

Mary Crowe's June 2006 annotative bibliography of peer reviewed journal articles focused on undergraduate research, retention and diversity issues

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, 62% 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 to form a "community".

Amenta, D. and Mosbo, J. 1994. Attracting the new generation of chemistry majors to synthetic chemistry without using pheromones. A research-based, group approach to multi-step syntheses at the college sophomore level. *Journal of Chemical Education* 71: 661-664.

This article describes a sophomore level research based inorganic/organic laboratory. Students work in groups to complete a particular synthesis. This lab experience builds on the first semester laboratory which students concentrated on techniques, keeping a notebook and writing papers in a journal format. During the first month of class, everyone works on a common synthesis. At week four, individuals are assigned to groups and an upper division "peer mentor". Groups are assigned a research synthesis, given limited information and expected to determine the needed reagents, materials etc. The projects usually require students to come into the lab outside of the regular designated laboratory period. At the end of the semester, groups orally present their work as well as hand in formal lab reports and their notebooks. There was no formal assessment of whether this format of a class influences students learning or attitudes.

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 research-teaching conflict and talks about how the Boyer commission recommended making research based learning standard in the curriculum. It begs the question for empirical evidence that the costs of undergraduate research are justified in terms of value added. Current assessment instruments range from 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: participated in research experience as part of a "university organized" program, participated in research on own with a faculty member or 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 a formal research program, 213 sought out faculty members on their own to work with and 355 had no research experience. Those in the first two groups were more likely to go on to graduate school (80 and 71% versus 59% respectively), reported a greater satisfaction of 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, they just had better time management skills.

Beer, R. 1995. Guidelines for the supervision of undergraduate research. *Journal of Chemical Education* 72(8): 721.

This article offers an example of a research contract for a student working in a chemistry laboratory but it could apply for any STEM discipline. The contract includes: objective, procedure, laboratory requirements, costs, schedule, additional projects, reading list, written report and presentation, grading criteria as well as a place for both the faculty mentor and the student to sign. The author suggests that the research mentor and student should meet to discuss and agree upon the contract before the project begins and that different items will initiate different conversations based on the student's experience. The contract allows for both the faculty mentor and student to have a good idea of expectations of the project. It also allows for easy identification of where a project is going wrong and a mechanism to put the research back on track.

Campbell, A. and Skoog, G. 2004. Preparing Undergraduate women for science careers. *Journal of College Science Teaching* 33(5): 24-26.

It is no surprise to hear that women are underrepresented in the sciences. They may be underrepresented 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, those seven that were currently enrolled in STEM PhD programs. Forty-three participants (75%) 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 women'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 is 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 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: re-assigned time for faculty to engage students in research during the academic year and summer; new courses in the research fields of the faculty; a program for students to learn about professional development activities, enrollment in special topics and summer research; and purchasing needed hardware and software to support research and instructional activities. 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: 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 helped

the faculty members 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 isn't just for brainy students. Each year a different professor teaches the course so the topic changes, sometimes research is done in a laboratory, sometimes in the field and even internationally. Week one students learn the background for the course, basic techniques and how to read primary literature, introductory statistics. During weeks two-four they work 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 left the biology majors. Eight of the 47 continued research and presented their research at a national meeting.

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 their time 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 teaching and research, with English faculty members on the lower end of the continuum. English faculty members tended to work with students in the 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 research.

Craig, N. 1999. The Joys and Trials of Doing Research with Undergraduates. *Journal of Chemical Education* 76: 595-598.

This article is a retrospect of what the author has learned in the past 40 years working with students in a 10-week long summer program. This faculty member expects a well-written comprehension report, keeping publications in mind. He made sure to carve out appropriate niches which meant finding a research project that fit a student's training and background. He found it essential to have top rate instruments so much so that sometimes he gave up summer salary for a piece of equipment. He collaborated with others off campus and worried about the "loose ends" so that the students could concentrate on the research. Expected enthusiasm and honored student work.

