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Student Outcomes from the LA-STEM Research Scholars Program:

An Evaluation of the LA-STEM Research Scholars Program at Louisiana State University, 2007-2008

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I. Executive summary

Despite recent increases in graduation rates for minority students in science and engineering disciplines, non-Asian minorities are still underrepresented at the undergraduate level (NSF, 2008). The Louisiana Science, Technology, Engineering and Mathematics (LA-STEM) Research Scholars program seeks to remedy the problem of the underrepresentation of minority undergraduate students in STEM disciplines at Louisiana State University (LSU). The LA-STEM Research Scholars program provides comprehensive support for high-achieving students, including mentoring, social support, financial aid, undergraduate research experiences, skills development, graduate school preparation, and a Summer Bridge program. Undergraduate research, a core component of the LA-STEM Research Scholars program, has demonstrated promise in increasing retention and graduation rates, particularly for minority students (Barlow & Villarejo, 2004; Foertsch et al., 1997; Maton et al., 2000; Nagda et al.,1998). This report will focus on LA-STEM students' and faculty advisors' perceptions of students' gains from participation in research. In addition, the report will address student outcomes from other key components of the LA-STEM Research Scholars program, including peer mentoring, academic enrichment courses, and financial aid, among others. Student outcomes from the Summer Bridge experience are addressed in a separate report.

A. Evaluation methodology

Survey instrument and data collection methods: This study was conducted through the use of a survey instrument to assess student gains from undergraduate research experiences. The survey is grounded in research and has been piloted on other campuses. Funding for the development of the student survey instrument, the Undergraduate Research Student Self-Assessment Instrument (URSSA), was provided by the National Science Foundation. The instrument was designed for administrators and faculty in science, technology, engineering and mathematics (STEM) disciplines to evaluate the outcomes and effectiveness of undergraduate research programs. Supplementary items were added to the URSSA survey to evaluate outcomes from program elements that are specific to the LA-STEM program, such as peer mentoring, academic enrichment courses, and financial support.

For this study, both students and advisors were surveyed with parallel instruments designed to probe student gains from research from each group's perspective. Surveys were collected in the 2007-2008 academic year from 38 students and 32 faculty research advisors who participated in LA-STEM-sponsored UR programs. Only sophomore, junior, and senior LA-STEM students were invited to complete this survey. Freshmen completed a survey about their summer bridge experience, the results of which are discussed in a separate report.

Analysis methods: The quantitative data were entered into the statistical software package SPSS where descriptive statistics were computed. Means are reported for most of the ratings items, and frequencies for some of the multiple-choice items. Tests of statistical significance, such as t-tests or one-way ANOVAs, were not conducted because the small sample sizes for the surveys precluded meaningful statistical analyses of group differences.

Write-in responses to the open-ended questions were entered into a spreadsheet and coded as follows. Each new idea raised in a response was given a unique code name. As these same ideas

were raised by later respondents, a tally was added to an existing code reflecting that idea. At times the write-in answers were brief and represented a single category, but more frequently, responses contained ideas that fit under multiple categories, and these were coded separately.

B. Demographic characteristics of student and faculty samples

There were 38 student respondents and 32 faculty survey respondents. Students were at varying points in their degree programs: seniors comprised 42%, juniors were 33%, and sophomores were 25% of the sample. A range of career positions were represented by faculty respondents: 28% were assistant professors, 13% were associate professors, 44% were full professors, 13% were non tenure-track research faculty, and one respondent was a staff scientist. Close to two-thirds of both the student and faculty samples are white. The faculty sample contained higher proportions of Asians and Hispanics. However, there were more African-Americans in the student sample. There was greater gender disparity in the faculty sample than in the student sample: a little over half (52%) of students are male, while almost three-quarters (72%) of faculty are male.

C. Research outcomes

Students' rating of their overall research experience: Students rated their overall research experience very highly. Almost 80% of students rated their experience as "good" or "excellent." In addition, 17% rated the experience as "fair" and 3% rated it "poor." The mean for this item was 3.24 on a 4-point scale, indicating that students' average responses fell between "good" and "excellent" on the rating scale. Although overall student ratings indicate that the vast majority of students had positive research experiences, a minority of students were neutral or dissatisfied with their experience.

Costs and benefits to faculty of directing undergraduate research: The primary benefit of directing undergraduate research for the majority of faculty is the opportunity to teach and mentor students and to help them become scientists. Secondary benefits include students' contributions to the work of the research group, the opportunity to engage in exploratory research, and a potential pool of graduate students. The foremost cost to almost all faculty research advisors is the time that it takes to properly train and mentor undergraduate students. Secondary costs include lack of money and resources, diminished research productivity, and lack of recognition in the university rewards system.

Overview of student and faculty ratings of students' gains from research: Students and faculty were asked to rate student gains across six categories of benefits identified through our previous qualitative work on UR: thinking and working like a scientist, personal and professional gains, becoming a scientist, enhanced career and graduate school preparation, clarification and confirmation of career plans and interests, and skills. With the exception of the thinking and working like a scientist category, student and faculty ratings of student gains were remarkably similar. Faculty rated students' gains in the "thinking and working like a scientist" category lower than students' self-ratings. Students reported that their strongest gains from UR were the intellectual benefits of "thinking and working like a scientist," while faculty reported that

students' strongest gains were in clarification and confirmation of career aspirations and interests.

Thinking and working liked a scientist: The category of "thinking and working like a scientist" encompasses gains in the application of scientific knowledge and skills, understanding the process of scientific research, and increasing disciplinary and conceptual knowledge. Students rated this category as their strongest category of gains, while faculty rated students' gains somewhat lower. Both faculty and students perceived that students' strongest gains were in increasing their understanding of the scientific research process and data collection methods. Students made weaker gains in higher-order scientific thinking skills such as research design, data interpretation, and understanding of the nature of scientific knowledge. Prior research has also demonstrated that students make strong gains in lower-order intellectual skills and more moderate gains in high-order scientific thinking skills (Hunter et al., 2007; Kardash, 2000).

Personal and professional gains: The category of "personal and professional gains" describes students' increased confidence in their ability to do research, to make a contribution to scientific knowledge, and to establish collegial relationships with faculty and peers. This category was the second highest category of student gains, according to both students and faculty. Faculty and student ratings for all items in gains in confidence were remarkably similar. Students noted strong gains in confidence, particularly comfort in discussing scientific concepts, and in their ability to contribute to science. Personal and professional gains are particularly important for minority students because their persistence in STEM disciplines is more closely related to their enthusiasm for their discipline than their academic achievement, as measured by GPA (Grandy, 1998).

Mentoring: Students, though not research advisors, also rated the quality of their mentoring and collegial relationships in the lab. Students rated their working relationship with their research mentor quite highly, though they did not rate the amount of time they spent with their research mentor quite as highly. In fact, 31% of students described the amount of time spent with their research advisor as "fair." Although LA-STEM students on the whole seem to be satisfied with their relationships with their research mentors, some students may need to spend more time with their mentors in the lab. In addition, the quality of students' relationships with their mentors and the quantity of time spent with them was highly correlated with students' overall satisfaction with their research experience and the LA-STEM program. Students with supportive, collegial relationships with their mentors were more satisfied with research and the LA-STEM program overall.

Becoming a scientist: In the "becoming a scientist" category, students begin to adopt the behaviors and attitudes necessary to become a scientist. Students demonstrate gains in learning to work and think independently, to take responsibility for their own learning, and to take initiative to solve problems on their own rather than simply relying on experts for the answers. By engaging in authentic scientific research, students gain a better understanding of the nature of scientific research and the temperament that is required to succeed in science. Faculty and students rated students' gains in "becoming a scientist" similarly; however, students viewed themselves as making greater gains in all areas than faculty. Both students and faculty perceived

that students made the greatest gains in understanding what everyday research is like, and conducting lab procedures carefully.

Students and faculty also rated students' gains in understanding the scientific research process. Students began to understand that research can be long, slow, and tedious at times. Interestingly, faculty perceived that students made greater gains in this area than students themselves, primarily because a few students reported that they made "no" or only a "a little" gain in understanding the scientific research process, while most faculty rated students as having made at least "some" gain. Students' reports of "no" or "little" gain in understanding scientific research may indicate that a few students did not engage in authentic research projects that allowed them to discover the unpredictability, ambiguity, and frustrations of real scientific work.

Enhanced career and graduate school preparation: Undergraduate research also helps students to feel prepared for graduate school and future careers. Research enhances students' résumés, provides opportunities to network with faculty and other scientists, and exposes students to new experiences. There was little difference in students' and faculty research advisors' ratings of students' preparation for future work. Students rated résumé enhancement as the strongest gain received in this category, while faculty rated preparation for graduate school as the strongest gain. Faculty and student ratings on these items were very similar, indicating that both faculty and students see value in the research experience for contributing to students' preparation for graduate school and future careers.

Clarification or confirmation of career and educational aspirations and interests: Through their participation in research, students sustained or increased their interest in the field, gained knowledge about graduate school and career options, clarified or confirmed their intentions to go to graduate school, and clarified whether scientific research would be a suitable career. Students and faculty both rated the career clarification benefits of UR quite highly, though faculty rated these gains slightly higher than students. Specifically, faculty thought students made the greatest gains in increasing their interest in science, while students thought that they made the greatest gains in increasing their knowledge of career and education options—a particularly important outcome for minority students who may not have the same awareness of career and educational options as their majority peers (Dryburgh, 1999; Mulkey & Ellis, 1990).

Skills: The category of "skills" encompasses gains in written and communication skills, as well as laboratory, organizational, time management, reading comprehension, and information retrieval skills. Students ranked gains in communication skill higher than their gains in other skills, such as information retrieval or organizational skills. Both faculty and students rated students' gains in "making oral presentations" and "preparing a poster," higher than other types of communication skills, indicating that students' research experiences fostered stronger gains in oral communication than scientific writing.

Authenticity of the research experience: We asked LA-STEM students to assess the authenticity of their research experience by rating how often they engaged in certain behaviors that are markers of an authentic research experience. Most students seemed to have frequently engaged in authentic activities according to their ratings on this scale, while a minority did not seem to have consistent access to "real-world" scientific research. Students often felt responsible for their

research projects and most students (64%) responded that they engaged in "real-world science research" a good amount or great deal. On the other hand, about one-third of students did not perceive that they frequently engaged in real-world research. For instance, 12% of students responded that engaging in real-world research was "not applicable" to their research experience, while 20% of students responded that they engaged in real-world research only "some" of the time. However, the evidence still suggests that the majority of LA-STEM students engaged in original, authentic scientific work. For example, most students had the opportunity to disseminate their results of their research to a scientific community: 70% of students presented their research to other students or faculty, 56% of students attended a professional conference, and 42% of students presented a paper or poster at a professional conference. Nevertheless, students without consistent access to authentic research tasks were less satisfied with their research experience and the LA-STEM program overall than their peers who frequently engaged in authentic activities in the lab.

D. Program Outcomes

LA-STEM program elements that contribute to student success: Both faculty and students rated the impact of specific elements of the LA-STEM program on student success. According to both faculty and students, many different aspects of the LA-STEM program influenced student learning. Faculty rated "students' access to and opportunity to engage in authentic research" as the program element that contributed the most to student learning. However, faculty had less knowledge of other program activities with which they were not directly involved. A significant minority of faculty did not know about student outcomes from participation in Summer Bridge, mentoring from program staff and other aspects of the program not directly related to research.

Students thought that financial support was the most helpful aspect of the program for their success. Degree completion in science and engineering fields for minority students has been positively correlated to financial aid (U.S. DOE, 2000). Summer learning activities (summer research and Summer Bridge) were the second most significant contributors to students' success. Students also rated "support from program staff," "the culture of achievement among participants," and "the culture of achievement fostered by the program" as quite helpful to their learning. The creation of a community of scholars is particularly important for high-achieving minority students who may otherwise feel isolated from their peers (Fries-Britt, 1998). On the other hand, students were less enthusiastic about the academic support provided by LA-STEM; students thought that the academic enrichment courses (UC50, 70 and 80) were the least helpful aspect of LA-STEM, yet over half of students still found these to be "much help" or "great help."

Academic enrichment courses: The UC courses were more effective earlier in students' undergraduate careers; students rated UC50 activities as more beneficial than UC70 and 80 activities. For instance, UC50 students placed value on peer mentoring and individual development plans, while UC70 and 80 students rated these activities consistently lower as they advanced in their academic careers. Instead, UC70 and 80 students valued workshops and seminars that helped to prepare them for graduate school, such as GRE preparation and graduate school application workshops. Therefore, UC50 students found academic and social support to ease their transition to college to be most valuable to their learning, while UC70 and 80 students found activities that prepared them for their life after graduation to be the most beneficial.

Nevertheless, academic enrichment courses and peer mentoring were not rated as highly by students as other aspects of the LA-STEM program, such as participation in research, financial support, or the social support provided through the program. In addition, students reported declining value in academic enrichment courses and assignments as they advanced in their undergraduate careers. More advanced students began to see some of the assignments or activities as repetitive and felt they were less relevant than their younger peers.

Personal gains from LA-STEM participation: Students and faculty both rated the extent to which students received personal gains in confidence and enthusiasm from participation in the LA-STEM program. Students made the greatest gains in "belonging to a community of learners" and "confidence in their ability to succeed at LSU." However, students also cited strong gains in enthusiasm for research, enthusiasm for attending graduate school, and appreciation for diversity. Students rated enthusiasm for coursework lower than other personal gains from LA-STEM, indicating that their increased enthusiasm for out-of-class activities may not have translated directly to coursework. Faculty perceived that students made the greatest gains in "enthusiasm for research," perhaps because they were able to directly witness this aspect of the program and had the most awareness of students' orientation toward research. Gains in enthusiasm and confidence are particularly important for minority students because these gains are stronger indicators of persistence in their discipline than academic achievement (Grandy, 1998).

Skills gains from LA-STEM participation: Students rated most of their gains in skills relatively equally, indicating that students did not differentiate between the different skills gained from participation. Students cited the strongest gains in giving presentations and communicating with faculty in a professional manner, echoing the communications skills they gained from their research experience. Students also cited strong gains in learning/study strategies, and effective long-term planning.

Career aspirations: The LA-STEM Research Scholars program had an impact on students' career and educational aspirations, particularly their intentions to attend graduate school. Although some students (40%) originally intended to receive a graduate degree in a STEM field prior to college enrollment, almost all LA-STEM students (90%) reported that the LA-STEM program increased the likelihood that they would pursue a Ph.D. degree. Therefore, a substantial number of students may have changed their educational goals to graduate school (or at least began to consider graduate school as a future goal) as a result of their participation in LA-STEM, while a significant minority strengthened their pre-existing commitment to attend graduate school.

Transfer of gains from LA-STEM to other areas of students' lives: Many LA-STEM students reported that their experiences with the program will transfer into other aspects of their lives. Most LA-STEM students (85%) responded that they will remember the LA-STEM experience overall "a lot" or "a great deal." Students also cited friends, feeling part of a community, and support from program staff as important elements of LA-STEM that they will carry with them into the future. While students also reported that academic gains from LA-STEM would transfer to other areas of their lives, the social benefits of LA-STEM seemed to be more meaningful for them in the long-term.

"Best" and "worst" part of LA-STEM: In open-ended questions, students commented on the "best" and "worst" aspects of the LA-STEM program. The "best" part of LA-STEM, according to students, was the informal community of peers and scholars created by the program. Students appreciated belonging to a community of like-minded, academically oriented peers. Students also mentioned access to opportunities, research, mentoring, and financial support as other important program elements. On the other hand, most students thought that the UC courses and assignments were the "worst part" of LA-STEM. In keeping with their other survey responses, students saw less value in these activities as they advanced in their undergraduate careers. The activities and assignments began to seem repetitive and time-consuming for some students.

Advice for improving LA-STEM: In an open-ended question, students and faculty were asked to offer advice to improve the LA-STEM program. In line with students' responses on other sections of the survey, the majority of students' responses offered advice for changing the UC courses and required assignments. Specifically, students recommended making the courses or assignments optional for upperclassmen. A few students also advised the program to hire more staff and institute more guidelines and greater accountability measures for students. On the other hand, there was not a clear consensus among faculty about advice for improving the program; however, faculty commented that the program should provide students with clear guidelines for selecting research labs, and the program should better inform faculty about the program's expectations of faculty research advisors. In addition, a few research advisors mentioned that students should be held more accountable.

E. Conclusion

Many aspects of the LA-STEM Research Scholars program benefited students, however, research experiences (summer, in particular), and financial support were the most helpful to student learning. Research experiences enhanced students' intellectual, personal, and professional development. Students also regarded the personal and social benefits of the LA-STEM program to be helpful aspects of the program. Students particularly appreciated belonging to a community of learners with similar academic interests, and highly valued the support they received from program staff. Students also gained confidence in their ability to succeed in science and enthusiasm for science through their participation in the LA-STEM program. Finally, participation in the LA-STEM program increased the likelihood that students would pursue terminal degrees in their field.

In many respects, students benefited greatly from participation in the LA-STEM program. However, student and faculty means on many survey items fell between 3.0 and 4.0 on a 5-point scale, indicating that there is room for improvement. In particular, some faculty were not knowledgeable enough about aspects of the LA-STEM program to rate the program's performance in these areas. Faculty research advisors were knowledgeable about students' outcomes from research, but some research advisors were unaware of other program elements. Some faculty also requested clearer program guidelines and expectations of faculty research advisors. Students also provided feedback about areas for improvement. Students found the academic support services, such as UC courses and assignments and peer mentoring, to be less beneficial as they advanced in their undergraduate careers. Though the vast majority of students had authentic, "real-world" research experiences, a small fraction of students may not have had

access to challenging, authentic scientific research or adequate mentoring. Survey responses from this small cadre of students indicate that they either did not engage in “real” research often enough in the lab or they did not have the proper guidance and support they needed from their research mentor. For a few students, a poor research experience impacted their overall experience in the LA-STEM program and they did not gain as much from the program as their peers. Nevertheless, the program clearly had a positive impact on most participants and their personal, professional and cognitive growth and development.

II. Evaluation design and methodology

A. Introduction

Between 1998 and 2008, jobs in science, technology, engineering, and mathematics (STEM) fields will increase at four times the rate of other employment opportunities (NSF, 2000). However, there are concerns over how these positions may be filled given the persistent homogeneity of the domestic STEM workforce: in 2000, white and Asian Americans constituted 82% and 10% of the STEM workforce, respectively (NSF, 2000). Despite the national need for a highly skilled and diverse STEM workforce, undergraduate retention and degree completion in STEM disciplines is a consistent problem, particularly for minority students (Bonous-Harmouth, 2000). In 2005, only 17% of bachelor's degrees in science and engineering were awarded to minority students—African-Americans, Hispanics, and Native Americans—even though these groups comprised 28% of the U.S. population (NSF, 2008; U.S. Census, 2006). Additionally, only 9.5% of doctoral degrees in science and engineering fields in 2005 were awarded to minorities (NSF, 2008). Despite slight gains in the graduation rates of minority students in STEM disciplines in recent years, the undergraduate years are still a "leaky" point in the academic pipeline. In addition to concern with meeting workforce needs, demands for equal access to opportunity has led to an increased focus on the recruitment of underrepresented students into STEM fields.

The Louisiana Science, Technology, Engineering and Mathematics (LA-STEM) Research Scholars seeks to remedy the problem of the underrepresentation of minority undergraduate students in STEM disciplines at Louisiana State University (LSU). To meets its goal of increasing the number of underrepresented students receiving terminal degrees in STEM disciplines, the LA-STEM Research Scholars provides comprehensive support for high-achieving students, including mentoring, social networks, financial aid, undergraduate research, skills development, graduate school preparation, and a Summer Bridge experience. Nonetheless, as with similar programs, the LA-STEM Research Scholars program is also available to highly qualified, majority students.

Upon the request of Dr. Isiah M. Warner, Vice Chancellor, Office of Strategic Initiatives (OSI), Louisiana State University (LSU), Ethnography & Evaluation Research conducted an independent external evaluation of the Louisiana Science, Technology, Engineering and Mathematics (LA-STEM) Research Scholars Program, The scope of the external evaluation is directed at:

- independent documentation of program impacts for student and faculty participants, and for LSU as an institution and that provides other summative information concerning the degree to which program objectives are being met;
- providing formative information that may be incorporated into program assessment and further program development.

