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COUNCIL ON UNDERGRADUATE RESEARCH

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Student Voices in Undergraduate Research

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Cover Photo:
Left: Samuel Calvin Brown, University of Arkansas-Little Rock, discusses his research on The Bible and William Faulkner's The Sound and the Fury with 2012 Posters on the Hill Committee Chair Mike Castellani. Right: Cat Bradley, University of Central Florida, explains the importance of arts research at the 2012 Posters on the Hill Arts and Humanities Luncheon.

CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

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One can never underestimate what being a mentor can mean.

Reading advance drafts of the student pieces for this issue of the *CUR Quarterly* caused my brain to pull from my memory thoughts and images from my undergraduate years, when I was fortunate to have Dr. Samuel H. Gruber (Sonny) as my undergraduate research mentor. I owe a huge debt of gratitude to this man. I need to thank him for taking a very green, Midwestern born and bred, and non-travelled undergraduate student into his shark research group for three summers.

I will never forget arriving in Miami after my very first airline flight with two massive suitcases and having Sonny and his family make space in their home for me. He introduced me to the global world by introducing me to, and letting me learn from, his internationally diverse team and then taking me on my first international trip to Israel where I got to dive in the Red Sea and learn about doing behavioral research at a field station. I learned so much from Sonny—what a tide cycle is (remember, Midwestern born and bred), the importance of planning and having back-up plans, and how to plan for the unexpected. I learned how to keep a field notebook, how to extract the stomach contents of baby lemon sharks, and how to handle a 10-foot lemon shark on a long line. I also learned how expensive and protocol-intense working with vertebrate animals was; I switched to invertebrate animals as I earned my PhD and have continued my work with them throughout my career.

When Sonny took me on as an undergraduate researcher, he probably didn't know it was a lifetime commitment. We kept in touch with Christmas cards and occasional phone calls as I worked on my PhD. As I became a faculty member, and now as an administrator, Sonny has opened up opportunities at the Bimini Biological Field Station for my own undergraduate students. Countless students have had the opportunity to take a "Field Studies in Shark Biology" course thanks to Sonny's willingness to continue our relationship. Little do they know that when I steal away with a few of his crew to check long lines it takes me back to the carefree days of my twenties. I relish the time with Sonny as he continues to impart his wisdom, humor, and insight.

As I write this column and think about the role Sonny has played in my life, I wonder if we intentionally think about the impact we will have on the undergraduate researchers we mentor. Descriptive studies suggest that it is the student-faculty interaction that plays a key role in enhancing student confidence (Blackburn et al. 1981; Jacobi 1991; Koch and Johnson 2000), student retention, and academic growth (Pascarella and Terenzini 1991, Astin 1993; Tinto 1998). The research on undergraduate researchers—and the pieces written by students in this *CURQ* demonstrate—that the most important things we can do as mentors is to help students find their voices, develop their confidence in framing questions, and let them see us as we struggle to answer questions in our research programs.

One cannot deny that the quality of mentoring that students receive on research projects varies considerably, depending on the students' academic disciplines, the environment they work in, and the characteristics of the individual mentor. The research experience of a student working in relative isolation will be different than the experience of a student embedded within an active laboratory group. Mathematicians and humanists usually do not have laboratories whereas chemists and biologists sometimes have undergraduate students work on projects as part of a group. Students mentored by a faculty member were more satisfied with their research experience than those mentored by someone other than a faculty member (Shellito et al. 2001; Cox and Androit 2009), but does that mean they learned more? Exactly which components and to what extent do the different components of the research environment bring about intellectual growth? Is it the process of answering a unique question or the mentoring that the students receive as they undertake their projects? This issue was best stated by Malachowski (1997): "It is as if two separate but related conversations are occurring concurrently; one pertaining to the research project itself, and one about the student's life and personal development."

Given the potential impact we mentors have, I think about the training (or lack thereof) we provide graduate students, post-doctoral researchers, and faculty members regarding mentoring undergraduate research projects. It is as if we believe that with enough trial and error individuals will learn how to be good mentors. CUR's publications and institutes can help us be better mentors, but is there something more systematic CUR might do to help us be the best mentors we can be?

Mary Crowe
Associate Provost of Experiential Education
Florida Southern College
CUR President

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Undergraduate Research Highlights

From CUR's Executive Officer

3 18 23 34 105 57. Depending on your perspective, this series might be the answers to a mathematics word problem or a winning Powerball combination. As you might guess, however, the numbers represent statistics associated with the Spring 2013 *CUR Quarterly* issue, which is both a ground-breaking and record-breaking issue for CUR. Ground-breaking as it represents the first time CUR has devoted a themed issue to student-authored articles. Record-breaking as the breadth and depth of the response to the call for articles exceeded all previous *CUR Quarterly* submission records.

The Spring 2013 issue is international, with academic institutions from three countries represented—the U.S., Canada, and Chile. Students from eighteen academic institutions contributed articles or vignettes in 23 separate manuscripts, authored by 34 students. These authors' home Institutions range from small private colleges to mid-size comprehensives to large public research universities. The topics these authors address with verve and (often) trenchant humor explore dimensions of the faculty-student mentoring experience (note: CUR President Mary Crowe's column in this issue provides a multi-faceted view of the mentoring experience, including observations of her own experiences as an undergraduate researcher), document the processes by which students develop as scholars, and provide insights to best practices for facilitation of the undergraduate research experience. The 23 articles were selected from 105 manuscript proposals, the largest response, by far, to any previous solicitation of articles for a special issue of *CUR Quarterly*.

A year and a half ago, when the *CUR Quarterly* editors proposed an issue focusing on student voices in undergraduate research, the idea was framed as a visionary "what if?" The response by the undergraduate researcher community was by no means assured. What if few articles were submitted? What if the voices the *CUR Quarterly* drew to the issue were not broadly representative of the diverse constituencies that CUR serves? Not only were these fears allayed, but expectations also were thoroughly exceeded by the response.

Oh, and the 57? It's not a statistic directly related to the Spring 2013 *CUR Quarterly* issue, but it is a number that links to the growing visibility and prominence of undergraduate research, and one that illustrates its critical importance to the professional aspirations of a broad segment of the undergraduate student population. The Association of American Medical Colleges (AAMC) annually surveys attributes of first-year medical students, including aspects of their pre-medical preparation. In the latest year of statistics provided on the AAMC website (2011), more than 57 percent of first-year medical students indicated that their pre-medical preparation included a research apprenticeship; more than 75 percent expected to conduct research while in medical school (https.//www.aamc.org/data/msg). So there is a clear relationship between undergraduate research and our collective future health and well-being!

This spring, there is another number of importance to CUR, one that illustrates its healthy growth as an organization: 35. For 2013 marks the 35th year of CUR's existence. From its beginnings in 1978 as a group of ten chemistry teacher-scholars, CUR has evolved into a thriving organization of more than 650 institutional members and more than 8,000 individual members. Most of CUR's current members are faculty members and administrators at colleges and universities with strong undergraduate research programs, much like those described in the Spring 2013 issue. At the time of CUR's inception in 1978, some of these faculty members were undergraduates participating in their first research experience, the one that would shape their professional lives and ignite their passion for their discipline. Now, 35 years later, as seasoned professionals, they promote the practice and culture of undergraduate research through mentorship of students similar to those whose articles are published in this issue. We can predict that the cycle will continue: Today's undergraduate researchers become tomorrow's mentors.

So this year, we have much to celebrate. Congratulations to all of the authors in the Spring 2013 issue. Your articles and vignettes will inform and guide the future development of undergraduate research. For those students presenting at the National Conference on Undergraduate Research, April 11-13, at the University of Wisconsin, La Crosse, congratulations on taking the important further step of disseminating your research!

Elizabeth Ambos
Executive Officer

From the CUR Issue Editor

Student Voices in Undergraduate Research

We all know from our experiences mentoring undergraduate researchers that students can become pretty passionate about the opportunities that UR presents. Even so, we were a bit overwhelmed by the response when we opened this issue of the *CUR Quarterly* to student authors. We invited them to tell the story of undergraduate research from their perspective. More than 100 proposals for articles were submitted, and it was a daunting task to sort through them all and make decisions about which articles to include. In the end, it was our desire to include as many student voices as we could, so this issue is a bit different than most.

A good percentage of the proposals we received were in the form of "tips," sometimes the tips were offered to fellow undergraduates, sometimes to faculty mentors, sometimes to administrators. We also had proposals from students telling a story from a particular point of view—that of a first-generation college student, a non-traditional student, a student conducting research while studying abroad. And we received proposals from students at different points in their research experience—offering their perspectives on how to get involved in the first place, how to keep track of the many details of research, how to present the results of research. We also received proposals from students from different disciplines—making the point that UR happens in all disciplines (not just the sciences).

Justin Whitaker from the University of Ottawa writes with passion about the many exciting opportunities available to undergraduates when they choose to participate in research. Justin began his research career while still in high school, and he has pursued a variety of opportunities since then, including research abroad. This has given him a perspective about which elements of the research process are common, what strategies can work for students in a wide variety of settings, and what it feels like to contribute to the academic community.

A group of students from the University of Central Florida—Mario Pita, Christopher Ramirez, Nathanaelle Joacin, Sarah Prentice and Christy Clarke—address their article to faculty members who mentor undergraduate researchers. These students put their heads, and their experiences, together to recommend several ways that research mentors can support, encourage, and challenge students, empowering them to do excellent work and also inspiring other undergraduates to plunge into the research enterprise. Also from the University of Central Florida, another group of students—Linh Anh Cat, Jacquelyn Cook, Natalie Holloway, Tyler Wittman and Adrienne Showman—articulate five traits that they have found help students to successfully solve research problems. Their advice is aimed at helping undergraduates make the transition from student to researcher, from learning to discovery.

In order to include as many contributions as possible, you will see something different in this issue—a variety of short vignettes from students about different aspects of the research enterprise. These vignettes appear as sidebars to the longer articles. These vignettes cover a range of issues, from the benefits that undergraduates derive from being research mentors themselves, to "what to do when everything goes to hell" in one's research project. You will see many ways in which a UR experience has a profound impact on these students.

As usual, we have some non-themed articles in this issue as well, but as it happens, all of these include student co-authors. Students Trevor Cross, Deborah Moran, and Donna Wodarski from Cabrini College joined with Professors Melinda Harrison and David Dunbar to write about course-based research in an introductory biology course and how this kind of early participation in research has led to more advanced, independent research on the part of the students.

Faculty members Michelle Vieyra and Echo Leaver at the University of South Carolina Aiken joined with their student Alison Carlson and colleague Briana Timmerman from the University of South Carolina, Columbia to report findings from a survey conducted at USC Aiken, which requires all biology majors to participate in a senior semester of research. They found that ethnicity and gender impacted students' knowledge about and interest in this research requirement and also their participation in individual research projects. Given the substantial data on the benefits of UR for the students who participate, understanding and addressing these differences is important.

Our book review in this issue was also authored by a student. Kylie Leffler from the University of Portland reviews *Undergraduate Research in the Sciences: Engaging Students in Real Science* by Sandra Laursen, Anne-Barrie Hunter, Elaine Seymour, Heather Thiry, and Ginger Melton. Kylie finds much good advice for students and feels inspired to move forward into the world of undergraduate research.

Please also take a look at *CURQ on the Web*, which contains one more full-length article and another dozen shorter vignettes, all from the student perspective. Adam Crews, from Truman State University, argues for the benefits of using undergraduate research as an assessment metric in academic-program assessment. Successful UR involves many of the undergraduate learning outcomes that we seek: mastery of methodologies, written and oral communication, collaboration, etc., and Adam makes the point that using UR as an assessment tool will enhance the educational impact of academic programs on students.

We also invited a student editor to help with this issue. Cat Bradley, who is now a graduate student at the University of Oregon, worked with a dozen authors of vignettes that we've included in *CURQ on the Web*. Cat's experience as an undergraduate researcher, and her perspective from the arts and humanities, added a lot to this issue, and Cat was a real pleasure to work with.

Let us know what you think of this idea of inviting student authors to contribute to the *Quarterly*. It certainly was a lot of fun to work with these students throughout the process. And they have a great deal of wisdom to share with us. Perhaps we'll do this again sometime.

Janet Stocks
Trinity Washington University
CURQ Issue Editor

CUR Calendar

APRIL 2013

11-13	National Conference on Undergraduate Research (NCUR), University of Wisconsin-La Crosse
15-19	Undergraduate Research Week
23-24	Posters on the Hill, Washington, D.C.

MAY 2013

17-18	Tapping the Potential of All Students: Undergraduate Research for Community Colleges, North Hennepin Community College, Brooklyn Park, MN

JUNE 2013

20-22	CUR Annual Business Meeting, Chapman University, Orange, California
22-23	Windows of Opportunity: Undergraduate Research Conference, Chapman University, Orange, California

CUR Focus

Justin Whitaker, *University of Ottawa*

Evaluating the Experience and Principles of Good Practice in Undergraduate Research

Undergraduate research, in my opinion, is an unparalleled opportunity to explore something of great interest to an individual student. The scientific process, albeit with trials and triumphs, serves to enrich the learning experience. As a researcher, one must be open to innovative thought, develop a hypothesis that is worthy of further pursuit, and then set a logical course of action to unearth answers to the overall query.

This process presents a great opportunity to survey the knowledge and research that exists in a chosen discipline, while developing and improving study and interpersonal social skills. The student's pursuit of research may arise from a desire to integrate classroom teaching with independent learning. It can satisfy a student's natural curiosity, allowing him or her to explore and understand concepts currently unknown or less-well-defined in the field. Enthusiasm for the chosen topic is fuel to draw upon during the times when research may not go as planned. With an idea in mind and a desire to learn, the scientific process can begin. It is paramount to begin, though, by studying something of real interest to the undergraduate researcher.

Within the academic community there is a niche for publications that effectively depict the undergraduate research experience. Thus, I will describe the dynamic aspects of the undergraduate research experience from my personal point of view and outline how the scientific process unfolded for me. I hope this will enlighten both novice and practiced students about the investigative process.

My Beginnings in Research

My initial endeavors with scientific research began as a student in grade 12. My earliest area of interest was engineering. I began my research with an intensive examination of proven methods for building bridges. I accessed designs in books and on the Internet. I spent a good deal of time postulating the best way to advance bridge construction before I placed my ideas to paper or began to build a model. My emphasis was perceiving how I could learn from past successes, as well as failures, and improve upon them with a new idea. This is where my knowledge of physics, mathematics, and geometry came into play. I was able to fabricate a successful truss bridge model that caught the eye of several engineers.

My design was entered in a local contest, and I won an award for the "most successful truss innovation" from the Professional Engineers Ontario association. Although I was happy to win, that was never my intended goal. Rather, it was exploring the topic, meeting with engineering professionals, and discussing my design with others that fueled my desire to continue to explore. I had been "bitten by the research bug." I would encourage novice undergraduate researchers to begin their journeys into research science by similarly pursuing a topic that deeply intrigues them.

My next venture as a high-school student was at the Quinte Regional Science and Technology Fair (QRSTF), a local science fair. I re-examined information collected from my effort in bridge design and also was moved by a recent earthquake in Haiti to look at soil variants and what types support solid bridge construction during an earthquake. Once again, I began by reading journals, texts, articles, and online data about soil engineering to design a bridge that could better withstand earthquake damage. I contemplated what I had found, and after much assessment, I established an innovative technique to cement soil foundations with urea, a calcium salt and a urease-positive bacterium. This development launched me into a new research project to strengthen the soils that bridges are built on, as opposed to improving their design, with a technique that was also of great ecological interest to other scientists and engineers. This demonstrates how one idea, mitigating earthquake damage with a strengthened bridge, can open the door to an extended branch of novel investigation, applying a biological process to reduce earthquake hazards.

My third foray into research began after I had won first place at the QRSTF with presentation of my soil cementation ideas. I contacted universities to see if I could expand my research at the postsecondary level even though I was still in high school. I began research at the University of Ottawa and worked with graduate students and a professor who endorsed the expansion of my own concepts. I was fortunate to meet with experienced mentors who allowed me to do independent work in their lab setting. I encourage other faculty mentors to do the same—provide students who have strong research ideas with the resources needed to explore them. Challenge their understanding of the topic with a full research project and encourage an interdisciplinary approach to their study. In doing so, students will become more thoughtful researchers, stronger academics, and wholly rounded persons.

I went on to win the top awards at the 2010 National Canada-Wide Science Fair, including the awards for best in

fair, best senior project, and gold medal standing in earth and environmental science. I met many top students and faculty from across Canada during the fair. This strengthened my interpersonal skills and gave me a first-hand understanding of the breadth of the scientific research under way. I was thrilled to have been able to attend, present, exchange ideas and discuss my findings with many scientists and fellow students.