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 Rica fertilizer application, London communication new air quality regulations. The authors describe the philosophy and pedagogy of the program. In 1970 project based program emphasizing teamwork was adopted, student outcomes are centered around 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 T/S project abroad; if they are not selected they complete the project on the home campus. Students get nine credit hours (one semester) for the work and if they go overseas and they are gone for 8 weeks. Every week of the projects 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 spend a good portion of the last part of the narrative telling about how the overall program is evaluated (good tables!). Lastly the article describes 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 Lickert scaled scale.

Doyle, M.P. 2002. Academic Excellence – The role of research. *Journal of Chemical Education* 78: 1038-1044.

The published text of Doyle's speech accepting the George C. Pimentel Award. After describing his senior undergraduate independent project Doyle then turns to undergraduate research. Doyle began working with undergraduates because he was in an academic environment with limited access to graduate students. Each semester he taught 12 contact hours, but the institution had hallmarks of excellence research program: supportive start up packages, matching costs for instruments, flexible departmental budgets, and a sabbatical leave program. The expectation was, and continues to be, that faculty members write a grant prior to arriving on campus as well as one during their first year. The article then goes on to discuss the results of the following study: Academic Excellence: the role of research in the natural science at university institution. The study was based on surveys from 2,900 faculty from 136 private/public institutions. Of the 40% of institutions that received RC, NSF-RUI or NIH-AREA awards only had more than one such award over 15 years even though the number of faculty increased 20%. Additionally the number of grants to RC, NSF-RUI and NIH-AREA remained constant. The average publication rate for faculty is .54 publications a year and only 25% of faculty publications have undergraduate students as authors. The average external funding for chemistry faculty is \$13,000 per year. One note, this study only surveyed the faculty members for peer reviewed articles, not presentations. Doyle said counting only peer reviewed publications, rather than presentations by students, was sign of excellent programs and justifiable.

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 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.

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.

An example of 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 and 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.

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 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 in the 10 year period, 63% of which were African American. The students, from a variety of majors, worked on a research project and also gained experience writing reports, giving presentations and attended a GRE preparation workshops. This qualitative report of structured, open-ended questions posed to participants and alumni of the program, directors of SROP programs 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. 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 into getting into graduate school and the relationship with a mentor was key to their success.

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 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 studied 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 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.

Gafney, L. 2005. The role of the research mentor/teacher: student and faculty views. *Journal of College Science Teaching* 34(4): 52-57.

This summary article was written by an outside evaluator of many undergraduate research programs. The text is a result of gleanings from written surveys and 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. In a nutshell, 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, 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 at which students need quite a bit of supervision and the times at which a student's skills are such that the student can function pretty much independently from the mentor. Both students and faculty stressed that mentors need to be aware of the development/transition from the first to the second and adjust their actions accordingly. Both students and faculty had varied expectations with respect to 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.

Giebelhaus, C. and Bowman, C. 2002. Teaching mentors: is it worth the effort? *The Journey of Educational Research* 95(4): 246-254.

This article does not directly address undergraduate research. Rather, the article examines the effect of training of mentors has on the mentee's training. In this case, the mentees were preservice educators undergoing their practicum. In the study, 14 of the mentors received training while 15 of the mentors did not. Classrooms interactions of the mentees and students were videotaped and analyzed. The mentees were graded on: organizing content knowledge, creating a learning environment, teaching for student learning and teacher professionalism. A variety of variables made up the categories. Analysis of the videotapes showed that mentees whose mentors received training scored "higher" (better) than mentees whose mentors did not undergo training.

Gurin, P., Nagda, B. and Lopez, G. 2003. The benefits of diversity in education for democratic citizenships. *Journal of Social Issues* 60 (1): 17-34.