B. Evaluation design

Evaluation of the LA-STEM Research Scholars programs was designed to focus on the gains students make from participation in undergraduate research (UR) and other LA-STEM program activities, such as Summer Bridge, peer mentoring, and academic enrichment courses. This report will focus on students' gains from UR and other LA-STEM program elements, with the exception of the Summer Bridge program. Freshman who had completed the summer bridge program were surveyed separately. This report also includes faculty research advisors' perceptions of students' gains from UR and the LA-STEM program.

This study was conducted through the use of survey instruments grounded in research and partially piloted on other campuses. Funding for the development of the student survey instrument, the Undergraduate Research Student Self-Assessment Instrument (URSSA), was provided by the National Science Foundation.

For this study, both students and advisors were surveyed with parallel survey instruments designed to probe student gains from each group's perspective. The surveys and data collection methods are described in detail in the methods section. First we summarize our previous work and other relevant literature on UR and programs designed to increase minority representation in STEM disciplines, and then we describe the evaluation methodology used in this study.

1. Relevant findings from previous research on UR

Ethnography and Evaluation Research (E&ER) has been interested in student gains from UR experiences for some time. This previous work gave us insight about the types of gains to probe in this evaluation study and the factors that might be important in outcomes from the student UR experience.

Since 2000, E&ER has been engaged in a comparative and longitudinal study of STEM undergraduates and faculty who did, and did not participate in summer UR programs at four liberal arts institutions with a strong history of UR. The study is both comparative—with student and faculty participants and non-participants of various types—and longitudinal, tracking both participating and non-participating students through their senior year and beyond graduation. Previous articles have described the benefits of UR as perceived by participating students (Seymour et al., 2004) and as compared to faculty perceptions of student gains (Hunter et al, 2007). A forthcoming article (Thiry et al., 2009) examines whether students' gains from UR can be achieved through other means, such as jobs, internships, or coursework. Collectively, these findings support the proposition that UR is an intellectual, personal and professional growth experience with many transferable benefits.

One of the main benefits to students from UR was the opportunity to engage in "thinking and working like a scientist." We noted in students a process that is encouraged by active engagement in research: many students improved their ability to bring their knowledge, critical thinking, and problem-solving skills to bear on real research questions; some students went further, gaining insights into how to generate and frame research problems; and a few developed a more profound understanding of how scientific knowledge is constructed.

However, the most distinctive characteristic of students' reports of benefits from UR was their focus on personal-professional transitions. Overwhelmingly, students defined UR as a powerful affective, behavioral, and personal-discovery experience whose dimensions had profound significance for their emergent adult identity, sense of career direction, intellectual and professional development. Students' comments in two categories ("personal-professional gains" and "becoming a scientist") described growth in confidence to do science, independence in their approach to both research and learning, responsibility for the direction and quality of their projects, and collegiality in their working practices.

Though the research literature on UR is sparse, our findings have echoed those found in other studies. Indeed, our findings have extended the previous research literature on UR as we documented many personal, professional, and affective gains from UR that had not been found in previous work. The majority of previous work on UR has documented the educational and career gains from participation, including increased interest in science careers (Bauer & Bennett, 2003; Russell, 2005; Zydney, Bennett, Shahid, & Bauer, 2002), particularly for students from groups underrepresented in STEM fields (Nagda, Gregerman, Jonides, von Hippel & Lerner, 1998); greater awareness of career options (Hunter et al., 2007; Ward, Bennett & Bauer, 2002); and enhanced preparation for graduate school (Alexander, Foertsch & Daffinrud, 1998; Hunter et al., 2007; Merkel, 2001; Russell, 2005). The influence of undergraduate research on career choice is a subject of substantial interest but little consensus; it appears to depend strongly on the student group under study. Although our research has demonstrated that UR participation serves principally to confirm or clarify pre-existing career and educational goals (Seymour et al., 2004; Hunter et al., 2007), other studies have reported that participation in UR increases the likelihood that students will pursue graduate school (Bauer & Bennett, 2003; Kremer & Bringle, 1990; Russell, 2005), particularly for minority students (Alexander, Foertsch, & Daffinrud, 1998; Barlow & Villarejo, 2004; Hathaway, Nagda, & Gregerman, 2002). Undergraduate research has also been argued to increase graduation rates (Kim, Rhoades, & Woodard, 2003), especially for minority students (Barlow & Villarejo, 2004; Nagda et al., 1998) and retention in the major for minority students (Barlow & Villarejo, 2004; Nagda et al., 1998).

Perhaps more importantly, recent research on UR has begun to demonstrate the cognitive, personal and professional benefits to students of participation. Documented in our research and corroborated by other studies are increases in students' skills in communication (Bauer & Bennett, 2003; Kardash, 2000; Ward, Bennett & Bauer, 2002), technical and laboratory work (Ward, Bennett & Bauer, 2002; Lopatto, 2004), teamwork (Ward, Bennett & Bauer, 2002), critical thinking and scientific analysis (Bauer & Bennett, 2003; Ishiyama, 2002; Merkel, 2001) and scientific research (Kardash, 2000; Lopatto, 2004). Through UR, students begin to take greater initiative and responsibility for their own learning (Seymour et al., 2004; Hunter et al., 2007; Bauer & Bennett, 2003; Lopatto, 2004; Rauckhorst, 2001; Ward, Bennett & Bauer, 2002) and gain confidence in themselves as independent learners (Hunter et al., 2007; Merkel, 2001; Rauckhorst, 2001; Russell, 2005, Ward, Bennett & Bauer, 2002). A few studies have addressed students' awareness of the nature and character of scientific research, finding that students gained an increased ability to cope with setbacks and ambiguity (Hunter et al., 2007; Lopatto, 2004; Merkel, 2001; Ward, Bennett & Bauer, 2002). Though UR clearly has many intellectual benefits, students have less often reported gains in desirable but difficult higher-order thinking skills such as identifying a research question, and designing and refining an experiment (Hunter et al., 2007; Kardash, 2000).

Finally, it is important to note that our group's previous research refers specifically to summer research experiences at liberal arts colleges. While these colleges have a long history of conducting undergraduate research, and represent, we believe, some of the best available educational experiences from UR, many more students participate each year in UR programs on research university campuses. We do not know to what degree our previous findings may apply to students' UR experiences in research universities, or how UR experiences differ in these two contexts. In addition, almost all of our study participants were affluent, white college students and there is less research available about how the nature of gains from UR may differ for underrepresented or first-generation college students. The present evaluation study and piloting of the URSSA survey instrument at other research universities may provide insight into the question of whether institutional type or demographic characteristics influence students' gains from the UR experience.

2. Relevant findings from research on students' academic and social integration into campus life

The LA-STEM program is designed to enhance the academic and social integration of students into undergraduate life and their discipline. Students' adjustment and transition to college life is a key factor in their retention and degree completion rates (Tinto, 1993), particularly for minority students (Stoecker, Pascarella, & Wolfe, 1988). The academic and social integration of minority STEM students into scientific life is especially important because minority students often lack prior access to experiences and opportunities that presage membership in a scientific community (Dryburgh, 1999; Mulkey & Ellis, 1990). Further, high-achieving minority students may be isolated from their peers and the development of peer support networks for these students is essential (Fries-Britt, 1998).

The LA-STEM program shares many common elements with other comprehensive support programs that seek to increase minority representation in STEM fields. An examination of twenty exemplar programs designed to recruit and retain minority undergraduate STEM students demonstrated that most of them concentrated on five major areas of support: mentoring, financial support, academic support, psychosocial support (e.g. counseling, building a sense of community among participants, family involvement, etc.), and access to professional opportunities, such as research or internships (Gandara & Maxwell-Jolly, 1999). Several of these programs have been proven to increase the graduation rates of minority students in STEM disciplines, such as the Meyerhoff Scholarship program and the Louis Stokes Alliances for Minority Participation (LS-AMP) (Clewell et al., 2005; Maton et al., 2000). Components of the Meyerhoff Scholarship program that are integral to students' success include a Summer Bridge experience, peer support and study groups, financial assistance, research opportunities, and mentoring from faculty and program staff (Maton et al., 2000). The Meyerhoff Scholarship program has also been highly successful in building community and peer support among students (Fries-Britt, 1998).

The LA-STEM Research Scholars shares many common elements with these successful programs, namely, access to research opportunities, financial aid, academic and social support, mentoring, and a community of scholars. This report will focus on the impact and outcome of the strategies employed by LA-STEM to increase student retention in STEM majors and pursuit of a terminal degree in STEM disciplines. The report is divided into two sections, the first addresses student outcomes from the research experience, and the second addresses outcomes from other

elements of the comprehensive LA-STEM program. We will now discuss our evaluation methods in greater detail, beginning with our study methods and sampling strategies.

C. Study method and samples

The present evaluation was designed to focus on the gains that students make from their participation in UR and the LA-STEM program, and the influence of these experiences on their aspirations in STEM fields. Surveys evaluating students' outcomes from the research experience and the LA-STEM program were given to both students and faculty. The surveys were based on the Undergraduate Research Student Self-Assessment (URSSA) survey. In this section we outline the Undergraduate Research Student Self-Assessment (URSSA) instrument and trace its origins in previous qualitative work.

Previous qualitative research from our group, as discussed, has identified specific student gains from UR—some of which were consistent with gains hypothesized in the literature, and others which were not. These findings provided the foundation for the development of the URSSA instrument, a quantitative survey grounded in qualitative research and intended to become a general tool for evaluation of the UR experience and its impact on student growth and development. The survey was piloted at the University of Colorado, Boulder during the 2006-2007 and 2007-2008 academic years and piloted on multiple campuses during summer 2008.

The faculty survey was adapted from the student survey and, where possible, used the same items and same ratings scales to evaluate comparability between students' and faculty perceptions of student gains from the UR experience. We also expanded the URSSA survey to include new items to measure student outcomes from the LA-STEM program in general.

1. Description of the survey instruments

The instruments focused on students' and faculty ratings of students' research gains in a number of specific benefits areas that were originally described by students in the four-campus qualitative study. Original piloting of the instrument on the University of Colorado, Boulder campus demonstrated that not all students may have received the high-quality, apprenticeship model of UR received by students in the liberal arts study. Therefore, we added items to address the authenticity and quality of students' experiences in UR. Students evaluated the authenticity of tasks within their research experience and the quality of interactions with advisors and other research team members. Finally, students provided demographic data and answered questions about the specific activities in which they participated, the people with whom they interacted, their motivations to participate in UR, and their educational aspirations, including changes in these plans prompted by participation in LA-STEM. The faculty research advisor instrument is parallel to the student instrument, in that the advisors rated students' gains in the same domains as the student rated him or herself.

In addition, the survey includes items designed to provide summative information on the impact of specific LA-STEM program elements on students' knowledge, skills, and personal and professional growth and development. These items examine the impact of the LA-STEM program on students' academic and social integration to LSU and their major. The specific program elements evaluated by the survey include the UC academic enrichment courses, peer

mentoring, support and guidance from LA-STEM program, academic resources, and the culture of achievement fostered by the LA-STEM program.

Most items on both the student and faculty surveys are multiple choice, or numerical ratings, with a few open-ended response items. For the gains items, ratings were on a five-point scale, with 1 = no gain, 2 = just a little gain, 3 = some gain, 4 = good gain, and 5 = great gain (and NA = not applicable). Other items related to LA-STEM program activities were also rated on a five-point scale, with 1=no help, 2=a little help, 3=some help, 4=much help, and 5=great help. In some cases, ratings were on a 4-point scale (1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree).

2. Procedures for obtaining the samples

We collected surveys from both advisors and students during the academic year 2007-2008. All LA-STEM research scholars of sophomore, junior, or senior status and faculty advisors who had worked with LA-STEM students were invited to participate in the survey. Freshman LA-STEM students completed a separate survey about their summer bridge experience. The surveys, informed consents, and study procedures were approved by the Human Research Committee of the University of Colorado at Boulder.

LA-STEM Research Scholars staff provided the evaluators with lists of LA-STEM students and their faculty research advisors. Email invitations to participate in the survey were sent to 58 faculty research advisors and 32 of them completed the survey for a response rate of 55%. Email invitations were also sent to 52 LA-STEM research scholars and 38 students completed the survey for a response rate of 73%. Approximately two weeks after the initial email, reminders were sent individually via e-mail to persons who had not returned the survey.

3. Analysis methods

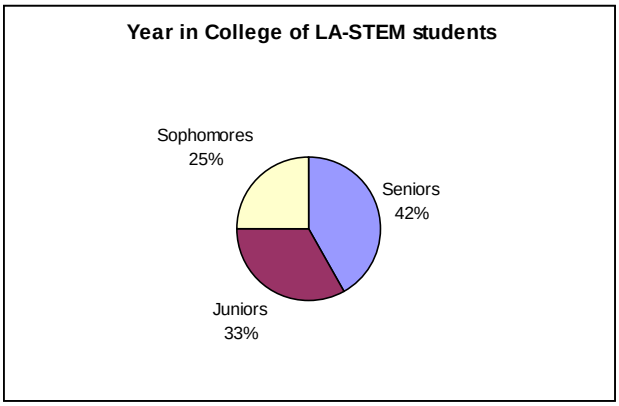
The quantitative data were entered into the statistical software package SPSS where descriptive statistics were computed. Means are reported for most of the ratings items, and frequencies for some of the multiple-choice items. Tests of statistical significance, such as t-tests or one-way ANOVAs, were not conducted because the small sample sizes for the surveys precluded meaningful statistical analyses of group differences.

Write-in responses to the open-ended questions were entered into a spreadsheet and coded as follows. Each new idea raised in a response was given a unique code name. As these same ideas were raised by later respondents, a tally was added to an existing code reflecting that idea. At times the write-in answers were brief and represented a single category, but more frequently, responses contained ideas that fit under multiple categories, and these were coded separately.

D. Demographic characteristics of student and faculty survey samples

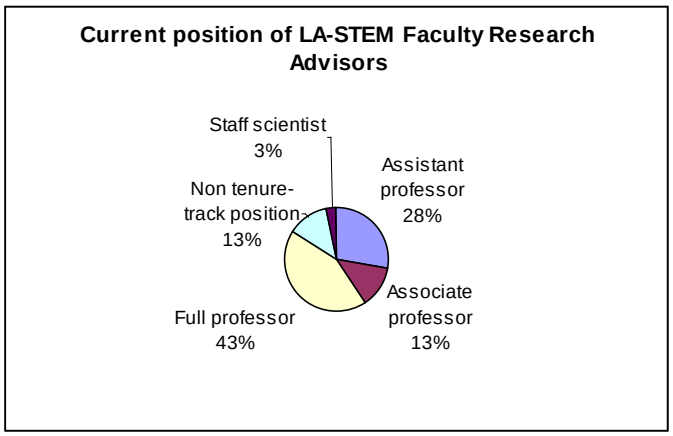
There were 38 student respondents to the undergraduate research survey. The sample represents gender, ethnic, and disciplinary diversity. Students were also at varying points in their degree programs. Seniors comprised 42% of the sample, juniors comprised 33%, and sophomores comprised 25% of the sample.

Fig. 1



There were 32 faculty respondents to the faculty research advisor survey. As might be expected, the sample held less gender and ethnic diversity than the student sample. However, a range of career positions were represented by faculty respondents: 28% were assistant professors, 13% were associate professors, 44% were full professors, 13% were non tenure-track research faculty, and one respondent was a staff scientist.

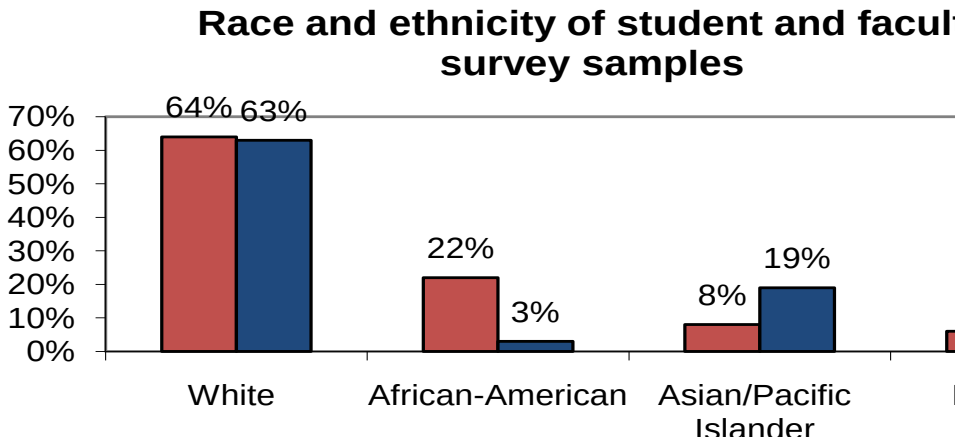
Fig. 2



1. Ethnicity of student and faculty samples

The majority of both student and faculty survey respondents were white. The faculty sample had a larger proportion of Asian and Pacific Islanders. There was also a greater proportion of Hispanic faculty than students. However, there were more African-American students than faculty in the survey samples.

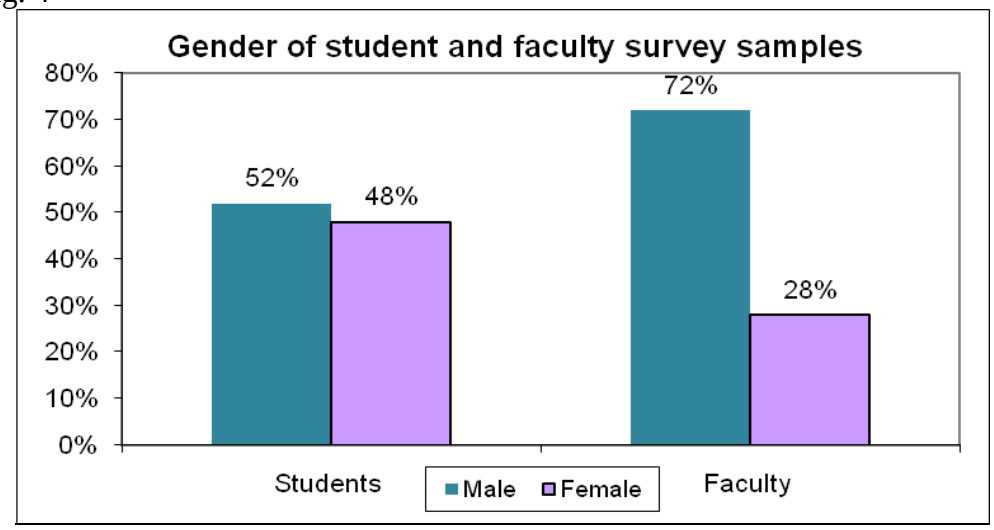
Fig. 3



2. Gender of student and faculty samples

The student sample was almost evenly split between women and men. However, there was greater gender disparity in the faculty sample.

Fig. 4



Finally, students hailed from a variety of disciplines. Biological sciences was the most frequent major (31%). Eleven percent of students were biochemistry majors while biological engineering, physics, and chemistry each comprised 8% of the sample. Computer science and chemical engineering each accounted for 6% of students in the sample. Other majors were represented by a single student in the sample: mathematics, mechanical engineering, computer engineering, civil engineering, electrical engineering, petroleum engineering, industrial engineering, and nutritional sciences.

3. Extent of faculty and students' experience with the LA-STEM program

Most students had a substantial amount of prior research experience, indicating that the LA-STEM program is helping students to begin research early in their undergraduate careers and helping them to maintain their commitment to research. Almost all students had conducted summer research and most had completed at least several semesters of academic year research. Two-thirds of students reported that they had conducted summer research in their home departments. A minority of students (14%) had never conducted summer research, while 30% of students had done one summer of research, 50% had completed two summers of research, and 6% had completed three summers of research. Many students also had a substantial amount of academic year research experience: 44% had completed 5 semesters of research, 19% had completed 4 semesters of research, 22% had completed 3 semesters of research, 3% had completed 2 semesters of research, and 11% had completed one semester of research.

