
# Cross-Discipline Perceptions of the Undergraduate Research Experience

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**PWP-CCPR-2009-054**

**December 2009**
**Last Revised: December 2009**

***California Center for Population Research***
***On-Line Working Paper Series***

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Multi-year assessment of self-reported benefits, outcomes, learning goals, and awards for diverse, liberal arts college undergraduate researchers found consistent benefits but discipline- and ethnicity-dependent outcomes. The role of the mentor-protégé relationship and the research projects' initiation both show disciplinary and ethnic group dependence. Research participation is associated with student achievement.

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The interest in undergraduate research as a "touchstone" for the integration of research and education (Bauer & Bennett, 2003, p. 212) has led to a large number of programs and models supported by a variety of public and private sources (Seymour, Hunter, Laursen, & DeAntoni, 2004). Assessments have examined students' progress toward advanced degrees, clarification of career path decisions, understanding of research-associated skills or attitudes, and access to research (Denofrio, Russell, Lopato, & Lu, 2007; Frantz, De Haan, Demetrikopoulos, & Carruth, 2006; Hunter, Laursen, & Seymour, 2006; Hurtado, Eagan, Cabrera, Lin, Park, & Lopez, 2008; Ishiyama, 2002; Lopatto, 2004; Russell, Hancock, & McCullough, 2007; Seymour et al., 2004). This study examines the benefits, outcomes, and goals for undergraduate research across disciplinary area, academic class standing, gender, ethnicity, and previous research experience.

This research was sponsored by the National Science Foundation award OIA #98738121 and DBI #9988059 and the Howard Hughes Medical Institute Undergraduate Science Education Program awards #52002651 and #52005135. The authors gratefully recognize the advice and encouragement of Elaine Seymour, David Lopatto, James Gentile, Peter Collings, John Van Zytveld, Patricia Mabrouk, Jeanne Narum, and site visits organized by Sherri Green (NSF) and Patricia Soochan (HHMI).

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*The Journal of Higher Education,* Vol. xx, No. x (xxx/xxx 2009)

*Prior Studies*

Undergraduate research has multiple benefits to science students in the areas of skill development, retention, and post-graduate education. An in-depth, multi-year, ethnographic study of summer undergraduate science researchers (69% male) and faculty advisors at four highly-selective colleges found the greatest gains for researchers in their personal and professional abilities, "thinking and working as a scientist," research specific skills, and clarification/confirmation of career plans (Seymour et al., 2004, p. 493; see also Hunter et al., 2006). A larger multi-institutional survey of 1,135 science undergraduate researchers found multiple benefits to participants, including a very strong interest in postgraduate study, and similar benefits across gender and ethnic groups (Lopatto, 2004). Looking over a broader time frame, 57 junior and senior science-interns participating in academic-year and summer research reported comparable degrees of research skills enhancement: with communication of results, data interpretation, and formulating a research hypothesis showing the greatest gains (Kardash, 2000). Further, in a longitudinal study of first and second-year research students at a research university, early participation in undergraduate research increased retention of African-American students (Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998). A subsequent alumni survey found undergraduate researchers were more likely to pursue graduate and professional education, and maintain faculty contact upon graduation (Hathaway, Nagda, & Gregerman, 2002). Finally a retrospective alumni survey of nearly 1,000 predominantly White science and engineering majors from a research university found a higher level of cognitive and personal development for undergraduates who participated in research, as well as increased attainment of graduate degrees (Bauer & Bennett, 2003).

Comparing disciplinary areas finds fewer assessments of undergraduate research in the social sciences and humanities than the natural sciences (Seymour et al., 2004). Collaborative research with social science and humanities faculty positively influences self-reported gains in independent analytical development (Ishiyama, 2002). Psychology students in a 10-week summer research program reported greater growth in research capabilities and were accepted to more highly ranked graduate programs (Kremer & Bringle, 1990). Undergraduate psychology educators identified research specific skills and preparation for graduate school as important outcomes of undergraduate research (Landrum & Nelsen, 2002). Research experience with subsequent conference presentation of results was the most important activity

in improving retention and subsequent admission to graduate school for McNair program participants (Nnadozie, Ishiyama, & Chon, 2001).

The benefits of undergraduate research can be placed within a broader educational framework. Astin's (1993) work argues that high quality interactions centered on educationally meaningful activities with peers and faculty mentors yield the greatest gains in student learning outcomes. In addition to enhancing learning, the integration of students into the social and intellectual fabric of institutional life promotes student retention (Tinto, 1993). Thus, the mentor-protégé relationship of undergraduate research should promote student achievement. For undergraduates from a variety of institutions and ethnic groups, the quality of the student-faculty relationship was identified as a "stronger predictor of learning than student background" characteristics (Lundberg & Schreiner, 2004, p. 549) and a multi-faceted analysis of student engagement concludes, "conducting research with a faculty member can be a life changing experience" (Kuh, Kinzie, Cruce, Shoup, & Gonyea, 2007, p. 38). Conversations with ethnographic researchers (Seymour, personal communication; NSF-RAIRE/AIRE Conference, 1998) and the scholarly traditions among the humanities, social sciences, and sciences would suggest that students might pursue different undergraduate research pathways, types of mentor-protégé relationships, and yet perceive common learning goals and outcomes. This study examines the learning goals and outcomes of undergraduate research participation, as well as the research pathways and mentor-protégé relationships of diverse students in the humanities, social sciences, and sciences assessed from 2001 to 2005.