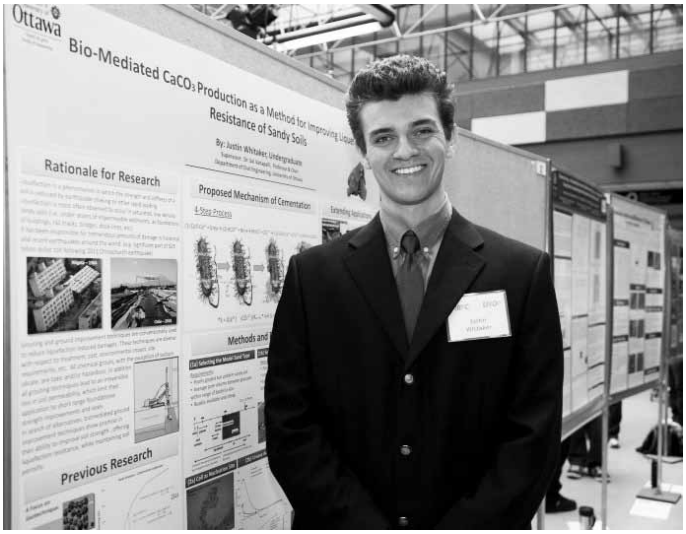
My Postsecondary Research

In commencing my post-secondary studies, continuing with research was a logical step. During my second year of classes in biomedical sciences at the University of Ottawa, I received a scholarship from the Undergraduate Research Opportunity Program (UROP) to further my explorations in soil science. I met with previous mentors to discuss my proposal and devise my approach. Since it involved a cross-disciplinary effort, it involved coordinating with the departments of biology and civil engineering to set up my soil and biological experiments. Following scientific procedures, I set out to improve upon the bacterial method for strengthening soil. I summarized my findings in a short paper and presented a summary poster at the 2012 UROP symposium, a day-long, university-wide event that brought together more than 250 students, from a variety of disciplines, to present their semester-long research projects.

I was fortunate once again to have my study receive the top honor at the symposium. I encourage institutions that do not already host such an event to add one to their undergraduate research programs. The opportunity to summarize and present one's findings to peers and professors provides a sense of finality and accomplishment, as well as encouraging students and their mentors to review and reflect on their efforts. The event also increases public awareness of undergraduate projects and strengthens undergraduate interest and participation.

Most recently in my academic career, I qualified as the top candidate in the DAAD (Deutscher Akademischer Austausch Dienst) RISE (Research Internships in Science and Engineering) Scholarship Program, a research initiative focused on international study abroad. I carried out a ten-week science internship in Braunchweig, Germany. The opportunity to be mentored by PhD students and professors working on cancer remedies was remarkable. Participation in research in a multicultural setting and sharing in scientific discovery abroad is an amazing and life-changing experience.

I urge students to take advantage of the opportunities available to perform research abroad, and recommend that academic institutions regularly inform students and faculty members about these opportunities.



Justin Whitaker presents his research at the UROP science symposium at the University of Ottawa in spring 2012.

Tips for Successful Research Experiences

The path to successful research, as I have discussed, can begin in personal ways. However, selecting the subject matter for research can be a daunting task for undergraduates new to the process. It is important for their ideas to flow and for faculty to encourage undergraduates to follow where their imagination and educational understanding may lead them. Giving students the time to honestly reflect on personal interests is a crucial process. Mind maps, word trees, and diagrams are helpful tools to organize and narrow students' interests. In my experience, starting with a topic as general as "chemistry," and performing a broad search of online academic databases is beneficial. Journal articles from these searches can be assessed and their content used to help narrow the field to a specific topic that a student finds most engaging. A student's personal level of academic interest should be his or her primary compass.

In my experience with scientific testing, I have found that preparation is imperative, but not necessarily a guarantee of successfully proving a hypothesis. Research does not always follow the prescribed plan, yet there is no study that is truly unsuccessful. All outcomes can assist the current or the following researcher to decide what the next best avenue of research might be. In fact, evaluation of successes and flops is what helps lead to an improved experiment. Students should attempt to relish the challenges of the project and accept that a discovery may sometimes unearth new uncertainty.

Research rests on details. Observations are best recorded in a notebook. Once the undergraduate internship or research project is complete, the supervisor and other staff will want to consult undergraduates' findings, and a paper notebook is the perfect medium. My major advice for students is that they should remain impartial about all of their findings. A seemingly negative outcome may in fact be a positive turn in the work, upon assessment. Take the time to snap pictures, construct diagrams and formulate tables to organize information. Do not forget to date research notes. Good researchers can describe what they saw for themselves, but great researchers will capture the sights, smells, and details

of their work, organized to the day, so that anyone who is interested later can get a true feel for the findings. Also, review notes regularly and think impartially about what they convey because this can lead to improvements in the project's design. In summary, a well-structured and thoroughly reviewed research journal cannot be underestimated.

It is important is to constantly review any findings and to revise expectations while a research study is under way. My personal experience dictates that setting realistic goals will help the undergraduate researcher to meet the timelines expected in the project. This is especially true when the other parts of undergraduate life—homework, midterms, and/or personal demands—compete for a student's attention. The research experience should be enjoyable and balanced. Remember that the purpose of research as an undergraduate is to garner an appreciation and a foundation for scientific investigation, not to complete an entire broad-scale research project. The student typically can rely upon other members of the research team, including graduates and mentors, to complete any data and findings. Undergraduate researchers should not be afraid to reach out to these colleagues to discuss their work or to ask for assistance.

The Mentor's Role is Crucial

Students should seek out a mentor who will be the best fit for their research proposals or perspectives, since all undergraduate work at the postsecondary level is done under the supervision of a professor responsible for overseeing the evolution of the project. Mutual compatibility and expectations must exist. Before contacting a professor, students are encouraged to do their homework to determine whether a professor's research area is a fit with their experience. I have found that it is very helpful to contact and communicate with not only the professor but also, if possible, any other people the student researcher will be working in close contact with during the internship or project. That allows students to feel comfortable asking probing questions and discussing any of their

CURQ Vignettes

Undergraduate Research: The Short List of Things I Want My Little Brother to Know

Cat Bradley, *University of Central Florida (undergraduate) and University of Oregon (graduate), Cbradle2@uoregon.edu*

As a new graduate student with a younger brother starting his own college career at Rensselaer Polytechnic Institute, I've experienced undergraduate research, and now I want to pass on that experience to younger students. The following is the list of everything I want my little brother, and all undergraduates, to know about undergraduate research.

- Research will do nothing but help you. It's time consuming and exhausting, but with some luck and elbow grease, you'll come out on top. It looks great on your resume, and employers and graduate schools will take your application more seriously if they see you have a personal project in which you've invested your time and energy.
- Start early. The earlier you decide you're interested in research, the better. Getting involved early in your college career allows you the chance to make more contacts and build up more research notes and citations.
- Once you decide you want to be involved with research, be involved! This doesn't mean you must start working on your topic immediately, but at least start working on your knowledge of how research is conducted and distributed. Attend undergraduate and graduate conferences on campus. Learn what makes a great research poster, and figure out the difference between an academic poster and infographics. Start researching how to get funding or academic credit for your work. Look up programs like the McNair Scholars awards and other scholastic opportunities.
- Introduce yourself to people who have successfully done research so they can help you with things like brainstorming about ideas, editing styles, or even where to start. Research isn't just about your topic; a lot of other details go into it as well. The sooner you acclimate yourself to the entire world of research, the steadier your foundation will be when you begin to write your research findings.
- Pick a topic you're really passionate about. Your topic is going to take a great deal of time, so it needs to be something you're not going to lose interest in. It needs to be something you can obsess over. I'm telling you right now: After spending nine months researching and writing an article, you will stop referring to it as a paper and start referring to it as your baby.
- Create a team. First and foremost, find an advisor who can really help to focus you on the project. Become best friends with the librarians on campus. They want to help you—they really do. No one is going to know the database system better than your librarians, and you want them on your side. Then find a buddy—perhaps another student who is interested in something completely different from what you're doing, but who is still involved with undergraduate research. You can help each other stay up late, shoveling through books and countless cups of coffee. You can help each other to think out loud and catch the missing comma or where passive voice was accidentally used in your paper. But most of all, you'll help to push each other, because face it: Success isn't nearly as much fun without someone else to enjoy it with.

CURQ Vignettes

The Other Side of Undergraduate Research

Olivia M. Chesniak, *Lewis University, oliviamchesniak@lewisu.edu*

Undergraduate research has the potential to equip students with the skills to be successful in all areas of research, from familiarity with laboratory techniques to discussing and presenting results. Without any "right" answer or "go-to" procedure to rely on, quick thinking and troubleshooting are key, but to go beyond the science and technical knowledge research demands, perseverance is necessary. One day may be more fruitful than the next, and sometimes you need to stop, reevaluate, and start over. The ability to keep going despite these frustrations is incredibly powerful, but also is dependent on a person's attitude and connection with the research team. Research is collaborative; one person's triumph or slump can positively or negatively affect the entire team.

The biggest transformative factor in undergraduate research for me was developing "emotional intelligence." At one point about four months after beginning research, my faculty advisor, Jason Keleher, pulled me aside and handed me Daniel Goleman's *Working with Emotional Intelligence*. Goleman emphasizes communication skills and the power of modulating one's emotions when working in a group. The book explores how "star performers" in industry are no longer evaluated solely by their IQ or credentials, but also on how they work with and lead others. These skills are also important in academia; I quickly understood my advisor's purpose in lending me this book. I stepped back, and a dose of self-awareness made me realize how volatile I had become and how hazardous it was to my project and others working in the lab.

Humility and communicating with others are two areas in which I focused on developing better skills. Though I have begun to see results, I will surely be honing these skills for years to come. This vignette also demonstrates important qualities in an undergraduate research advisor. Dr. Keleher's honest approach to helping me overcome my shortcomings made all the difference; putting the responsibility to change in my hands was the best thing he could have done. In my time as a researcher, I've learned a great deal about science and myself, and I have found that those skills that one must work the hardest to attain are indeed the most valuable.

ideas about a project with the research team. The student, professor, and associated research staff all must develop open lines of communication so that questions and information circulate easily among everyone involved.

It is important that students ask questions and observe how colleagues solve problems concerning their projects. Where possible, undergraduate interns should take part in group discussions and take note of how experienced researchers share their ideas and work as a team to achieve solutions. They should seek to understand experienced researchers' thought processes and problem-solving skills. The internship is a personal endeavor as well as a social experience. Be friendly, but stay professional.

For their part, faculty mentors should work to include their undergraduate interns in as many research discussions as possible, ideally at least once a week. Listen to the students' ideas since they have fresh perspectives, and work to adopt the most promising ones. In addition, broaden the student's understanding of the research topic by providing supplementary readings related to the project; urge them to connect their research ideas with published literature. Inclusive faculty mentors can look forward to strong, original research contributions from their undergraduate researchers.

Following an internship or other research endeavor, students should stay in touch with their research mentors as much as possible, including getting updates about any ongoing research. This will optimize students' learning and produce meaningful, professional connections that can be helpful to their future academic careers.

Conclusion

Opportunities for undergraduates to participate in research are a constructive way to benefit the entire academic community. Students develop an enriched appreciation of the scientific process, which helps strengthen the scientific community within an academic institution. In my personal experience, the investigative process has opened numerous doors to the amazing world of science, including teaching me how much fun it can be. I hope opportunities can be found to encourage all students to participate in a practical investigative study.

Justin Whitaker

University of Ottawa, jwhit117@uottawa.ca

Justin Whitaker is a third-year student in biomedical sciences at the University of Ottawa. An avid researcher since high school, he is on the dean's list with a 9.6 average and intends to pursue his passion for science by studying medicine. He is interested specifically in cardiac surgery.

CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

CUR Focus

Mario Pita, Christopher Ramirez, Nathanaelle Joacin, Sarah Prentice, and Christy Clarke, *University of Central Florida*

Five Effective Strategies for Mentoring Undergraduates: Students' Perspectives

Undergraduate research has been shown to provide an exceptionally positive experience for students (Seymour et al. 2004). In a study of student learning outcomes following participation in summer research programs, 1,135 undergraduate researchers reported the highest learning gains on closed-ended survey items related to understanding the "research process" and how to approach scientific problems, followed by gains in knowledge of laboratory techniques and areas of personal development (Lopatto 2004). Other studies investigating the merits of undergraduate research have shown development of research skills (Kardash 2000), enhancement of intellectual curiosity and logical thinking (Bauer and Bennet 2003), and increased college retention rates (Nagda et al. 1998). Positive effects are seen across the spectrum of disciplines from engineering (Zydney et al. 2002) to social science to the humanities (Ishiyama 2002).

Integral to facilitating such benefits for undergraduates is a faculty mentor who can successfully introduce this mostly younger population of students to academic research. Mentoring undergraduates is distinct from the process of mentoring graduate students. Unique challenges stem from, for example, differences in the students' general level of experience and stage of career development. Given the marked benefits of undergraduate research and the importance of effective mentor-student interactions, it is worth exploring the interpersonal strategies that mentors can employ to facilitate the best possible learning outcomes for their undergraduate researchers.

In this article we provide mentors with purely student-derived insights on how best to approach mentoring undergraduates. Our insights stem from personal experience as current undergraduate researchers; also we are all ambassadors to the Office of Undergraduate Research at our university. In that capacity we promote involvement in research to the student body, and we advise students across disciplines on how to be successful researchers. The following are the top five strategies we have found to be the most effective for mentors to generate excitement, expertise, engagement, and a sense of student responsibility that ultimately leads to quality work. Thus we advise mentors to:

Make Yourself Available

Certainly one of the most valuable commodities a mentor can offer is his or her time. If the principal investigator has no time left to give, he or she should at least guarantee that a postdoctoral fellow, a graduate student, or even an experienced undergraduate is able to devote a considerable amount of time to mentoring a new undergraduate researcher. Learning in a research environment can be a dynamic and unpredictable endeavor. Simply spending time with students as they perform tasks allows the mentor to be able to clarify the young researcher's nuanced questions and the subtle discrepancies from the norm or the expected outcome that inevitability arise during the workflow due to the often hyper-detailed nature of research. The mentor may also find himself or herself delving into interesting side topics with the student, all the while generating knowledge and excitement that facilitates the learning and retention process.

Quality time with a mentor is paramount for student success, but how can this process be optimized to ensure that the time students and their mentors spend together is wholly productive? Often mentors may be present but do not actively engage with the student as he or she works on the research—or vice versa. Such a scenario may arise due to a strain in the mentor-student relationship; if the two parties are unfamiliar with each other or not comfortable with each other, it can lead one or both to act in a reserved way that can inhibit interactive learning.

It is important to note that mentor-student relationships are not immune to standard social psychology. There must be mutual trust and respect, openness and companionship. With this in mind, a mentor should not discount the value of taking time to eat lunch or grab a cup of coffee with the mentee, for example. Conversations about topics unrelated to the research, such as those giving the student advice about classes or future goals, can have a lasting impacts. Essentially, building rapport in such a way can help make the mentor-student relationship more comfortable. It is this fundamental comfort and connectedness that allow mentoring relationships to evolve into the most productive, educational, and constructive interactions in the research environment.

CURQ Vignettes

The Roller Coaster of Undergraduate Research

Jordan E. Krebs, *Lycoming College, krejord@lycoming.edu*

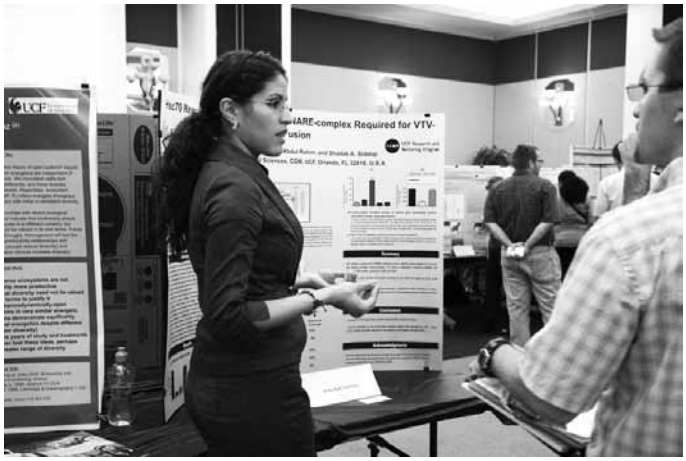
Trying to complete meaningful original research while juggling classes, homework, extracurricular activities, and some free time during the school year can be a very daunting task. Similarly, eight, ten, or twelve weeks during the summer is a short time in which to become familiar with a research topic. Yet thousands of undergraduate students not only want to have such an experience, they compete for it. The fundamentals of a successful research experience are careful selection of a mentor and project, ample preparation, and a final research presentation.

The experience itself is difficult to explain; it involves more than just the mere "ups" and "downs" of research. More specifically, the learning curve, loop-the-loops, climbs, and dips in the research process make undergraduate research resemble a ride on a roller coaster. The type and pace of each project is as unique as each roller coaster: launch, wooden, or even inverted. Every roller coaster, though, is dependent on the operator to guide it along its rails. Similarly, the undergraduate's research mentor holds the keys to easing the student's transition onto the ride of choice and to fulfilling the student's expectations. For example, a mentor may build the student's foundation for the project before the ride begins, providing ample time and information for an enthusiastic student to absorb while waiting in line for the fast-accelerating coaster. Once the student is in the seat and finally ready to go, the mentor reminds the student to hold on and enjoy.