Most of the faculty research advisors also had a substantial amount of experience in supervising LA-STEM students in undergraduate research. Twenty-two percent had never been a research mentor to a LA-STEM student during the academic year, yet 25% had served in that capacity for 5 semesters or more, 16% for 4 semesters, 5% for three semesters, 16% for two semesters, and 3% for one semester. Likewise, the majority of faculty research advisors had served as a research mentor to LA-STEM students for one or two summers. Twenty-eight percent of faculty advisors had not served as a research advisor to a LA-STEM student during the summer, yet 6% had supervised LA-STEM students for 4 summers, 9% for 3 summers, 28% for 2 summers, and 25% for one summer.

III. Research outcomes

We will now discuss outcomes from the research experience. We will begin with faculty perspectives on research mentoring, including faculty intentions to continue mentoring LA-STEM students, faculty selection of UR students, faculty beliefs about the benefits of research for underrepresented students, and the costs and benefits to faculty of mentoring UR students. We will then discuss students' outcomes from the research experience, specifically comparing students' and faculty perspectives about students' gains from UR.

A. Faculty perspectives on research mentoring

1. Faculty intentions to continue with UR mentoring

Faculty research advisors are committed to the LA-STEM program. Most faculty research advisors (75%) planned to continue to serve as a research mentor in the LA-STEM program during the summer. Only 4% of faculty research advisors reported that they did not plan to continue. The remainder (11% each) either reported that they may continue as a summer research advisor or that they did not know.

Likewise, most faculty research advisors (79%) planned to continue to serve as a research mentor in the LA-STEM program during the academic year. Similarly, only 3% reported that they did not plan to continue. The remainder either reported that they may (10%) continue as a research advisor during the academic year, or they did not know (7%).

2. Faculty selection of students

Faculty research advisors were asked how they "found" a LA-STEM student to work on their research. The majority of research advisors were contacted by a LA-STEM student seeking a research position. A few asked a specific student to conduct research and 19% of faculty contacted LA-STEM and requested a student. Fewer than 10% of faculty worked with a LA-STEM student because someone else in the lab recommended that particular student. Therefore, it appears that most LA-STEM students took the initiative to find faculty to work with to fulfill their research requirements. In open-ended responses which will be discussed later in the report, some faculty research advisors also expressed uncertainty about the process of finding a LA-STEM student to fill a research position. Advisors requested greater clarity from the program about the process of "finding" a LA-STEM student for research. The table below outlines the methods used by faculty to "find" and select LA-STEM students.

Table 1. Faculty selection methods for UR students

Item	% of positive responses
Student contacted me (in person or by email).	74%
I contacted LA-STEM and requested a student.	19%
I asked the student directly.	15%
Someone in the lab recommended the student.	7%
I have not yet worked with a LA-STEM student. (write-in response)	3%

3. Faculty views on the benefits of research for underrepresented students

In an open-ended question, faculty research advisors were asked, "In your opinion, are there particular advantages of doing undergraduate research for students of color, first generation college students, or women? Please comment." Seventeen faculty members responded to this question. Three advisors (18%) noted that undergraduate research benefits all students and does not have particular benefits for underrepresented students.

> *Undergraduate research is beneficial to college students, no matter race, gender or other identifiable population parameters.*

However, the other fourteen advisors (82%) believed that there are specific advantages of doing research for underrepresented groups. These research advisors noted that research helps to address issues of under preparation in science, and helps minority students to learn about career options, increase confidence, and remain in the field.

Seven research advisors (41%) commented that UR offers underrepresented students the opportunity to learn about research, particularly as a career option. Some advisors also believed that exposure to research increases the retention rates of underrepresented students.

> *Yes. They are less likely to have previous contact (e.g. through family, friends, teachers) with researchers or with people who know about research.*
>
> *Yes! Many underrepresented students have not been exposed to research or researchers. This exposure broadens their horizons.*
>
> *Without undergraduate research opportunities, these students would simply not know what research is, and some of them may have been lost to science.*

Five faculty research advisors (29%) commented that research helps to address the under preparation in science of many underrepresented students.

> *Most definitely, especially for those that have not had much lab experience due to the quality of their high schools (e.g., no chemistry labs).*

Three advisors (18%) reported that underrepresented students gain confidence from participation in research.

> *Yes, it is obvious that they gain in confidence in interacting with people, with public talking, etc, that they benefit from being part of a community of varied researchers.*
>
> *YES! Most of these students do not even know that this is a career choice. Not only do they find this out; they find out that they can be very good at it.*

Therefore, the majority of faculty research advisors felt that there are distinct advantages for underrepresented students to engage in undergraduate research.

4. Faculty costs and benefits of directing undergraduate research

In open-ended questions, faculty research advisors were also asked to evaluate the benefits and costs to them of directing undergraduate research. We will first discuss the costs of directing undergraduate research and then the benefits. The primary costs cited by faculty were time, lack of resources, and lack of productivity on projects. Sixteen advisors commented on the costs of directing undergraduates in research.

Overwhelmingly, the most significant cost to faculty was time. Fifteen faculty research advisors (94%) mentioned time as a cost of directing UR, particularly the time required to adequately train students.

> *It takes a significant initial investment in time to train and to keep the student motivated before s/he can become productive even to the smallest extent.*
>
> *It is extremely time-consuming to train students, making it often not worth one's effort to take on undergraduate students unless they are prepared to work extremely hard.*

Four faculty members (25%) mentioned that a lack of money and resources is a hindrance to their participation in undergraduate research.

> *It takes time and money. They make a lot of mistakes and some require a great deal of hands-on support to do something very simple (i.e. make a 1 M solution).*

In addition, two advisors (13%) felt that directing undergraduate research can slow research productivity because undergraduates are usually unable to substantially contribute to the work of the research group until they have a certain amount of training and research experience.

> *Slows down the graduate students supervising them, at least in the beginning year or so. Slower pace of resarch during that time. But a good undergrad can then positively contribute later on and speed up the research effort of the group.*

One faculty research advisor (6%) also mentioned the lack of rewards for faculty involved with undergraduate research, particularly given the significant investment of time and money that are required to properly mentor undergraduate students.

> *There are substantial costs in terms of "lost opportunities" to pursue activities that are rewarded by the university through pay raises, awards, and designated professorships. Serious mentoring takes times and often must take precedence, because undergraduate students cannot yet take the long view with respect to their problems and needs. In addition, supplies and other research costs have to be paid from the mentor's own research funds. Undergraduate research may prove significant enough for eventual publication, but this is not always guaranteed. Therefore, the investment of funds in a project performed by undergraduates is risky to a certain extent. All in all, mentoring undergraduate students, if done properly and personally by a faculty member (i.e., not delegated to a graduate student), takes time and money and is not rewarded by the university.*

Overall, faculty believed that the time and resources required to mentor undergraduates in research were substantial costs to their participation in the enterprise.

On the other hand, faculty also commented upon the benefits from their participation in undergraduate research. Seventeen faculty research advisors responded to this question. The opportunity to teach and mentor students, recruit potential graduate students, conduct exploratory research, and increase research productivity were the primary benefits to faculty of directing undergraduate research.

The opportunity to teach and mentor students was the foremost benefit of directing undergraduate research cited by faculty (n=10, 59%).

> *Able to help students decide their future life's path; instill in them that they have the ability to compete with the nation's best students.*

> *Mentoring undergraduate students is simply part of teaching and rewarding as such. This is why I do it. There is also the very real possibility to influence a young person into becoming a competent scientist!*
>
> *Very rewarding to teach undergrads in the methods of research, and to instill in them the work ethic and patience required to do the job right.*

Six advisors (35%) noted that undergraduates can provide assistance with research and contribute to the progress of the group. However, these responses seemed to vary in tone. Most advisors reported that students can contribute to the progress of the research group. In this scenario, students are fully integrated into the work of the group and contribute to the progress of the research project.

> *Good students can do good job, and obtain good publishable results.*
>
> *After some start up time, the students can really contribute to a research program.*

On the other hand, two responses indicated that some faculty may view undergraduates as "extra hands "in the lab to the engage in repetitive or simple tasks.

> *If and when the student becomes productive, many relatively simple but time-consuming tasks can be done by him or her that otherwise would need to be done by the faculty member.*

Three faculty members (18%) commented that directing undergraduate research allows them to perform exploratory research that may not have been conducted otherwise.

> *It allows faculty to explore research questions that are not directly related to existing projects in the lab, providing a good opportunity to obtain preliminary data for grants.*
>
> *Some of these students have contributed greatly to the development of my lab and its projects - performing "risky" experiments that sometimes provide very provocative data.*

Two advisors (12%) also reported that they recruit potential graduate students through their UR students.

In sum, the primary benefit of directing undergraduate research for faculty is the opportunity to teach and mentor students and to help them become scientists. Secondary benefits include students' contributions to the work of the research group, the opportunity to engage in exploratory research, and the opportunity to recruit from a potential pool of graduate students. The foremost cost to faculty of directing undergraduate research is the time that it takes to properly train and mentor undergraduate students. Secondary costs include a lack of money and resources, diminished research productivity, and lack of recognition in the university rewards system.

5. The Faculty Rewards System

A particularly salient issue for faculty in terms of costs is the lack of recognition for advising UR students in the faculty rewards system. A clear majority (71%) of faculty responded that conducting research with undergraduates is not overtly rewarded by LSU in the faculty rewards system. The rest of faculty research advisors reported that it was rewarded in the faculty promotion system (14%) or that they did not know (14%) whether it was rewarded. In addition, almost all faculty research advisors (86%) reported that LSU's faculty reward system should overtly reward faculty in some manner for conducting research with undergraduates. The remainder of faculty research advisors (14%) was unsure. Therefore, there was strong consensus among faculty that the university did not overtly reward their work in teaching and mentoring undergraduates in research and that university policies should be changed to recognize their contributions.

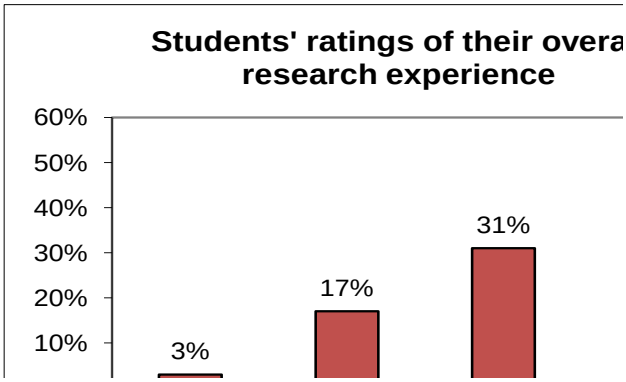
B. Student outcomes from the research experience

We will now discuss student outcomes from the research experience. In particular, we will discuss students' gains in the six categories of benefits identified in our previous research on UR. We will also address students' and faculty perceptions of student gains in these domains. However, we will begin with students' overall satisfaction with the research experience.

1. Students' satisfaction with the research experience

Students rated their overall research experience very highly. Clearly, research is a key element of the LA-STEM program and students' gains from the experience demonstrate that it effectively enhanced students' social and academic integration into a community of scientific practice. Almost 80% of students rated their experience as "good" or "excellent." In addition, 17% rated the experience as "fair" and 3% rated it "poor." The mean for this item was 3.24 on a 4-point scale, indicating that students' average responses fell between "good" and "excellent" on the rating scale. Although overall student ratings indicate that the vast majority of students had positive research experiences, a minority of students were neutral or dissatisfied with their experience. Survey responses from this latter group of students indicate that this small group of students did not always have regular access to "real-world," authentic scientific research projects or the appropriate level of guidance and mentoring that they needed in the lab.

Fig. 5



2. Student gains from the research experience

Students and faculty were asked to rate student gains across the six categories of benefits identified through our qualitative work: thinking and working like a scientist, personal and professional gains, becoming a scientist, enhanced career and graduate school preparation, career clarification and confirmation, and skills. As indicated in table 2 below, students rated their gains higher than faculty rated students' gains on almost all scales, with the exception of career clarification and confirmation. However, student and faculty ratings of students' gains were remarkably similar on most scales. Student and faculty responses were markedly different on the thinking and working like a scientist scale; faculty rated students quite a bit lower than they rated themselves. Overall, most student and faculty means were around 4.0 (4=good gain) on the 5-point scale, indicating that both students and faculty perceived that students received many personal, professional, and intellectual benefits from their participation in UR. Table 2 compares student and faculty means for student gains from UR across the six categories of gains. We will then discuss each category in greater detail.

Table 2. Comparison of student and faculty means of students' gains from UR

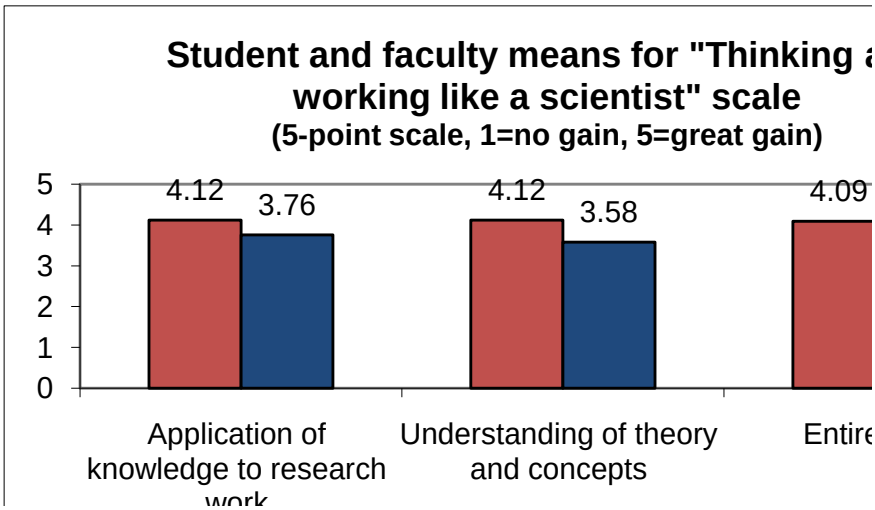
"Parent" categories: Grouping of gain-related codes and major subgroups of each	**Student Means (on a 5-point scale)**	**Faculty Means (on a 5-point scale)**
Thinking and working like a scientist (all items)	**4.09**	**3.70**
Application of knowledge and skills to research work: understanding science research through hands-on experience; understanding the nature of scientific knowledge; understanding how to approach research problems/design.	*4.12*	*3.76*
Increased knowledge and understanding of science and research work (theory, concepts, connections between/within sciences). Transfer between research and courses; increased relevance of coursework.	*4.12*	*3.58*
Personal/professional gains Increased confidence in ability to: do research, contribute to science, present/defend research, and in "feeling like a scientist." Establishing collegial, working relationships with professional mentor, faculty advisor and peers.	**4.02**	**3.83**
Becoming a scientist Demonstrated gains in behaviors and attitudes necessary to becoming a professional (student takes "ownership" of project; initiative; independent approach in decision-making). Greater understanding of the nature of research work and professional practice.	**4.00**	**3.81**
Enhanced career/graduate school preparation Real-world work experience; good graduate school/job preparation, résumé enhanced, career advice. .	**3.50**	**3.47**
Clarification, confirmation and refinement of career/education paths Clarification of career and graduate school intentions; greater knowledge of career/education options; clarification of which field to study; greater likelihood of going to graduate school. Increased interest/enthusiasm for field; introduced new field of study; validation of disciplinary interests	**3.89**	**4.00**
Skills (all items)	**3.85**	**3.74**
Communication skills: presentation/oral argument; some writing/editing.	4.09	3.80
Other skills: Lab/field techniques; work organization; computer; reading comprehension; working collaboratively; information retrieval.	3.78	3.76

a) Thinking and Working like a Scientist

There are two subcategories within this domain; gains in the first subcategory of "thinking and working like a scientist" encompass gains in the application of scientific knowledge and skills, and understanding the process of scientific research. A few students also gained a better understanding of the nature of scientific knowledge and that it is not absolute, but is subject to testing and revision. Benefits in the second subcategory include gains in students' conceptual and theoretical understanding, deepening of their disciplinary knowledge, an increased appreciation for the relevance of coursework, and an increased understanding of the connections within and between disciplines.

Students and faculty both agreed that students made gains in "thinking and working like a scientist" from their UR experience; however, students generally rated their gains about a half point higher than faculty on the 5-point scale. Student means fell above a 4.0 (4=good gain), while faculty means fell below that mark (3=some gain). In fact, students rated this category as their strongest category of gains, while faculty rated "career clarification and confirmation" as the strongest category of student gains.

Fig. 6



(1) Application of knowledge to research work

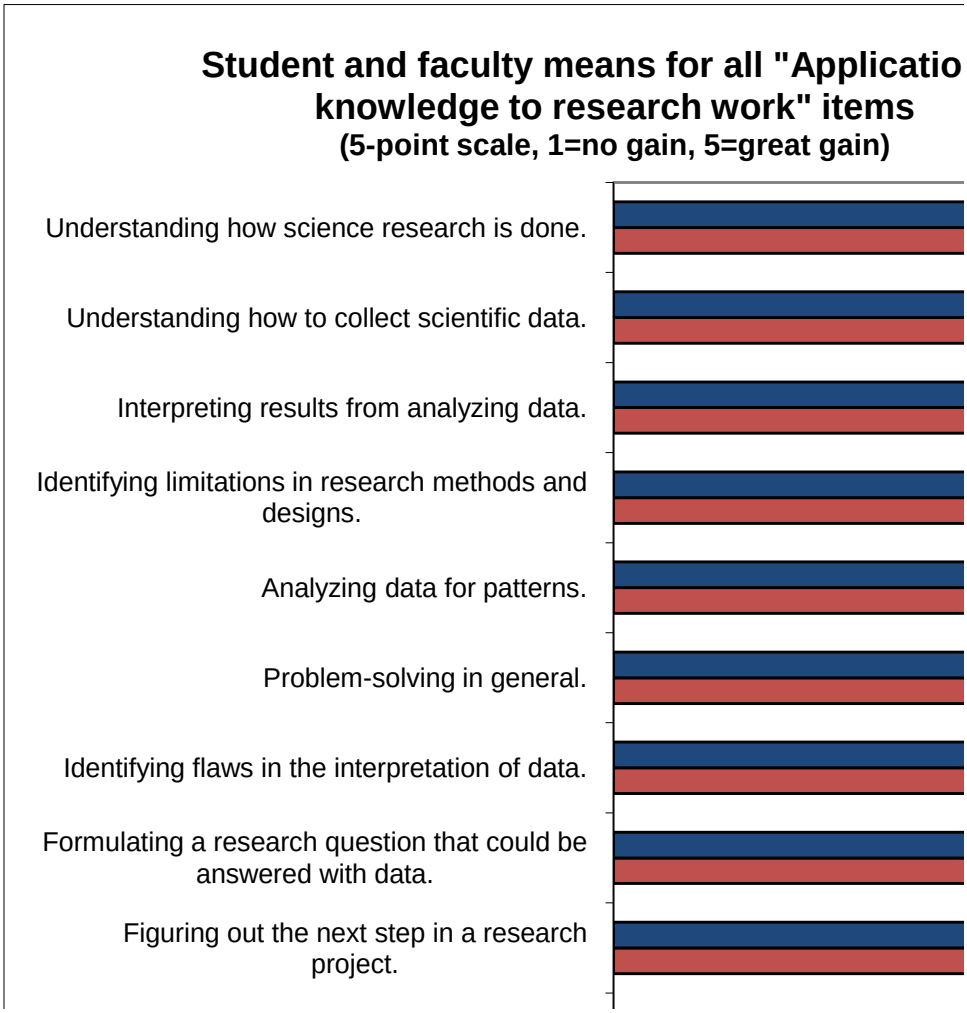
The subcategory of "application of knowledge to research work" describes students' gains in applying critical thinking and problem-solving skills to a real-world research problem, enhanced understanding of the scientific research process, and the development of students' abilities to design and refine a research question or scientific experiment. Despite students' higher self-ratings in "thinking and working like a scientist," there was agreement between both faculty and students about where students made the strongest and weakest gains in this subcategory. Both groups rated "understanding how science research is done" and "understanding how to collect scientific data" as the strongest student gains, indicating that most students had the opportunity to observe and participate in authentic scientific research and to learn about the nature of the

scientific research process. Specifically, the vast majority of students reported that they made a "good" or "great" gain in both of these areas (83% and 80%, respectively).