### *Research Questions*

Common instruments were used to assess the benefits, outcomes, and learning goals for undergraduate research as they vary across discipline, ethnicity, gender, academic class, GPA, and length of prior research experience at a highly diverse, urban, four-year liberal arts college. Five specific hypotheses were considered:

1. Science/math, social science, and humanities students perceive comparable general benefits (e.g., preparation for graduate school, learning to do research, or improving their resume) from summer undergraduate research.
2. The specific outcomes of summer undergraduate research (e.g., development of communication skills, problem solving skills, or formulation of a research question) depend upon disciplinary area, academic class, gender, ethnic background, and GPA.

3. The initiation of a research project and the frequency of the mentor-protégé interaction depend upon disciplinary area, gender, ethnic background and GPA.
4. Longer-term indicators of student achievement (e.g., graduation rate or national fellowship awards) are associated with undergraduate research participation.
5. The perceived importance of generalized learning goals (e.g., development of analytical skills, ability to synthesize information, or commitment to accurate work) depends upon the researcher's disciplinary area, gender, and ethnic background.

*Description of the Undergraduate Research Program*

Scientists at Occidental College established faculty-mentored undergraduate research in the 1950s and by 1985 it expanded to other disciplines. The National Science Foundation (NSF) Award for the Integration of Research and Education (AIRE) established the Undergraduate Research Center (URC). The URC merged individual faculty, department-centered, science division-wide, and college-funded research activities in the academic year and summer. One URC component, the Summer Research Program (SRP), includes: a primary focus on original research (Wenzel, 2004) and/or creative work; mentor-protégé collaboration to develop, draft, and implement a proposal; proposal review by a college-wide selection committee; an intense, 10-week long, residential, research experience culminating in a formal presentation at the "End-of-Summer Conference" and a Web-published abstract; weekly plenary seminars; and small group meetings and social activities. In contrast to research conducted during the academic year for which students often receive academic credit, very few students receive academic credit for work conducted during the summer.

During this five-year study, Occidental College had an annual enrollment of between 1,600 and 1,800 undergraduates (57% female) with 8% self-identifying as African-American, 15% as Latino, 21% as Asian-American, and another 10% from mixed cultural backgrounds (Occidental College Institutional Research and Assessment Group, 2004). The median combined SAT for first-year students increased slightly during this period to 1300; the College was recognized for the nearly 20% of students with Pell Grants (Post Secondary Education Opportunity, 2004). Since 1998, nearly three-quarters of the College's 120 regular faculty members have mentored students through the URC during the summer and/or academic year. The SRP conforms to Seymour et al.'s (2004) definition of undergraduate research: "authentic research con-

ducted in intensive summer-long programs under the direct supervision of faculty researchers" (p. 494). Initial findings were presented at the PKAL 2003 Assembly, "Motivating Students to Pursue Careers in STEM Fields" (Craney, 2004).

## *Method*

### *Instruments*

All SRP participants from 2001 to 2005 were asked to complete self-administered, pre- and post-surveys. Pre- and post-surveys were paired using a self-generated four-digit identifier code. Pre-surveys examined student's academic, demographic and research background, expectations for participation in undergraduate research, and 13 questions regarding specific benefits of undergraduate research answered on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). Post-surveys examined the students' reflections on their experiences using these same 13 questions plus additional questions regarding the general and specific benefits. The surveys were developed and piloted in 1998 and 1999 using information gathered at the 1998 NSF RAIRE/AIRE Conference, published reports (Mabrouk & Peters, 2000; NSF 1990; Volkwein & Carbone, 1994), and two summers of NSF-AIRE funded biweekly, focus group discussions (6–10 students) led by Dr. Andrea Gorman of Occidental's Psychology Department.

Following the post survey, researchers also completed a 52-item survey of educational goals based on the Teaching Goals Inventory (GI) developed by Angelo and Cross (1993). The GI was developed as a classroom assessment instrument and was used here to evaluate the importance of undergraduate research goals. The GI ranks a number of learning goals, such as higher order thinking skills, discipline-specific knowledge and skills, work and career preparation, and personal development. One personal development item "Develop primary role as a teacher" was removed and replaced with the item "Cultivate physical health and well-being;" Otherwise, the GI was unchanged. The GI was presented to the students as: "The overall Summer Research Program and each research project have a variety of intended student learning outcomes. General statements such as those listed in this inventory describe these outcomes. Please rate each of the following general statements of learning outcomes in terms of your experience and its relative importance to your project this summer." Learning goals were marked as either primary, secondary, tertiary importance to their summer research project or not applicable. No presumptions were made about the completeness of the list or relative importance of the items (Seymour et al., 2004).

### *Description of Participants*

All summer researchers ($N = 465$) received a stipend; one-third qualify as having very large financial need. Approximately three-quarters elected to live on campus and receive subsidized room and board. Students were expected to work fulltime on their projects during the 10-week period and were not permitted to pursue other significant activities (e.g. work or summer school) that occupied more than 10 hours per week during this period. Nearly all the College's 30 majors were represented. Each year five to eight community college students (Craney & DeHaan, 1991) and one international summer exchange student also participated. Of the 465 researchers, 53% were female; 6% self-identified as African American, 12% as Latino, 19% as Asian-American, 62% as White and 1% as Other. The mean college-reported GPA was 3.47 ($SD = 0.36$), with a range of 2.26 to 4.00. Eleven percent of researchers had completed one year of college, 34% two years, 40% three years, and 14% had recently graduated. Roughly half (53%) of the students reported conducting research during the previous academic year. Some (18%) participated in the program two or more successive summers.