Ultimately, the eager rider has the chance to test ride a research experience. After a long and sometimes slow climb to the top, he or she may finally attain a great view—understanding the broad scope of the project and thus being able to enjoy the upcoming thrills with minimal plummets. The possibilities of discovery at that height of view are endless and exciting. Once the coaster returns to the station, the riders share their experience with those waiting to soon embark on a similar journey. Much like a conference, one finds much joy in presenting the outcome of the test ride. Along the way, the rush of G-forces while pushing though the "ups" and "downs" excites a young research student and roller coaster fanatic.

Foster Community

In the broadest sense, community has always been vital to human progress. Human beings are fundamentally social creatures; we thrive in interpersonal relationships and synergistic interactions that allow us to better ourselves collectively. This collective progress is a hallmark of community, and it is important to recognize that the microcosm of the research environment is not immune to this core principle. Following are some examples of how to build a community within a research team; they show precisely why forming a robust community is helpful to undergraduates.



Students present research projects to the UCF community at the Showcase of Undergraduate Research Excellence (SURE).(Photo Credit: University of Central Florida Office of Undergraduate Research- Student Undergraduate Research Council)

As student researchers, we have had the most success when we have been in welcoming environments that provide us with a support system—one that not only encourages participation, but also holds us accountable for our respective duties. We have found this balance between positive reinforcement and negative consequences (e.g., embarrassment due to unpreparedness for a journal club meeting) to be crucial. The tighter and more supportive the community, the more likely we are to produce consistent and reliable work in an enjoyable manner. Conversely, too much pressure to succeed or obtain perfection can be unrealistic and off-putting for inexperienced researchers. Moreover, undergraduates are usually young; we are still learning how to act professionally. We have heard professors explain their reluctance to accept undergraduates for this very reason. Forming a community can counteract naive behavior by appealing to the innate psychological drives a true community elicits: a person's desire to feel that he or she belongs and a feeling of responsibility to the community.

As students and peer mentors who have experience with numerous research environments, we are confident that implementing activities to build a community will have profound effects on the behavior and productivity of undergraduate researchers. The following have been useful in our own research environments:

- ***Team meetings.*** It is important that all members of the research group become familiar with the projects and tasks of their peers and colleagues. Team meetings support discussion and collaboration among researchers in the same environment, and they can be particularly useful for the efficient use of available resources. During such meetings, one or two members of the research group can present the progress of their specific research projects and allow the mentor and other researchers to ask questions. We have found an open discussion period at the end of the presentation to be especially important for furthering the project in the best way possible.
- ***One-on-one meetings.*** We have found one-on-one or small group meetings to be an important supplement to team meetings. Such meetings give students time

Peer Mentors teach undergraduates about research at the Summer Research Academy (SRA). (Photo Credit: University of Central Florida Office of Undergraduate Research- Student Undergraduate Research Council)

to express their concerns to the mentor in a confidential environment. Interpersonal concerns with other researchers can be addressed, in addition to research-related questions. In these meetings, mentors are able to make their expectations of the student clear and set the stage for subsequent discussion.

- ***Journal clubs.*** In addition to meetings, a journal club can be a useful venue for the exploration of unfamiliar, yet relevant and exciting topics. Journal clubs are also particularly valuable for undergraduate researchers because the process teaches students how to effectively criticize and scrutinize research articles. Finally, these meetings will enhance the formation of a community and help lead to the benefits previously discussed. Journal clubs and team meetings can be combined into one weekly or bi-weekly event.
- ***Social outings.*** It is especially important to foster professional relationships with co-workers because effective teamwork is often crucial to a project's success. There are many ways this can be accomplished. For example, host a potluck where members bring an ethnic dish from their culture, go to sports games, have lunch together, or attend research presentations as a group. It is easy to discredit some of these activities as frivolous, but we have found them helpful in constructing a stronger and more natural community within the research environment.

Be Attentive

A mentor should be attentive to the student being mentored. Maintaining continuous communication with a mentee can be an effective way of curbing the occasional unreliability found among undergraduates because it allows for immediate accountability. While it may be somewhat time-consuming, such attentiveness is especially worthwhile for the younger undergraduates. To remain attentive, a mentor can employ multiple modes of communication, including email, phone calls, and even texting. Contacting students to inquire about their projects through such modes of communication can be useful if the mentor cannot do so in person due to other commitments.

In addition, setting deadlines for certain tasks may be an effective way to create structure and promote clear communication of expectations. Finally, knowing when a student plans to perform certain research tasks and promptly checking in with the student (or having the student check in with the mentor) about their progress around the time of the deadlines can be an important way to maintain the student's sense of responsibility and quality of work. Many undergraduates complete their work on nights and weekends, so having the mentor check in and respond to inquiries during off-hours can be helpful.

Encourage Participation in the Broader Research Community

Time spent as an undergraduate is formative and novel; getting a young researcher involved in the research community beyond the student's specific project (e.g., through departmental seminars, local or national conferences, and summer internships) can inspire and dramatically encourage students. A mentor can suggest that students travel to conferences in different cities or countries, help them construct research posters, or use other institutional contacts to help the students find summer research opportunities. It is important to realize that many undergraduates are not aware of these types of activities and that campuses usually have resources to help students participate, such as travel funding for conferences. Overall, we have found conferences and internships beneficial to the work we provide at our home institution. In terms of forming a better mentor-student relationship, these activities may increase a mentor's interest in the mentee's personal and academic development.

Be Understanding

Undergraduates are under tremendous stress at times for a number of reasons. They may have underestimated the workload and time commitment their classes require or they may be overwhelmed by the transitions faced in college and the responsibilities of adult life. Undergraduate research is frequently difficult due to the necessity for students to balance coursework (and its sometimes unaccommodating class schedules) with highly involved research projects. With all of this in mind, it is important for the mentor to maintain empathy for students, and to be understanding of the student context.

Due to time constraints and general inexperience, undergraduates may need considerably more time than graduate or postdoctoral researchers to fully adapt and thrive within the research setting. Mentors should be understanding about a student's failures; we have found that negativity only breeds more negativity. Mentors should make an effort to ensure their criticism is constructive and not demeaning

to the student. Always balance criticism with positive reinforcement. This does not mean, however, that the mentor has to accept repeated failure and unreliability, but rather should value a student's perseverance and enthusiasm over his or her initial results. Mentors who employ this strategy may find students who initially had difficulties evolving into valuable assets on their research teams.

CURQ Vignettes

What to Do When Everything Goes to Hell

Laurie Adams, *Ferrum College, ladams@ferrum.edu*

Dear student colleagues in research:

I call out to you from the Great Beyond (post-graduation), and, like Marley's ghost, I come bearing a message to save you from eternal torment, or at least, from project failure. The chains I forged in my academic life were the smelted remains of a research project that threatened to go straight to hell. That experience left me with the following instructions that I now impart to you, to be deployed in the event your own work begins to smell like sulfur and brimstone.

Don't panic and become entrenched in your approach to the research. Both reactions will cut off your ability to see other options. Don't hide the problem you have encountered or lapse into denial. (Similar to panic in terms of a sheer knee-jerk reaction, this is a normal response; however, it is just as self-defeating). Don't give in to negative feelings about your worth as a researcher (a direct route to panic and self-defeat).

Communicate with your professor at all times so he/she knows the project's status. Your best hope lies there.

Ask for help. Not just from your professor, but from any professional on campus, within your community, or through social networks, who has expertise in the area of your research. Help may come from unexpected quarters, but you first have to ask.

Look for inspiration in the thing that caused the breakdown of the project in the first place. This can spark your creativity by forcing you to look at an aspect of your topic you hadn't examined closely before, or it may make you look at your topic a completely new way. Be ready to reconfigure/redirect/drop back and punt as needed.

Never give up. Even if all possibilities seem to be exhausted, and the project is still failing, your professor may be able to present you with alternatives, such as writing a grant proposal instead.

Last, don't fake it. Do not attempt to bluff, cheat, or plagiarize your way out of a jam. You WILL get caught. An entire failed course; having to face an honor board; possible suspension; and destroyed credibility are far worse than a failed project. Unlike a failed project, there may be no future redemption.

Conclusion

What makes an ideal research mentor for undergraduates? While each of the strategies we have discussed is beneficial in the mentoring process, the overarching theme of each is: be involved. Be available to create a healthy and open line of communication with students. Take time to build companionship. Form a community to create an efficient environment and counteract unfavorable behavior. Follow up your statement of project expectations by regularly checking in with students. Encourage students to participate in presentations and off-campus experiences. Be mindful of the academic, social, and age-related context of undergraduates when judging their performance. As undergraduate researchers ourselves, we have found that these strategies facilitate a mentor-student relationship of mutual respect and transformative guidance, of productivity and mutual reliability. Employing these strategies should empower undergraduates to generate meaningful work and, in doing so, inspire the next generation of researchers.

As mentors, faculty members have the opportunity to have a lifelong impact on their students, particularly those early in their careers. In our experience as researchers, we are forever appreciative for the time our mentors have spent with each of us.

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Mario Pita

University of Central Florida, mario.pita@ucf.edu

Mario Pita is a senior at the University of Central Florida (UCF), majoring in biomedical sciences and psychology. He has worked in Dr. Kiminobu Sugaya's laboratory at UCF for over three years, performing experiments and collecting data for a project aimed at developing a novel therapy for Parkinson's disease. Pita also won a summer internship at the National Institutes of Health when he was a sophomore and worked for two summers in Dr. Mark P. Mattson's neurosciences laboratory at the National Institute on Aging. His work there led to four co-authored publications including a paper in the Proceedings of the National Academy of Sciences. *Pita has also worked in numerous outreach and mentoring programs and recently founded the Central Florida Chapter of the Society for Neuroscience, where he aims to foster public outreach and education, as well as collaboration and communication, among scientists, doctors, and students in central Florida.*

Christopher Ramirez is a junior at the University of Central Florida studying chemistry. He is part of the undergraduate research and mentoring program at UCF, and his research project investigates polyaniline and reversible photoacids. In his spare time, he mentors students and encourages them to get involved in research through the Summer Research Academy at UCF, which promotes undergraduate research. Ramirez has participated in research for almost two years and plans to attend medical school.

Nathanaelle Joacin is a senior at the University of Central Florida. She became interested in research when she attended the Summer Research Academy at UCF before her junior year. She serves on the Student Undergraduate Research Council at UCF and is part of the research and mentoring program. Her research concerns cardiovascular disease and stem cells. She is also involved in an independent project related to health issues concerning minorities in America.

Sarah Prentice is a senior at the University of Central Florida majoring in psychology and minoring in leadership studies. Her current research interests are focused on attention, cognitive psychology, and linguistic development in infants. She is completing her undergraduate honor's thesis under the supervision of Dr. Kim Renk and is also a research assistant in the Understanding of Children and Families Lab. Prentice serves as member of the university's Student Conduct Review Board and is president of the UCF Psychological Society. She plans to pursue a PhD in clinical psychology.

Christy Clarke is majoring in early childhood development at the University of Central Florida and minoring in child life studies, having always had a strong interest in working with children. She actively conducts research as a Ronald E. McNair Scholar and is on the university's Student Undergraduate Research Council. She is intrigued by research that involves mother and infant interactions, as well as early intervention methods. She is interested in pursuing a PhD in early childhood development geared toward the health development of children and adolescents. Her ultimate goal is to provide counseling to families and children.

CURQ Vignettes

A Self-Conscious Tutor Transforms Into a Confident Mentor

Francesca Luppino, *Hiram College, luppinofl@gmail.com*

It was a normal night at the campus writing center. After attempting—and awkwardly failing—to make conversation with Kaylyn and Devlin, the soon-to-be tutors I was mentoring, I started helping Kaylyn with the literary journalism essay she was writing.

I felt confident tutoring Kaylyn. I had several suggestions to help her connect the different sections of her essay. While I was tutoring her, though, I was anxious about what would come next—a tutoring session with Devlin. He was naturally a better writer than me, and he had self-confidence. Would he assume all of my suggestions were worthless?

My mind was slightly eased by Devlin's interest in receiving help from me; he willingly ran from the writing center to his dorm to get his essay in time for me to read it before we closed.

While Devlin read his essay about fruit art, I gained confidence. I knew his essay could be improved. He could focus less on his research and work on integrating it more smoothly into the reflective sections. This was a technique I had trouble with when I was training to become a tutor, so I could easily find the problem and relate to it. I became impatient, rather than reluctant, for my turn to give advice.

As I showed him where he went into too much detail and failed to connect facts to his reflective points, he fought against reducing the descriptions of his research. I knew it would be a more meaningful and readable piece if he followed my suggestions, though, so I encouraged him to make the changes. I felt Devlin's respect and trust increase as we finished.

I didn't learn specific research techniques that night. But by gaining the respect of a peer, I discovered that despite my lack of natural writing talent or adequate self-assurance, I have the ability to analyze writing and improve it. Knowing I have valuable ideas gave me confidence to analyze others' writing as well as my own, improving not only my tutoring but also my ability to incorporate research into my own writing.

CUR Focus

Adrienne Showman, Linh Anh Cat, Jacquelyn Cook, Natalie Holloway, and Tyler Wittman, *University of Central Florida*

Five Essential Skills for Every Undergraduate Researcher

> *"[B]eing my research problem, it was up to me to solve. …The crucial lesson was that the scope of things I didn't know wasn't merely vast; it was, for all practical purposes, infinite. That realization, instead of being discouraging, was liberating. If our ignorance is infinite, the only possible course of action is to muddle through as best we can (Schwartz 2008, 1771).*

Research is hardly easy. As Martin Schwartz points out in his 2008 essay "The Importance of Stupidity in Scientific Research," solving research problems requires us to immerse ourselves in the unknown. However intimidating it may be to overcome this infinite amount of ignorance, we believe there is a special set of traits that will equip an undergraduate researcher to successfully solve research problems. Creativity, judgment, communication, organization, and persistence are all equally important skills to make the leap from gaining knowledge from others' discoveries to making discoveries on your own. Having and honing these skills, skills that encompass every level of research in every discipline, are key to an undergraduate developing the foundation for a successful career in research. As a group of undergraduate researchers and mentors, we want to motivate students to solve problems and make discoveries, and to start a discussion on how to forge the right path for each student toward research success. Following is our list of key skills.

Creativity

It is difficult to find a definition of undergraduate research that does not include a reference to creativity or that does not contain terms such as original, authentic, or unique. Clearly, then, creativity is a constant for the undergraduate research process. In an article by Jeffrey M. Osborn, dean of The College of New Jersey, and Kerry K. Karukstis, professor of chemistry at Harvey Mudd College, originality is said to be a "common thread that runs through every undergraduate research activity on campus." Creativity and originality go hand in hand. Creativity is the ability to transcend mainstream ideas, and creativity all but requires originality. It is no surprise then that originality is so pervasive throughout the college or university campus. The Council of Undergraduate Research provides a universally applicable definition that describes undergraduate research as "an inquiry or investigation conducted by an undergraduate student that makes an original, intellectual, or creative contribution to the discipline" (Wenzel 1997, 2000). All researchers, not just undergraduates, require creative thinking and process development to build upon today's knowledge. Creativity is an essential trait that undergraduate researchers should seek to develop and utilize within their research experience.

The first step in research is developing a topic or a plan for exploring a problem, and creativity is fundamental to this effort. As members of our university's Student Undergraduate Research Council, we constantly come across prospective undergraduate researchers who don't know where to begin. Students in all disciplines are unsure, even lost, as to how they should start deciding upon a research topic. We encourage students to research their discipline extensively, to find out what has and has not been studied, and to attempt to find a topic in which they are genuinely interested. Even by studying research outside their own disciplines, budding researchers can use the creative process to make new connections, pushing the envelope of what is possible in discovery. Ingenuity, uniqueness, and, most importantly, creativity are all skills that need to be applied in creating that standout research concept.

Students who are still hesitant about delving into the creative process of undergraduate research as part of an independent endeavor should seek to develop their creativity by participating in ongoing research and watching how a faculty mentor or graduate student employs creativity in conducting that research. During this time, undergraduate researchers can learn how to think creatively within the context of their field and possibly discover a topic of interest that will provide them with an independent, unique research opportunity. But students should not limit themselves to the expertise of their faculty mentors. To be a true researcher, undergraduates should strive to reach beyond their own disciplines, either into closely related disciplines or those completely unrelated to their own, for possible ideas.

Judgment

A quite specific sort of judgment is critical when participating in the world of research. Just as the mentor may exercise judgment in selecting a mentee, an undergraduate researcher should likewise evaluate and choose a mentor who will help the researcher to grow in the best possible way. Personality,

temperament, and style of research are all factors to consider when choosing a mentor. Another important aspect of judgment is recognizing when to ask for help in solving problems. To gain the most experience from research, students must make a calculation between knowing when to ask for help when they encounter an obstacle or possibly lose time by deciding to tackle the problem on their own. The progress of the research and perhaps the opportunity for the project to be finished successfully may rest on what they decide.