However, both students and faculty ratings indicated that students made weaker gains in higher-order scientific thinking skills, such as "identifying flaws in the interpretation of data" and "formulating a research question that could be answered with data." In fact, the largest discrepancies between student and faculty ratings were in items related to research design and the interpretation of data. Students rated themselves almost .75 (on a 5-point scale) higher than faculty on some of these items, including "identifying flaws in the interpretation of data" and "identifying limitations in research methods and designs." Though they rated themselves higher than faculty, students still did not rate their gains very highly in these areas. Only 48% of students reported that they made a "good" or "great" gain in "formulating a research question that could be answered with data" and only 44% made a "good" or "great" gain in "identifying flaws in the interpretation of data." Similarly, Hunter (2007) and Kardash (2000) found that UR students made only modest gains in "higher-order" scientific thinking skills, particularly the development of the ability to generate and frame research questions and design experiments.

Overall, LA-STEM students reported strong intellectual gains in understanding the process of scientific research, data collection and analysis and problem-solving. Faculty also generally rated students as making strong gains in understanding how research is done and data collection, yet rated their gains lower in other areas, such as understanding of research design. Figure 7 displays all of the student and faculty means for the "application of knowledge to research work" subcategory of "thinking and working like a scientist."

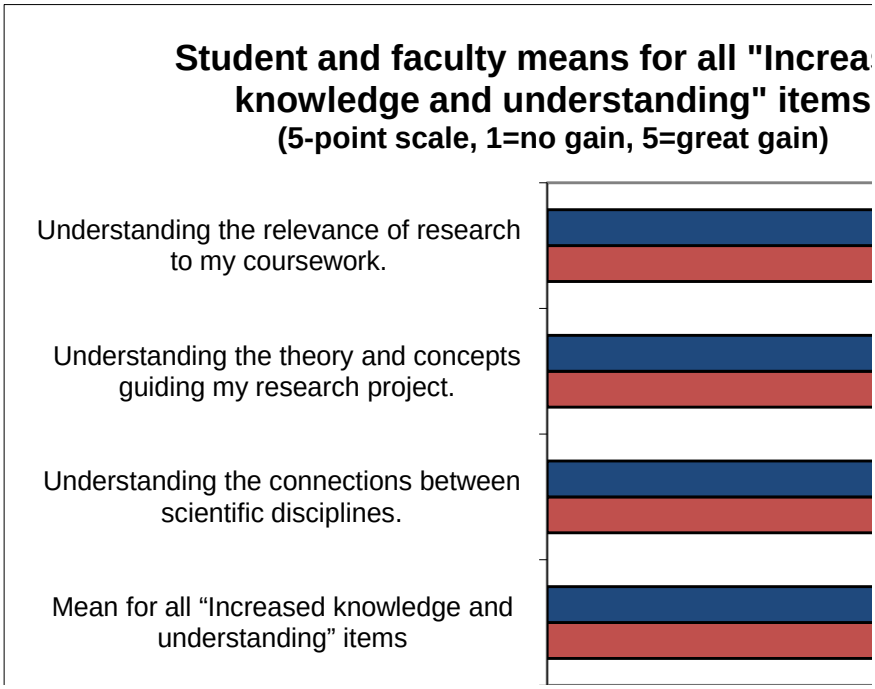
Fig. 7



(2) Increased knowledge and understanding of theory and concepts

The second subcategory within “thinking and working like a scientist” is “increased knowledge and understanding of theory and concepts.” This subcategory describes gains in students’ disciplinary knowledge and understanding, and their understanding of the connections between scientific disciplines. Through hands-on research work, students also begin to see the relevance of research to their scientific coursework. Student self-reports of gains in this subcategory were higher than faculty reports of student gains. For example, the student mean for the entire sub-scale was 4.12 (slightly above “good gain), while the faculty mean was 3.58 (closer to “some gain”), indicating that students perceived stronger gains in this area than faculty observed in their students. The student and faculty means for all items on this scale are detailed in the figure 8.

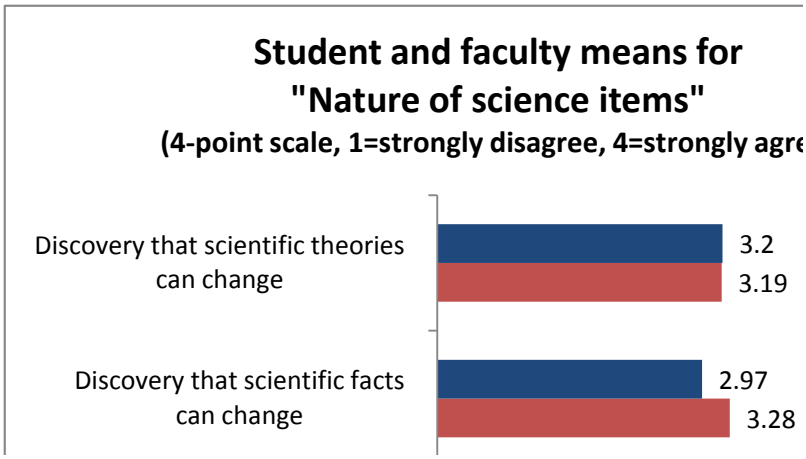
Fig. 8



(3) Nature of Scientific Knowledge

Students also reported that they made gains in understanding the nature of scientific knowledge, particularly that scientific knowledge and theories are falsifiable and subject to revision. Students rated these gains lower than their other intellectual gains; likewise, our prior research has shown that undergraduate students make fewer gains in understanding the nature of scientific knowledge than other areas of scientific thinking (Hunter et al., 2007). Faculty also rated students lower in this area; however, there was less difference between students’ and faculty scores on “nature of science” items than other “thinking and working like a scientist” items. Faculty and student means for “nature of science” items are shown in figure 9 below.

Fig. 9



In an open-ended question, students were also asked, "What did you discover about the nature of science?" Eighteen students responded to the question. Half of students (n=9) commented that scientific knowledge is subject to revision and change.

> *Science is never set in stone. As soon as we think we know something it turns out to be a special case of something more general, something more elegant.*
>
> *It is constantly changing and new things are discovered every day.*

Five students (28%) commented that there is a lot more to learn in the scientific disciplines.

> *That the more you learn, the more you realize how much more there is to learn.*

One student mentioned that scientific knowledge is constructed and built upon prior research. A few students did not seem to understand the question and commented that science is "rewarding" or "frustrating." With the exception of a few responses from students who did not understand the question, students' comments indicate that they came to an accurate understanding about the nature of scientific knowledge through their research work. This outcome indicates that these students participated in authentic research projects that helped them to understand the way in which scientific knowledge is constructed, debated, and verified within a scientific community.

b) Personal and Professional Gains

In the category of "personal and professional gains," students noted increased confidence in their ability to do research, and to make a contribution to scientific knowledge. They also described the benefits of establishing a collegial relationship with a mentor and peers.

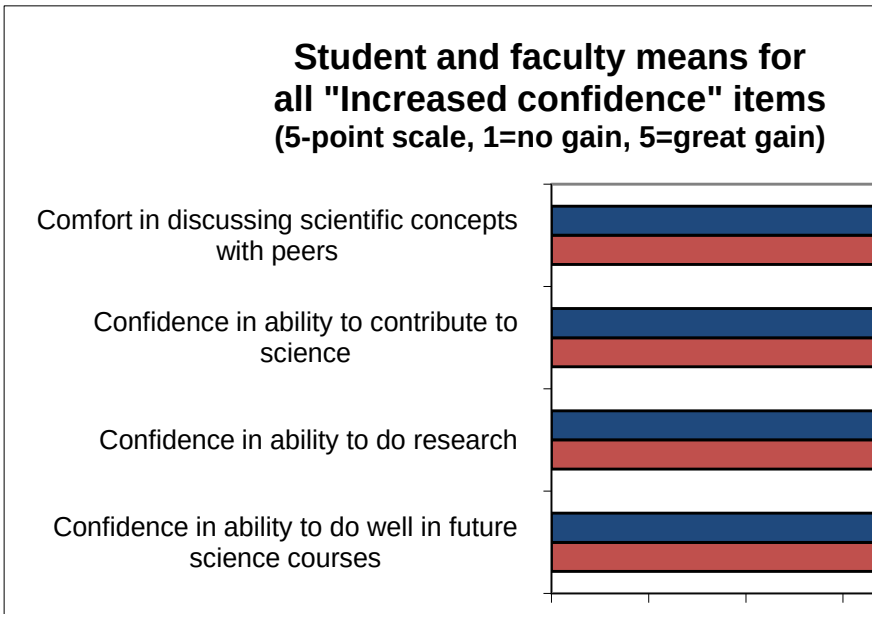
The first subset of personal and professional gains for students was increases in confidence, particularly in students' ability to undertake an open-ended research project and to contribute to their field. Faculty and student ratings for all items in gains in confidence were remarkably similar (student mean of 4.02 and faculty mean of 3.83 on a 5-point scale, mean of 4.0= "good gain"). Personal and professional gains are especially important for minority students because

their persistence in their major is more closely related to their enthusiasm for their field than their grades (Grandy, 1998).

The "personal and professional gains" category was the second highest category of student gains, according to both students and faculty. This finding suggests that both students and faculty felt that gains in confidence were an important outcome of the UR experience. However, faculty rated these gains lower than students, indicating that students may make greater gains in confidence from UR than some faculty realize. Students' gains in confidence may not be overtly evident to faculty and it may be difficult for faculty to accurately observe their gains in confidence.

Faculty rated "students' ability to work collaboratively with others,"[1] as the strongest gain in the category while students rated "comfort in discussing scientific concepts with my peers" as the strongest gain. However, gains in confidence were rated highly across the board by both students and faculty. Our previous research on underrepresented groups in computing fields has shown that gains in confidence can contribute to students' persistence in the major and aspirations for a career in the field (Thiry, Hug, & Barker, 2008).

Fig. 10



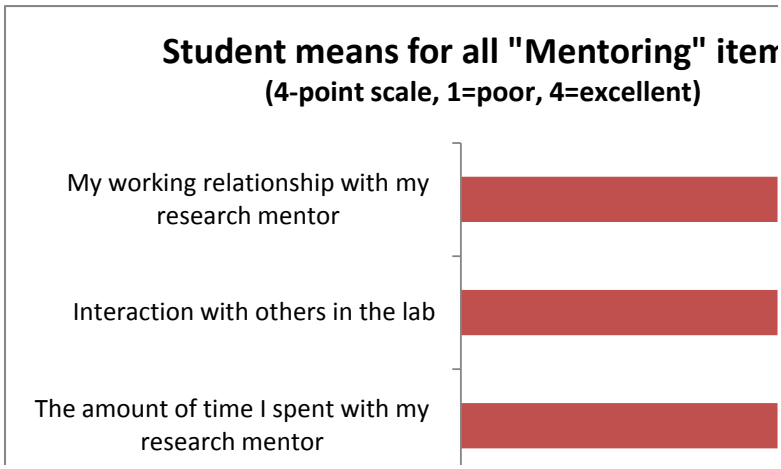
Students, though not faculty, also rated the quality of their mentoring and collegial relationships in the lab. Students held their relationships with their research mentors in high regard (mean=3.34 on a 4-point scale, 1=poor, 4=excellent; 86% of students rated this relationship as "good" or "excellent"), though they rated the amount of time spent with their mentor almost a half-point lower (mean=2.9; 66% of students rated the amount of time spent with their research advisor as "good" or "excellent"). In fact, 31% of students described the amount of time spent with their research advisor as "fair." Though LA-STEM students on the whole seem to be

[1] This item was not on the student survey.

satisfied with their relationships with their research mentors, some students may need to spend more time with their mentors in the lab.

Our previous work on undergraduate research has demonstrated that the quality and quantity of students' interactions with their research mentors are critical to students' outcomes from the research experience, particularly in terms of learning, future aspirations, and overall satisfaction with the experience (Thiry et al., 2009). Likewise, there was a strong correlation between students' overall satisfaction with their research experience and the amount of time that they spent with their research mentor (r=.558, p=.002, significance at the .01 level), and their working relationship with their mentor (r=.601, p=.001, significance at the .001 level). On the other hand, there was little correlation between students' relationships with their mentors and their intentions to enroll in graduate school or their desire to pursue a career in research. Therefore, students' interactions with their mentors greatly affected the quality of their experience and their satisfaction with the research experience overall; however, student-mentor interactions did not influence students' educational or career aspirations in STEM fields. Figure 11 provides students means for all "mentoring" items.

Fig. 11



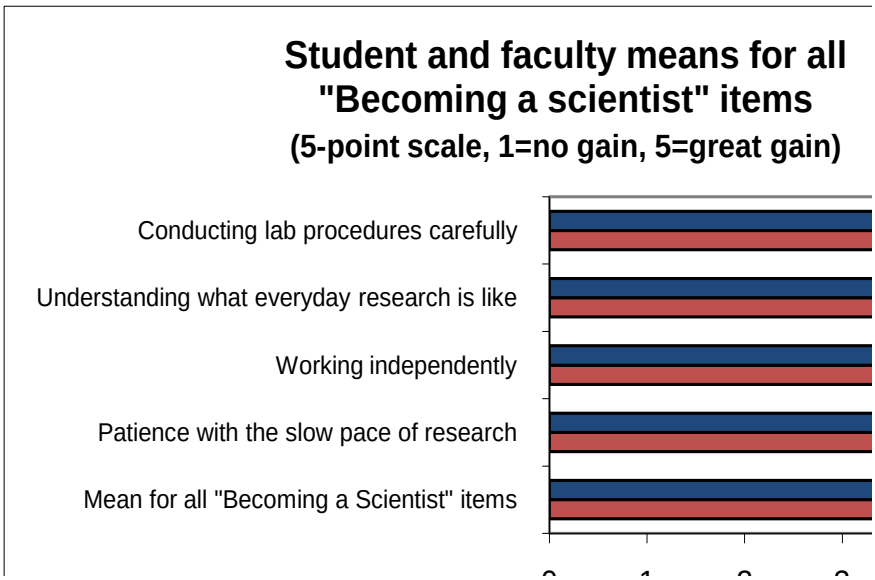
c) Becoming a Scientist

Through research, students begin to adopt the behaviors and attitudes necessary to become a scientist. Our qualitative research has shown that UR students learn to work and think independently, to take responsibility for their own learning, and to take initiative to solve problems on their own rather than simply relying on experts for the answers. Students also begin to pay careful attention to details in their research projects and take pride in the results of their work. Students come to recognize that research is slow, messy, can be boring and tedious at times, and is often rife with failure and setbacks. By engaging in authentic scientific research, students gain a better understanding of the nature of scientific research and the everyday work of scientists. They also gain a better understanding of the temperament, traits, and characteristics that are required to succeed in science.

Students viewed themselves as making greater gains in all areas of "becoming a scientist" than faculty. The greatest discrepancies between students' and faculty responses were in

"understanding what everyday research is like" and "conducting lab procedures carefully." Though the percentage of student and faculty responses that rated students as having made a "good" or "great" gain was almost equal between students and faculty on this last item (73% and 71% respectively), the mean was almost a half-point apart. A small proportion of faculty felt that students made "no" or only a "little" gain in this area, while most students rated themselves as having made at least "some" gain. Nevertheless, students rated themselves as having made "good" gains in almost all areas of becoming a scientist. Faculty also saw student progress in this area, though they rated students' gains slightly lower than students themselves. Figure 12 below displays student and faculty means on "becoming a scientist" items.

Fig. 12



In an open-ended question, students were asked, "What did you discover about the process of doing scientific research?" There were 21 responses to the question. Seven students (33%) commented that they discovered that scientific research is tedious and monotonous. Nevertheless, most of these students also found the end results of research to be rewarding.

> *I discovered that the research process in math can be tedious, often with only an hour or two a day of truly productive research, but that eventually everything comes together.*

> *I discovered it is a long tedious process that is extremely rewarding when you realize you are expanding the web of knowledge.*

Five students (24%) mentioned that scientific research is a long, slow process.

> *The process is long, sometimes indefinitely long. There is never only one solution so you have to be thinking of multiple solutions in case one fails.*

Five students (24%) commented that scientific research takes a lot of hard work and perseverance.

[I discovered] the time and effort required for it.

Four students (19%) learned that scientific research is rewarding. All of these students mentioned negative aspects of scientific research, such as its tediousness or difficulty, yet also commented that despite these frustrations, it is rewarding.

That it is very tedious and slow but rewarding in the end.

Two students (10%) learned that setbacks and failures are an inherent part of the scientific research process.

Things often go wrong and it's easy to get discouraged.

Two students (10%) commented that scientific research requires patience.

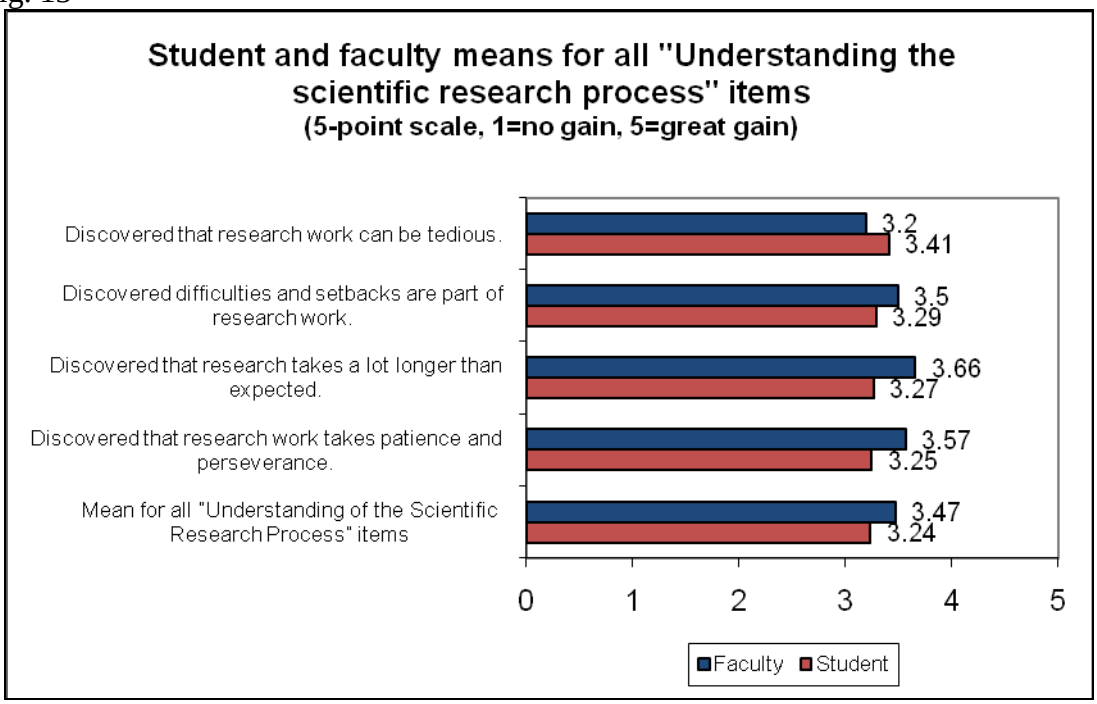
Patience and commitment are crucial.

Individual students also mentioned that scientific research requires independence, teamwork, and a lot of disciplinary knowledge. One student also commented that he or she had not learned enough about scientific research to be able to comment. Overall, students gained an accurate understanding of both the frustrations and rewards of the scientific research process, indicating that these students had access to authentic research activities in their labs that helped them come to a better understanding of the nature of the research process.

(1) Developing the temperament of a scientist

Similar to their open-ended responses, students' responses to quantitative items also demonstrated that they made gains in developing an understanding of the temperament required to be a successful research scientist. Students began to understand that research can be long, slow, and tedious. Students also discovered that setbacks and failures are an inherent part of the scientific research process. Interestingly, faculty perceived that students made higher gains than students themselves in these areas, primarily because a few students reported that they made "no" or a only "a little" gain, while most faculty rated students as having made at least "some" gain. Faculty research advisors' higher ratings of students' gains on this scale stands in contrast to their lower ratings of students' gains on most other scales. Figure 13 below demonstrates student and faculty means for "understanding the scientific research process items."