The article begins with an overview of the importance of diversity in higher education. Is it enough to have diversity but no integration of people from different ethnicities. In this study they looked at 87 students in a curricular diversity program at the University of Michigan. What is the role of diversity and unity? Complex social structures fall into the "discontinuity and

discrepancy” role in a fostering cognitive growth. The UM has the intergroup program (IGR). Freshman from diverse backgrounds are brought together to discuss papers, lectures and engage in intragroup dialogue. Groups have 12-14 members that decide early on the ground rules of discussion, how to negotiate conflict etc. The presented in this paper is from a longitudinal study where they sent the 87 students and an equivalent group of 87 students a survey their senior year. The questions on the survey dealt with perspectives taking, different values across groups, community service, civic participation and interest in politics. There were significant differences between the two groups specifically with respect to democratic sentiments and could take/appreciate the perspective of others. They were more likely to engage in civic activities, more interested in politics and more likely to attend events like MLK celebrations. Students of color had a lower sense of community than the white students that participated in the program. The results suggest that it isn’t just enough to have a diverse student body but that interaction is very important.

Hakim, T. 1998. Soft assessment of undergraduate research: reactions and student perceptions. *Council of Undergraduate Research Quarterly* ?? : 189-1192.

A call to others that anecdotal information is no longer enough to document the benefits of undergraduate research. Suggests that research has four components: mentorship, originality, acceptability and dissemination. Talks about qualitative assessment of 25 undergraduate research students at Jacksonville University. The students were asked about their relationship with mentors, the challenges/rewards of undergraduate research, their gains in their academic discipline, their feelings and personal changes. The #1 conclusion was that their research started out as directed but then proceeded to self-driven and motivated. Students felt more connected to their discipline, they contributed new information and allowed them to problem solve.

Hammer, S. 2001. Enhancing biological understanding through undergraduate field research. *The Journal of General Education* 50(3): 192-201.

A descriptive article about a faculty member’s research with non-biology majors. The author participated in a NSF partnership for enhancing expertise in taxonomy program. He recruited non-majors in their sophomore year to explore lichens in the field. The article talks about what a day in the field was like, what the benefits of working as a team were and how students trained each other. There was no evaluation data presented in this paper although it is clear sophomores contributed to the research program in an effective way.

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 enquiry elective their second year. The authors administered an anonymous survey to the 2002 cohort of students. Sixty-six of 71 students returned the survey, 60% male and 96% were between the ages of 22-27. Most of them had had a research experience prior to medical school but this research experience prompted 47% of respondents to say there 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. 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 students perception of factors influencing their decision to pursue a medical research career.

Ishiyama, J. 2001. Undergraduate research and the success of first generation, low income college students. *Council on Undergraduate Research Quarterly* 22: 36-41.

Describes a program in which first generation or low income students get involved in research program that begins their sophomore year and continues until their senior year. They 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 undergraduates; a greater percentage of these students went onto graduate school than the control group. Seventy-one percent of the students felt that the research was important while 95% of them indicated that mentoring was important.

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 pre and post summer program while faculty mentors were given the survey post program. As a result of a summer research experience, students reported gains in their ability to orally communicate their project, had become better at making observations, collecting data and relating their study to the big picture. Skills that were least improved upon 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 analyze data or improve statistical knowledge. This last sentence shouldn't be too surprising given that faculty mentors indicated that they didn't give students training in writing, statistical or data analysis.

Kenny, S. 2003. New challenges in a post-Boyer world. *American Scientist* 91(2): 103- 106.

The article describes the impetus for the now infamous Boyer report: graduates of R1 institutions were not going on to graduate study in the arts and sciences. R1 institutions graduate 32% of all undergraduates but represent only 6% of all institutions of higher learning. The immediate discord over the Boyer report then results in new inventiveness in pedagogy and more attention to the undergraduate experience. Funding from NSF and pressure from societies (Sigma Xi etc) and US World News and Report that lists undergraduate research as one of eight programs that work. The other seven are: freshman seminars, internships, senior capstones, learning communities, study abroad and writing in the disciplines. A follow-up survey, occurring just three years later (2001) of in which 91 R1 institutions responded. Sixty-two percent of the respondents said they involved >50% of the science students in undergraduate research but only 44% of engineering students, 25% of social scientists and 21% of humanists. She suggests we still do not know if undergraduate research creates a better undergraduate research experience and record keeping is difficult. Problems still need to be addressed: supervising undergraduate research as part of promotion and tenure, financial support and philosophical support.

