate and how many of the students pursue graduate or professional degrees. In this study, the author developed a list of quantifiable skills to assess whether/how the skills were met by a summer research experience. Student participants were given the survey before and after the summer program. Faculty mentors were given the survey after the program ended and were asked to identify which skills students would have gained experience in as part of their project. As a result of a summer research experience, students reported gains in their ability to orally communicate their project, and had become better at making observations, collecting data

and relating their study to the big picture. Skills that were least improved include the ability to ask a question, develop a workable hypothesis and reformulating a hypothesis based on the results of their work. Students felt that the experience did not help them learn how to write a paper, how to analyze data, or improve their statistical knowledge, although faculty mentors indicated that they didn't give students training in writing, statistical or data analysis.

Lopatto, D. 2004. Survey of undergraduate research experiences (SURE): first findings. *Cell Biology Education* 3: 270-277.
This article is a preliminary report of a long-term study of 10 week research programs sponsored by HHMI. One thousand, one hundred and thirty-five (1,135) undergraduate students who participated in undergraduate research from a variety of campuses filled out an on-line Lickert-scale survey. Students self-reported their attitudes and opinions. The topics in the survey were centered on: interest in graduate/professional study, the research process and skills associated with doing research, expectations of the experience, and the overall research experience. There were difference between responses of female vs. male students, with respect to field of study (more males in physical sciences) and women reported higher learning gains then men. There were no differences between ethnic groups. The study does not have a control group.

Seymour, E., Hunter, A., Laursen, S., and DeAntoni, T. 2003. Establishing the benefits of research experiences for undergraduates: first findings from a three-year study. *Science Education* 88: 493-534.
The authors of this study examine the current literature regarding the benefits of undergraduate research and describe their qualitative study of students engaged in undergraduate research experiences. The article begins with the authors dividing published manuscripts on evaluating undergraduate research into groups, those in which the hypothesized benefits are both claimed and well-supported, those in which the hypothesized benefits are stated but not adequately demonstrated (the majority of studies to date) and descriptive pieces. The authors then describe their research focused on students from four small liberal arts colleges who participated in a summer research experience. Each of these campuses had a strong history of undergraduate research and had 10-week summer research programs. Data was collected over three years but only the first two years of the experience is reported here. Researchers conducted focus group interviews with the 76 students before they began the program and at predetermined times post-program. Their 63 student comparison group consisted of students that applied, but were not accepted to programs, students who did not apply to any research program and students that participated in a different type of experience (clinical or industrial research). The researchers also interviewed 14 faculty members. Focus group interviews lasted between 60 and 90 minutes and were tape recorded and transcribed and then coded using *The Ethnograph.* Student learning outcomes were divided into personal/professional gains, thinking and working like a scientist, skills (communication, computer, reading etc), clarification of career goals, enhanced career/graduate school preparation and changes in attitudes. Overall this comprehensive study confirms a variety faculty claims about the benefits of hands-on research experiences while disputing a few others. This detailed study is useful in many respects, however the ethnographic analysis and length of time required for interviews with students is well beyond the capacity or ability of most undergraduate research programs.

Assessment of the impact of UR on faculty members

Colbeck, C.L. 1998. Merging in a seamless blend: how faculty integrate teaching and research. *Journal of Higher Education* 69(6): 647-671
Administrators and legislators often cause faculty to view the time they spend working as either teaching or research. The authors of this study were interested in determining what percent of faculty time could be considered to benefit both teaching and research? This study was conducted at a research university in which the faculty members belong to a union. Faculty members in English and Physics were interviewed and the author found that between 8-34% of a faculty member's time overlapped between teaching and research, with English faculty members on the lower end of the continuum. English faculty members tended to work with students in a counselor mode while Physics faculty members used a master-apprentice model. Physics faculty members tended to divide up research questions into smaller questions while the English faculty members had a holistic view of their own research.

Drennon, L. 2001. Quality assessment and the tension between teaching and research. *Quality in Higher Education* 7: 167-178.
As a result of a major expansion of universities in the United Kingdom, the government demanded quality assessment of research, teaching and learning. The authors suggest that it is easier to generate performance indicators for research than for teaching. As such, research is rewarded and teaching is not. The authors interviewed 15 faculty members from the Scottish system of higher education using 20 semi-structured questions. They found a strong relationship between a high rating in research and excellence in teaching.