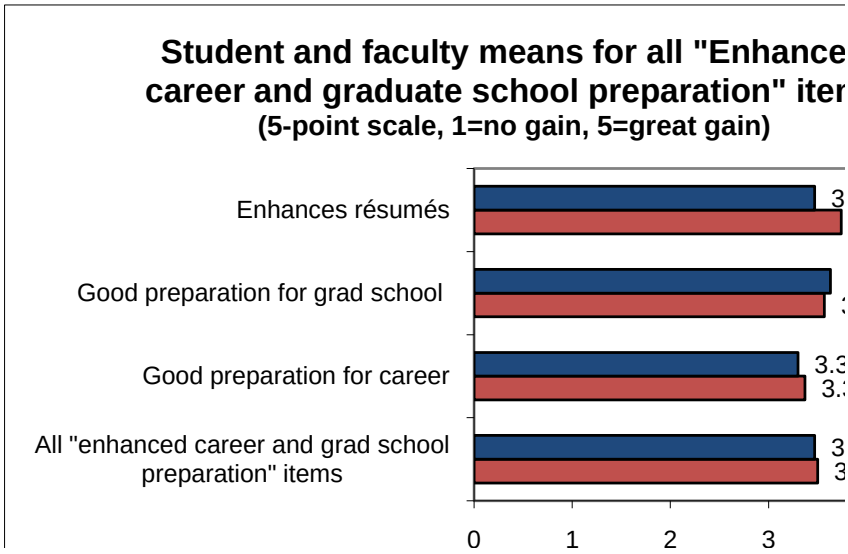
Fig. 13



d) Enhanced Career and Graduate School Preparation

Undergraduate research also helps students to feel prepared for graduate school and future careers. Research enhances students' résumés, provides opportunities to network with faculty and other scientists, and exposes them to new experiences. There was little difference in students' and faculty research advisors' ratings of students' preparation for future work. Students rated résumé enhancement as their strongest gain received from UR, while faculty rated preparation for graduate school as the strongest gain in this category. There was strong agreement among both students and faculty on student gains in this area: 100% of students "agreed" or "strongly agreed" that research enhanced their résumé, while 93% of faculty reported the same. Likewise, 93% of students and 97% of faculty "agreed" or "strongly agreed" that research is good preparation for graduate school, while similar numbers (93% of students and 90% of faculty) reported the same for research's role in enhancing career preparation. Faculty and student ratings on these items were remarkably similar, indicating that both faculty and students see value in the research experience for contributing to students' preparation for graduate school and future careers. Student and faculty means for "enhanced career and graduate school preparation" items are shown in figure 14 below.

Fig. 14



Research mentors also provided students with advice about graduate school and careers. Students rated advice about graduate school higher than the general advice that they received about careers. Students rated the "advice my research mentor provided about careers" as a 2.89 on a 4-point scale (1=poor, 4=excellent) and the "advice I received about graduate school" a 3.21. Therefore, students were generally satisfied with the advice they received about their future plans, though the advice they received about graduate school seemed to be more helpful than the career advice offered by their mentors.

e) Clarification and confirmation of career aspirations and interests

Through their participation in research, students sustained or increased their interest in the field, gained knowledge about graduate school and career options, clarified or confirmed their intentions to go to graduate school, and clarified whether scientific research would be a suitable career. Research experiences helped students to "try out" a scientific career to see whether it would be worth pursuing after graduation. Students also expressed an increased interest in research, the discipline, or field of study.

Students and faculty both rated the career clarification benefits of UR quite highly, though faculty rated these gains slightly higher than students. Specifically, faculty rated "increased interest in science in general" as students' strongest gain, while students reported that they made the greatest gains in increasing their "knowledge of career and education options." These scales were slightly different between the student and faculty surveys; nevertheless, student and faculty means for the scale were remarkably similar (3.89 and 4.0 on a 5-point scale, respectively). Interestingly, faculty perceived that students made stronger gains in "interest in attending graduate school" and "interest in science in general" than students themselves. However, students reported stronger gains in "knowledge of career/education options" than faculty. This latter gain may be particularly important for underrepresented students who may have had less access to experiences and opportunities that enhance their knowledge of science and scientific

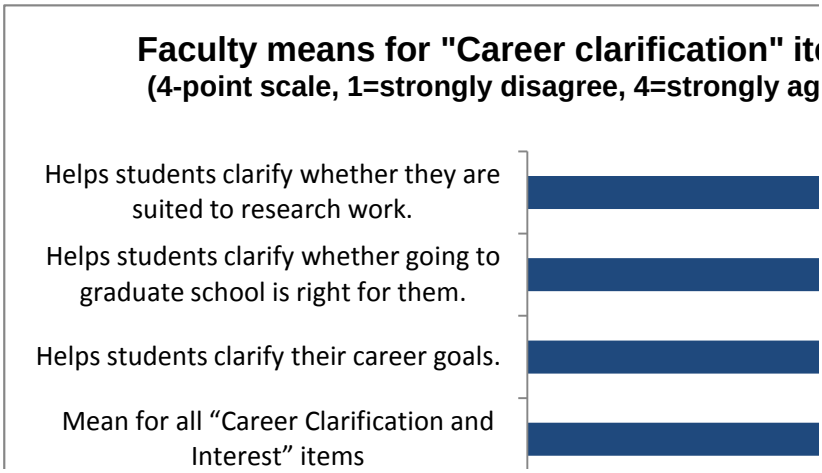
careers than their majority peers. Table 3 below demonstrates student and faculty means for "career clarification" items.

Table 3. Student and faculty means for all "Career clarification" items

Item (Items rated on a **5-point scale**)	**Student Mean**	**Faculty mean**	**Student** % of "good" or "great gain"	**Faculty** % of "good" or "great gain"
Knowledge of career/education options.	4.09	N/A	75%	N/A
Knowledge of career options.	N/A	3.92	N/A	76%
Knowledge of education options.	N/A	3.96	N/A	76%
Interest in attending graduate school.	3.71	4.08	58%	79%
Interest in science in general.	3.91	4.19	64%	85%
Mean for all "Career clarification and interest" items	**3.89**	**4.00**		

Faculty responded to a few extra "career clarification" items that were not on the student survey. Again, faculty rated student gains in "career clarification" quite highly. All means were between 3 and 4 on a 4-point scale. Faculty rated student clarification of whether they are suited to research work the highest, yet also rated students' clarification of graduate school and career goals highly. Moreover, over 90% of faculty agreed or strongly agreed with each of the items on the career clarification scale in the figure below.

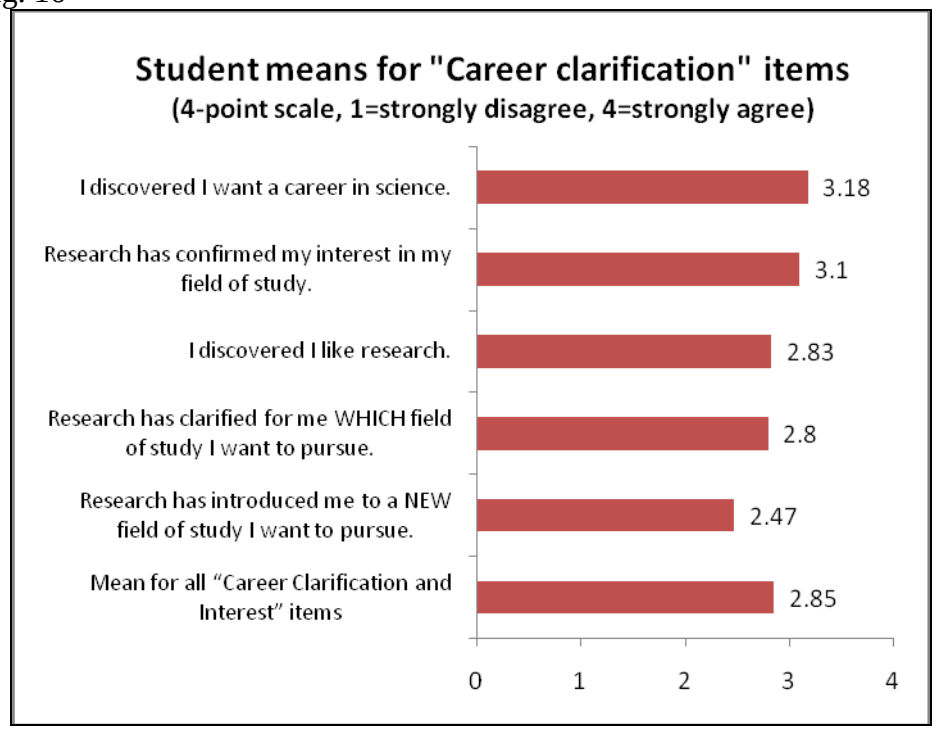
Fig. 15



Our previous research has shown that UR can be a powerful experience in helping students determine whether research is a "good fit" for them and a career path that they would like to pursue. Research can also help students to clarify their field of interest. Almost three-quarters of LA-STEM students reported that they discovered that they like research. The mean for this item is lower than for some other "career clarification" items because 17% of students strongly disagreed with the statement, indicating that a few students either discovered that they do not have the temperament for research work or had poor research experiences that caused them to lose interest in research. A little over half of students (55%) discovered that they want a career in science, indicating that the LA-STEM program has been successful in influencing students'

aspirations to remain in science. However, we do not know whether the students who did not agree with this statement were already interested in a science career, or whether they were somehow "turned off" to a career in science from their research experience. Given that very few students had poor research experiences, it is more likely that students who did not agree with the statement were already interested in a career in science. Further, there were no negative responses in the open-ended question about the influence of research on students' career and educational goals, providing further evidence that students who did not "discover that I want a career in science" may have already intended to pursue a career in science. Research also helped students to clarify their field of study more often than introducing students to a new field of study; 73% of students agreed or strongly agreed that research helped to clarify the field of study they would like to pursue. The means for these items are shown in the figure below.

Fig. 16



In an open-ended question, students were asked, "How did research influence your thinking about career or graduate school plans?" Twenty students responded to this question. Overall, research was integral in helping students to clarify or confirm their goals and interests. Students were divided as to whether research influenced them to enroll in graduate school, or clarified that they were not interested in a research career. Research also helped several students to confirm pre-existing plans to attend graduate school and helped several students identify their field of interest.

Four students (20%) commented that their research experience had clarified that they are not interested in a research career.

I decided I did not want to do research for the rest of my life.

I have decided that, although I do thoroughly enjoy participating in research, I do not want to make a career of it.

Three students (15%) commented that research had clarified the field of study that they are interested in pursuing in graduate school or a career.

It made me realize which fields of science I am interested in and how research works.

Three students (15%) also mentioned that research had clarified or confirmed their pre-existing plans to attend graduate school.

My research experience reinforced my desire to attend graduate school.

Three students (15%) commented that research had increased their interest in attending graduate school.

[Research] moved me to want to pursue a PhD.

Individual students also commented that research had increased their interest in the professoriate, clarified the type of institution that they would like to attend for graduate school, helped them to feel prepared for graduate school, increased their confidence in their research abilities, and increased their interest in research. One student commented that research had no effect on his or her educational or career plans.

f) Skills

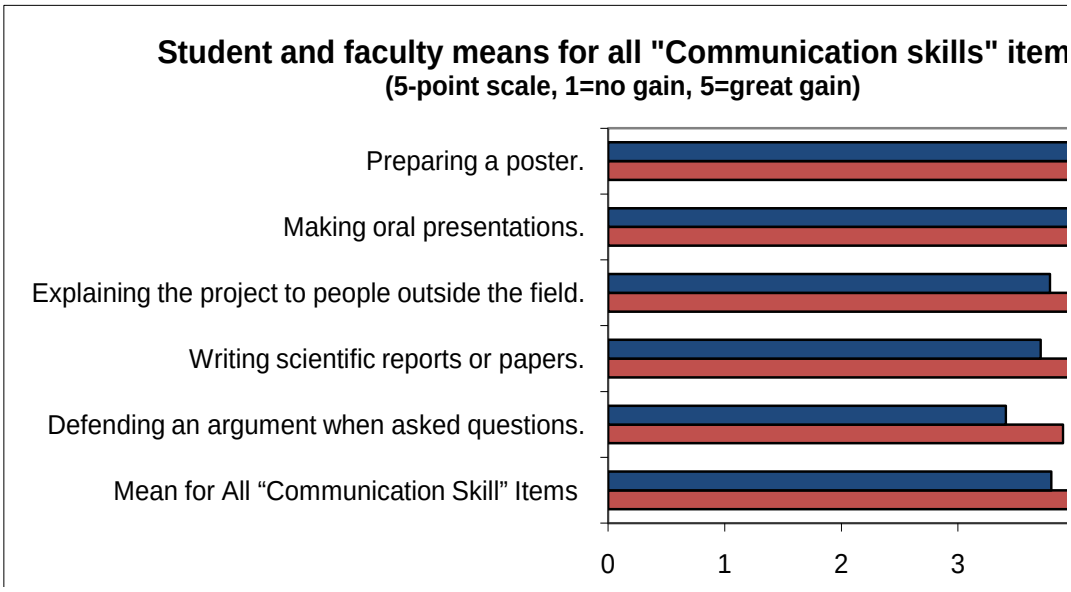
In our qualitative study of UR, students mentioned gains in written and communication skills, mastery of new research and laboratory techniques, and gains in organizational and time management skills. Students also mentioned augmentation of their reading comprehension skills, particularly for scientific journal articles, information retrieval skills, and abilities to work collaboratively with peers, faculty, and other professionals.

LA-STEM students also rated their gains in scientific skills quite highly. LA-STEM students reported stronger gains in communication skills than other skills, such as information retrieval or organizational skills. Likewise, our prior research in undergraduate research affirmed that students made stronger gains in communication skills than other types of skills (Hunter et al., 2007, Seymour et al., 2004).

Both faculty and students rated students' gains in "making oral presentations" and "preparing a poster," higher than other communication skills, indicating that students' research experiences fostered stronger gains in oral communication than scientific writing. For example, 79% of students reported that they made a "good" or "great" gain in preparing a poster and 75% of students made a "good" or "great" gain in giving oral presentation. Over half of students (61%) also reported that they made "good" or "great" gains in scientific writing. Faculty also perceived that students made strong gains in oral presentation with 84% of faculty reporting that students made "good" or "great" gains in both giving oral presentations and presenting posters.

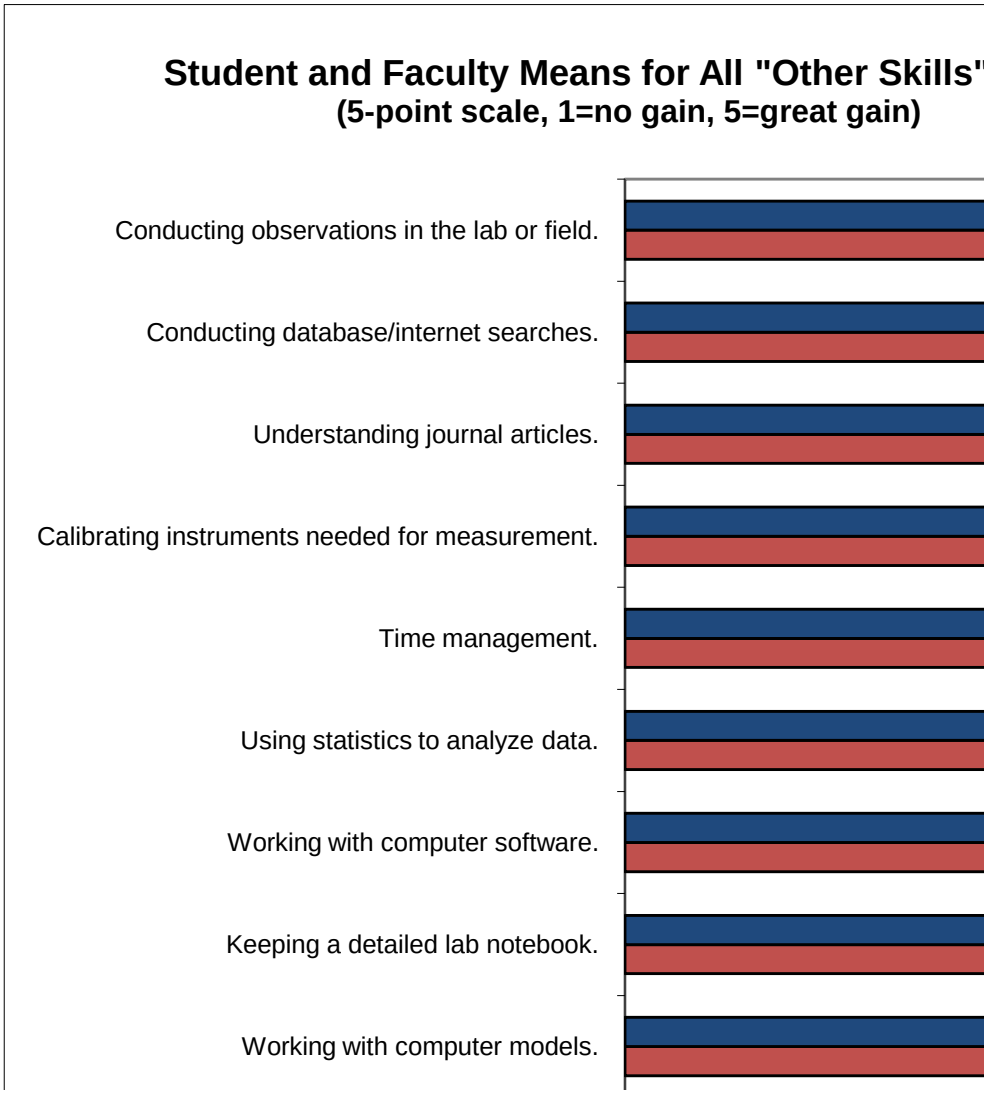
Nevertheless, students rated most of their gains in communication skills quite a bit higher than faculty rated their gains. The figure below displays student and faculty means for "communication skills" items.

Fig. 17



In the "other skills" category, students reported the strongest gains in "conducting observations in the lab or field," and "conducting database/internet searches." Faculty rated students' gains the highest in "conducting observations in the lab or field," and "understanding journal articles." Eighty percent of students and 92% of faculty reported that students made "good" or "great" gains in "conducting observations." Likewise, 72% of student and 75% of faculty rated student gains in "conducting database/internet searches" as "good" or "great." Therefore, there was strong agreement between faculty and students regarding student gains in skills other than communication skills. Interestingly, faculty rated student gains higher than students in several categories, including "keeping a detailed lab notebook," and "working with computer models." Figure 18 below displays student and faculty means for "other skills" items.