Of the 465 researchers, 314 (68%) completed the pre-, post-, and GI surveys, 139 researchers (30%) completed only the pre-survey, and 12 (3%) declined to participate. The researchers who only completed the pre-survey did not differ demographically or in their general expectations of the program from those who completed both surveys, with one exception: "Undergraduate research will improve my chances of admission into advanced study programs" ($M_{\text{pretest only}} = 4.20$, $SD = 0.94$; $M_{\text{both}} = 4.41$, $SD = 0.73$; $t(463) = 2.669$, $p < 0.01$).

### *Statistical Analyses*

Descriptive statistics were calculated for all demographic, academic and research background, benefit, and learning goal variables overall, and within disciplinary area, for academic class, gender, ethnic background, and GPA. Bivariate tests compared students' benefits and learning goals by disciplinary area, academic class, gender, ethnic background, and GPA. Chi-square tests were used to test differences in categorical variables (e.g., general benefits and pathways to undergraduate research); additional comparisons were used to determine the association among two groups when categorical variables had three or more groups. One-way analyses of variance (ANOVA) were used to test for differences in the 13 scaled variables (e.g., specific benefits of undergraduate research) across disciplinary area, academic class, gender, ethnic background, and GPA; Bonferroni adjustments were used for post hoc comparisons. As roughly half of the participants reported no prior

undergraduate research experience, the analyses focused on the post-survey as a more informed measure of the participant's perceptions. Graduation, receipt of a nationally competitive award, participation in the SRP, or other URC funded research activities, and off-campus conference presentations were coded 0 = "No" and 1 = "Yes" in a data base along with GPA. We report Odds Ratios and Confidence Intervals (from a logistic regression) for the likelihood of receiving a national award by students who participated in undergraduate research compared with students who did not, holding GPA constant.

### *Results*

Overall, participants reported high expectations prior to beginning their 10-week experience and these high expectations remained largely unchanged or deflated slightly in the post-survey with a few positive exceptions. Nearly all (99%) of the 314 post survey researchers would recommend the SRP to another student.

#### *Benefits of Participation*

As a broad measure, post-survey researchers were asked: "What did you get out of your undergraduate research?" Researchers selected gaining "knowledge about the topic (92%)," "improving my resume" (86%), "learning how to do research" (84%), and "preparation for graduate school" (78%) from a list of eight general benefits. These general benefits were consistent across discipline areas, academic class, ethnicity, gender, and GPA (hypothesis 1). These benefits were also consistent across previous research experience, with two exceptions. Science students with previous research experience were more likely than those without to report that participation in undergraduate research improved their resume [$\chi^2(1, N = 213)=7.51, p < 0.01$] and increased their knowledge of the topic of study [$\chi^2(1, N = 213)=5.53, p < 0.05$].

We also asked researchers to indicate the general outcomes of undergraduate research that they valued most. The most highly valued general outcome was "specific technical skills/job experience" (74%), followed by those that involved personal interactions: "friendship/relationship" (61%), "resume" (59%), and "references" (51%). In support of hypothesis 1, the researchers were largely consistent in their evaluations of these outcomes across discipline areas, academic class, ethnicity, gender, or GPA. Nevertheless, some outcomes held different value for researchers across disciplines: whereas 78% of science students valued obtaining specific technical skills, only 66% of social science and 58% of humanities students valued these skills. In contrast, while a minority (36%) of

science students highly valued the production of publications and papers, 49% of social science students and 54% of humanities students listed publications and papers among their most valued outcomes.

We assessed the impact of participation on specific outcomes with 5-point Likert scale questions (Table 1). Supporting hypothesis 1, researchers in all disciplines strongly agreed that undergraduate research strengthened their interest in advanced study ($M_{\text{overall}} = 4.23$, $SD = 0.84$), and developed their communication ($M_{\text{overall}} = 4.14$, $SD = 0.82$) and problem-solving skills ($M_{\text{overall}} = 4.03$, $SD = 0.83$).

Differences in specific outcomes were also observed, consistent with hypothesis 2. One-way ANOVA examined differences in specific outcomes by discipline, academic class, gender, ethnicity, GPA, and prior research experience. Five of the eleven outcomes differed across disciplines. These outcomes included: formulating research questions [$F(2, 305) = 4.68$; $p < 0.01$], providing an opportunity to publish [$F(2, 305) = 6.80$; $p < 0.001$], providing a realistic career option [$F(2, 305) = 6.44$; $p < 0.01$], improving employability after college [$F(2, 305) = 11.28$; $p < 0.001$], and improving chances of admission to advanced study [$F(2, 305) = 7.04$; $p < 0.001$]. For all these outcomes, participation in undergraduate research had a more substantial effect for science students compared to humanities students, while social science students fell between the two groups.