Lancy, D. 2003. What one faculty member does to promote undergraduate research. *New Directions for Teaching and Learning* 93: 87-92.

The article begins with how a faculty member in anthropology integrates research into a course he teaches. Students complete an annotative bibliography, a grant proposal with timeline and a budget. They then do the research and present the results to their peers. The author also involves students as teaching fellows: as caretakers for a museum. Lastly the author has students evaluate the effectiveness of the honors program as part of a research question. The author then presents a checklist for faculty members interested in working with students. The checklist is divided into the following sections: how does a course lay the ground work for undergraduate research, how might students be involved in the development of courses, how can undergraduates be involved in faculty research, what can a faculty member do as a university citizen.

Lopatto, D. 2004. Survey of undergraduate research experiences (SURE): first findings. *Cell Biology Education* 3: 270-277.

A preliminary report of a long-term study of 10 week research programs sponsored by HHMI. 1,135 undergraduates 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 than men. There were no differences between ethnic groups. The study does not have a control group.

Leonard, W.H. 2000. How Do College Students Best Learn Science? An assessment of popular teaching styles and their effectiveness. *Journal of College Science Teaching* 29: 385-388.

The article really isn't an assessment piece. Rather the author describes the basis for constructivist learning. The author cites a number of studies/articles that are testimonials to this method and the philosophical under-pinnings of constructivist theory. A portion of the article is devoted to talking about how students learn in different ways based on Meyer Briggs personality type. The article concludes that professors should use more active learning and implement constructivist learning in the classroom. Engage, explore, elaborate, evaluate. We should use lab before lecture, to provide students with conceptual framework and advanced organization. We should also consult that National Science Education Standard for content.

Malachowski, M. 2003. A research across the curriculum movement. *New Directions for Teaching and Learning* 93: 55-68.

The chapter begins with a description of why do research at PUIs: faculty can continue to make progress in their field, are intellectually challenged, can improve teaching and can engage students in scholarship. Suggests that if faculty members conduct research without students it might be detrimental to learning and institutional quality. Faculty that are student orientated value interactions with students and engage them in a variety of ways. Why would faculty members not include students? A few reasons given include departmental culture and no institutional commitment. To institutionalize undergraduate research he suggests that cultural issues (humanists, artists) need to be addressed through faculty development. Faculty members

must be committed to seeing the research projects as an opportunity to teach. Administrators must plan for it in promotion and tenure, budgeting, workload issues, merit pay, public relations of the institution. Describes what a centralized office of undergraduate research should look like and do.

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 the list 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 while others are good at only one.

McIntosh, G. 2001. Intellectual development and Undergraduate Research in Physics. *Journal College Science Teaching* 30: 412- 413.

Basically an opinion piece about why faculty members should work with students on undergraduate research projects. In fact, the section of the journal that this is found is called "Point of View".

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 the school ranks a faculty member on a scale of 0-5 on productivity, examined the Science Citation Index and the Social Science Citation Index. Dean's 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 of the study was that faculty members varied in their experience levels.

Mills, N. 1984. Undergraduate research from the perspective of a young faculty member. *Journal of Chemical Education* 61(6): 513-514.

The article outlines reasons why a faculty member should immediately begin a research program at their undergraduate institution. In addition to conveying "excitement" about the discipline they have a better chance of not having a lapse in their publication record making it more likely a grant proposal will be funded. By writing the grant and staying active, the faculty member remains active in networking with others. The author mentions some funding opportunities just for new faculty members. The article then gives some helpful advice about how to work with

undergraduate students such as weekly meetings, giving straight forward advice, assembling teams of researchers. Lastly the article addresses the importance of having senior faculty mentors be supportive of their junior colleagues.

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 and also 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 lower achieving African American students impacted the most positively. The program had a greater impact on sophomore vs. freshmen and that peer advising helped to bridge the gap between intellectual and social lives.