Fig. 18

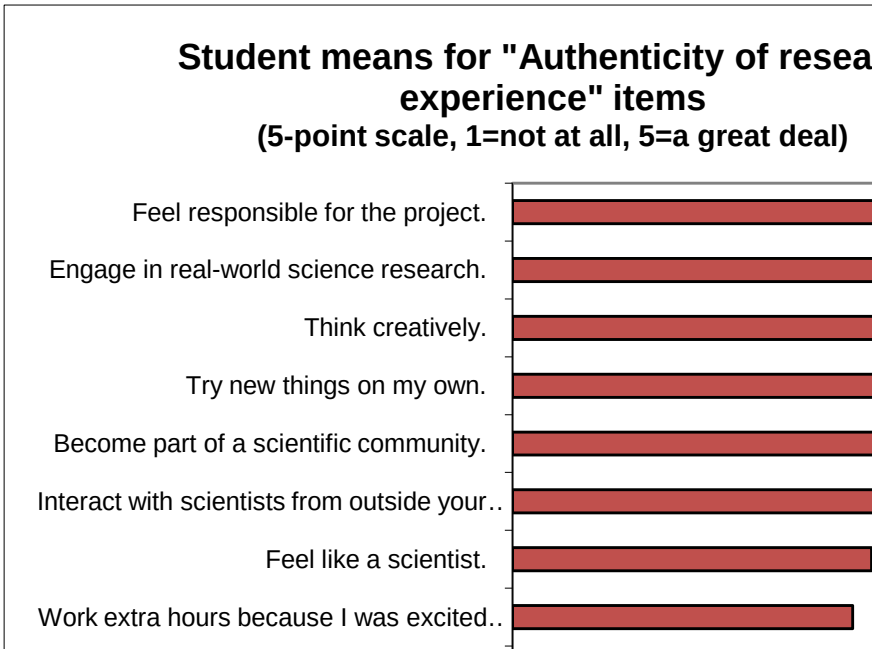


3. Authenticity of students' research experiences

Our previous research on UR at research universities has demonstrated that the research experience for students may be more variable than the high-quality, apprenticeship model of UR in which students at the four liberal arts colleges engaged (Coates, et al., 2006; Hunter et al, 2007; Seymour et al., 2004). To test this hypothesis, we asked LA-STEM students to assess the authenticity of their research experience by rating how often they engaged in certain behaviors that are markers of an authentic experience, such as "engaging in real-world science research," "thinking creatively," "feeling like a scientist," and "becoming part of a scientific community." Most students seemed to have engaged in authentic activities quite often, according to their ratings on this scale. Students rated a feeling of "responsibility for the project" as the highest item on the scale (81% of students felt responsible for the project "a good amount" or "a great deal"). Most students (64%) also responded that they engaged in "real-world science research" a good amount or great deal. On the other hand, that means that about one-third of students did not perceive that they frequently engaged in real-world research. Most students (65%) also reported

that they were able to think creatively about their projects. However, students gave lower ratings to other markers of authenticity, such as “working extra hours because I was excited about the project,” or “feeling like a scientist.” Overall, the majority of students appear to have engaged in authentic research; however, a minority of students may have had limited access to authentic research. For instance, 12% of students responded that engaging in real-world research was “not applicable,” while 20% of students responded that they engaged in real-world research only “some” of the time. Nevertheless, very few students (typically only 1 or 2 per item) marked “not at all” on the authenticity items, suggesting that most students had the opportunity to engage in authentic research activities either somewhat often or quite often. On the other hand, the findings also suggest that students differed in the amount of time spent on authentic tasks. Figure 19 below displays student means for the “authenticity” items.

Fig. 19



In addition, students’ exposure to authentic, “real-world” research also impacted their overall satisfaction with their research experience and with the LA-STEM program. There was a significant relationship between students’ ratings of the authenticity of their research experience and their overall satisfaction with research ($r=.616$, $p=.001$, significance at .001 level), and students’ overall satisfaction with the LA-STEM program ($r=.577$, $p=.003$, significance at .01 level). Therefore, both students’ quality and quantity of interactions with their mentors and exposure to authentic research impacted their perceptions of their research experience and the LA-STEM program. However, there was not a significant correlation between the authenticity of students’ research experiences and their intentions to pursue a terminal degree in a STEM field. Therefore, the level of students’ engagement in “real-world” research influenced the short-term outcomes of their satisfaction with research and LA-STEM; however, it did not impact their long-term educational goals.

Another marker of an authentic research experience is whether students worked on original research that made a contribution to their field. LA-STEM students engaged in a variety of professional activities to communicate the results of their original research, indicating that the majority of them did engage in original research. The most common method of professional dissemination was presenting a talk or poster to other students and faculty. However, almost half of students presented a talk or poster at a professional conference and over half of students attended a professional conference. In addition, one student received an award or scholarship based on his or her research. LA-STEM students' opportunity to present their work in various professional contexts is another indicator that the majority of students engaged in authentic research experiences. Table 4 below indicates students' involvement with professional activities in their field.

Table 4. Students' dissemination of research results in professional environments

Professional Activity	% of students who engaged in this professional activity
Presented a talk or poster to other students and faculty.	70%
Presented a talk or poster at a professional conference.	42%
Attended a conference.	56%
Won an award or scholarship based on my research.	3%

4. Students' "best" and "worst" parts of the research experience

In open-ended questions, students were asked to comment upon the "best part" and "worst part" of their research experience. Their responses are described in detail in the following sections.

a) Best part of the research experience

Students mentioned several types of gains as the "best part" of their research experience. These gains could all be categorized within the six categories of research gains identified through our qualitative research on UR and assessed on this survey. All of the students' comments about the "best part" of their research experience fell within four of these categories: thinking and working like a scientist, personal and professional gains, becoming a scientist, and skills. There was no mention of gains in career clarification or enhanced career preparation as the "best part" of the research experience. Nineteen students responded to this question. Therefore, students valued the intrinsic intellectual and personal gains from research more than extrinsic career gains.

Nine students (47%) mentioned gains in "thinking and working like a scientist" as the "best part" of their research experience. Most of these responses referred to the opportunity to learn about scientific research through hands-on, authentic experience. This is also in keeping with their rating of "thinking and working like a scientist" as their strongest category of gains from research. Students clearly valued the intellectual benefits they received from research.

> *The hands on research and investigation of mathematical concepts and the feeling of accomplishment when things finally worked out were the best parts of my research experience.*

Several of these responses also described developing a better understanding of the discipline or the theoretical underpinnings of the research project. These responses also described an enhanced appreciation of the relevance of coursework to understanding science.

> *I am able to see real information for my field of study and I have the ability to analyze it how I would like.*
>
> *Applying techniques learned in my coursework.*

Eight students (42%) described "personal and professional gains" as the "best part" of their research experience. Almost all of these comments referenced either gains in developing a mentoring relationship with a faculty member (n=3 students) or the opportunity to network with other scientists outside of the university (n=3 students).

> *I got to travel to other universities and meet a lot of different people.*
>
> *The best part of my research was my mentor, who was there to help me with anything that I needed.*

Two students also mentioned the opportunity to make a contribution to the field.

> *Getting valuable results, and publishing a paper.*

Four students (21%) referred to gains in the "becoming a scientist category." Half of these students described gaining a better understanding of the nature of scientific research and the other half described developing the traits and attitudes necessary to be a scientist, such as independence, creativity, perseverance, and patience.

> *Being exposed to the "real" science world; creating new things.*
>
> *The learning experience, being able to have a project of my own.*

Two students (11%) also mentioned gains in skills as the "best part" of the research experience. One of these students simply described generic gains in "skills," while the other student described gains in organizational skills.

b) "Worst part" of the research experience

Students were also asked to describe the "worst part" of their research experience. Twenty students responded to this question. Students' answers primarily focused on the time commitment necessary to conduct research, the failure and frustration inherent in research work, a lack of interaction with others in the lab, and unmet needs.

Eight students (40%) mentioned that failures, setbacks, and lack of progress in the lab were the worst part of the research experience. On the other hand, the development of an understanding that research is slow, tedious, and prone to failure is classified as a "gain" in our analytic

framework because students have gained a greater understanding of the nature of scientific work. Nevertheless, this can often be a frustrating realization for students.

> *The worst part of my research experience was the hours spent trying to prove something to no avail.*
>
> *The worst part of my research experience was not gathering any data because of consistent failed experiments.*

Seven students (35%) mentioned the extensive time and effort required to conduct research as the "worst part" of research. Students' time issues referenced both their lack of ability to spend more time in the lab due to coursework and other obligations as well as the inherent amount of time necessary to perform experiments and conduct research.

> *Very time consuming, but such is the nature of research.*
>
> *Managing time with all of the classes.*

Six students (30%) referenced unmet needs during their research experience, including a need for more guidance and support from personnel in the lab, a need for more independence on the research project, and greater clarity of goals and expectations for the project. However, the most common concern (n=4) was a lack of guidance in the lab.

> *My professor got sick when I needed direction and I was forced to waste time and hurry to finish my project at the end.*
>
> *I've had some bad experience with one of my previous mentors; she was too busy for me.*

Two students (10%) also mentioned a lack of interaction as a negative aspect of their research experience.

> *Interactions with others are very limited.*

Overall, students' responses to the "best part" of their research experience suggest that most of them engaged in authentic research with the opportunity to learn about and contribute to their field. However, students' responses to the "worst part" of their research experience also suggest that a few students did not receive proper direction and guidance in the lab or did not have access to a community of scientists and peers in their research experience. As mentioned previously, a lack of mentoring and interaction in the lab can greatly diminish a student's research experience.

We will now address outcomes from the LA-STEM program in general, including outcomes from the academic enrichment courses, personal and skills gains, and the transferability of gains from the LA-STEM program to other aspects of students' lives. We will also address the impact of the program on students' educational and career aspirations.

IV. LA-STEM Research Scholars program outcomes

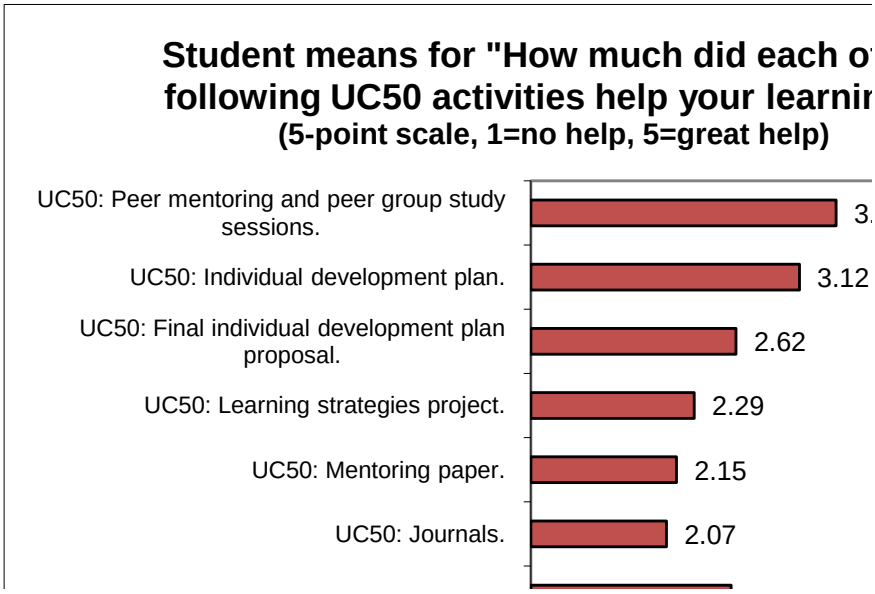
A. Academic enrichment courses

In general, students did not rate program activities and seminars quite as highly as they rated their research experiences. However, students did report benefits from a variety of these activities. The activities that students found to be helpful to their learning from the academic enrichment courses changed as they progressed through their undergraduate careers. For instance, UC50 students found peer mentoring and group study sessions to be somewhat beneficial, while UC80 students found peer mentoring to be less helpful. Instead, they rated GRE workshops and other graduate school preparation seminars to be very helpful. Therefore, students placed less value on formal peer and social support as they moved through the LA-STEM program, and became more focused on preparation for their future educational and career paths. Students' survey responses to other items suggest that they continued to value the informal support and community fostered by the program throughout their undergraduate careers; however, they became less enthusiastic about formal peer mentoring as they advanced through college.

1. UC50 activities

Students had a range of responses to UC50 activities. Students rated peer mentoring and peer group study sessions to be the most helpful UC50 activities. Almost half of students (48%) rated these activities as "much help" or great help." Students also rated the individual development plan relatively highly (42% rated it as "much help" or "great help"). On the other hand, students did not rate journals, the learning strategies project, or the mentoring paper as highly. Moreover, all of the standard deviations on these items were above 1.0 on the 5-point scale, indicating that there was a wide range of responses and that some students rated the activities very highly, while others did not. In contrast, almost all of the research items had standard deviations below 1.0, indicating that there was stronger agreement among students about the gains they made from research. Figure 20 below displays the student means for UC50 activities.

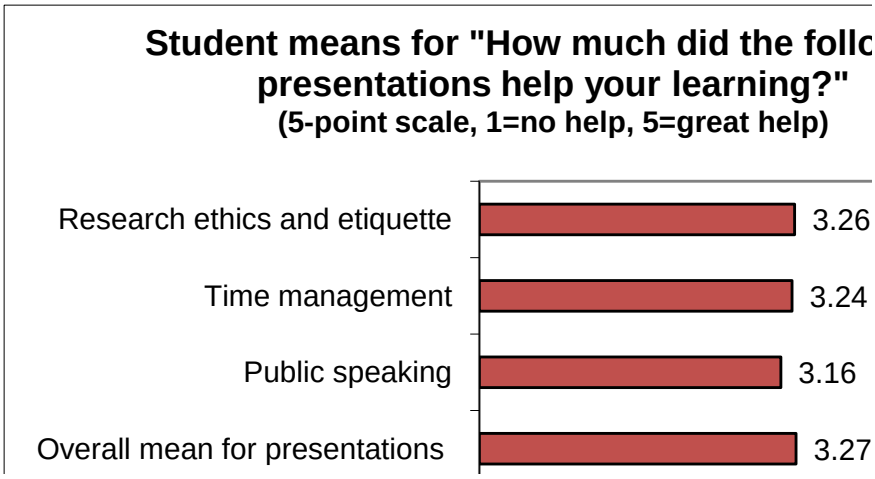
Fig. 20



2. UC50, 70 and 80 Presentations

Overall, students found UC50, 70, and 80 presentations to be somewhat beneficial. The means for all of the presentations fell between “some help” and “much help” (3.0 and 4.0 on a 5-point scale). Students rated the research ethics presentation the highest. Figure 21 displays students means for the UC50, 70, and 80 presentations.

Fig. 21

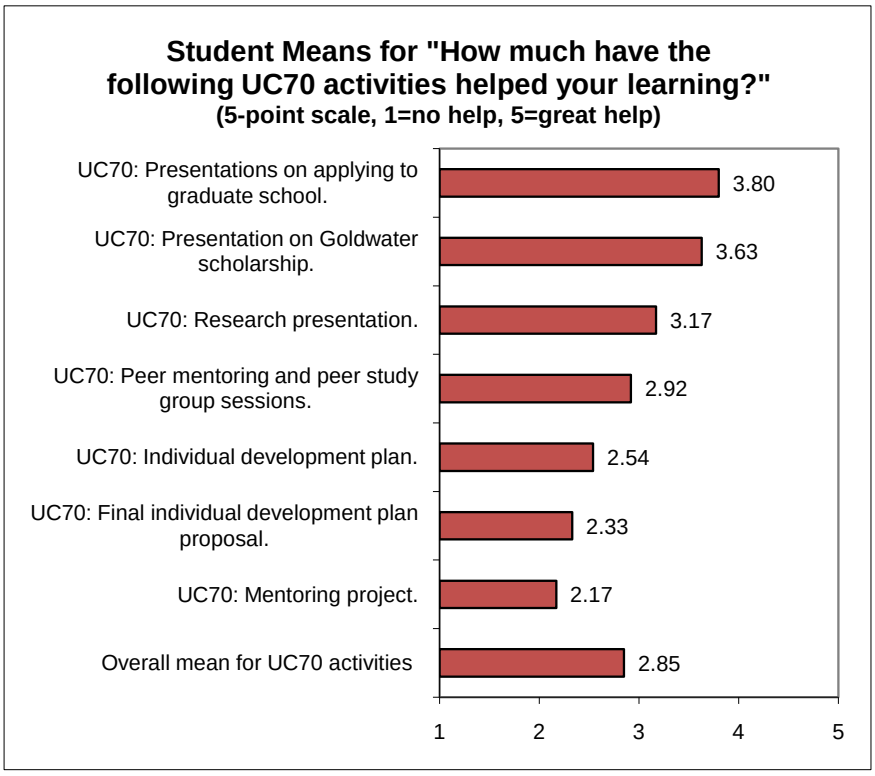


3. UC70 activities

As their undergraduate careers progressed, students began to perceive less value in some of the UC activities. Overall, students rated UC70 activities slightly lower than UC50 activities,

suggesting that students found the academic and social support to be more helpful in the beginning of their college careers and they may have felt less of a need for such support as they advanced in their undergraduate careers. As students became comfortable with research, coursework, and campus life, they found presentations on planning for the future to be the more helpful than activities focused on planning, organization, or learning strategies. Students rated the presentations on applying to graduate school and the Goldwater scholarship as the most beneficial (60% and 62%, respectively, found these presentations to be “much help” or “great help”). Students still found peer mentoring and the individual development plan to be somewhat helpful, though less helpful than at the beginning of their college experience. For instance, 31% of UC70 students found peer mentoring to be “much help” or “great help” to their learning, while 48% of UC50 students did. Students gave the mentoring project the lowest rating of all UC70 activities. Overall, students found workshop activities that were focused on their future educational goals and financing to be the UC70 activities that best supported their learning. Figure 22 below displays student means for all UC70 survey items.

Fig. 22

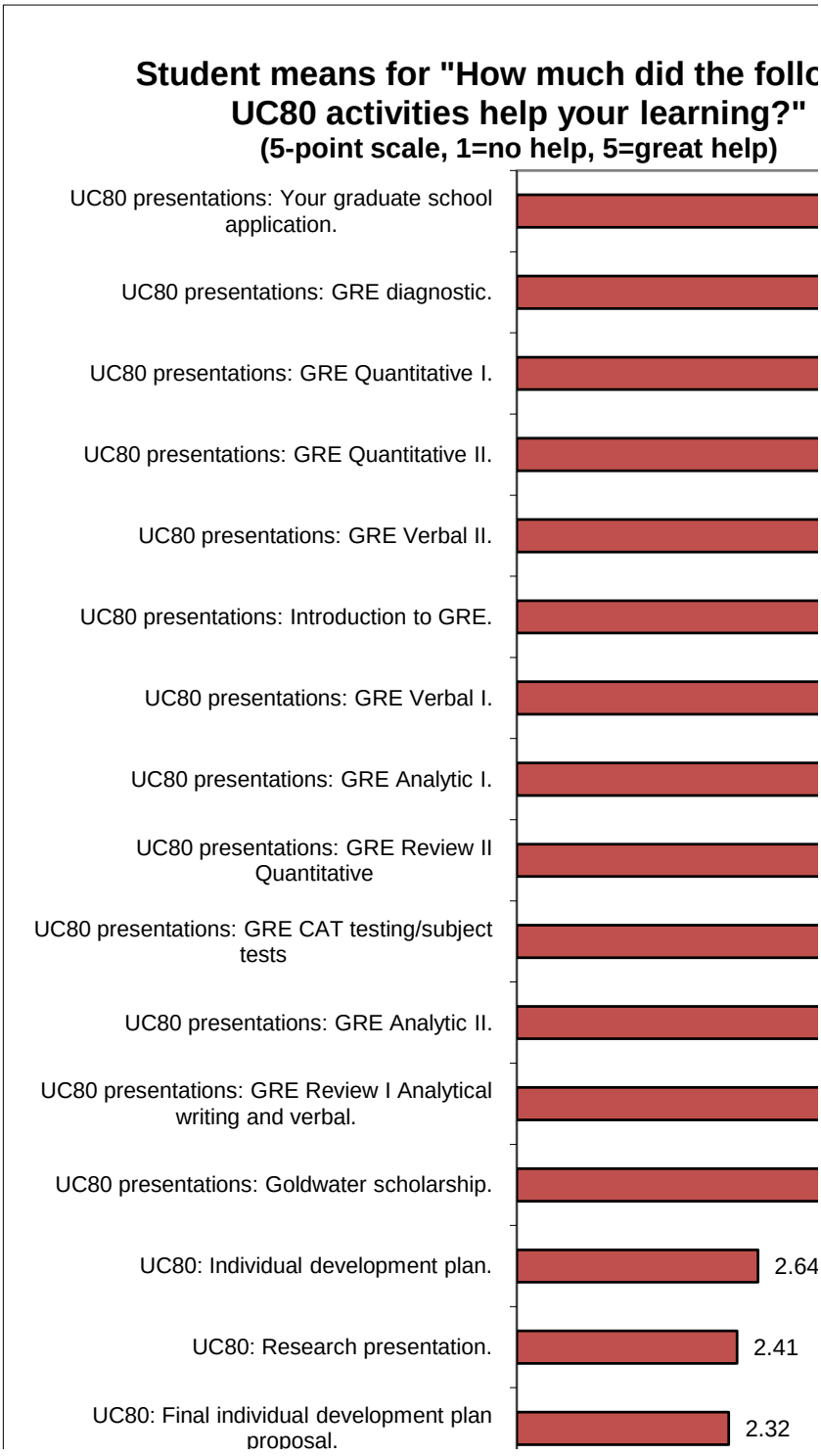


4. UC80 activities

Like UC70 students, UC80 students rated GRE and graduate school activities seminars highly. On the other hand, students' ratings of peer mentoring and peer study group sessions continued to erode as UC80 students found these activities to be less helpful than their peers in UC70 and UC50.