However, student researchers should not over-utilize a mentor's valuable time; instead, they should strike a balance between independence and seeking assistance. As undergraduate researchers move on to higher-level studies and professional careers, this ability to discern their own and others' needs, and thus make judgments in a fluid environment, must become automatic and unconscious, so they do not waste precious time and energy weighing the pros and cons of every single decision.

Undergraduate researchers also should consider and study the importance of good judgment as it applies to ethical dilemmas in research. Failure to exercise good ethical judgments can seriously jeopardize the careers and integrity of not only the student researchers, but also of their mentors, colleagues, and possibly even their college or university. Undergraduate researchers must be careful not to rely solely on the examples set by faculty mentors or fellow students. Additionally, students should spend ample time learning about the ethical issues associated with their particular fields and strive to utilize their own considered judgments to arrive at appropriate, safe, and ethical conclusions. Today's undergraduate researchers should be cognizant of and conversant with common areas of ethical failings, such as misuse and misrepresentation of findings, wrongful disclosure, and even plagiarism. Being aware of potential ethical issues will help to maintain the integrity of the research for all parties involved.

Although it may be difficult to always make the best choices in as unpredictable a world as research, undergraduate researchers have the opportunity to develop ethical and rational decision-making skills in a lower-stakes environment with oversight by experienced researchers. They can, through practical application, gain experience in making ethical judgments. They can learn to recognize the issue at hand (whether it be time conflicts or personality conflicts or something else); determine the pros and cons of each possible way of dealing with the conflict; seek advice from veterans of research; and, when appropriate, take the occasional risk. Studying these different types of decision-making processes (Bennis et al 2010, 191) can help students develop the skills in exercising judgment that undergraduate researchers require. Eventually the skills should become second nature.

Communication

For this article, we refer to communication as the set of skills necessary to develop and maintain an effective relationship between an undergraduate researcher and his or her faculty mentor. The importance of a mentee-mentor relationship to all undergraduate students is best characterized by UCLA's Alexander Astin, who counts these interactions as one of the most important factors in the development of a student's undergraduate experience (Astin 1991). The positive implications of these relationships extend to undergraduate research as well, because these interactions "potentially have the longest-lasting impact" on the undergraduate researcher's personal growth and academic development (Malachowski 1996, 90). Faculty mentors are the most valuable link between the student and the new and unfamiliar world of research. Mitchell Malachowski, in his discussion of the importance of faculty mentors to research projects, states they "encourage and guide the student's personal growth and academic development, while providing support and assistance as the student works through the challenges" of undergraduate research (Malachowski 1996, 90).

Initiating communication with a faculty mentor during the early phases of the undergraduate research process can be an intimidating situation; students sometimes begin the process with faculty members with whom they have little experience. They may be hesitant to contact mentors outside of the predetermined research time at first, worried that their questions could be "annoying" or their concerns "silly." However, in our experience, mentors are more than willing to accommodate students with in-person meetings and email exchanges, or to suggest the use of more-experienced student researchers as "peer mentors" for inexperienced undergraduate researchers.

Nonetheless, undergraduate researchers should be respectful of their mentors and their time; faculty mentors often balance a schedule consisting of multiple courses, their own independent research endeavors, and mentoring of additional undergraduate or graduate researchers. In our experience as undergraduate researchers, however, we have found that the creation and maintenance of productive relationships with our mentors have led to an increased understanding and knowledge of our respective fields, additional research opportunities, and overall enhanced personal and professional skills.

Organization

Well-honed organizational skills facilitate effective research and good science, as well as allowing students to balance classes, studying, research, socializing, hobbies, and maintaining a healthy lifestyle much easier. Keeping an organized

CURQ Vignettes

Dear Mentors/Professors: Tips to Maximize Research Value from Your Undergraduate Research Assistants

Jasmine Mah, *University of Ottawa, jmah080@uottawa.ca*

It is a common misconception that success as an undergraduate researcher depends solely on the student's initiative, hard work, and dedication. The contributions of the supervisor in the student-mentor relationship, however, are equally crucial in promoting efficient and sustained undergraduate research (UR).

As a participant in the University of Ottawa's Undergraduate Research Opportunity Program, I was enticed into research by an amazing professor who is not only renowned in his field, but also is able to enthusiastically communicate and transfer his knowledge. While research has been the most intellectually stimulating and useful opportunity of my university career, I soon discovered that many of my peers did not feel the same way about their experiences. In discussion with my fellow researchers, it became apparent that the supervisor's involvement is the key to success. Drawing on my colleagues' experiences, I present a few simple tips for UR mentors that will benefit faculty members' work and improve the accomplishments of their UR assistants.

- **Schedule regular meetings with your undergraduate researcher.** This gives you a chance to check progress, answer questions, and minimize potential miscommunication concerning your research.
- **Communicate your research in layman's term.** Explaining the bottom line and importance of your research motivates your undergraduate assistant by providing an overall goal to achieve.
- **Establish networking opportunities by introducing your student to colleagues and graduate students.** Your researcher will gather resources, develop partnerships between projects, and maximize the return received from the student's investment in your research projects.
- **Express your energy, enthusiasm, and interest.** Passionate leadership results in passionate results!
- **Mutual respect is a two-way street.** Although undergraduates are at the bottom of research hierarchy, consideration and kindness encourage devotion and loyalty on the part of both parties.
- **Provide resources for your undergraduate researcher.** It is surprising how much a designated workspace or computer will encourage work in the lab.
- **Be available to your undergraduate researcher.** Professors will often shift the mentorship role onto graduate students. While a graduate student provides a great resource, the faculty member must also be available to teach and directly guide the undergraduate researchers.

Perhaps the real secret of any successful endeavor is communication!

journal or lab notebook of all work is critical for analyzing data, generating new ideas or proposals, or determining the next step in a project. Most importantly, organized lab notes and data help tremendously in the process of writing papers and publishing work. These skills can make the difference between a solid report and an unsupported essay. An unorganized undergraduate researcher may have a harder time getting work done within any deadlines and may have a more difficult time finding data and relevant notes on past research. As undergraduate researchers, we have all experienced working with a deadline, but our faculty mentors didn't regularly check that we had lab notebooks or sources recorded properly. Without a good organizational structure, it is difficult to finish work in a timely manner, and the researcher is likely to find it difficult to locate the exact data point or specific quote and author when needed. Being able to keep to a schedule of research and other responsibilities, as well as writing effective "to do" lists, will help greatly. Class work, class notes, lab notes and lab work should be efficiently organized to facilitate better coordination between coursework and research information.

Undergraduate researchers are likely to be involved in a variety of other pursuits and to be incredibly busy, so it is easy for them to reach that "burn out" point. Organization is a key part of avoiding being overwhelmed and can help students avoid over-scheduling themselves, leading to more success in all their commitments. Those who continue to do research will find this skill crucial to balancing multiple or larger projects, as well as to having a healthy life outside of research.

Persistence

Persistence is the drive to never give up. But it is important to realize that persistence involves facing failure. Failure could involve coming up with a bad research design, not anticipating future roadblocks, or not knowing every detail of a proposed research project. However, failure is a normal part

of progress, and we often learn more from our mistakes than our successes, especially in research, where the investigator must consider many aspects of a problem. Many students pass up an opportunity to do research if there is a chance they might not succeed. Mistakes should be embraced as an opportunity to learn, and students should stop harboring a fear of failure. Although it is difficult to remain persistent at times, students must remember that it will pay off in the end, in the form of quality data, a solid synthesis, or even simply an educational experience.

Persistence is especially useful for budding undergraduate researchers who do not have strong resumes or previous experience. It's a trait definitely noticed by most faculty mentors. Sometimes, a faculty mentor will pick a student for his or her lab even though the student has less experience than other candidates simply because the student has displayed strong motivation. Later, when a student is committed to research, persistence is essential to developing and carrying out a thorough project. Students who overcome roadblocks successfully by being diligent in reading the research literature and making use of their faculty mentor's expertise will find that when it comes time to present their work, answering questions is effortless because the students have put in the foundational work. Persistence becomes an increasingly integral part of the research process as student researchers progress to graduate school and future academic endeavors. The majority of researchers must write several grants in order to initiate their research. This process inevitably involves rejection and, therefore, the motivation to rewrite and edit grant applications is crucial to launching the research process and a productive research career.

Conclusion

Applying the five skills outlined above will help an undergraduate transition from being a student to becoming a researcher and move from learning to discovering. Although we come from various backgrounds and research fields and have different personalities, we have found that these skills are common to all of our successes, from attending conferences on human factors in psychology, to writing a thesis on Italian architecture, to restoring oyster reefs, and even to studying molecular genetics in Germany. Creativity, judgment, communication, organization, and persistence are universally applicable in the pursuit of becoming a better researcher. We hope that this set of essential skills will provide a foundation not only for what it means to be an undergraduate researcher, but also will create the opportunity for a dialogue among researchers at all levels, from the undergraduate to the tenured professor, regarding what makes undergraduate researchers truly succeed.

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Adrienne Showman

University of Central Florida, adrienne.s@knights.ucf.edu

Adrienne Showman is a senior pursuing her bachelor's of science in molecular biology and microbiology at the University of Central Florida. Having worked in a biochemistry and X-ray crystallography lab for the past year and a half, her research interests include molecular biology and structure determination. She spent a summer abroad in Germany, working at Humboldt University in the Breeding Biology and Molecular Genetics Department through the German Academic Exchange Service: Research Internships in Science and Engineering Program (DAAD RISE). She hopes to pursue a PhD in biochemistry, and enjoys hiking, traveling, and mentoring outside of class and lab work.

Linh Anh Cat is a junior studying environmental studies and biology at the University of Central Florida. She has worked on oyster reef restoration and monitoring at the National Canaveral Seashore and is currently working on investigating the effects of invasive snails and aquatic plants on ecosystems. She has led volunteer trips to the Florida Keys to help create habitats for endangered species and to remove exotic species. Cat also educates high-school students about sustainability and guides them in creating new initiatives for their schools. She enjoys scuba diving, triathlons, and other outdoor activities in her free time.

Jacquelyn Cook is currently a senior pursuing her BS in psychology at the University of Central Florida. She has been working on human-robot trust research at the MIT2 lab since the spring of 2011 and has also assisted in team research at the Institute of Simulation and Training at the University of Central Florida since fall 2011. Her primary research interests include human factors psychology, team processes, and leadership. Cook plans to pursue a PhD in industrial/organizational psychology. In her free time, she enjoys playing video games and writing.

Natalie Holloway is a senior at the University of Central Florida, double majoring in art history and anthropology. She is currently in her second semester of undergraduate research, in which she is evaluating the influence geography has on 17th century Baroque Italian architecture. Her primary research interests are the Renaissance and Baroque periods of Italian art and architecture. Natalie plans to pursue a PhD in art history or museum studies and pursue a career either as director of a museum's cultural education program or a university professor.

Tyler Wittman is a senior pursuing his degree in biology at the University of Central Florida. He has worked in an evolutionary biology lab for the last year studying the antagonistic coevolution of reproductive and immune systems. He plans to pursue a PhD in evolutionary biology; his primary research interests are the evolution of eusociality and immune systems. He enjoys weightlifting, biking, fishing and hiking in his free time.

CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

Course-Based Research as a Catalyst for Undergraduates' Interest in Scientific Investigation: Benefits of the SEA-PHAGES Program

Trevor Cross, Deborah Moran, Donna Wodarski, Melinda Harrison, and David Dunbar, *Cabrini College*

Undergraduate students at our institution have reported several advantages of early participation in research, including a stronger desire to continue their education and to gain more research experience (Harrison et al. 2011). A key model of the undergraduate research experience is found in course-based research, in which students are immersed in a research environment during their scheduled class time. There are several excellent models of course-based research, but what these have in common, according to the research literature, is that they engage upper-level science students (Boomer & Dutton 2002; Brodl 2005; Drew & Triplett 2008; Elwess & Latgourelle 2004; Howard & Mislowski 2005; Shaffer et al. 2010). Course-based research strives to illustrate that science is unpredictable, and it gives students a chance to participate in the trouble-shooting and success that research brings. The studies cited above have also shown that course-based research experiences increase students' mastery of content, their interest and enthusiasm during laboratory exercises, and their critical-thinking skills.

Because of the constellation of benefits of undergraduate research, there is a growing movement to offer more course-based research opportunities to students earlier in their undergraduate careers (Lopatto 2009). One such opportunity sponsored by the Howard Hughes Medical Institute (HHMI) is the Science Education Alliance's Phage Hunters Advancing Genomics and Evolutionary Science (SEA-PHAGES) program. It was established over four years ago to offer course-based research to college freshmen and was patterned after the highly successful Phage Hunters Integrating Research and Education (PHIRE) program run by Graham Hatfull's laboratory at the University of Pittsburgh (Hatfull et al. 2006; Hatfull 2010). The SEA-PHAGES program now has been implemented at more than 70 institutions (private and public), ranging from research-intensive institutions to primarily undergraduate institutions. Currently, more than 2,000 undergraduates have gone through the program, which allows students to experience a research-intensive course because the majority of class time is spent in a laboratory.

In the fall semester of the year-long course, students isolate unique mycobacteriophages from soil samples collected on campus, and characterize their bacterial viruses using restriction digests and electron microscopy (Harrison et al. 2011; Caruso et el. 2009). Mycobacteriophages are a group of bacterial viruses that infect mycobacterial cells such as *Mycobacterium tuberculosis*, the causative agent of tuberculosis. The host that students use to isolate their mycobacteriophages is the non-pathogenic mycobacterial strain *Mycobacterium smegmatis* mc^2155. The students in the class then send purified genomic DNA isolated from one of the characterized phages for DNA sequencing to one of three HHMI-designated DNA sequencing centers.

The spring semester commences with a switch from wet-lab work to *in silico* bioinformatics analysis. During this second portion of the course, students become acquainted with DNA-annotation software upon receiving their selected phage's DNA sequence; they work in pairs to annotate sections of the genome (Harrison et al. 2011; Caruso et al. 2009). By the end of the academic year, students are well-versed in introductory-level biology skills such as aseptic technique, genomic DNA isolation, restriction digest analysis, annotation, and comparative genomics. Students also have a much greater appreciation for the process of biological research.

Overcoming Obstacles

During the entire process, from isolating mycobacteriophages to annotating a genome, students must overcome hurdles requiring trouble-shooting experiments in order to achieve their goals. During the fall semester, students find out early on that there is a fair amount of luck involved in isolating a mycobacteriophage from a soil sample. Some students obtain mycobacteriophages during the first week of class, whereas others must persist for several more weeks in order to successfully isolate a mycobacteriophage from a soil sample. Contamination is always an issue, and often students must repeat earlier steps because of sample contamination.

Thus, early in the fall semester, students already find themselves at different stages of the process of meeting the semester's research goals. During the spring semester when students are actively involved in genome annotation of one mycobacteriophage genome, students depend on one another for the successful completion of an annotation project. Students work in pairs annotating different sections of the genome and report their results to the rest of the group before the annotated genome is submitted for publication in GenBank, which is maintained at http://www.ncbi.nlm.nih.gov/genbank.

When confronted with a deadline for annotation submission before the end of the semester, students learn the importance of teamwork. They come to understand how heavily they must depend upon one another. Unexpected setbacks do occur during the annotation part of the course when Internet connections are down or the annotation software must be fixed or adjusted by bioinformatics personnel at HHMI. This adds another layer of complexity to completing the annotation task on time.

Due to the nature of the year-long, research-intensive course and the usual unexpected setbacks, students must spend additional time outside of normal scheduled laboratory periods in order to complete their research goals—with little to no guidance from course instructors. This opportunity gives first-year students the competence to work independently, but also teaches them to lean on each other for advice instead of waiting for the course instructor's input when they are trouble-shooting problems in their experiments. Learning to work on their research projects with little guidance from course instructors gives students the confidence and experience they need to undertake summer research projects. Furthermore, students come to fully realize the hard work involved in an intensive research environment and therefore have more realistic expectations of a summer research experience.

The three student authors of this article, Deborah Moran, Trevor Cross, and Donna Wodarski, had completed SEA-PHAGES in the 2011-12 academic year prior to beginning to their summer research experiences. Two of them, Moran and Cross, remained at Cabrini College and worked on independent research projects on mycobacteriophages during the summer. Wodarski won a summer internship at the University of Pennsylvania, which familiarized her with cancer genomics research in an unfamiliar environment. In the following, the three students share their personal stories of how the SEA-PHAGES experience benefited them and prepared them for additional undergraduate research opportunities.

Moran and Cross on Summer Research at Cabrini:

Participating in a summer research program after completing the SEA-PHAGES undergraduate course seemed like the logical next step in our pursuit of a four-year undergraduate education. Participating in SEA-PHAGES was a great catalyst in fostering our interests in scientific research.