Narum, J. 2004. Science spaces of the twenty-first century. *Change* (Sept/Oct) 8-21.

Winston Churchill: We shape our buildings and then they shape us. This article talks about the history of thinking about how to design places for students to learn. Today we know that the science spaces support learning that is community based, open twenty-four, seven, are problem posing and solving recognize that social interactions take place, reflect interdisciplinary. In 1986 Oberlin was one of the first studies that showed the value of undergraduate research as a learning experience. It lead to changes in how we teach and the spaces we teach in. The transformation of facilities and programs happened at the same time. Three years later the Academic Research Facilities Modernization Act occurred; our research spaces were becoming outdated and we needed to improve introductory courses, the laboratories and incorporate technology. The article talks about the importance of “sandboxes”, multipurpose spaces and the trend for the future in incorporating what is learned, how it is learned and where it is learned.

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/when the McNair Program began. Interestingly enough it was authorized in 1965 but not funded/established until 1986. The components of a McNair Program include: undergraduate research, workshops, counseling, helping applying for financial aid and graduate school and GRE preparation. Success in this article means not only getting in graduate school but completing it as well. The authors sought to find out what major characteristics of the McNair research program are important, specifically looking at the frequency of workshops, the rigor of the experience and GRE preparation. They hypothesized the more rigorous of experience the better the success of the program. A 12 item Lickert questionnaire distributed to 157 program directors that queried the number of sessions, the types of workshops and the requirements of the research project. They asked for programmatic histories with respect to McNair student's admission into graduate school, whether the student got funding and their completion rates. Got a response rate of only 22% (35 surveys). They computed an overall rating of the program and recorded the # of students who went onto graduate school vs. the total # 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 nor submission for publication.

Program directors reported that the most important components of the McNair program were: seminars, faculty mentoring, visits to graduate schools while GRE preparation was rated as the least effective. They thought the more rigorous the research project the higher the success rate of their students in graduate school. They 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 with respect to rating the importance of undergraduate research in getting in and securing funding for graduate school as well as in resulting in a higher success rate in graduate school.

Oliver-Hoyo, M., Allen, D., Hunt, J., Hutson, W. and Pitts, A. 2004. Effects of an active learning environment: teaching innovations at a research I institution. *Journal of Chemical Education* 81: 441-448.

These researchers adopted Scale up for an introductory chemistry course. In a nutshell, classes meet for a two hour session, with two short lectures interspersed between activities normally covered in the course. Nine students sit at a round table, three groups of three in a technology rich classroom. The authors also describe techniques used to efficiently grade large classes without too much time (bonus performance points for the group exam grade, random assignment of assignments to be handed in, using electronic submission of homework, scan of “white” board answers: affective use of computers). The authors compared the learning outcomes of students in this class with those of students who took the course in a traditional format. They carefully controlled “time” to a given content area, used the same instructor and gave examples of examples of how the same topic would be taught to two different groups. Assessed student content using a pre/post test as well as other exams throughout the semester. Statistically examined the results using a three-way ANOVA with class, major, exam as main factors. Their results show that students in the active learning environment did better, but not statistically better, on two lecture exams. However, the lowest 25% of the students in the new class did statistically better than the lowest 25% in the traditional class. An article examining the attitudinal survey will be published later.

O’Sullivan, D. and Copper, C. 2003. Evaluating active learning: a new initiative for a general chemistry curriculum. *Journal of College Science Teaching*

Describes efforts of examining general chemistry instruction at the U.S. Naval Academy. The transformation began with a series of discussions. A core group began to accumulate active learning strategies: problem solving worksheets, creative test taking strategies, hands on activities and explain the demo. Took the best of the above and tested them out with 2 experimental groups of students. Compared the academic performance of those taught traditionally and the “regular” course. Made sure that prior to assignment of the course were the same (SAT, math placement etc). Compared exam grades, those in active learning did significantly better. Please note that the criterion for significantly better was relaxed significantly and statistically.