Students nearing the end of the college careers found information about their future educational plans, such as GRE and graduate school workshops, to be the most valuable UC80 activities. In fact, students rated the "graduate school application session" very highly with almost all students (92%) rating it as "much help" or "great help." Students also found the GRE diagnostic and Quantitative I and II sessions to be very helpful. For example, 79% of students rated the GRE diagnostic session as "much help" or "great help," while 73% of students rated both the Quantitative I and II sessions as "much help" or "great help." Therefore, while students found the academic and social support provided through individual development plans and peer mentoring to be not very helpful as their college careers progressed, they found information and support related to their future educational goals to be very beneficial. Figure 23 below displays student means for UC80 activities.

Fig. 23



B. Achieving program objectives

LA-STEM faculty research advisors were asked to rate whether they thought the program was meeting its objectives in key areas. For the most part, faculty reported that LA-STEM is meeting

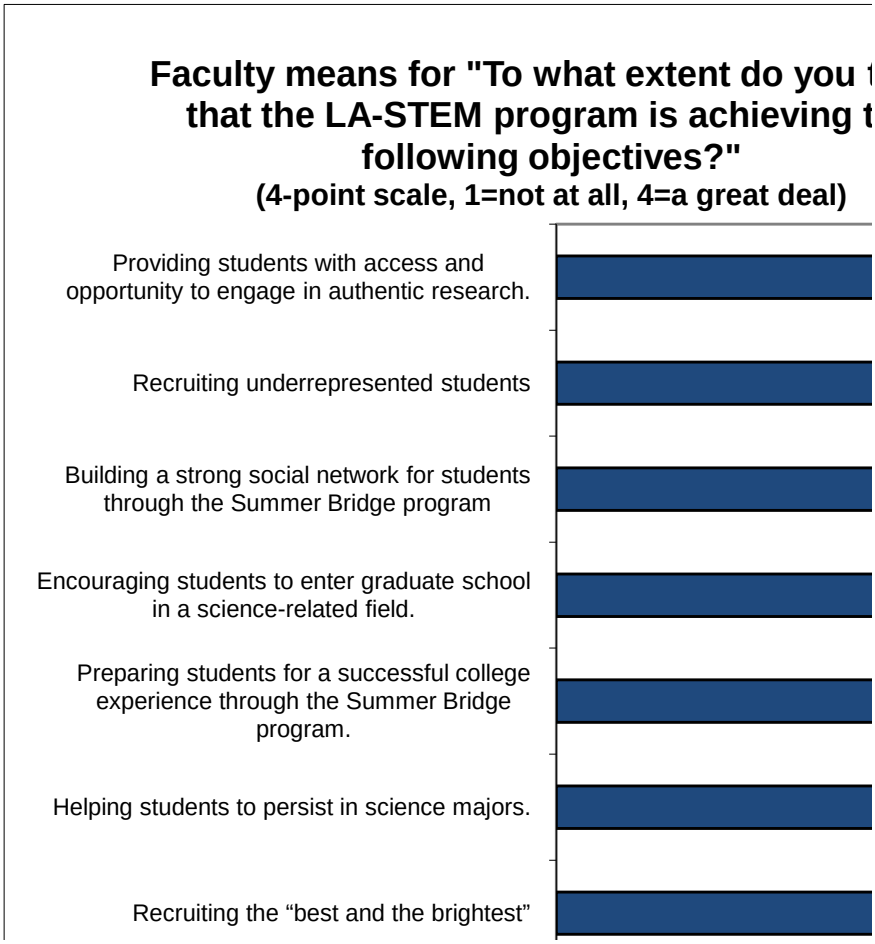
its objectives, although some faculty demonstrated greater awareness of some program areas than others. Students did not rate these items.

Most faculty members (80%) felt that LA-STEM is meeting its objective of recruiting underrepresented students a “good amount” or “a great deal,” and 13% of faculty professed that they did not know about this area. Faculty had less awareness of whether LA-STEM is recruiting the “best and brightest” students with almost one-fifth of faculty reporting that they did not have knowledge of this aspect of the program. However, 58% of faculty felt that LA-STEM was meeting its objective of recruiting the “best and the brightest” either “a good amount” or “a great deal.”

Some faculty research advisors were also unaware of the outcomes of the Summer Bridge program. Over half of faculty (61%) felt that LA-STEM is meeting its objective of preparing students for college life through the summer bridge, but almost a quarter of faculty (23%) did not know the extent to which LA-STEM is meetings it objectives for the Summer Bridge experience. Almost three-quarters of faculty (71%) felt that the Summer Bridge program helped to build a strong social network for students, but 19% of faculty did not know about this area.

Almost all faculty research advisors (90%) agreed that students have access to authentic research experiences. While most research advisors agreed that LA-STEM is meeting its program objectives on many fronts, a minority of advisors (15-25%, depending on the item) were largely unaware of the program objectives. The means for these items are shown in figure 24 below.

Fig. 24



C. Impact of LA-STEM program activities on student success

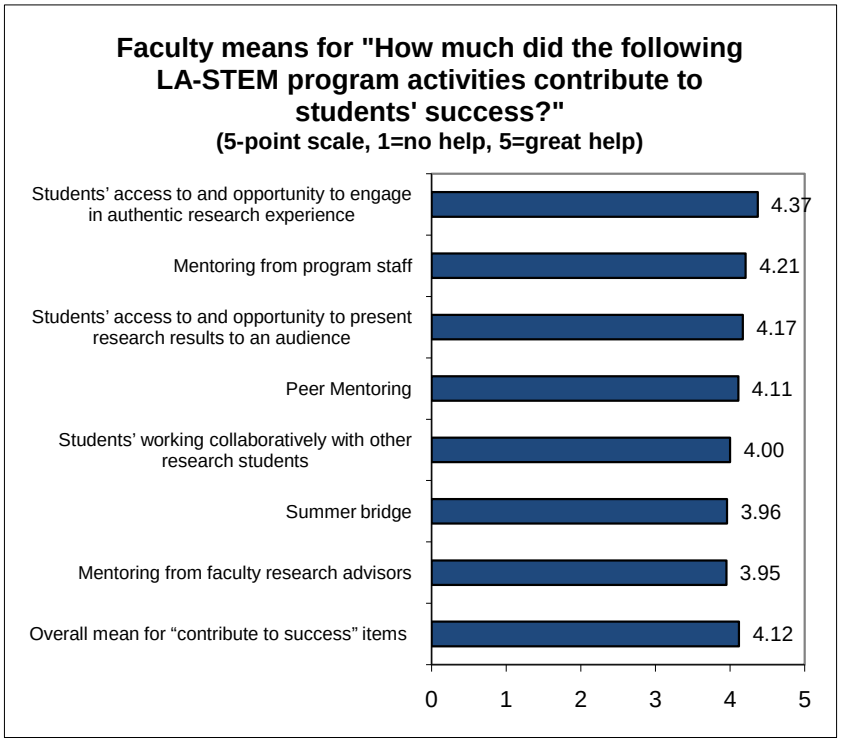
Faculty and students were both asked to rate the extent to which certain LA-STEM program elements contributed to students’ success. We will discuss student and faculty responses separately, because students and faculty survey items differed slightly. We will discuss faculty responses, and then student responses.

As with other comprehensive programs designed to support underrepresented groups in STEM disciplines, many different aspects of the LA-STEM program influenced student learning and success. Faculty rated “students’ access to and opportunity to engage in authentic research” as the program element that contributed the most to student learning; 84% of faculty reported that participation in research contributed to students’ success either “a good amount” or “a great deal.” Faculty also rated students’ opportunity to present research results to an audience very highly, though this item was not on the student scale. Seventy-seven percent of faculty rated students’ opportunity to present their research as contributing to students’ success either “a good amount” or “a great deal. Therefore, most faculty research advisors believed that the opportunity to present is an important learning experience for students and an integral element of the research experience. Faculty also rated students’ opportunity to engage in collaborative work as an important program element; this item was also not rated by students. Seventy-one percent of

faculty reported that collaborative work contributed to students' success "a good amount" or "a great deal."

Faculty research advisors clearly believed that student access to and opportunity to engage in research is an essential element of the LA-STEM program; however, faculty had less knowledge of other program activities with which they are not directly involved. For example, 61% of faculty believed that Summer Bridge contributed to students' success, but 16% reported that they "do not know." Likewise, 47% of faculty reported that mentoring from program staff contributes to students' success, although 37% professed that they "do not know."

Fig. 25



In addition, faculty responded to an open-ended question, "What elements of the LA-STEM program do you believe are important to its achieving success?" Fifteen faculty members responded to the question. The majority of responses cited the opportunity to do research as the most important element of the LA-STEM program. Other responses referred to faculty mentoring of students, Summer Bridge, the community fostered by the LA-STEM program, and the selection process for LA-STEM students.

Eight faculty research advisors (53%) commented that the opportunity for research was a critical element in the success of the LA-STEM program. Faculty also emphasized the importance of recruiting students into research early in their undergraduate careers.

Early involvement of the best and most promising students into actual research.

> *Providing the students with the ability to perform and learn from state-of-the-art research.*
>
> *Getting students into a research environment early in their career.*

Three faculty research advisors (20%) mentioned that faculty mentoring and the opportunity to form collaborative, working relationships between students and faculty was an important asset of the LA-STEM program.

> *I've only really participated in undergraduate research mentoring, but believe this to be an important part of the program.*

Two faculty research advisors (13%) commented that Summer Bridge was an important element of the program's success. In addition, two advisors also mentioned that the sense of community fostered by the program contributed to its success.

> *The students being able to interact with each other during Summer Bridge and to continue their connections together throughout college (that support network is critically important).*

Two faculty research advisors (13%) noted the selection process was critical in selecting students with the traits and attitudes necessary to do research.

> *Continue to recruit students who are inquisitive!*

One faculty research advisor also commented that the program's diversity contributes to its success.

Students also rated the impact of LA-STEM program elements on their success. Financial support was the most helpful aspect of the program for students' success. They rated "summer research" and "Summer Bridge" as the next most helpful program elements. Both of these summer experiences offered more in-depth opportunities for student learning and social support than are typically available during the academic year.

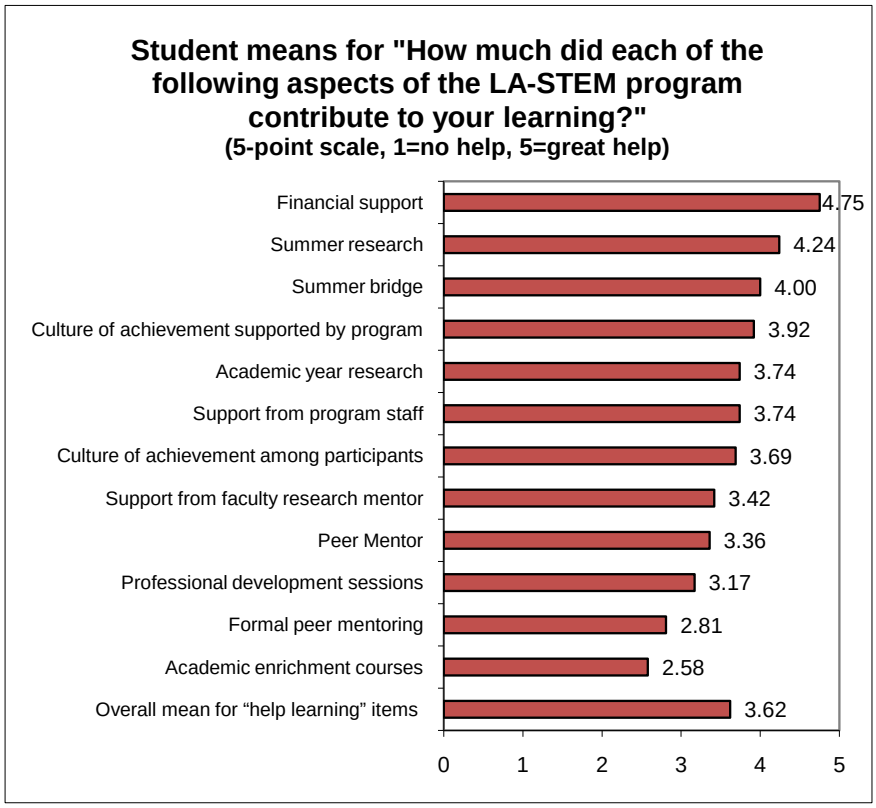
Students also rated "support from program staff," "the culture of achievement among participants," and "the culture of achievement fostered by the program" as quite helpful to their learning. Therefore, students believed that the financial support, social support, and research opportunities provided by the program contributed the most to their learning. The culture of achievement fostered through the LA-STEM program also set high expectations for student success.

Interestingly, peer mentoring was rated higher by faculty than students; this outcome may be a result of the declining importance that students placed on peer mentoring activities as they advanced in their college careers. Exactly half of students reported that peer mentoring had been "much help" or "great help" to their learning. In addition, faculty also placed greater importance on mentoring from faculty research advisors and program staff than students; though students

still rated these items highly. Students rated academic enrichment courses the lowest, yet over half of students (53%) still found these to be “much help” or “great help.”

Overall, students reported that financial support and summer learning activities were the most influential aspects of the LA-STEM program on their learning. In fact, 100% of students rated the financial support offered by the LA-STEM program as “much help” or “great help” to their learning. Students also rated summer research and Summer Bridge highly (72% of students rated the activities as “much help” or "great help”). Student means for these items are detailed in figure 26.

Fig. 26



D. Students’ personal gains from LA-STEM participation

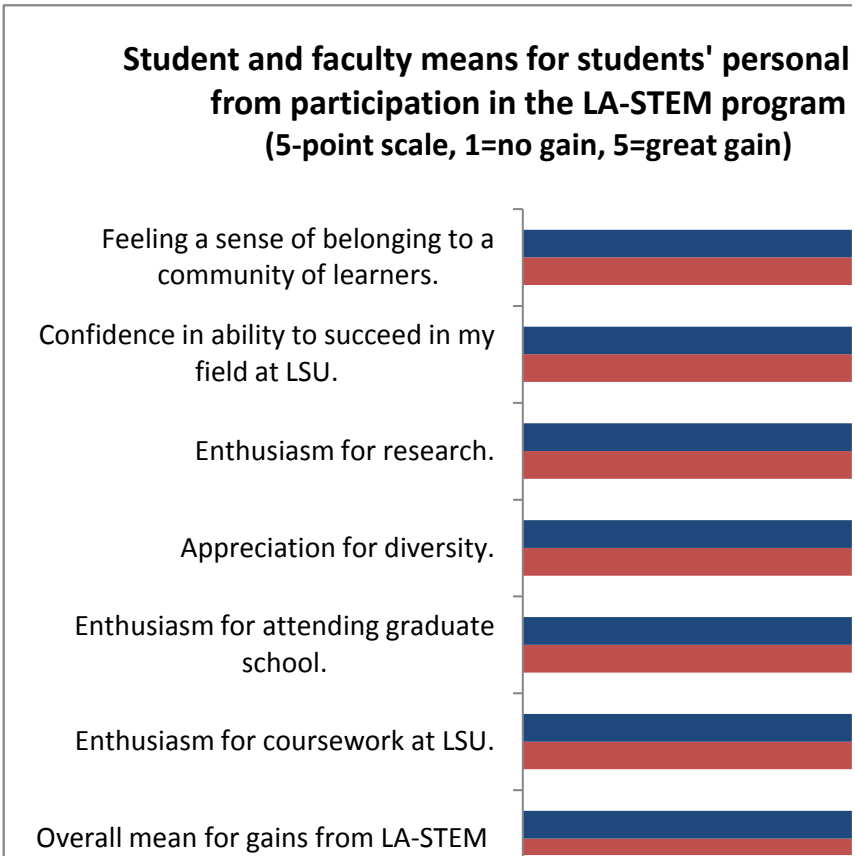
Students and faculty both rated the extent to which students received personal gains in confidence and enthusiasm from participation in the LA-STEM program. According to both faculty and students, participation in LA-STEM yielded many personal benefits for students. Students rated all “personal gains” items relatively highly. Students made the greatest gains in “belonging to a community of learners” and “confidence in their ability to succeed at LSU.” However, students also cited strong gains in enthusiasm for research, enthusiasm for attending graduate school, and appreciation for diversity. Gains in enthusiasm are particularly important

for minority students because their persistence in their majors is more closely linked to their enthusiasm for their discipline than their grades (Grandy ,1998).

In contrast, faculty perceived that students made the greatest gains in “enthusiasm for research,” perhaps because they were able to directly witness this aspect of the program and have the most awareness of students’ orientation toward research. Faculty also rated program elements aimed at students’ social integration to campus and community life quite highly, such as feeling a sense of community within the program and appreciation for diversity. In addition, faculty ratings of students’ gains were higher than students’ self-ratings for all personal gains items.

Students rated enthusiasm for coursework almost a half-point lower than other personal gains from LA-STEM, indicating that their enthusiasm for out-of-class experiences and future goals may not have translated directly to coursework. Likewise, faculty also rated gains in enthusiasm for coursework more than a half-point lower than enthusiasm for research. Nevertheless, over half of students still cited that they received “good” or “great” gains in enthusiasm for coursework. Overall, both faculty and students agreed that students’ participation in LA-STEM yielded many personal benefits for students and facilitated their social and academic integration into college life. Student and faculty means for these items are detailed in figure 27.

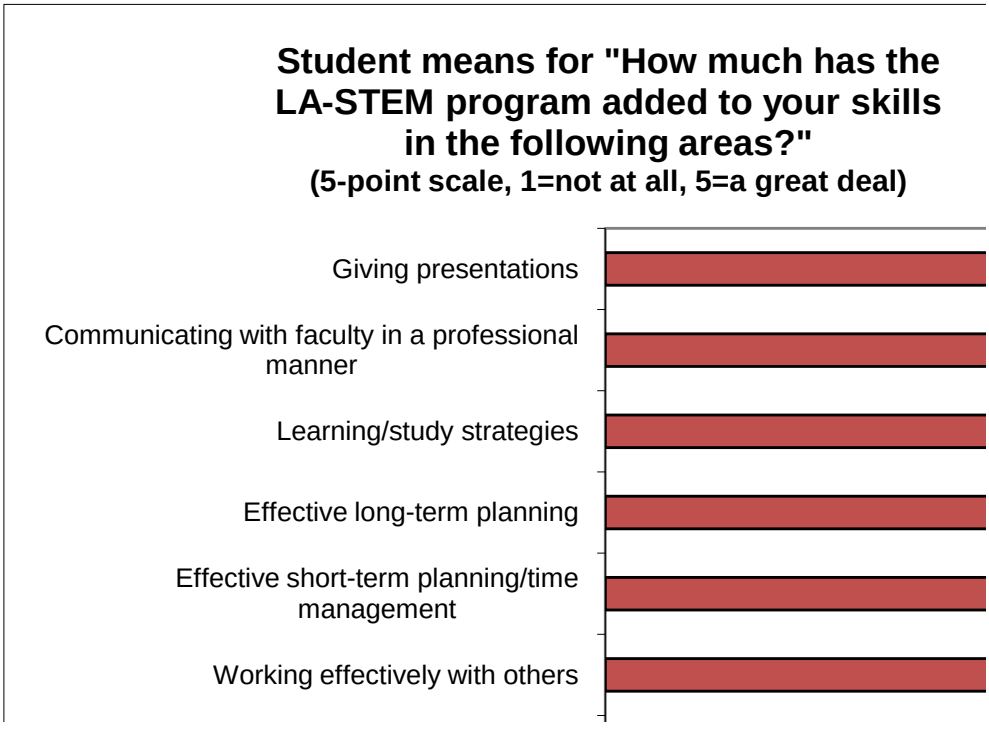
Fig. 27



E. Skills gained from LA-STEM participation

Students assessed the skills they gained from participation in the LA-STEM program. Faculty did not rate students' gains on these items. Students' ratings indicated that they gained many skills from participation in LA-STEM. Students rated most items between "some gain" and "good" gain, suggesting that, though their skills had grown in these areas, they still viewed themselves as learners and had not mastered these skills yet. Students rated most of their gains in skills relatively equally, indicating that the program as a whole was valuable for students and students did not differentiate between the different skills gained from participation. Students cited the strongest gains in giving presentations and communicating with faculty in a professional manner, echoing the communications skills they gained from their research experience. Almost three-quarters of students (72%) reported that they gained a "good amount" or "great deal" of skill in giving presentations. Students also cited strong gains in learning/study strategies, and effective long-term planning. Almost two-thirds of students (62% for each) reported that they made a "good amount" or a "great deal" of gains in learning/study strategies and long-term planning. Therefore, while students rated academic enrichment courses lower than other aspects of the LA-STEM program, those courses seemed to have moderately improved students' skills in certain areas critical to their academic success.