SEA-PHAGES provided a challenging but structured template for conducting research in the classroom. The environment of the SEA-PHAGES course created a healthy balance between structured work and the opportunity for individual growth in scientific research. Since we did not have prior research experience, the course served as a roadmap through which we could learn techniques as a group and as individuals. The program provided enough organization to prevent confusion, but we were also given enough independence to think through protocols and comprehend them on our own.

The subsequent summer research offered an opportunity that we had been eagerly anticipating since taking the SEA-PHAGES course. Our research in the course provided the springboard that led us to ask a plethora of additional questions about the mycobacteriophages that we had isolated and studied earlier. We could also see the importance and practical application of the research as it related to the human pathogens *M. tuberculosis* and *Mycobacterium leprae*. We felt that at the end of the SEA-PHAGES course, we had just scratched the surface of what was possible in terms of phage characterization, and we desired to continue to explore this field of research. During the summer we had an actual lab that we could go to in order to conduct experiments on our own time; this was something we had always desired but never really knew was possible. True, we did work in a teaching lab as part of the SEA-PHAGES course, but now we worked in a faculty member's lab with added responsibility.

SEA-PHAGES had provided some of the formal training that we needed to complete our summer research in the lab, which left us feeling confident that we did not require as much assistance as we once had. We were able to walk in and know how to set up a phage harvest, calculate titers of phage stocks, and employ many more techniques we had learned in the SEA-PHAGES class. Since we lived on campus during the summer, it was possible to spend many hours in the lab to "get our hands dirty" and have plenty of time to really experience the process of trial and error. Working as a pair provided a wonderful support system so that we could bounce ideas and questions off each other, leading us to accomplish more than we otherwise could have without the direct intervention of our mentor.

The SEA-PHAGES course had encouraged group discussion, both at our laboratory tables and as a class, and set a foundation for the dynamics we still employ as research students. This group discussion proved to be a great learning tool, and we had honed our skills by the time the new academic year began following our summer research. Our experience over the summer proved to be very powerful; it certainly taught us that learning new techniques and being able to complete them properly takes time and patience. The SEA-PHAGES course taught us that experiments are not confined to a mere class period, but rather operate on their own time and demand both careful planning and constant maintenance—points that our summer research experience solidified.

During the SEA-PHAGES course, we and several other classmates had to come in on our own time at least once to perform some task that was time-sensitive so that our experiments would be successful. In the summer we were able to schedule other activities around our time in the lab, but the academic year did not allow such a luxury. Thus the SEA-PHAGES course taught us crucial organizational and time-management skills. For example, the SEA-PHAGES course illustrated the importance of lab notebooks, especially when we needed to trouble-shoot an experiment that did not work as planned. The notebooks that we used during the SEA-PHAGES course were crucial to our success in the summer and beyond; we still use them to refer to protocols if we have not done them for a while.

Our summer research experience, as well as the SEA-PHAGES course, affirmed our interest in science and, specifically, steered us on a path toward conducting research for the rest of our undergraduate years and into the future. The SEA-PHAGES course instilled a confidence in us by providing a structured experience in which we were free to explore individually and become familiar with the workings of a laboratory and research methods.

Wodarski on Summer Research at the University of Pennsylvania:

This generation of college students is aware of the need for experience in original research. The SEA-PHAGES course gave me a foundation of skills that I would need to conduct research in many labs, but my summer research opportunity opened my eyes to just how helpful it is to have a background in basic biological lab techniques. Qualities that I learned in SEA-PHAGES included heightened dexterity, quicker connections among concepts, and a healthy respect for the sometimes-daunting challenge of research. These qualities were a tremendous help to me as I started my summer internship.

My summer research was conducted at the University of Pennsylvania under Marcia Brose, who holds both an MD and a PhD. I explored thyroid cancer genomics. I was accepted into the program based solely upon having conducted research in the SEA-PHAGES course. This was my first lesson in learning that research experience opens other doors, even at an early stage in a scientist's career.

Upon starting my internship, I was immediately expected to master the many techniques needed for genomics research. If it had not been for the SEA-PHAGES course, I know I would not have been as capable of acquiring these skills. It was a process that consisted of using the skill-set I developed in the course as a baseline and then building upon it. For example, in any procedure, even the most seasoned researcher will be faced with setbacks. A major part of the SEA-PHAGES course was applying the critical-thinking abilities necessary to address these setbacks. This was very useful when I was determining the cause of a contamination problem.

Another tremendous advantage of the course was that it helped me develop the habit of documentation. I cannot count the number of times I was commended for keeping a neat, detailed notebook that allowed easy review when it was necessary for others in the lab to do so. Furthermore, while familiarizing myself with new procedures, I started to see why the methods I used for phage experiments had to be modified in certain ways to work with human blood samples, thus deepening my understanding of cell biology. The internship was possibly the most enlightening experience in any field of science that I ever encountered because it exposed me to how vast scientific knowledge really is and how multifaceted a researcher's background must be for success. Learning those two concepts were milestones in my development as an undergraduate researcher. I am certain that the SEA-PHAGES course fostered my success as a researcher because it allowed me to make the most of my internship.

Conclusion

The SEA-PHAGES course at Cabrini College proved to be full of benefits for the three undergraduate authors of this article. The course gave them more confidence in the laboratory and permitted them to continue to conduct research throughout their undergraduate careers. Through the discovery-based SEA-PHAGES laboratory course, students learned that creativity, patience, and experience are integral parts of the scientific process. The students were also able to obtain summer research experiences because of the SEA-PHAGES course. In the case of Moran and Cross's summer research experience, their comprehension of the SEA-PHAGES course material and the prospect of acting as peer mentors for the following semester deepened their interest in research. Wodarski's experience in the SEA-PHAGES course helped her secure a prestigious internship at the University of Pennsylvania because she had a foundation in research from which she could further grow professionally.

The information obtained by the students following their course-based research experience assisted them in subsequent classes at Cabrini College and provided skills that can be used in many disciplines. Not only did SEA-PHAGES give the students a strong background in bacteriophage research, but the concepts and protocols used were transferable to several other courses at Cabrini. In the microbiology laboratory, for example, students learn to plate samples on Petri dishes, a technique used often in the SEA-PHAGES course. The *in silico* portion of the course proved useful in genetics and bioinformatics classes. In genetics, students learn about data-

base storage of sequenced genomes and the central dogma: DNA makes RNA makes protein. Both topics were covered in great detail in the SEA-PHAGES course. The bioinformatics course focuses on the use of genome-annotation software with a fruit fly genome, as part of the Genomic Education Partnership (GEP) program (Shaffer et al., 2010), and SEA-PHAGES students have experience with gene annotation.

The course also taught the students that trouble-shooting is a critical component of the scientific process—allowing them to witness the process alongside their mentors and professors. The ability to trouble-shoot is an indispensable tool in any scientific environment, and the thought process involved can be applied to a multitude of situations not necessarily limited to science. The experience provided by this course-based research experience was and will continue to be invaluable to the students' current and future research endeavors.

We have learned several lessons from SEA-PHAGES that should be applicable to science departments considering offering freshman-level, course-based research. First and foremost, students agree that ownership of project results is a strong motivating factor for course-based research projects. For the SEA-PHAGES course, students get to name their unique mycobacteriophage and submit their phage properties to www.phagesdb.org in order to share them with the greater scientific community. Students are also required to send a phage extract of their unique mycobacteriophage to the University of Pittsburgh Bacteriophage Institute for archiving for future research purposes by any interested laboratory. Even students who experience few setbacks in isolating their mycobacteriophage are motivated to learn more about its properties by doing additional experiments outside of normal laboratory time, so that they can understand and post additional properties on www.phagesdb.org. Students are more motivated and excited to be part of a project that is shared and valued by the greater scientific community.

Another lesson learned by students successfully completing SEA-PHAGES is that they no longer view research as something that can only be undertaken by more advanced or accomplished students with a stronger knowledge base. They gain the confidence to conduct and trouble-shoot experiments on their own. Students' perceptions of the somewhat "mystical" nature of research are removed when they become more involved in the research process. One of the student authors, Cross, admitted that the SEA-PHAGES program gave him confidence that he could have a successful scientific career even though he struggled in several of his previous high-school science courses.

Cross believes that without the research experience, he would have many more doubts that he could be good in science and probably would have switched majors by now. Thus he presents an excellent example for departments of the importance of having all students engage in a research-intensive experience earlier rather than later in their undergraduate careers. A positive early research experience, whether in the classroom or outside of it, might be the motivation that students struggling with the content of their initial disciplinary courses need in order to convince them to persevere and succeed within their chosen majors.

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David Dunbar

Cabrini College, dunbardavid75@gmail.com

David Dunbar is an associate professor of biology at Cabrini College. He teaches bioinformatics, cell and molecular biology, genetics and heredity, watershed ecology, and the SEA PHAGES course. Dunbar has an active undergraduate research laboratory in which he currently studies mycobacteriophage proteogenomics.

Trevor Cross is a junior at Cabrini College working towards a bachelor's degree in the biological sciences with plans to earn minors in chemistry and Spanish. He currently does research in David Dunbar's laboratory and is a classroom coach for introductory biology laboratory classes.

Deborah Moran is a junior at Cabrini College studying biology, with a concentration in biotechnology and molecular biology. She continues to do research in David Dunbar's laboratory, which is investigating mycobacteriophage proteogenomics. She will continue to act as a classroom coach for the introductory biology laboratories during the 2012-13 academic year.

Donna Wodarski is a senior at Cabrini College studying biology, with a minor in environmental science. She is researching epigenetics and Alzheimer's disease for her senior thesis and is currently conducting phage-annotation experiments in David Dunbar's laboratory.

Melinda Harrison is an assistant professor of chemistry at Cabrini College. She currently teaches courses in introductory chemistry, biochemistry, and analytical chemistry, as well as the SEA-PHAGES course. Harrison has an active undergraduate research laboratory in which her group studies various metals in biology at the cellular level and via computational modeling.

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New CUR Book!

Faculty Support and Undergraduate Research: Innovation in Faculty Role Definition, Workload, and Reward

Nancy H. Hensel and Elizabeth L. Paul

American colleges and universities, and many international institutions, are embracing undergraduate research as a powerful learning pedagogy across all disciplines and all types of institutions. Faculty and administrators have firsthand experience in observing the transformative power of undergraduate research. Though many professors consider mentoring undergraduate researchers a central part of their faculty role, finding time to work with these researchers is a major concern. Even with administrative commitment to undergraduate research, institutions find it challenging to fund reassigned time for faculty or provide courses that support undergraduate research. And there is often significant controversy about whether and how faculty engagement in undergraduate research should be rewarded in reappointment, promotion, and tenure decisions. The authors in this book discuss many aspects of providing support for faculty who involve undergraduates in research. It is the editors' hope that this book will inspire and encouragement to administrators and faculty to design solutions to these challenges that can be integrated into campus practices and cultures.

"These thoughtful essays, by faculty members and administrators who have had extensive experience in the use of undergraduate research, address in practical ways the benefits and challenges of this technique for improved teaching and learning. Rather than speak only to the increasing popularity of this pedagogy, the essays address faculty members where they live—balancing concern with helping students with aspirations to carry out significant research—and provide institutions with cautionary guideposts as they work to encourage this practice. The book will be a valuable guide for both institutional newcomers in encouraging faculty/student research projects and colleges where the practice is already flourishing."- Richard Ekman, Council of Independent Colleges

"There is ample evidence for the unique learning and developmental gains students realize through participation in undergraduate research and other high impact practices. The essays in this volume take the important next step of addressing the challenges inherent in integrating these practices into the curriculum, not least of which are the implications for faculty roles and responsibilities." -Simon Gray, Program Officer, Great Lakes Colleges Association

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CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

Undergraduate Research: I Am Not Sure What It Is, But I Don't Have Time to Do It Anyway

Michelle Vieyra, Alison Carlson, Echo Leaver, *University of South Carolina Aiken*
Briana Timmerman, *University of South Carolina, Columbia*

Introduction

According to the National Science Board (2010), a shortage of professionally trained scientists persists in the United States. One factor that contributes to this shortage is the continuing underrepresentation of women and minorities in the sciences (Margolis and Fisher 2001; Preston 1994). It has been reported that although a similar percentage of Caucasian and African-American students begin college planning a science major, the attrition rate is much higher for minority students than for non-minority students (Busch-Vishniac and Jarosz 2007; Maton et al. 2000; Seymour and Hewitt 1997) A substantial body of evidence suggests that students who participate in undergraduate research are more likely to be retained in science majors to graduation. This finding is especially pronounced for students from underrepresented groups (Bauer and Bennett 2003; Foertsch et al. 2000; Nagda et al. 1998; Summers and Hrabowski 2006). Participation in undergraduate research has been shown to produce higher graduation rates for African-American science majors as compared to peers who do not participate (Nagda et al. 1998; Summers and Hrabowski 2006). Participation in undergraduate research also has been shown to increase retention in science fields after graduation (Bauer and Bennett 2003). A study by Foertsch et al. (2000) found that 75 percent of African-American students who participated in an undergraduate research program continued on to graduate school, compared to only 8 percent of those who did not participate.

Undergraduate research experiences improve science retention for many reasons. Students who have participated in undergraduate research report an improvement in many skills that help them to be better scientists, including oral communication and scientific writing (Bauer and Bennett 2003; Hunter et al. 2007; Kardash 2000; Seymour et al. 2004). In addition, these students report increases in confidence and self-efficacy, intellectual curiosity, and the ability to think like a scientist (Bauer and Bennett 2003; Hunter et al. 2007; Kardash 2000; Russell et al. 2007; Seymour et al. 2004). Many students also report that undergraduate research experiences increase their interest in attending graduate school (Russell et al. 2007). Similar improvements in skills and abilities have been cited by students at the University of South Carolina Aiken, a university that requires all of its biology majors to complete a research project (Vieyra et al. 2011), suggesting that even students who would not voluntarily participate still benefit from an undergraduate research experience.

Regardless of the many benefits, the majority of science undergraduates do not participate in research. The National Survey of Student Engagement estimates that only around 40 percent of biology majors participate in research (American Council of Learned Societies, 2007). Russell et al. (2007) surveyed students who did not conduct research and found that many chose not to engage in undergraduate research due to lack of time, interest, opportunity, or knowledge of opportunities. Additionally, Vieyra et al. (2011) found that African-American females are even less likely to participate in research than their Caucasian peers. In an alumni survey at USC Aiken all Caucasian students indicated that they had at least considered participating in research before knowing about the requirement. In contrast, only 20 percent of the African-American females said that they would have considered participating in research if it had not been required. A review of course enrollments for biology students at this university from the last three years corroborated this disparity. Only 9 percent of the African-American students participated in research for longer than the required semester, while 49 percent of the Caucasian population participated in two or more semesters of research.

Why are some students, particularly African-American females, less likely to seek out research opportunities? A study we conducted investigated student perceptions of the nature of research, confidence in being able to do research, and attitudes towards participation in research. Based on previous studies , it was hypothesized that minority students, particularly minority females, would have more misconceptions about or negative perceptions of research and would express less willingness to participate.

Research Methods and Design

This study was conducted at USC Aiken, a small public baccalaureate university with a required senior semester of research integrated into the biology curriculum. Paper surveys were administered to all biology majors enrolled in introductory biology in the fall of 2011. The surveys were handed out to the students by their laboratory instructors in the second week of fall classes. The students were not required to complete the survey nor were they compensated for doing so but participation was above 95 percent. These

anonymous surveys included seven open-ended questions designed to gather basic demographic information on ethnicity, sex, and family educational history, and to evaluate knowledge, interest, and perceptions regarding the research requirement for biology majors. The survey included the following questions:

1) Are you male or female?
2) What race or ethnicity do you consider yourself to be?
3) Were you the first person in your family to go to college? Did your parents go to college?
4) Why did you choose biology as a major? For how long have you been interested in biology?
5) Are you aware that all biology students getting a BS degree have to conduct a research project for at least one semester?
6) When you hear the phrase "research project" what comes to mind? What do you imagine you will have to do?
7) If you were not required to do a semester of research, do you think you would do it as an independent study project?
8) Do you like the idea of doing a research project? Why or why not?

One hundred and six completed surveys were collected and reviewed, and the responses to each question were compiled and examined for overall themes. Seventy percent of respondents were female, and 38 percent were minority. At this institution, 67 percent of students over all are female, and 32 percent are minority, so the survey respondents were broadly representative of the student body. Using a small, random subset of surveys, taxonomies were created by two survey reviewers by categorizing responses to each survey question. The coding scheme was then reviewed for internal consistency; codes that were not mutually exclusive or that failed to provide sufficiently unique information were combined, and new codes were added when needed. Surveys were then coded independently by the two reviewers. Agreement in coding was higher than 98 percent, and the few areas of disagreement were resolved by discussion between the reviewers (Johnson et al. 2000; Johnson et al. 2005). After all survey responses were coded, the frequency of each code was computed. This process of quantifying qualitative data assisted in identifying patterns in the data and maintaining analytical integrity (Teddlie and Tashakkori 2009).