Pladzewicz, J.R. 1984. Factors important to the maintenance of undergraduate research programs. *Journal of Chemical Education* 61: 513.

Although this article is over 20 yrs old, it provides an interesting perspective on UR research of respect to “expected outcomes” of new UR programs funded by NIH-AREA, NSF-RUI, and Petroleum Fund. Suggests a great way to continue as a research would involve collaborating with individuals from R1 institution. Provides the following checklist of excellent institutional support for research: accepts research as valid reason for resources, provides faculty travel, start-up costs, internal equipment and salary grants, P and T are based on it; recognizes the need for sabbaticals, is included in public relations, and there is support for space and equipment.

Rodrick, R. and Dickmeyer, L. 2002. Providing undergraduate research opportunities for communication students: a curricular approach. *Communication Education* 51(1): 40-50.

The article begins with an overview of what is undergraduate research and listing what some commonly cited definitions. They settle on Hakim’s 2002 definition: it is a faculty-student collaboration, it generates new knowledge/scholarship and it is shared with the appropriate audiences. They list the benefits of undergraduate research and the increased interest in it that was a result of the Boyer report and national organizations. It wasn’t until the 1980’s that undergraduate research that undergraduate research began to found in course descriptions. Eighty-three percent of departments that answered a 1998 survey had a separate course called Research Methods. The content of this course typically covers qualitative/quantitative methods, research design, interpreting results, how to sample, etc. They suggest that in addition to the Research Methods course that departments should offer a capstone experience so that students can use what they learned in the research course. They then describe the course they developed at UW-LaCrosse which enrolls 20 students a section. Each student completes an independent project under the direction of a faculty mentor, a faculty reviewer and an editor (the person responsibility for teaching the course). During the first three weeks members of the class meets formally but for the rest of the semester work independently with another faculty mentor and reviewer. Each student hands in a research proposal, final report as well as gives an oral presentation of their project during the last two weeks of class. Lastly the authors address the tradeoffs to the time investment needed for this course: larger introductory class sizes.

Rao, P, Arcury, T. and Quandt, S. 2004. Student participation in community-based participatory research to improve migrant and seasonal farmworker environmental health: issues for success. *Journal of Environmental Education* 35(2): 3-15.

Community-based participatory research (CBPR) occurs when community members are engaged in the research. The projects addressed in this paper focus on environmental and occupational health issues for migrant workers. North Carolina ranks 5th in the nation in employing seasonal migrant workers that typically are Latino. This work is hazardous and the population tends to be medically underserved as these workers are not usually part of studies because of their migratory nature as well as because of transportation issues. CBPR increases the likelihood that research will be done in a culturally and educational appropriate way and is more likely to be sustainable. The authors admit that working with community members adds a layer of complexity to the research. The authors suggest that when involving students in research the following questions be asked: is it suited for the student? Is the student suited for the project? Curricular preparation as well as experiences need to be considered. In the case of their research one of the primary determinants of the student involvement is the ability to speak the language of the workers. The

authors report on four different projects and in this article there is no formal evaluation of the program. They do report, however, that students were frustrated when community members failed to show up for meetings.

Saacks-Giguette, M. and Lang, R. 1999. Implementation of a Research Program at an Undergraduate Institution. 29th ASE/IEEE Frontiers in Education Conference 13C 51-56.

This article describes how a Computer Science Department at a HBCU runs a research program. Students involved in this program (funded by NSF) had to have at least a 2.8 GPA. They submitted an application that required an essay of what they hoped to gain, their transcripts as well as faculty letter of support. A faculty committee interviewed the students. There are four phases of research, phase I in the summer was an introduction to research, reading the literature etc. Phase II was during the AY when students worked 10 hrs a week with faculty members at Xavier; Phase III was in the summer and students went off campus to do research while Phase IV was much like Phase II. Eleven students submitted 13 papers/conference proceedings and of those that graduated, 4/5 went on to graduate school. Only three students got dropped from the program. The article ends with a list of the different projects the students worked on.