The specific outcomes of undergraduate research were comparable for males and females with two exceptions. Females felt that participation was more prestigious [$F(1, 310) = 10.47$, $p < 0.001$] and that they had developed their communication skills to a greater extent than males [$F(1, 310) = 5.24$, $p < 0.05$]. Similarly, Black and Latino researchers experienced comparable outcomes of participation in undergraduate research to those of White and Asian students on all but a few specific outcomes. Black and Latino researchers felt that participation in the undergraduate research program allowed them to develop their communication skills [$F(2, 287) = 3.58$, $p < 0.05$] and contribute new knowledge to society [$F(2, 287) = 4.94$, $p < 0.01$]. They also felt participation provided a realistic career option [$F(2, 287) = 4.26$, $p < 0.05$], improved their employability after college [$F(2, 287) = 2.98$, $p = 0.052$] and their chances of admission into advanced study [$F(2, 287) = 6.35$, $p < 0.01$] more than White researchers. Results showed no effect of academic class or GPA on students' perceptions of the outcomes.

We examined the effect of previous research experience on the specific outcomes of undergraduate research. Researchers with any previous research experience perceived undergraduate research as providing greater chances of admission to advanced study [$F(1, 310) = 15.27$,

TABLE 1

Researchers' Post-Survey Ratings of the Specific Outcomes of Participating in the Undergraduate Research Program

| Participating in undergraduate research allowed me to: | Overall ($n$ = 314) | Discipline[†] | | | Gender | | Ethnicity | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Science/ Math ($n$ = 213) | Social Science ($n$ = 71) | Humanities ($n$ = 26) | Males ($n$ = 146) | Females ($n$ = 168) | White ($n$ = 163) | Asian ($n$ = 56) | Black/ Latino ($n$ = 62) |
| 1. Develop communication skills | 4.14 | 4.11 | 4.20 | 4.11 | 4.03[a] | 4.24[b] | 4.03[a] | 4.16[ab] | 4.34[b] |
| 2. Develop problem-solving skills | 4.03 | 4.09 | 3.91 | 3.81 | 4.05 | 4.01 | 4.04 | 3.89 | 4.09 |
| 3. Formulate research questions | 4.14 | 4.18[a] | 4.17[a] | 3.69[b] | 4.14 | 4.14 | 4.09 | 4.04 | 4.31 |
| 4. Earn prestige | 3.87 | 3.91 | 3.80 | 3.62 | 3.69[a] | 4.02[b] | 3.87 | 3.91 | 3.93 |
| 5. Contribute new knowledge to society | 3.96 | 3.98 | 4.00 | 3.77 | 3.99 | 3.93 | 3.87[a] | 3.88[ab] | 4.24[b] |
| 6. Provide an opportunity to publish | 3.82 | 3.95[a] | 3.64[ab] | 3.31[b] | 3.89 | 3.77 | 3.90 | 3.73 | 3.71 |
| 7. Provide a realistic career option | 3.90 | 4.05[a] | 3.64[b] | 3.50[b] | 3.90 | 3.91 | 3.74[a] | 3.93[ab] | 4.17[b] |
| 8. Strengthen interest in advanced study | 4.23 | 4.22 | 4.26 | 4.27 | 4.20 | 4.25 | 4.16 | 4.11 | 4.40 |
| 9. Improve employability after college | 4.12 | 4.25[a] | 3.94[b] | 3.54[b] | 4.16 | 4.08 | 4.19[a] | 3.88[b] | 4.11[ab] |
| 10. Improve chances of admission to advanced study | 4.36 | 4.44[a] | 4.26[ab] | 3.92[b] | 4.32 | 4.39 | 4.43[a] | 4.05[b] | 4.44[a] |

NOTE: Group means that do not have superscripted letters in common are significantly different from each other at the $p < 0.05$ level.

[†]Four researchers conducting interdisciplinary research are not represented here.

$p < 0.001$], opportunity to publish [$F(1, 310) = 19.21$, $p < 0.001$], employability after college [$F(1, 310) = 11.85$, $p < 0.001$], and a more realistic career option [$F(1, 310) = 8.58$, $p < 0.01$] than those with no previous research experience.

These differences in specific outcomes extend to researchers who had participated multiple summers. Comparison of the 210 researchers who participated in the SRP for a single summer to the 47 researchers who went on to participate multiple summers (repeat researchers) finds that the two groups begin their first summer research experience with similar ratings on all questions except career expectations: repeat researchers agree more strongly ($M = 4.04$, $SD = 0.75$) than researchers only participating one summer ($M = 3.96$, $SD = 0.99$; $F(1, 253) = 5.60$, $p < 0.05$) that "Undergraduate research provides a realistic sense of one career option after graduation." This difference between one-time and repeat participants continues to be significant at the end of the summer [$F(1, 253) = 9.41$, $p < 0.01$]. While repeat researchers' pre- to post-survey assessment of research as a career option is unchanged [$M = 4.06$, $SD = 0.90$; $t(45) = 0.172$, ns], researchers who participated a single summer show a decrease from presurvey to postsurvey [$M = 3.78$, $SD = 1.10$; $t(208) = 2.17$, $p < 0.05$]. Differences between repeat and one-time researchers appear in three other post-survey questions: a) "Undergraduate research will allow me the opportunity to publish" [$M_{\text{onetime}} = 3.70$, $SD_{\text{onetime}} = 0.99$; $M_{\text{repeat}} = 3.94$, $SD_{\text{repeat}} = 0.94$; $F(1, 253) = 3.98$, $p < 0.05$]; b) "The poster/talk I gave about my research provided me with a valuable experience" [$M_{\text{onetime}} = 3.98$, $SD_{\text{onetime}} = 0.98$; $M_{\text{repeat}} = 4.11$, $SD_{\text{repeat}} = 0.73$; $F(1, 253) = 5.88$, $p < 0.05$]; and c) "Having my abstract posted on the URC website was a satisfying event" [$M_{\text{onetime}} = 3.41$, $SD_{\text{onetime}} = 1.06$; $M_{\text{repeat}} = 3.70$, $SD_{\text{repeat}} = 0.82$; $F(1, 253) = 8.449$, $p < 0.01$]. Overall, individuals who repeat their summer research experience begin with a more positive orientation toward research as a career option and generally do not change that opinion, whereas those who do not repeat begin with a similarly favorable opinion but report a slight decrease in interest at the summer's end.