Survey Results

Willingness to participate in undergraduate research. Analysis of the completed surveys indicated that 41 percent (43 out of 106) of the new biology majors reported that they would likely participate in an independent research project even if the semester of research were not a graduation requirement. This is consistent with national survey data regarding the number of students who actually do a research project (American Council of Learned Societies 2007). As shown in Figure 1, considerable discrepancies existed among the various demographic groups, however. Forty-five percent (14 out of 31) of the male respondents indicated that they would participate in elective independent research. In contrast, 39 percent (29 out of 75) of the female respondents indicated that they would elect to participate in research.

There was little difference in willingness to engage in independent research between minority and non-minority male respondents, (44 percent of the Caucasian males and 46 percent of minority males reporting that they would participate in an independent research project). Differences between female Caucasian students and female minority students were readily apparent, however. Nearly half (48 percent) of Caucasian female respondents would elect to participate in independent research, compared to only 22 percent of minority females. No significant differences were found between the two male groups (χ^2 p = 0.484) or the two Caucasian groups (χ^2 p = 0.412). However, analysis of the two female groups showed a significant effect of minority status on willingness to participate in research, (χ^2 p = 0.04). These results support the earlier findings, based on enrollment in independent study courses, that minority female students are less likely to participate in undergraduate research (Vieyra et al., 2011).

Figure 1 shows the percentage of freshman biology students, by demographic group, who would elect to participate in an undergraduate research project regardless of institutional requirements. No significant differences were found among males. Female attitudes varied by minority versus non-minority status at p = 0.04.

Attitudes towards research in general. Although only 41 percent of the respondents reported an interest in participating in research, 61 percent (65 out of 106) reported feeling favorable about doing a research project in general. As shown in Figure 2, there were differences among the demographic groups in their attitudes towards research. Sixty-eight percent (21 out of 31) of the male respondents reported feeling favorable towards a research project in general, while 59 percent (44 out of 75) of the female respondents felt similarly.

Figure 1. Desire of Freshman Biology Students to Participate in Research If Not Required

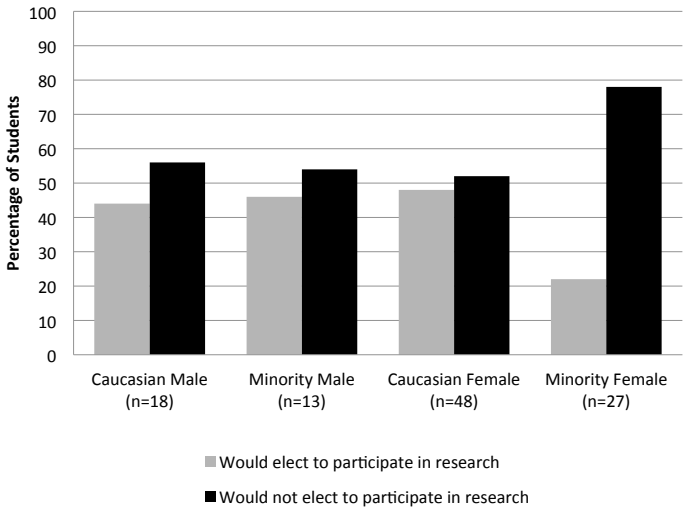
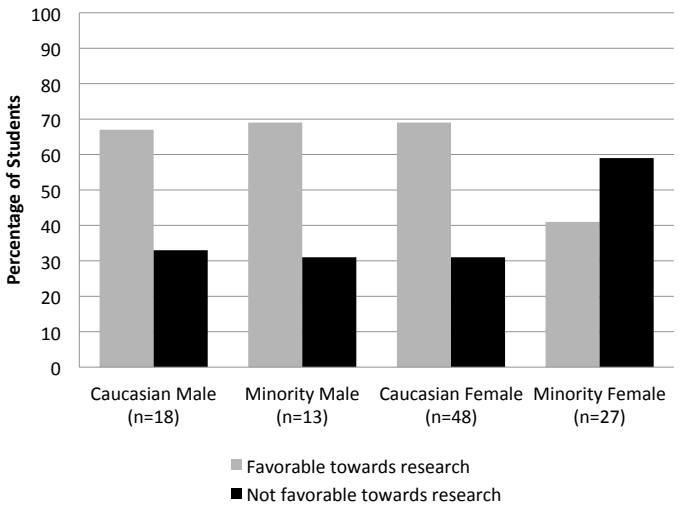


Figure 2. General Attitudes Toward Conducting Research Among Freshman Biology Students



Males differed little by racial group in their attitudes regarding research. Sixty-seven percent of Caucasian males reported favorable feelings towards research, while 69 percent of minority males reported similar feelings. As with interest in participating in research, however, differences between female Caucasian students and female minority students were readily apparent. Sixty-nine percent of Caucasian female respondents had favorable feelings towards the idea of a research project, compared to only 41 percent of minority female respondents. Differences between Caucasian female and minority female attitudes towards research were significant, χ^2 $p = 0.03$.

Interest in participating in research and attitudes about research were correlated, with 71 percent of the respondents reporting either that they felt favorable towards research and were interested in doing research or that they had negative feelings about research and were not interested in participating. Twenty-five percent reported that they had a favorable opinion about doing research but would not choose to participate. Four percent stated that they did not have a favorable opinion of research but would elect to participate anyway.

Factors in not wanting to participate in undergraduate research. One reason that has been cited for lack of participation in undergraduate research is students' not being aware of research opportunities (Russell 2007). Many (45 percent) of the students surveyed in this study were not aware that they were required to participate in research as part of their major. Within demographic groups, only 37 percent of minority female freshmen reported that they were aware of the requirement, compared to 58 percent of the Caucasian females, 61 percent of the Caucasian males, and 77 percent of the minority males. Awareness of the requirement may be correlated with interest in participation since 40 percent of the minority females who were aware of the requirement said they would elect to participate even if it were not required, compared to only 12 percent of those who were not aware of the requirement.

Reasons reported for not wanting to participate in a research project included lack of interest, a perceived lack of time, low self-confidence, confusion about what research is, and negative past experiences with research. The following were among the responses to the survey question "Do you like the idea of doing a research project? Why or why not?":

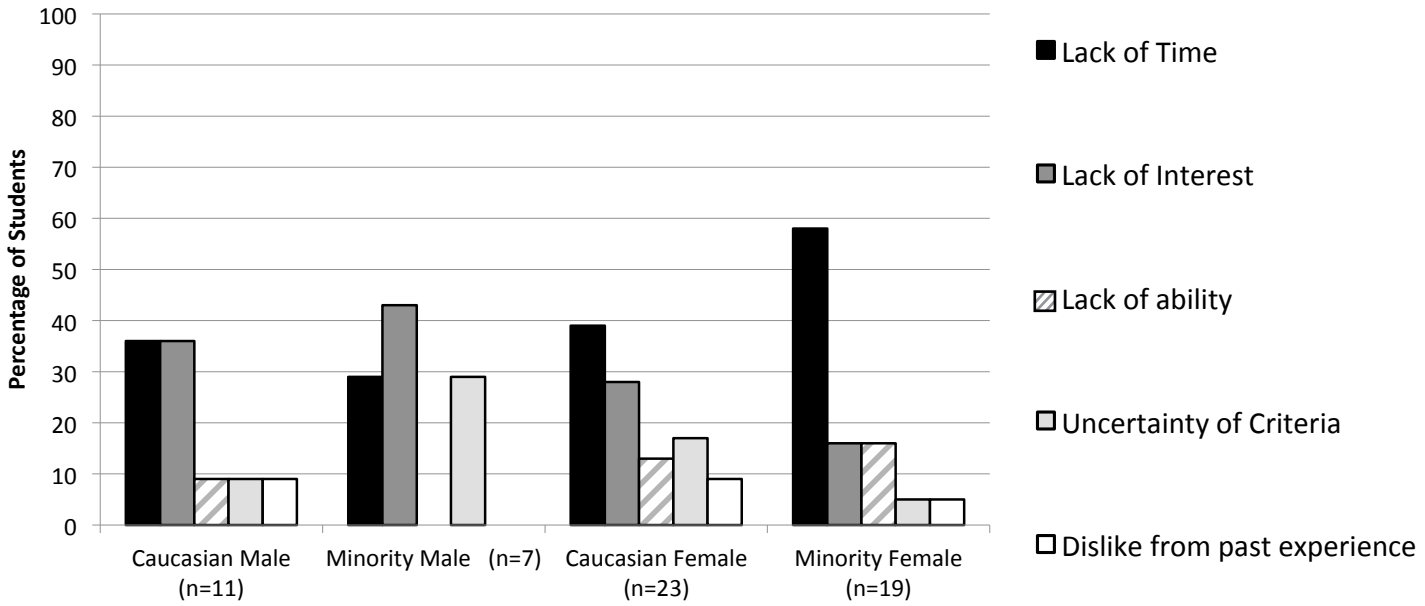
> "No. I would probably forget about it or screw it up."
>
> "No because it is one more thing on top of the countless other things that have to be done."
>
> "No because they take a lot of time"
>
> "No because I hate the science fair and it reminds me of that."
>
> "I was never good at science fairs in high school."
>
> "No because I am not sure what it would entail."
>
> "No because it would be boring."

As seen in Figure 3, the most common reasons given by freshman biology students for not wanting to participate were a perceived lack of time or interest. In addition, some of the female students in both demographic groups, and one Caucasian male, indicated that they doubted their competency for performing research or developing a research model. Some of the students also listed bad experiences with research in high school or confusion about what research would entail. Lack of self-confidence may account for a slightly lower percentage of females who would elect to participate in research as compared to males, but this does not account for the large difference between minority and Caucasian females. Lack of time seemed to be the biggest concern among minority females, with 58 percent citing that to explain why they would not engage in research, compared to fewer than 40 percent of respondents in all other groups. Lack of time was the primary reason cited by minority females for not wanting to conduct research, with all other reasons cited 15 percent or less of the time. In contrast, the three other demographic groups cited lack of interest at similar rates to lack of time as reasons for not wanting to participate in research.

Another factor that might bias a student against participation in an undergraduate research project is confusion or uncertainty about what that project actually entails. Answers regarding what a research project would entail fell into four categories: (1) research conducted in the library culminating in a research paper, (2) "science fair projects," (3) experiments involving hypothesis formation, testing, and/or data collection; and (4) no clear idea. Differences among the frequency of these answers within the various demographic groups were found to be significant, χ^2 $p = 0.009$ (Figure 4). Given that "experiments involving hypothesis formation and testing" is a fairly clear and accurate perception of college-level research, all other categories were combined and the frequency of a clear idea of research versus misconceptions about research were compared. Having a clear understanding of research was found to be significantly different among demographic groups, χ^2 $p = 0.001$.

While the idea of writing a research paper was not intrinsically distasteful to the majority of students who perceived research as involving that, fewer than half of these students reported the desire to participate. Of the students who identified research as primarily a writing assignment, 61 percent said they liked the idea of doing a research project, while

Figure 3. Reasons Cited by Freshman Biology Students for Not Wanting to Conduct Research



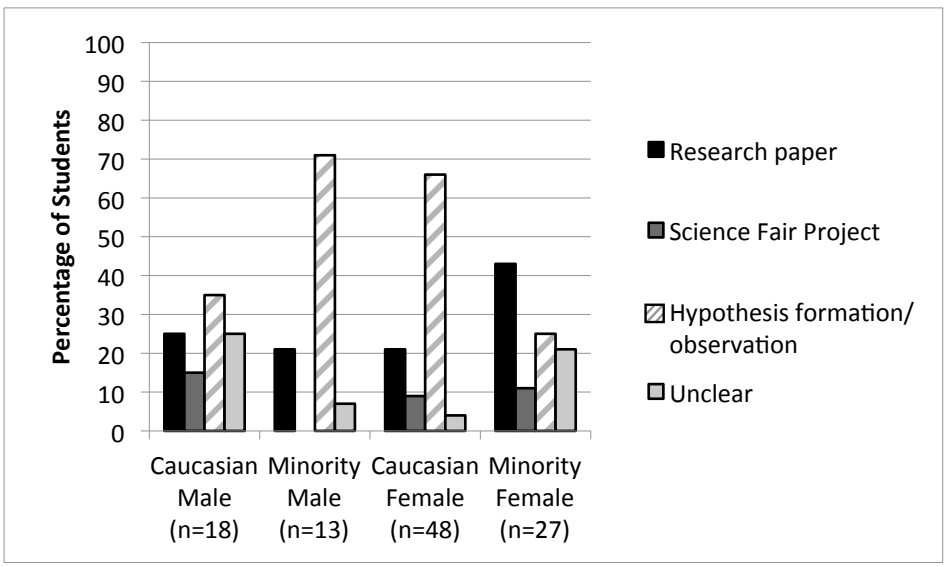
only 36 percent said they would elect to participate. The most common reason cited for this was lack of time (45 percent). Many minority females (43 percent) thought that they would be conducting "library research" and/or writing a paper if they participated in research, a disproportionate number compared to the other groups, in which between 21 percent and 25 percent of respondents defined research as library research or writing a paper. Misconceptions about research, coupled with a perceived lack of time, may discourage some minority females from pursuing research opportunities.

Having a clear and accurate understanding of what a research project would entail seems to be correlated with increased interest in participating in an undergraduate research experience. Seventy-seven percent of the students who mentioned hypothesis formation and/or observation and data collection liked the idea of doing research, and 44 percent of these students reported that they would elect to participate, higher than the levels described above for students who thought research was a library project. Caucasian females and minority males seemed to have a very clear sense of what a college-level research experience entails, with over 65 percent of each demographic group mentioning hypothesis formation and/or observation and data collection (Figure 4). In contrast, only 25 percent of minority females and 35 percent of Caucasian males had an accurate perception of research. This lack of accurate perceptions of the nature of research is particularly troubling in regard to minority females, as they cite a lack of time as their primary obstacle. Having an accurate understanding of undergraduate research may also turn some students away, however. Revealingly, most (67 percent) of the students who doubted their ability to do research and 58 percent of the students who cited lack of time as a factor did have accurate perceptions of what research is.

The majority of students who perceived undergraduate research as "a science fair project" responded very negatively to participation in research. It was unclear what these students think a science fair project entails or whether this was synonymous with hypothesis formation and testing but, regardless of demographic group, 87.5 percent of the students who identified research as a science fair project said that they would not elect to conduct research in college and did not like the idea of doing it. This raises questions about why the science fair experience is perceived so negatively by students. Several Caucasian males (15 percent), Caucasian females (9 percent) and minority females (11 percent) described research as "a science fair project."

Caucasian males and minority females were also most likely to report being unsure about what research is. Only 38.5 percent of students who report being unsure about what research is said they would elect to do research and liked the idea of doing it.

Figure 4. Varying Perceptions Among Freshman Biology Students About the Nature of Research



Differences in conceptions about the nature of research varied significantly by demographic group (p = 0.009). Differences in having a clear idea of the nature of research versus misconceptions also varied significantly by demographic (p = 0.001).

Interest in undergraduate research related to career goals. Students' motivation for pursuing a science degree may not factor very heavily into their interest in conducting research. Students' answers for why they elected to declare a major in biology fell into five categories: (1) pursuing specific medical career (doctor, dentist, pharmacist, or veterinarian); (2) general interest in science or biology; (3) love of or interest in animals, nature, or the environment; (4) perceived marketability without a specific career indicated; and (5) high-school performance in science classes. Reasons for majoring in biol-

ogy did not differ significantly between Caucasian and minority females, with the majority of students (65 percent overall and 71 percent of females) reporting an interest in a medical career. While students who major in biology due to a general interest were the most likely to report liking the idea of doing research (73 percent compared to 65 percent of those pursuing a medical career and 56 percent of those who like animals or nature), they were no more likely to report wanting to participate than other groups (45 percent compared to 44 percent of those who wish to pursue medical careers and 45 percent who like animals or nature). Interestingly, while only 25 percent of the students who pursue biology due to the marketability of the degree liked the idea of doing research, 50 percent of them said they would participate in a research project.

Conclusions

Previous studies (Bauer and Bennett 2003; Foertsch et al. 2000; Nagda et al. 1998; Summers and Hrabowski 2006) provide significant evidence for the benefits of undergraduate research participation, particularly for groups who are historically underrepresented in the sciences. Undergraduate research may be a powerful means for increasing the number of students retained in the sciences, so measures must be taken to increase the number of students who participate. Unfortunately, minority females, the group most underrepresented in the sciences, appear to select least often to participate in research.

Across nearly all survey questions, minority females responded differently from Caucasian females and both male groups, suggesting that the combined influence of race and gender was impacting these students' experiences, rather than either factor alone. As this institution is predominately female (67 percent) with a high percentage of minority students (32 percent)—and the portion of biology majors and the demographic breakdown of the course in which the respondents were enrolled were representative of the institution—it seems unlikely that these differences are due to a lack of a sense of community or of belonging on campus (Rizzuto et al. 2009). In contrast, minority males made up only 12 percent of the students in the freshman biology course but did not appear to feel differentially isolated or to lack a sense of community since their responses mirrored those of Caucasian students.