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 divide published manuscripts in to those in which the hypothesized benefits are both claimed and well-supported and those in which the hypothesized benefits are stated but not adequately demonstrated (the majority of studies to date). They then go on to 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 will be collected over three years, the first two years of the experience is reported. 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.

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 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; 45% of respondents were not tenured while 55% were. Lots of the faculty 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 their time. Average class size was 28. Eighty-nine percent of the faculty members did not receive any help with lectures while 41% received no help with laboratories. 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 (Christmas, summer). Faculty members reported that support for research tended to be verbal and that 40% of their colleagues are not active in research. Their institutions tended to provide limited start up costs, matching for grants etc. Given the above, in reality the faculty members published one peer reviewed publication a year but only 25% received external grants worth an average of \$69K.

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 criteria in satisfaction. The most satisfied students spent 2.5 hrs a week with their mentors while those that were somewhat satisfied reported 1.1 hrs a week of contact. 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.

Terenzini, P., Theophilides, C., and Lorang, W.G. 1984. Influences on student's perceptions of their academic skill development during college. *Journal of Higher Education* 55(5): 621-636.

Can non-classroom interactions with faculty be a significant influence on student learning? The authors surveyed incoming freshman and then each subsequent year with respect to the interactions students had with faculty outside of the classroom. A total of 250 students from on institution were followed over a 4 year period to see what effect non-classroom interactions had on their intellectual development. Students were asked to keep track of the number of times, the duration and the subject of their interactions with faculty outside the classroom. Sophomore students indicated that the quality of the interaction was more important than the quantity, while juniors indicated that both the quality and the quantity were important.

VanHecke, G, Karukstis, K., Haskell, R., McFadden, C and Wettack, S. 2002. An integration of chemistry, biology and physics: the interdisciplinary laboratory. *Journal of Chemical Education* 79(7): 837-844.

The article begins by citing peer reviewed articles that describe other ways institutions have developed interdisciplinary courses. The majority of the article describes a first year interdisciplinary laboratory for science and engineering majors. Students either enrolled in the traditional course or traditional chemistry and physics lecture but the interdisciplinary laboratory. Over the course of the year the students in the experimental laboratory completed 8 different experiments that were interdisciplinary in nature. The article describes in detail the laboratory activities. Evaluation of the course indicates that students had a more positive attitude about the sciences, had a better understanding of how the sciences were related but no measurable higher order thinking skills. It was measured but not clear if they were affected.

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 Carnegie II institution and included faculty from 27 different departments because the authors recognize 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 on the research productivity scale. 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 was rated weak in both teaching and research.

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. 154/183 had written a comment with respect to this overall question. 73% of the students felt they experienced greater learning and 25% of the students felt they experienced equal learning to completed course work. 39% of respondents felts that their learning was as valuable as course work but was of a different kind. 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. 32% 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 the research had given them insight into what graduate school would be like while nearly a third reported and increased desire to learn. No control group or input from faculty mentors.

Weimer, M. 1997. Integration of teaching and research: myth, reality and possibility. *New Directions for Teaching and Learning* 72: 53- 62.

Suggests that the argument of teaching versus research is an old debated but 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 that were ranked high in both categories but all of them were private, residential, enrolling students with very high SAT and 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, in writing textbooks, service learning, and as part of courses.

Wubah, D., Schaefer, D., Brakke, D., Downey, D., Gasparich, G and McDonald, G. 2000. Retention of minority students through research. *Council of Undergraduate Research Quarterly* 20(3): 120-126.

This article begins by citing a number of statistics regarding minority enrollment in STEM disciplines, as undergraduate, graduate students and employment in the field. It then describes a variety of programs at NSF, NIH and NSAS that have been put in place to increase the number of minority students pursuing STEM degrees. The last part of the article focuses on two summer undergraduate research programs run at Towson University and James Madison University. Participants in this program not only worked with mentors on a research program but also attended research seminars, had group meetings, went on field trips and attended professional development workshops. The authors say that proper academic preparation, good study skills, financial aid and the environment and culture at an institution all influence minority students pursuing STEM degrees.