### *The Mentor-Protégé Relationship*

The mentor-protégé relationship is an important component of the undergraduate research experience. We expected that students would vary in their pathways to undergraduate research and the amount of time researchers spent with mentors (hypothesis 3). Table 2 shows that researchers' responses to the pre-survey question "How did you select your research project?" depend on disciplinary area [$\chi^2(8, N = 286) = 132.78$, $p < 0.001$] and ethnic background [$\chi^2(12, N = 241) = 30.08$,

TABLE 2

Percentage Distribution of the Pathways to Undergraduate Research, by Discipline and Ethnicity

| Pathways: | Overall ($n$ = 448) | Discipline | | | Ethnicity | | |
|---|---|---|---|---|---|---|---|
| | | Science/ Math ($n$ = 303) | Social Science ($n$ = 97) | Humanities ($n$ = 35) | White ($n$ = 227) | Asian ($n$ = 76) | Black/ Latino ($n$ = 62) |
| A professor asked me to join an on-going project | 28 | 35[a] | 19[b] | 3[c] | 26 | 22 | 36 |
| I asked to join an on-going project | 24 | 32[a] | 9[b] | 3[b] | 26 | 26 | 23 |
| A professor suggested the project to me | 22 | 28[a] | 12[b] | 9[b] | 18[a] | 34[b] | 21[ab] |
| A professor suggested the area and I designed the project | 9 | 4[a] | 21[b] | 23[b] | 8 | 8 | 8 |
| I planned a project to study something that interested me | 21 | 7[a] | 47[b] | 63[b] | 28[a] | 13[b] | 16[b] |

NOTE: For items with significant group differences, percentages that do not have superscripted letters in common are significantly different from each other at the $p < 0.05$ level.

$p < 0.01$] supporting hypothesis 3. There were no other significant differences in the distributions across gender, GPA, and academic class.

The post-survey found the research advisor "provided needed instruction/direction" for 79% of the participants. In addition to their advisor, researchers also worked with another faculty mentor (14%) or another undergraduate student (19%). Some students (12%) did not meet with anyone, including their advisor, on a regular basis. Students working with other undergraduates were more likely to be conducting research in science/math [$\chi^2(2, N = 310) = 14.50\ p < 0.001$]; whereas those working alone were more likely to be in social science and humanities [$\chi^2(2, N = 310) = 25.72, p < 0.001$]. These differences across discipline in the day-to-day interactions with research advisors and other student researchers support hypothesis 3 and impact student outcomes. Students working within a research group comprised of other faculty and/or students agreed more strongly than students working with no one that participation in undergraduate research strengthened their interest in pursuing advanced study [$F(1, 310) = 7.87; p < 0.01$] and provided a realistic career option [$F(1, 310) = 12.40; p < 0.001$].

### *Achievement*

We found an association between undergraduate research participation and longer-term achievement (hypothesis 4.) Of the original 465 researchers, 338 individual matriculated students (excluding community college and exchange students) participated in the SRP during 2001 to 2005 *and* received additional financial support on a competitive basis for stipends, travel, or supplies needed for scholarly activities during the academic year from the URC. Prior to participating in the SRP, 34% of these 338 researchers had received URC support during the academic year, whereas 54% self-reported having previous research experience. Thus, a number of summer research students are involved in academic year research that does not require URC funding. After the SRP, 316 of the 338 students remained undergraduates and 49% participated in research during either the following academic year or summer, suggesting that students perceive additional benefits from continued research activities.

Undergraduate research is also associated with longer-term student achievement including higher graduation rates and receipt of national awards. Nearly all (98.5%) of the SRP researchers between 2001 and 2005 who were eligible to graduate ($N = 202$; does not include continuing, community college, and exchange students) graduated in five years, compared to the overall college graduation rate of 82%. Expanding the cohort to include all students who had received *any* URC funding for any research purpose between 2001 and 2005 and who were eligible to

graduate ($N = 661$) finds a 98.2% graduation rate. Narrowing the cohort to underrepresented researchers who were eligible to graduate between 2001 and 2005 ($N = 65$) finds a 100% graduation rate among SRP participants and a 96% graduation rate among those funded by the URC for any research purpose ($N = 138$).