These results lead to the key questions: Why are minority females less research-oriented and what can institutions do to increase their participation in undergraduate research?

Perplexingly, compared to all other student groups, minority females were significantly less aware of the research requirement, more often (mis)perceived research as an extended library-based paper, and more frequently expressed a dislike of research. Yet their major motivation for not participating was a perceived lack of time rather than a lack of interest, ability, or understanding.

It is not clear why significantly fewer minority females were aware of the research requirement compared to their peers. The requirement is discussed at freshman orientation and is printed in the manual given to the students at registration. Required research does not occur until senior year, however, so it is possible that students with less interest in participating in research are less likely to pay attention to a discussion of future requirements related to research. Lack of attention to a discussion of research requirements could reflect an overall lack of attention to announcements of research opportunities on any campus. If minority females are less likely to pay attention to research opportunities, then measures must be taken beyond simply announcing opportunities in the classroom or putting up fliers in hallways. Announcement of research opportunities must include discussion of how and why these opportunities will personally benefit students, with emphasis placed on particular career applications. Further, efforts should be made by advisors and instructors to discuss research opportunities with students one-on-one and to relate research benefits to their specific career goals. The first step in increasing minority female participation is making sure that they are aware of research opportunities at their institution and that they realize how beneficial these opportunities can be for them personally.

Minority females had the highest rates of misconceptions regarding the nature of research, with their major conception being that research was mostly conducted in the library, similar to a paper they would do for a class. A lack of self-efficacy is often cited as a source of attrition from STEM majors (Leslie et al. 1998). It is possible that concerns related to writing ability, difficulty accessing or understanding professional scientific writing, or bad experiences with writing in the past could be contributing to this group's lack of interest in research. Despite the misconception as to the nature of research, writing is a critical component of the research experience (Yore et al. 2002; Yore et al. 2004). Therefore, it is important that students' possible concerns regarding writing be explored further and efforts made to improve scientific writing across the science curriculum. More time must be spent in the classroom discussing, modeling, and practicing how to find and interpret primary literature, how to properly use and cite it, and how to structure a scientific paper. If students become more confident in their ability to read and write about science in their freshman and sophomore science classes, more of them may become less fearful of participating in the scientific process.

Since undergraduate research is about much more than writing, however, to correct misconceptions regarding how

research is conducted, efforts should be made to introduce science majors to the research being conducted at their institution. We recommend that time be allocated in freshman science classrooms to specifically discuss research being conducted by students on campus. Personal relevance is often a critical factor in motivation to engage in new experiences (Glynn et al. 2009). If faculty familiarize themselves with what undergraduates are doing in labs in their departments and discuss this research in the context of the course material, it could improve interest and participation in undergraduate research. Students, particularly underrepresented students, could be invited to discuss their research with their peers in the classroom, and departments could host student and alumni research seminars. By placing an emphasis on what undergraduates are doing across the institution, there could be fewer misconceptions regarding the nature of undergraduate research, and students might feel more confident in their ability to participate.

Minority females cited a lack of time almost twice as often as the other demographic groups for wishing to avoid research—indeed they cited lack of time as an obstacle more often than all other reasons combined. We initially hypothesized that this perceived lack of time might be due to minority females more often being first-generation college students, with a corresponding need to be employed (Fischer 2007), but they reported the lowest rate of first-generation enrollment (22 percent compared to 28 to 35 percent of the other demographic groups). Indeed, of the students who cited a lack of time as their major reason for not participating, only 37 percent were first-generation college students. Among first-generation students, white males were actually the most frequent demographic (43 percent), followed by white females (29 percent), further suggesting that first-generation status is not a major contributing obstacle to minority females engaging in research.

One limitation of this study is the ambiguity inherent in the phrase "I don't have time for research." It is possible that this expresses a lack of perceived value in doing research rather than an actual lack of time. If the perceived lack of time is really a failure to see value in the research experience, early efforts to inform students about undergraduate research opportunities and activities on campus and the benefits that students receive from these activities, as discussed previously, would help reduce misconceptions about the value of participating in research. Even if efforts are adopted to dispel misconceptions and increase interest in research participation, determining why minority females perceive themselves to be "too busy" to engage in research could provide valuable insights to this challenge. Accurate views of the nature of research and its benefits will not improve participation if minority females truly lack time to participate. If time is truly a factor, funding to support research stipends may be needed to assure equal participation in and benefit from undergraduate research.

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Michelle L. Vieyra

University of South Carolina Aiken, michellev@usca.edu

Michelle Vieyra is an assistant professor in the Department of Biology and Geology at the University of South Carolina Aiken. She serves on the Curriculum Assessment Committee and chairs the Recruitment and Retention Committee for her department. Her research interests include sensory biology and nutrition, and she has mentored thirty undergraduates conducting research projects in the last five years. Her research focus has recently also included quantifying the benefits of participation in undergraduate research experiences and how freshman perceptions of science and research correlate with retention and success in a science major.

Alison Carlson has a master's degree in hospital administration and is an undergraduate nursing major at the University of South Carolina Aiken. She has assisted Dr. Vieyra with several science-education research projects and worked as a student assistant in Vieyra's biology classes. She has also been a tutor and supplemental instruction leader for several science and math courses and has an interest in strategies for improving student success.

Echo Leaver is an assistant professor of psychology at the University of South Carolina Aiken. She teaches courses in neuroscience, statistics, and research methods and coordinates an interdisciplinary neuroscience learning community at the university. Her research interests include brain imaging and cognitive aging, and she has mentored thirty-two undergraduate research projects.

Briana Timmerman is a visiting research associate professor at the Center for Advanced Study of Teaching and Learning in Higher Education at the Curry School of Education at the University of Virginia. Prior to that she was assistant vice president for research and graduate education at the University of South Carolina in Columbia and associate dean in the South Carolina Honors College, where she oversaw the undergraduate research program for all disciplines. She also holds a research associate professorship in the Department of Biological Sciences at USC Columbia. Her research areas include investigating how students gain research skills (as evidenced through students' scholarly writing) and the impact of peer review, inquiry-based teaching, and other common graduate and undergraduate experiences on the transformation of students into practicing scholars.

CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

Improving Student and Parental Perceptions of Faculty Research Via an Event Showcasing Faculty Research

David F. Nichols, Julie S. Lyon, *Roanoke College*

Roanoke College is a classic liberal arts college in Salem, Virginia, with ambitions to become one of the top 100 liberal arts institutions in the country. While our focus has been and will always be on teaching, faculty are proud of their research accomplishments and are committed to mentoring undergraduate research and other firsthand learning opportunities. In order to increase students' participation in research with faculty, a group of junior faculty members who are focused on raising awareness of faculty research activity held a "Faculty Research Showcase" in spring 2010. Our assessment of the results informed the development of a second, larger event held during Family Weekend in fall 2010, called the "Faculty Showcase" (which we hoped would be more inclusive of both research and creative work). This article documents the impact of these events on student and parental perceptions of faculty research, discusses lessons learned, and encourages other colleges to consider similar events as a way to involve more students in undergraduate research.

Context

Roanoke College enrolls about 2,000 students, of whom approximately 300 currently collaborate on research with faculty members. While students' involvement in research has steadily increased in recent years, an informal group of junior faculty (known as the Junior Faculty Research Colloquium or JFRC) believed that a lack of student awareness of faculty scholarship prevented some students from considering collaborating on research with faculty. Additionally, tenure and promotion standards changed two years ago, making research productivity in the form of journal or book publications and conference presentations an explicit component of tenure and promotion criteria.

In this context, JFRC hosted a "Faculty Research Showcase" for the first time in spring 2010. While the event was open to everyone, promotion largely focused on faculty and college administrators, with personal contact, announcements at faculty meetings, and emails. Advertising for students consisted of posters in buildings with classrooms and announcements in the classrooms of some of the faculty who were participating. This event primarily entitled faculty at all levels to present a research poster, though a few faculty members presented their work using other methods such as sitting at a table with their published books or showcasing a web-based project on a small collection of laptops. Most of the research presented was recent, although this was not a requirement. The event was intended to increase students' awareness of the quality of faculty research, as well as to encourage students to participate in undergraduate research.

Due to the perceived success of the first event, the dean asked the event's organizers to host a similar event (a "Faculty Showcase") over our Family Weekend in October 2010. The Faculty Showcase included more types of faculty professional life (note that "research" was removed from the title of this second event). Additional presentation modes were included, such as slides projected on a large screen, short poetry/narrative readings, and a display of paintings. At both of these 2010 events, voluntary surveys were completed by the attendees, which included students and faculty at the first event, and, additionally, a substantial number of parents at the second event.

Survey Results

Voluntary surveys were distributed to all attendees at the events. Respondents did not have to provide their names. Although exact attendance figures for the two events are not available, we believe that surveys were collected from the vast majority of student attendees at the first event, a majority of student attendees at the second event, around half of the parent attendees at the second event, and a majority of the faculty and administrator attendees at both events. Surveys were distributed and collected by student volunteers who were stationed at a table outside of the room in which the events were held. The surveys were approved by Roanoke's Institutional Review Board prior to the events.

The actual surveys used for the first and second events can be seen in Figure 2 and Figure 3, respectively. Therefore, just a summary of the surveys will be presented here. For the first event, all attendees received the same survey, and they were asked to indicate if they were faculty, staff, student, or other; for the second event, there were separate surveys for students, parents, and school affiliates (i.e. faculty/staff/administrators). Questions assessed the effectiveness of the event itself, including changes in student impressions of faculty research, enjoyment of the event, and open-ended questions seeking information on what was learned and

feedback for future events. We also asked students to rate the likelihood that they would participate in research in the future, although because the surveys were anonymous, we have no way of tracking whether student attendees' behavior was altered by the event.

For the second event, held over Family Weekend, our surveys again focused on changes in student perceptions of faculty, but we also asked parents for their impressions and changed the wording from "research" to "research/creative work" in order to include all types of faculty scholarship represented at the event. Also, students were asked whether or not they attended the Faculty Research Showcase the previous spring, as we were concerned that responses might differ for students who had previously attended (that is, it might be less likely for the second event to lead to a change in impressions). We also sought a sense of whether the data we gathered were from different students or largely the same group of students.

Students' Responses.

A total of 75 students completed the surveys, with only three students at the second event (all of whom were involved in research with faculty) indicating that they also attended the first event. The students were from a broad range of majors, although science and social-science students predominated. They were also relatively evenly distributed across the ranks of undergraduates (27 percent were freshmen, 30 percent sophomores, 24 percent juniors, and 19 percent seniors), although the percentage of freshmen jumped from 6 percent to 43 percent at the second event, likely due to the involvement of students attending with their parents over Family Weekend for the second event.

The change in students' impressions regarding faculty research/scholarly activity were determined by asking students for their impressions before and after the event, on a 5-point scale from very negative (1) to very positive (5). Impressions among students coming into the event were generally positive regarding faculty members' research or creative activities; across both events, only 1 percent were negative (1 or 2), 35 percent were neutral (3), and 64 percent were positive (4 or 5). Importantly, students reported that their impressions of faculty work had improved substantially following the event. Across both events, post-event impressions indicated that 0 percent of students reported having a negative impression (1 or 2), 4 percent were neutral (3), and 96 percent were positive (4 or 5). The effect that the event had on the impressions of the students is also reflected in some of the open-ended student comments, many of which expressed surprise that so many faculty members were involved in research and noted that they learned about particular topics.

We also wanted the event to be enjoyable as we believed this would indicate a positive impression of research and encourage students to promote the event to their friends in the future. We were pleased that 91 percent of students reported that they enjoyed the events.

The survey for the first event also included questions about whether students were currently involved in research and how this event changed their likelihood of doing research with a faculty member in the future—less likely (1); equally unlikely (2), i.e. were unlikely to be involved in research before the event and are still unlikely; equally likely (3), i.e. were likely to be involved in research before the event and are still likely; more likely (4). While only 6 of 33 student attendees at the first event (18 percent) were currently involved in research, 38 percent of students indicated they were more likely to get involved in research following the event. Of the students who were not currently involved in research, 71 percent indicated that they were equally or more likely to be involved in research following the event. Unfortunately, we were not able to track whether students' behavior followed their intentions because the surveys were anonymous. We did not ask this question in the survey for the second event because we chose to focus on students' impressions of faculty research.

Parents' Responses

While the focus of the events was to encourage student/faculty and faculty/faculty interactions, an added bonus of holding the second event over Family Weekend was the possibility for parents also to be involved, providing them an opportunity to interact with faculty members and learn new

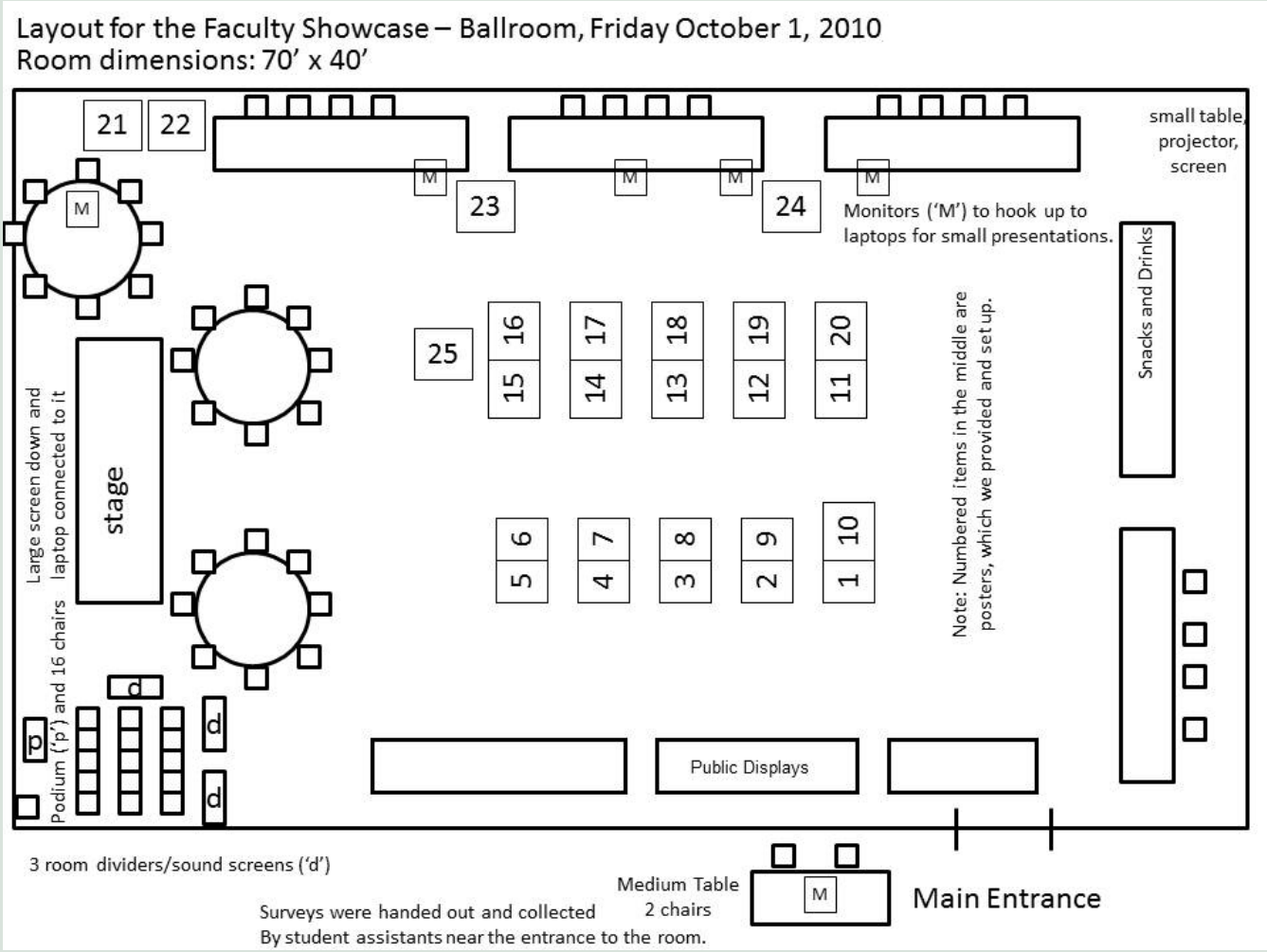
Roanoke College professor Roland Minton interacts with parents and students at the Faculty Showcase event at Roanoke College in 2010 (photo credit: Brenden Bush).

scholarly information. Just as with the students, the impressions of parents (40 filled out the survey) also improved regarding the scholarly activity of faculty members—from 5 percent negative, 35 percent neutral, and 60 percent positive before the event to 2.5 percent negative, 2.5 percent neutral, and 95 percent positive after the event. Also consistent with the students, a vast majority of parents (95 percent) said they enjoyed the event. Comments from parents about what they learned from the event reflected a high regard for the faculty and the research opportunities available at the college.