Friedrich, R. and Michalak, S. 1983. Why doesn't research improve teaching? Some answers from a small liberal arts college. *Journal of Higher Education* 54(2): 145-163.
This article reviewed nine different studies that examined a relationship between research and teaching. Only one of the nine studies showed a slight positive correlation between the two. The authors conclude that the previous studies were too short in duration and did not closely examine the assumption of the relationship between research and teaching directly. In this study, the authors examined faculty members at a small liberal arts college who had all been there at least five years. They examined scholarly productivity from annual reports and teaching from evaluations of courses by students. The authors conclude that the single most important contribution to teaching that being research active provides is improved organizational skills. According to student evaluations, researchers have clearer presentations and are explicit in the requirements of assignments. Research active faculty members are slightly more available, give more feedback and are faster at returning work than those faculty members who are not active in scholarship. Students felt that faculty members who maintain an active scholarship program were less knowledgeable about the subject, but that they learned more from them. (very weird observation)

Marsh, H. and Hattie, J. 2002. The relationship between research productivity and teaching effectiveness: complimentary, antagonistic or independent constructs? *Journal of Higher Education* 73(5): 603-642.
The authors review a list of reasons why one would assume that teaching and research are mutually reinforcing activities. For this study, they examine teaching evaluations and research productivity of 182 faculty members from a variety of disciplines in the Australian system of

higher education. They found no relationship between teaching effectiveness and research productivity. However, they did find that faculty members who use a master-apprentice model rather than a counselor model are more likely to integrate teaching and research. These faculty members were successful at devising ways to have their courses contribute to their research productivity. The authors conclude that institutions of higher learning need to be more flexible in letting faculty members choose their role; some faculty members are excellent at research and teaching, effectively integrating them, while others are good at only one.

Michalak, S. and Friedrish, R. 1981. Research productivity and teaching effectiveness at a small liberal arts college. *Journal of Higher Education* 52(6): 578-597.
Historically, faculty members at primarily undergraduate institutions have had to justify their research with respect to the contributions it makes to their teaching effectiveness. In this study, the authors used the following tools to measure research productivity: the Deans at the school ranked a faculty member on a scale of 0-5 on productivity, and they examined the Science Citation Index and the Social Science Citation Index. The Deans also ranked a faculty member's teaching effectiveness on a scale of 0-5, taking into account student evaluations, new course development and pedagogical professional development. The overall conclusion is that research and teaching have something to do with each other, but not very much. Research and teaching were more strongly correlated in the humanities than they were in the natural sciences. A caveat in the study was that faculty members varied in their experience levels.

Sharobeam, M. and Howard, K. 2004. Teaching demands vs. research productivity and faculty workload in predominantly undergraduate institutions. *Journal of College Science Teaching* 31(7): 436-441.
In an effort to appease a state legislature interested in monitoring faculty responsibilities and how they spend their time, the authors set out to see what faculty members actually do. They surveyed 154 faculty members (all involved in Project Kaleidoscope), 127 of which were at PUI's. Many were from the field of biology, while 45% of respondents were not tenured. Many of the faculty members said that their Dean supported research but very few had release time. The average teaching load was 13 contact hours a week with labs taking up about 50% of faculty member's time. The average class size reported was 28 students, with 89% of the faculty members not receiving any help with lecture-based courses while 41% received no help with laboratory based courses. Faculty members served on average of five committees over a 2 year period. Eighty-seven percent of the faculty only did research during their breaks (i.e., Christmas, summer). Faculty members reported that support for research tended to be verbal and that approximately 40% of their colleagues are not active in research. Their institutions tended to provide limited start up costs, matching for grants, etc. The faculty members surveyed published one peer reviewed publication a year, but only 25% received external grants worth an average of $69K.

Volkwein, J. and Carbone, D.1994. The impact of departmental research and teaching climates on undergraduate growth and satisfaction. *The Journal of Higher Education* 65(2): 147-159.
The research for this paper was done at a Carnegie II institution and included faculty from 27 different departments, recognizing that academic departments possess variable climates for the support of teaching and research. The department's research climate was evaluated by: examining grant applications, grant recipients, the Dean's rating and the percent of active

scholars. The department's teaching climate was evaluated by: student evaluations, the Dean's rating, instructional contact hours and out of course faculty/student interactions. They also measured senior student intellectual growth and growth in disciplinary field. Over an eight year period, departments stayed relatively the same in research productivity. Research climate was not significantly correlated with the teaching climate. Students from departments that were strong in research and teaching had the highest intellectual growth. Students from departments that were weak in either field had equivalent intellectual growth as those students from department that were rated weak in both teaching and research.

Weimer, M. 1997. Integration of teaching and research: myth, reality and possibility. *New Directions for Teaching and Learning* 72: 53- 62.
This article suggests that the argument of teaching versus research is an old debate and must be reconciled because 75% of all faculty must have publications in order to get tenure. On national rankings it appears that the two are mutually exclusive because not one institution that was ranked within the 10% of research was also found in the top 10% for student orientation. There were 11 institutions ranked high in both categories but all of them were private, residential schools, enrolling students with very high SAT and with high socioeconomic status. These institutions tended to spend about twice the amount of money per student than the national average. The author suggests that faculty and administrators need to add the scholarship of teaching into the mix, as well as be very creative in integrating teaching and scholarship wherever possible.