An analysis of the 61 competitive national awards received by any Occidental student from 2001 to 2005 finds that 37 award winners (61%) had participated in URC supported research activities during either the summer or academic year and 25 (41%) in the SRP. In comparison to other Occidental students, students who participated in the SRP were three times more likely (OR = 3.20, CI = 1.81–5.65) to receive a national award, even after controlling for the large positive effect of GPA. In bivariate analyses, presentation at an off-campus conference also emerged as a predictor: roughly one quarter (26%) of SRP researchers presented their work at an off-campus conference. SRP researchers who presented their research at an off-campus conference were two and one half times more likely (OR = 2.51, CI = 1.15–5.48) to receive an award compared to researchers who did not make a presentation. However, this effect became non-significant when GPA was controlled for in multivariate analyses.

### *Goals Inventory*

The particular goals of SRP researchers were assessed using an adaptation of the GI. The reliability of the 52-item scale was very high ($\chi = 0.95$). Following Cross and Angelo (1993), we grouped responses to the 52-item survey into six thematic clusters and examined the relative importance of each cluster overall and across subject area. "Discipline specific knowledge and skills" and "higher order thinking skills" (Cross & Angelo, 1993, p. 22) were the top ranked clusters for all researchers in all subjects. However, the relative importance of work and career preparation (number three for science/math and social science but number five for humanities) and liberal arts and academic values (number four for humanities but number six for science/math) indicates disciplinary differences that are consistent with hypothesis 5.

Table 3 shows the top five goal statements considered most important by researchers as a function of disciplinary area, gender, and ethnicity. While common threads are readily apparent (e.g. develop analytical skills), differences also support hypothesis 5: a primary goal for 83% of the science students was to develop skills using the materials, tools, and/or technology central to their subject, compared to 32% of humanities and 33% of social science students. Roughly 70% of social science and science students rated developing the ability to draw reasonable

TABLE 3

Percent of Students Ranking Specific Learning Goal Statements as "Primary," by Discipline, Gender, and Ethnicity

| Goals, by Cross & Angelo (1993) Cluster | Overall (*n* = 314) | Discipline† | | | Gender | | Ethnicity | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Science/ Math (*n* = 213) | Social Science (*n* = 71) | Humanities (*n* = 26) | Males (*n* = 145 | Females (*n* = 167) | White (*n* = 163) | Asian (*n* = 56) | Black/ Latino (*n* = 62) |
| I. Higher Order Thinking Skills | | | | | | | | | |
| Develop analytical skills | **74** | **74** | **72** | **72** | **78** | 69 | **70** | **72** | **83** |
| Develop ability to synthesize and integrate information | **69** | 67 | **74** | **72** | **69** | 69 | **70** | 69 | 71 |
| Develop ability to draw reasonable inferences | 68 | 72 | 67 | 44 | 67 | **70** | 61 | **74** | **83** |
| Develop ability to apply principles and generalizations | 64 | 68 | 58 | 42 | 61 | 61 | 63 | 56 | **80** |
| Develop ability to think holistically | 59 | 53 | **75** | 60 | 59 | 60 | 50 | 69 | 69 |
| Develop ability to think creatively | 44 | 39 | 51 | 60 | 48 | 41 | 42 | 35 | 54 |
| III. Discipline-Specific Knowledge and Skills | | | | | | | | | |
| Learn techniques and methods used to gain knowledge | **75** | **81** | 65 | 44 | **76** | **73** | **76** | **80** | **77** |
| Learn concepts and theories in this subject | **74** | **77** | 65 | **75** | **80** | **70** | **76** | 70 | 74 |
| Learn to evaluate methods and materials in this subject | **69** | **77** | 55 | 44 | **70** | 68 | 69 | 69 | **77** |
| Develop skills using materials, tools, and/or technology | 67 | **83** | 33 | 32 | **69** | 66 | 69 | **72** | 71 |
| Learn terms and facts of a particular academic subject | 66 | 70 | 55 | 56 | 67 | 65 | **73** | 54 | 74 |
| V. Work and Career Preparation | | | | | | | | | |
| Develop a commitment to accurate work | **70** | 73 | **68** | 56 | 64 | **76** | 69 | **72** | 74 |
| Develop the ability to perform skillfully | 65 | 65 | 62 | 68 | 61 | 69 | 64 | **72** | 71 |
| Develop a commitment to personal achievement | 65 | 60 | **75** | **72** | 56 | **71** | 59 | 70 | **77** |
| Improve ability to organize and use time effectively | 65 | 65 | 63 | 60 | 52 | **76** | 60 | **74** | 66 |
| VI. Personal Development | | | | | | | | | |
| Develop a capacity to think for one's self | 65 | 63 | **68** | **72** | 63 | 68 | 63 | 67 | 74 |

NOTE: Top five for each subgroup shown in bold face. Where more than five are bold-faced, there was a tie in rankings. Clusters not represented (II. Basic Academic Success Skills, and IV. Liberal Arts and Academic Values) did not have any top five rankings in any participant category.

†Four researchers conducting interdisciplinary research are not represented here.

inferences from observations as primary, but only 44% of the humanities students shared that viewpoint. Female and male researchers share many goals in common, as do researchers from different ethnic backgrounds.

### *Discussion*

The impact of undergraduate research on science students at a variety of institutions has been well documented (Hunter et al., 2007; Russell et al., 2007; Seymour et al., 2004), but a comparison of student perceptions and outcomes across disciplinary areas, demographic groups, and academic experience has not been reported.