Figure 28.



F. Educational aspirations

The LA-STEM Research Scholars program had an impact on students' career and educational aspirations, particularly their intentions to attend graduate school. This finding is in contrast to our previous research that demonstrated that research simply clarified or confirmed students' pre-existing interest in graduate school (Hunter et al., 2007; Seymour et al., 2004). However, research on minority UR students has demonstrated that participation in UR or a comprehensive support program like LA-STEM can increase the likelihood that they will pursue graduate degrees (Clewell et al., 2005; Maton et al., 2000). Although some students originally intended to receive a graduate degree in a STEM field prior to college enrollment, the majority of students reported that the LA-STEM program increased the likelihood that they would pursue a Ph.D. degree. In fact, 90% of students said that their participation in LA-STEM made them "somewhat more likely" or "much more likely" to pursue a Ph.D. degree. Almost half of students reported that they were more likely to enroll in an M.D./Ph.D. program because of their participation in LA-STEM. A few students also indicated that they were more likely to enroll in a medical degree program or professional degree program.

Table 5. Impact of participation in the LA-STEM program on the likelihood of students' enrollment in graduate school

Item (Items rated on a **4-point scale,** 1=much less likely, 4=much more likely)	Mean	% of "somewhat more likely" and "much more likely
Enroll in a graduate program leading to a Ph.D. degree	3.14	90%
Enroll in M.D./Ph.D. program	3.06	41%
Enroll in medical degree program	3.33	34%
Enroll in a professional degree program	3.00	17%

Some students had pre-existing career and educational goals upon entering the LA-STEM program. For example, 40% of students reported that they already planned to go to graduate school in a STEM field prior to college. However, 13% of students were introduced to the idea of graduate school through LA-STEM. A significant minority (27%) of students already planned to go to medical school prior to college; however, LA-STEM did not introduce the idea of medical school to any students. Therefore, the LA-STEM program seems to be meeting its goal of promoting the Ph.D. rather than M.D. as a terminal degree for students.

Table 6. Students' educational aspirations prior to participation in the LA-STEM program

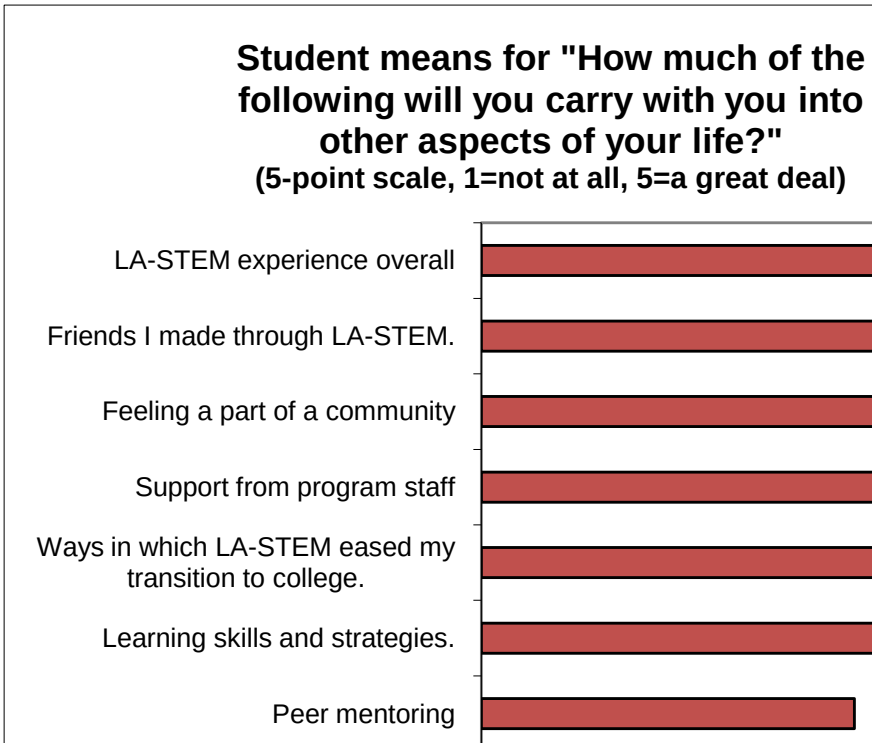
Item	# of students	Percentage
I planned to go to graduate school in a STEM field prior to college and summer bridge	12	40%
Participating in LA-STEM introduced me to the idea of graduate school in a STEM field	4	13%
I planned to get a medical degree prior to college and summer bridge	8	27%
LA-STEM introduced me to the idea of going to graduate school to get a medical degree.	0	0%
I planned to get a professional degree prior to college and summer bridge	3	10%
LA-STEM introduced me to the idea of a professional degree.	2	7%
Other degree planned/introduced through participation in LA-STEM. **(one student responded teaching and another student responded M.D./Ph.D)**	2	7%

G. Transfer of gains from LA-STEM to other aspects of students' lives

Many LA-STEM students reported that their experiences with the program will transfer into other aspects of their lives. Students were asked to what extent they will "remember and carry with them" different elements of the LA-STEM program. Students had the strongest feelings about the program in general, as this was the highest rated item. Almost all students (85%) responded that they will remember the LA-STEM experience overall "a lot" or "a great deal." Therefore, the LA-STEM experience was more important to students in its entirety than were any of its components.

In keeping with students' responses on other sections of this survey, it appeared difficult for students to tease apart the particular elements of the program or research experience that were most helpful; however, it is clear that they will remember the program as a whole. Nevertheless, students also cited friends (85% of students), feeling part of a community (85%), and support from program staff (77%) as elements of LA-STEM that they will carry with them. Indeed, all of these elements aim to increase students' social integration into campus life and appear to have been successful in doing so. To a slightly lesser degree, students reported that their academic gains from LA-STEM, such as learning skills and strategies (62%), would transfer into other aspects of lives. In keeping with the decreasing importance of peer mentoring to students as they made their way through college, students rated peer mentoring lower than other program elements. A little over half of students (54%) responded that they would carry peer mentoring into other aspects of their lives. The means for these items are displayed in figure 29.

Fig. 29


Student means for "How much of the following will you carry with you into other aspects of your life?"
(5-point scale, 1=not at all, 5=a great deal)
LA-STEM experience overall
Friends I made through LA-STEM.
Feeling a part of a community
Support from program staff
Ways in which LA-STEM eased my transition to college.
Learning skills and strategies.
Peer mentoring

H. Students' "best part" of the LA-STEM program

In an open-ended question, students were asked about the "best part" of the LA-STEM program. Students' responses mentioned the community created through the program, access to opportunities, research, mentoring, financial support, and the overall learning experience. Twenty-two students responded to this question.

By far, the strongest response from students about the "best part" of the program was the sense of community fostered by the LA-STEM program. Fifteen students (68%) commented that the community of peers and scholars created through LA-STEM was the best aspect of the program. While a few students mentioned the friends that they had made through LA-STEM, most students' responses focused on the learning community fostered by LA-STEM. Students appreciated the formation of a community of scholarly peers with a similar work ethic and academic interests.

> *The diverse community of students with common goals.*
>
> *LA-STEM students are all hard workers who share a common interest in the sciences.*
>
> *It is a close-knit community of scientists.*

Four students (18%) mentioned the access to opportunities offered through the LA-STEM program. Unfortunately, these answers were not specific as to the exact opportunities offered through LA-STEM, but instead referred to generic "opportunities" and "resources."

> *I have met some great people through LA-STEM, and I was given so many great opportunities and resources through this program. I am so thankful.*

Three students (14%) responded that their participation in research was the best part of the LA-STEM program. These statements were also generic and did not provide much insight into how research benefited students, although those issues were addressed by other parts of the survey.

> *Great introduction to research.*

Three students (14%) commented that mentoring and social support were the best part of LA-STEM.

> *There is always a support system to approach in times of trouble.*

In addition, two students mentioned financial aid, two students mentioned the overall learning experience provided by LA-STEM, and one student each mentioned career clarification, gains in maturity, and help with the transition to college as the best parts of the LA-STEM program.

In sum, though students valued the social connections and sense of community fostered through the LA-STEM program as the "best part" of the program. Students also valued their research experiences and their access to opportunities and resources through the program.

I. Students' "worst part" of LA-STEM program

Students were also asked to address the "worst part" of the LA-STEM program in an open-ended question. Twenty students responded to this question. The overwhelming majority of responses referred to the UC courses or assignments within the UC courses as the "worst part" of LA-STEM. Ten students (50%) reported that UC assignments were the "worst part" of the program. More advanced students, such as juniors and seniors especially, felt that assignments were repetitive of what they had done in previous years, were too time-consuming given all their other obligations, and did not see the value of engaging in the same types of assignments each year. These sentiments are echoed in their responses to the survey items about the UC activities in an earlier section of the report. Students commented that the "worst part" of LA-STEM was:

> *The repetitive assignments.*
>
> *The assignments can be cumbersome as I approach graduation.*
>
> *Journal assignments, they seem pointless after four years of completing them.*

Four students (20%) also mentioned the UC courses as the "worst part" of LA-STEM. Again, these concerns were similar to those that students had with UC assignments and primarily originated from more advanced students who found less value and relevance in the UC courses after three or four years of participation.

> *As a senior, the continued required class activities that have no relevance to me are the worst part of LA-STEM.*

Two students (10%) reported that the program was disorganized.

> *I feel that things aren't planned as well as they should be.*

One student also reported that LA-STEM did not have enough staff. In addition, one student commented that s/he "felt ignored" one time when s/he needed help from program staff, and another student commented that s/he felt "left out" because s/he was not a minority.

J. Advice for improving the LA-STEM program

a) Students' advice for improving the LA-STEM program

Students were also asked what advice they would offer for improving the LA-STEM program. Eighteen students responded to this question. In line with students' responses on other sections of the survey, the majority of students' responses offered advice for changing the UC courses and required assignments. A few students also advised the program to hire more staff and institute more guidelines and greater accountability for students. On the other hand, a few students requested less structure for the program.

Nine students (50%) advised the program to abolish or adapt the UC courses and required assignments.

> *As you increase in UC level, you should be allowed to attend class less often.*
>
> *I would suggest less work for graduating seniors.*
>
> *To give less wordy assignments and more presentations on Grad School, different areas of study, guest speakers.*

Three students (17%) called for greater accountability for students, clear guidelines about what is expected of students, and regular assessment of student progress in the program.

> *Making more strict guidelines to go by so that everyone knows where they stand in the program and making sure that everyone is on the same page.*

In contrast, two students (11%) requested less structure to the program.

> *I think there should be more importance placed on accomplishing one's goals than on following a strict routine.*
>
> *Less structure and more flexibility. There should not be cut and dry rules but a case by case basis.*

Two students (11%) also advised that the program should hire more staff to manage the program and support students. One of these students also recommended that the program needed more office space.

> *Get more help / new office for the managers. They do such a great job, and soon they will need their own building.*

Finally, one student requested that the program make more changes, but did not specify what those changes should be, and one student requested that the program make fewer changes.

b) Faculty research advisors' advice for improving the LA-STEM program

Faculty research advisors were also asked to provide advice for the improvement of the LA-STEM program. Ten advisors responded to this question. There was not a clear consensus among faculty about advice for improving the program; however, faculty commented that the program should provide students with clear guidelines for selecting research labs, and the program should better inform faculty about the program's expectations of them. In addition, a few research advisors also mentioned that students should be more accountable. A single research advisor also mentioned that the program could be more organized and another research advisor recommended that faculty contributions to the LA-STEM program should be noted and rewarded.

Three faculty research advisors (33%) recommended that the program inform faculty about the program's mission and its expectations of faculty mentors.

> *Provide more information to mentors on what is expected.*
>
> *Better inform faculty of what the program is about and how they can help. It seems that only a few faculty assist in the program administration and this leads to some problems. Faculty orientation should include a course on undergraduate research.*

Three advisors (33%) also suggested that the program could provide clear guidelines for student selection of research and provide more ways for faculty to access students in the program.

> *Provide more ways to meet the potential students in this program, so that both mentors and students can know each other.*
>
> *A student came to me and stated interest in my research. Then he disappeared and did not return email inquiry. LA-STEM may want to provide guidance for the proper steps for them to follow, so that neither the students, nor the professors waste their time unnecessarily.*

Two advisors (20%) mentioned that students should be held accountable for their participation in research activities and professional behavior while doing so.

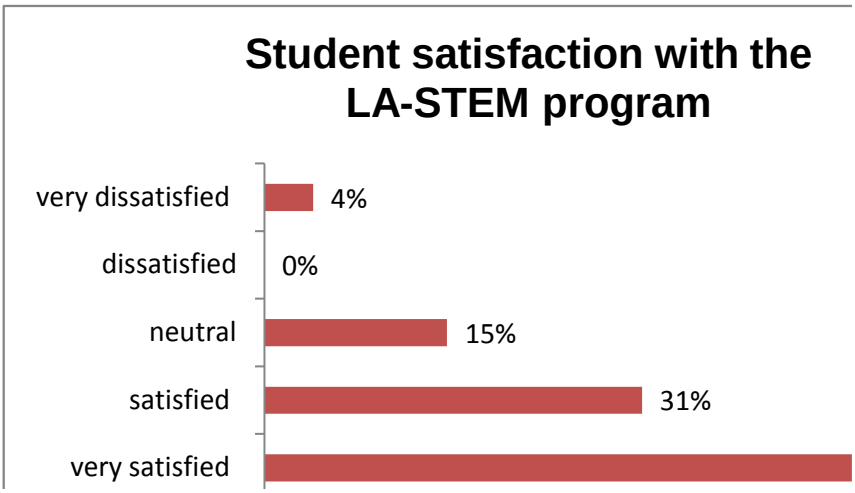
> *There needs to be some accountability to ensure that LA-STEM students actually participate in research activities beyond the group/mentoring activities.*
>
> *Personally, I feel that the LA-STEM program could emphasize professional behavior a bit more. Professionalism, ethics, maturity are integral aspects of science.*

There was no clear consensus among faculty, however, about areas for improvement of the LA-STEM program. In conclusion, faculty suggested that the LA-STEM program provide them with more information about the program and its expectations of faculty mentors, and provide both faculty and students with guidelines for the selection process for undergraduate research.

K. Students' overall satisfaction with the LA-STEM program

Overall, students were highly satisfied with the LA-STEM program. Almost all students (81%) reported that they were "satisfied" or "very satisfied" with the program. Only one student stated that he or she was "very dissatisfied" and no students reported that they were "dissatisfied." A few students felt neutral about the program, but almost all students gave the program a positive rating. In fact, 50% of students reported that they were "very satisfied" with the program. The mean for satisfaction was 4.27 on a 5-point scale.

Fig. 30



V. Conclusion

Many aspects of the LA-STEM Research Scholars program benefited students; in particular, research experiences, the informal sense of community fostered by the program, and the financial support provided from the program were the most helpful to student learning. Research experiences enhanced students' intellectual, personal, and professional development. Students also appreciated belonging to a high-achieving community of learners with similar academic interests. Students highly valued the support they received from program staff. Students also gained confidence in their ability to succeed in science and enthusiasm for science through their participation in the LA-STEM program. On the other hand, students found some of the academic resources offered through LA-STEM to be less valuable as they advanced in their undergraduate careers. In particular, students felt that UC courses, journals, individual development plans, and peer mentoring were less beneficial as they progressed toward graduation. Throughout their undergraduate careers, with the exception of research, students placed higher value on the personal and social aspects of the program, than the academic support elements.

Both students and faculty agreed that research was a beneficial experience for students. Students and faculty ratings of students' gains were remarkably similar in most areas, with the exception of "career clarification" and "thinking and working like a scientist." Faculty perceived that students received greater benefit in confirming or clarifying career and educational goals than did students themselves, yet students rated the intellectual gains of "thinking and working like a scientist" as their strongest gains though faculty rated them lower in this area. Nevertheless, both students and faculty responded that students made strong gains in lower-level research knowledge and skills, such as understanding the scientific research process and data collection methods. Students made weaker gains in higher-order scientific thinking skills, such as interpretation of data and experimental design. Similarly, other studies have also found that students' gains in higher-order thinking skills are more modest (Hunter et al., 2007; Kardash, 2000). Students also gained confidence from their research experience, particularly in their ability to discuss science and to contribute to their field. Finally, students made strong gains in skills, particularly in oral communication skills. Students and faculty both noted that students made great progress in their ability to prepare a poster and to give an oral presentation. Students made stronger gains in oral, rather than written, communication skills, a finding echoed in our prior research (Seymour et al., 2004; Hunter et al., 2007).

Students also rated the authenticity of their research experience. Almost all students appear to have engaged in authentic, "real-world" research that benefited them cognitively, personally, and professionally; however, a minority of students (10-15% of students) did not seem to have access to authentic work and adequate support in the lab. A lack of engagement in authentic research activities and inadequate support in the lab can ultimately diminish students' gains from the research experience (Thiry et al, 2009). In this study, students without adequate mentoring or authenticity in their research experience were less satisfied with the research experience and the LA-STEM program overall than their peers. Nevertheless, the majority of students had access to authentic work and professional scientific communities as evidenced by the large numbers of students who reported gains from engaging in real-world research, and the number of students (over half) who attended or presented their work at professional conferences.

The LA-STEM Research Scholars program also had an impact on students' career and educational aspirations, particularly their intentions to attend graduate school. Although some students (40%) originally intended to receive a graduate degree in a STEM field prior to college enrollment, almost all LA-STEM students (90%) reported that the LA-STEM program increased the likelihood that they would pursue a Ph.D. degree. In contrast, our prior research with affluent, white students has demonstrated that participation in UR simply serves to confirm or clarify pre-existing plans to attend graduate school. Participation in UR and multi-faceted support programs, such as the LA-STEM Research Scholars program, seems to have a more profound impact on the career and educational decisions of minority or first-generation college students (Alexander, Foertsch, & Daffinrud, 1998; Barlow & Villarejo, 2004; Hathaway, Nagda, & Gregerman, 2002).

Besides access to research, the other comprehensive support services offered through the LA-STEM program also benefited students. Although, student and faculty means on many of these survey items fell between 3.0 and 4.0 ("some gain" and "much gain") on a 5-point scale, indicating that there is some room for improvement. In particular, some faculty were not knowledgeable enough about aspects of the LA-STEM program to rate the program's performance in these areas. Some faculty also requested clearer program guidelines and expectations of faculty research advisors. Moreover, students found the academic support services, such as UC courses and assignments, to be less beneficial as they advanced in their undergraduate careers. Students felt that the courses were repetitive and they seemed less relevant to students of junior or senior standing. Though students highly valued the informal sense of community fostered by the program, they did not express the same enthusiasm for formal peer mentoring activities. Students' ratings of their peer mentors also declined as they progressed in their college career and they felt less need for formal peer support. Nevertheless, the program overall clearly had a positive impact on participants and their personal, professional and cognitive growth and development.

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