#### *Participants*

Researchers generally reflect the College's population, across gender, ethnicity, and financial means. The response rate of 67.5% for all three instruments compares favorably with other survey-based assessments (e.g., 74% Lopatto, 2004; 59% Hathaway et al., 2002; 42% Bauer & Bennett, 2003; 22% Nnadozie et al., 2001; 21% Landrum & Nelsen, 2002; 17% Ishiyama, 2002). Researchers' high expectations prior to their summer research is consistent with Kardash (2000) who found that junior and senior science interns had very high initial expectations for the development of 15 specific research skills. High ratings are also consistent with Bauer and Bennett (2003), Frantz et al. (2006), and Seymour et al. (2004). As with other studies (e.g., Lopatto, 2004) about half of the student researchers had prior research experience.

#### *Perceived Benefits*

General benefits of the undergraduate research experience were largely consistent across disciplinary fields. Most researchers (78%) were preparing for graduate school (similarly observed at 75% by Hathaway et al., 2002; and 83% by Lopatto, 2004), and a larger fraction were learning to do research (84%) and/or gaining knowledge in the area (92%). Along with Kremer and Bringle (1990), Seymour and colleagues (2004) report that personal/professional gains are among their strongest findings. Consistent with Lopatto (2004) and Kardash (2000) female and male researchers reported few differences in general benefits of participation. Researchers most valued specific technical skills and professional development skills (Bauer & Bennett 2003; Landrum & Nelson 2002; Seymour et al., 2004).

Researchers in different disciplinary areas (Table 1) highly ranked many benefits in common (hypothesis 1) but also perceived different specific outcomes (hypothesis 2) from the SRP. Science students per-

ceived a greater impact of research participation on their subsequent academic and career paths compared to social science and humanities students. Humanities researchers are less likely to associate their experience with improved admission to advanced study, employability after college, and an opportunity to publish their work. Many of the specific benefits and skills researchers ranked highly are consistent with Kardash's (2000, p. 196) study of science interns; however, Occidental researchers may perceive the enhancement of communication skills, problem solving skills and formulating a research question as "higher-order skills involved in doing science [research]" (see Table 3). Consistent with other studies, we observed few differences associated with ethnic background, academic class, GPA, or gender (Frantz et al., 2006; Russell et al., 2007); however, female researchers agree more strongly than male researchers that "undergraduate research gives students prestige during college" and "will allow me to develop my communication and presentation skills." These findings support Kardash (2000, p. 198) who noted, "When ratings are provided confidentially [as they were in this study], women do not rate themselves lower than men." We did not observe significant differences in the specific outcomes for researchers by ethnic group, academic class, or GPA.

A key specific outcome of undergraduate research is the clarification and reinforcement of a graduate school career path (Lopatto, 2004; Lopatto, 2005; Seymour et al., 2004; Sun, Barolo, Bilder, Montgomery, & Sinha, 2006). Students who were involved for multiple summers also expressed more favorable attitudes toward research as a career option after graduation and toward the likelihood that they might publish their results.

### *Mentorship of Researchers*

Seymour and colleagues (2004, p. 499) noted, "It is important to learn what motivates students to participate" in undergraduate research. Researchers were asked, "How did you select your research project?" Table 2 indicates that the mentor-protégé relationship, a key aspect of the undergraduate research experience (Guterman, 2007; Russell et al., 2007), is important for all students (hypothesis 3) but especially for underrepresented researchers. This finding extends those of Hathaway and colleagues (2002) who surveyed alumni of the U. of Michigan; Lundberg and Schreiner (2004) who studied primarily undergraduates from doctoral and masters level institutions; Melton and colleagues (2005) who studied underrepresented students in the Atmospheric Sciences at the University of Colorado; and Hurtado and colleagues (2008) who studied first-year minority students in the health professions. Gender, GPA, and

academic class did not show significant differences in this distribution and may reflect, as Kardash and Wallace (2001) observe, "The students' perception of personal, encouraging, and open relationships between students and faculty" (p. 207).

Over half the faculty members in any individual year serve as mentors, yet a few social sciences and humanities researchers (11%) did not conduct their research with faculty or other students on a day-to-day basis. These students were less interested in graduate study or pursuing research as a career option than those students who were involved daily with a faculty member or other undergraduate students. Undergraduate research is seen as having a "confirmatory role" for students (Hurtado et al., 2008; Russell et al., 2007; Seymour et al., 2004; Sun et al., 2006). Lopatto (2004, p. 270) found that a small group of students "who discontinued their plans for postgraduate science education reported significantly lower gains on 20 potential benefits" and Seymour and colleagues (2004, p. 525) found a "group of seven students [who] discovered that research was not the kind of career that they wanted" (see also Frantz et al., 2006, for neuroscience researchers). While the population of "repeat researchers" in this study was mostly drawn from the sciences, the above findings for post-graduate study, presentation, and web-based publication support a "confirmatory role" for undergraduate research.

### *Researcher Achievement*

Participation in undergraduate research was hypothesized to influence student learning outcomes and retention thus increasing graduation rate and receipt of national awards, important College metrics. Nearly all (98.5%) of the researchers graduate in five years compared to the college average of 82%. Consistent with the suggestion by Matsui, Liu, and Kane (2003) and the findings of Nagda and colleagues (1998), underrepresented researchers not only persisted at the college but graduated at a rate comparable to their peers (96% vs. 99%). Bauer and Bennett (2003) suggest that researchers with high academic ability refine their time management skills to reach an ever higher level of achievement. Thus, researchers with higher academic ability continue to refine these skills. SRP participants had a wide range of academic ability as indicated by GPA (range from 2.26–4.00) but GPA was not associated with graduation rate.

A second question was whether researchers were more likely to receive off-campus recognition. The URC researchers comprise a majority (61%) of the college's students receiving competitive national awards; those participating specifically in the SRP comprised 41% of national

award recipients. To account for potential differences in academic achievement between student researchers and other students, we assessed receipt of national awards net of the positive effects of GPA on receipt of awards. After controlling for GPA, summer researchers were still more than three times more likely to receive an award. Twenty six percent of SRP researchers presented at an off-campus conference. In a study of comparable institutions, 21 of 76 researchers attended an off-campus conference and 12 (5 posters and 7 papers; 16%) presented their work (Seymour et al., 2004). Together, graduation rate, national awards and off-campus presentations are recognized by the institution as important indicators of student achievement.

### *Perceived Learning Goals*

Recent work examined how researchers' themselves perceive and experience undergraduate research. Bauer and Bennett (2003, p. 227) advocate "qualitative investigations of undergraduate research students' perception of their own learning" and Seymour et al. (2004, p. 500) suggest investigations to determine "what benefits accrue … and their relative importance to students" (see also Hunter et al., 2007). Further, Kardash and Wallace (2001, p. 200) note, "It is precisely students' perceptions of what transpires that decreases students' initial interest in science and lead many of them to switch to non-SME majors." The GI identifies the instructional goals for college classes at a wide variety of institutions. We used the inventory (with a change of only one specific goal) to investigate the students' perceptions of their own experience. Internal reliability of the GI was very high ($\chi$=0.95) for this population and is consistent with the values reported by Angelo and Cross (1993).

Consistent with Table 1, Table 3 demonstrates that discipline-specific knowledge/skills and higher-order thinking skills are viewed by researchers as most important for their summer experience. The relative ranking of specific goals by researchers in the present study and those of instructors in the discipline areas are almost identical (Angelo & Cross, 1993) suggesting common disciplinary norms. In the GI, arts and humanities students highly rank "Develop ability to synthesize and integrate information" which is consistent with the finding that humanities students report significant gains in their ability to "think analytically and logically" (Ishiyama 2003, p. 380). Reflecting on the response of 2,800 faculty members who completed the GI, Cross and Angelo (1993, p. 369) write "one of our most compelling findings is that what you teach has a good deal to do with how you teach." The relative ranking of primary goals in Tables 3 suggests a parallel for undergraduate research: what you research strongly influences how you conduct and value your research.

This study had three primary limitations: it lacked a control group, largely relied on observations occurring over a 10-week time period, and largely used self-reported instruments. As elegantly articulated by Lopatto (2004), establishing a control group for the study of undergraduate research students presents methodological, ethical, and practical problems. Neither a substantial change in researchers' responses over the 10-week summer research period nor a substantial difference between researchers who only completed the pre-survey and those that completed both pre- and post-surveys was observed (also see Frantz et al., 2006). Ten weeks is a short time interval, whereas Kardash (2000) included 19 researchers from both the 8-week summer and 32-week academic year period and found differences over time. Given the modest number of repeating SRP researchers ($N = 47$ distributed over 5 years), significant comparisons across years of participation and demographic groups is limited; nevertheless, the continued participation by a majority of researchers in the subsequent academic year and the responses of the 18% of researchers who participated in the SRP for two or more summers suggest that research experience largely confirms previous intentions (Hunter et al., 2007). Astin and Lee (2003) note one-time assessments of students are difficult to interpret because they largely reflect the characteristics of the students prior to the assessments. Hence, we anticipate using the GI for a larger number of repeat researchers to identify changes in student thinking over a longer time period. Kardash (2000) notes, using pre- and post-"self-ratings raises the question of a potential response shift bias in the data" (p. 199), as students may rate the program more highly if they perceive the program's future funding opportunities as linked to their post-test evaluations. The researchers in this study were funded from a wide variety of internal and external sources, thus diminishing the "possibility that students might skew their rating in such a manner as to present the most favorable picture" (Kardash, 2000, p. 200) to the funding agencies.

Overall, this study identified multiple benefits, outcomes, and learning goals perceived by research students from a variety of disciplines over a five-year period at a diverse, urban, liberal arts college. Many of the benefits reflect personal and professional growth. These findings confirm that undergraduate research is a "powerful affective, behavioral, and personal-discovery experience" (Seymour et al., 2004, p. 531) that benefits all students regardless of their discipline or career directions, although students in the social sciences and humanities may experience the benefits of participation differently than science students. The study utilized objective indicators of program success including graduation rate and national fellowships, which serve to justify the institutional

investment. Finally, the field has become increasingly concerned with students' subjective experiences and motivations for participating in research. The learning goals identified by the researchers largely parallel the instructional goals held by faculty members in their respective disciplines. The instruments developed in this study yielded high internal consistency estimates and could be adapted for use at other institutions.

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