Organization of Events

Both events were organized on fairly short notice and with very limited budgets. Simple refreshments were served, consisting of coffee, hot chocolate, juice, and cookies. For the first event, money for the refreshments was solicited from student organizations. For the second event, refreshments were provided by the Alumni Relations Office, which funded many Family Weekend events. The timing and location were somewhat constrained by availability, but both events were held in the student center, which has a number of rooms of

Figure 1. Layout of the Faculty Showcase Event



various sizes that often host a variety of events. The room for the first event (approximately 42 x 38 feet) could physically hold posters for about 35 faculty members, with the posters lined up in rows and along the walls (essentially anywhere we could fit them), though space was limited for moving around.

The second event was held in a significantly larger ballroom space (approximately 70 x 40 feet, see Figure 1), which was organized with four rows of five posters each, a line of tables around two walls, and a small space in a corner with 15 chairs and a partial dividing wall to allow for readings by humanities faculty members. Future events of this kind will accommodate other forms of faculty presentations (readings, art viewings, musical performances) in a separate space from the posters, as it was too noisy in the room for the readings, and we feel other presentation formats will be better served in a separate space.

The first event occurred during lunch on a Thursday, which is an open period across campus (no classes scheduled). It lasted from around 12 pm to 1pm and was on the same floor as the main cafeteria, although posters were not visible from the eating area. The set-up and breakdown were rushed due to the limited time the room was available, though with the help of six to eight faculty members, it was done sufficiently well. The second event was held on a Friday evening (6-7:30 p.m.) after a college-sponsored picnic on the quad. Set-up was accomplished earlier in the day, with a group of five faculty members and two students, making it much easier on the organizers. However, breakdown was rushed because of another scheduled event in the space right afterwards.

Regarding timing, the Friday evening time slot was preferred over the Thursday lunch time slot because of ease of set-up; more possibility for students, parents, and faculty members to attend; closeness in time to a scheduled Family Weekend dinner on campus; and the fact that it still fell within the workweek for faculty (i.e., participants did not have to come back to campus on Saturday).

While attendance was considered strong at the first event, with 30 faculty presenters, at least 40 student attendees, and five administrative/staff attendees, attendance could certainly have been improved with better advertising. Outreach before the first event mainly consisted of posters on walls in a few select buildings, a campus-wide email announcement about a week before the event, and promotion by two co-organizers in their classes. It was clear that a majority of attendees were from the classes of the two co-organizers, with many of the other attendees not having seen the advertisements but learning of the event through word-of-mouth.

Publicity, and subsequently the attendance, was much better for the second event, in large part because of the assistance of the Alumni Relations Office, which asked parents to "register" for the event in advance. Though the event was open to all, having over 100 parents register for the event in advance created greater anticipation for the event.

To encourage participation in the second event, we also invited all faculty members from all disciplines to participate, and the organizers made repeated assurances that we would be accommodating to whatever presentation styles participants wished, including posters, readings, projects, tables with books laid out, and personal computers with monitors on individual tables, and sometimes combinations of these formats. We also allowed faculty members to bring already printed posters (many acknowledged simply grabbing a poster off of the wall and bringing it over for their presentations), and we did not require abstracts to be sent in ahead of time. While this made it impossible to advertise in advance the specific topics that would be presented, we felt doing so was unnecessary. Providing parents with a list of faculty members who would be presenting (at the request of Alumni Relations) was sufficient to educate them about the nature of the event that we were organizing. In the future, we plan to give more advance notice to faculty about the event, as well as to better accommodate faculty from the fine arts and humanities by providing a separate space for readings and art and music presentations.

We also piloted a joint event for student and faculty presenters in fall 2011 titled "Student/Faculty Showcase of Research & Creativity." Students had the opportunity to present their research alongside the faculty members with whom they conducted the research, and we hope that other students will be more interested in doing undergraduate research after seeing their peers present.

Discussion

Overall, we believe our Faculty Showcase, the second event, was successful at increasing student and parental perceptions of faculty research and is worth continuing in the future. From our work in organizing this event, we firmly believe in the importance of:

- introducing students to the nature and quality of research being carried out by faculty on campus ("student awareness"),
- providing an opportunity for students to interact in a research-oriented setting with faculty members with whom they may be interested in working in the future ("student involvement"), and
- organizing a regularly occurring means for faculty to present and discuss ongoing research projects with other faculty across campus ("faculty interaction").

FIGURE 2.

Survey for Faculty Research Showcase Event

1. Please indicate: ❑ Faculty ❑ Staff ❑ Student ❑ Other _____

   1a. If you are a student: ❑ Freshman ❑ Sophomore ❑ Junior ❑ Senior

2. Please indicate which department or major you are affiliated with: _____

3. Please indicate: ❑ Male ❑ Female

4. Are you currently involved in research? ❑ No ❑ Yes

5. After attending this event, what is your likelihood of participating in research on campus in the future? (check one)

   ❑ Less Likely ❑ Equally Unlikely ❑ Equally Likely ❑ More Likely

6. Before the event, what were your impressions of research carried out on campus by the Roanoke College faculty? (check one)

   ❑ Very Negative ❑ Somewhat Negative ❑ Neither Positive Nor Negative ❑ Somewhat Positive ❑ Very Positive

7. After attending this event, what are your impressions of research carried out on campus by the Roanoke College faculty? (check one)

   ❑ Very Negative ❑ Somewhat Negative ❑ Neither Positive Nor Negative ❑ Somewhat Positive ❑ Very Positive

8. I enjoyed this event.

   ❑ Strongly Disagree ❑ Disagree ❑ Neither Agree Nor Disagree Agree ❑ Strongly Agree

9. What did you learn (if anything) from attending the Faculty Research Showcase?

_____

_____

10. Please let us know about any poster/presentation that you particularly enjoyed/learned from: (both which one and why)

_____

_____

11. Other comments, questions, or suggestions for next year's event (please use the back if necessary):

_____

_____

FIGURE 3

Survey for Faculty Showcase Event, Student Version*

1. Please indicate ❑ Current RC Student ❑ Other _____

   1a. ❑ Freshman ❑ Sophomore ❑ Junior ❑ Senior ❑ Other _____

   1b. (If applicable) Which department or major are you affiliated with? _____

2. Please indicate: ❑ Male ❑ Female

3. Please answer the following question about scholarly activities:

a. Students: Are you currently involved in research/creative work with a faculty member? ❑ No ❑ Yes

   Other, please describe: _____

4. Before attending this event, what were your impressions of research/creative work carried out by the Roanoke College faculty? (check one)

   ❑ Very Negative ❑ Somewhat Negative ❑ Neither Positive Nor Negative ❑ Somewhat Positive ❑ Very Positive

5. After attending this event, what are your impressions of research/creative work carried out on campus by the Roanoke College faculty? (check one)

   ❑ Very Negative ❑ Somewhat Negative ❑ Neither Positive Nor Negative ❑ Somewhat Positive ❑ Very Positive

6. I enjoyed this event. (check one)

   ❑ Strongly Disagree ❑ Disagree ❑ Neither Agree Nor Disagree Agree ❑ Strongly Agree

7. Did you attend the RC Faculty Research Showcase held in Spring, 2010? ❑ No ❑ Yes

8. What did you learn (if anything) from attending this Faculty Showcase during Family Weekend?

_____

_____

9. Other comments, questions, or suggestions for next year's event (please use the back if necessary).

_____

_____

* (There were three different versions of this survey used for the second event, one for students, one for parents, and one for faculty / staff / administrators. The surveys contain the same essential questions, yet word the demographics questions slightly differently.)

Improved student awareness is validated in the quantitative summary of the student attendees' survey responses, indicating an improvement in the students' impressions of faculty research, as well as in the qualitative responses, which demonstrate an expansion of students' knowledge about and appreciation of the depth and breadth of research being carried out by faculty members. The potential fruits of the student involvement component are reflected in qualitative responses indicating newly discovered common interests with faculty members and the desire to engage in research with faculty in particular departments. The need for such an opportunity is reflected in the low percentage of the student attendees who were already involved in research.

Regarding faculty interaction, positive comments from faculty, both presenters and attendees, validate that such an event is welcomed, encouraged, and will be worthwhile to continue in the future. (Details on the faculty reactions and feedback were not included here due to space considerations but are available from the authors.) In fact, after the second event, the faculty formed a group called the Professional Life Cluster, which provides an outlet for faculty to interact with each other on research and is open to faculty at all levels.

The level of parental involvement and interest in the Faculty Showcase over Family Weekend was pleasantly surprising. We believe that parents who send their students to small liberal arts colleges are keenly interested in knowing that faculty members are accessible and interested in working closely with students on academic endeavors. This event was worthwhile in that students came away with a better appreciation of the level of work and commitment their faculty members have to scholarly activities, and the students and their parents also enjoyed themselves in the process.

In terms of recruiting students to do research with faculty, we realized that holding an event midway through the spring semester, as we did with our first event, is too late to recruit students for our Summer Scholars program. That program generally includes a great deal of prior interaction between students and the faculty members with whom they plan to work during the summer. Although holding the event during Family Weekend (late September/early October) also does not allow students to immediately begin research with a professor, we hope that it will encourage students to work with a faculty member in subsequent semesters, including a possible Summer Scholar position.

For other colleges interested in creating their own Faculty Showcases, we suggest a partnership with the alumni relations office because of the extra assistance it may be able to provide in organizing, advertising, and funding the event. We also suggest finding a space that allows for faculty, students, and parents to interact in a manner that fits with disciplinary differences. For the latest version of the event (held in September 2012), the poster presentations were in a large open space, but we moved oral presentations, readings, and other types of performances to other rooms in the same building.

With more years of preparation behind us, starting in September 2011 we created a conference program with abstracts, several concurrent sessions for oral presentations to complement the poster session, and opened the showcase to student researchers so that they present alongside faculty. We have also been more diligent in lining up our events with opportunities to reach prospective students. In spring 2013, our Showcase of Student Research & Creativity will coincide with Alumni Weekend.

David F. Nichols

Roanoke College, dnichols@roanoke.edu

David F. Nichols, an assistant professor of psychology at Roanoke College, received his PhD from Florida Atlantic University and completed a three-year, post-doctoral research position at the Centre for Vision Research at York University before joining Roanoke. His research interests include visual perception and pattern classification of brain recordings. He was co-organizer of both faculty showcase events described in this article.

Julie S. Lyon, an assistant professor of business administration and director of student-faculty research at Roanoke College, received her PhD from the University of Maryland, College Park. Her research interests include diversity and selection, organizational climate and culture, and the scholarship of teaching and learning.

Interested in Submitting a Piece to the *CUR Quarterly* or *CURQ on the Web?*

The *CUR Quarterly* serves as the official public "voice" of CUR to both its members and to a broader community. Its purpose is to provide useful and inspiring information about student-faculty collaborative research and scholarship from all types of institutions.

The *CUR Quarterly* sends out calls for themed articles four times a year. However, we also publish non-theme articles in each issue. You may submit manuscripts on any topic that will appeal to CURQ readers at anytime during the course of the year.

The *CUR Quarterly* publishes articles relating to all aspects of undergraduate research that are of interest to a broad readership, while the *CURQ on the Web* highlights pieces more focused by discipline or institutional type. Articles regarding the effects of the research experience on the development and subsequent endeavors of students, and how to initiate, support, or sustain undergraduate research programs are appropriate for this journal.

HOW TO SUBMIT

Authors are encouraged to discuss disciplinary articles with the appropriate Division Editor prior to submission. Contact information for all Editors is listed at the front of every issue of the CUR Quarterly. Once you are ready to submit you will need to visit http://curq.msubmit.net and complete the online submission process. The CUR Quarterly team is only accepting articles through the manuscript management software. For further details on the submission process please see the inside back cover of this issue

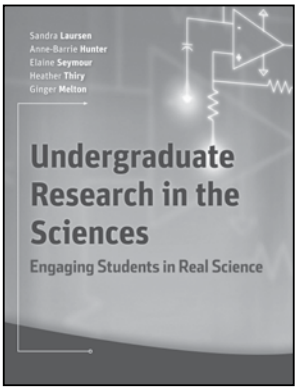
CUR Quarterly
COUNCIL ON UNDERGRADUATE RESEARCH

CUR Book Review

Undergraduate Research in the Sciences: Engaging Students in Real Science

By Sandra Laursen, Anne-Barrie Hunter, Elaine Seymour, Heather Thiry, and Ginger Melton.

Reviewed by Kylie Leffler, University of Portland,leffler14@up.edu



Jossey-Bass, 978-0-470-22757-2, 2010. 282 Pages, $42.00

As a teenager, I was given an opportunity to study the game of soccer at a local club. It was there that I experienced the transition from being mentored as a player to mentoring younger players as a coach. This role reversal provided me with a more balanced perspective on "mentoring" and its influence on how we learn. It allowed me to reflect on the growth that I experienced as a player, and it now guides the growth I wish to nurture in my players. Whether it is on a soccer field or through undergraduate research (UR), the mentor-mentee model is a powerful way for students in any discipline to acquire knowledge and experience personal development.

Until recently, documenting these achievements of mentoring had not attracted much scholarly attention. However, the book *Undergraduate Research in the Sciences: Engaging Students in Real Science*, provides empirical evidence for what has been suggested all along about the benefits of UR for students, faculty, and administrators at collegiate institutions. And although this book reports on UR programs in the sciences, the material can be applied to any academic pursuit because the benefits and outcomes should be comparable. The book can serve as a resource for students hoping to pursue a UR experience in the future and can help instill in them the right mindset and attitude to enhance their UR experience and maximize the outcomes.

The organization of the book and the writing style of the authors encourage one to read the book from cover to cover, but they also allow a reader to choose a section that provides information especially pertinent to one's needs or interests. The first four chapters discuss what UR is and the benefits students acquire from a quality experience. These benefits include an increase in confidence, "feeling like a scientist," developing collaborative skills, patience, resilience, and many more positive traits. Undergraduate researchers frequently said that conducting research was crucial to the process of "becoming a scientist." One undergraduate biology student commented, "How can someone like me be doing this? [But now] I'm coming up with valuable information and it's great. I mean, actually producing data and actually doing it, I felt like a scientist." UR experiences in general allow students to see what doing science is all about, serving as either an introduction to the idea of pursuing science as a career for some, or as a means of clarification for others who are already interested in science.

Research mentors observe numerous gains in their UR students, motivating them to continue doing research with students even though it often means slower completion of projects. More information on the cost and benefits to faculty who serve as UR mentors is addressed in the last four chapters of the book. Surprisingly, unbeknownst to one another, advisors employed very similar and strategic methods regarding how to structure their UR programs and provide individualized guidance to each student. The authors summarize this well: "These methods were not arrived at by formal or collegial decisions but were part of a received tradition from which many advisors had themselves benefited as student researchers."

It is surprising that the majority of advisors knew instinctively which methods would lead to the greatest student gains, and now there is empirical evidence for these successful strategies. Among the most important requirements of a successful UR program is the need for authenticity and having a "real world" problem for students to solve. Even though every student, project, and outcome will vary, the authors note, "Multi-week engagement in an authentic scientific project, carefully chosen and scaled to students' preparation, interests, and time frame, is the core."

The organization of the information presented was just one of the book's many strengths. The use of tables to highlight the data summarized in the text made the shear abundance of information manageable. I also appreciated the opportunity to discover the significant impact UR can have on students illustrated in a quantitative format and in the quotes gathered from UR students interviewed by a few of the authors. Since I will be pursuing my own UR experience, it was a real eye-opener to read my peers' comments describing the many positive outcomes of their research experiences.

I now have specific expectations for my upcoming UR experience because of what I learned from reading this book. In particular, a quality UR experience is a growth-promoting endeavor that teaches you patience, dedication, and the need to have an open mind. It can also create lifetime bonds with your mentor and the peers with whom you shared the experience. The transparency with which the mentor presents him or herself allows the students to see the mentor as a collaborator and comrade. Even now, before my research experience has begun, I have been fortunate to work one-on-one with my advisor in reading this book. We had many discussions about academics, life experiences, and how this book is relevant to them. Not only have I been given insight into how my mentor thinks and works, but I also found someone to whom I can relate and from whom I can seek insightful guidance. It is this type of relationship that is so rewarding for all associated with UR. This includes the institution, which indirectly benefits from increased student retention, better student placement upon graduation, and a more engaged and scholarly campus environment.

In conclusion, *Undergraduate Research in the Sciences: Engaging Students in Real Science* proved to be a thoughtful and thorough presentation of empirical data confirming the benefits of authentic, scientific UR that is of high quality and adequately supported. This book is not a "how-to manual," which is emphatically stated by the authors, but it does "identify the good outcomes of UR for students" by describing how and why these results are obtained and by "clarifying what factors support or constrain UR." This book can be useful to anyone interested in mentoring in any arena of academics or life, serving as an informative resource for the benefits of the mentor-mentee UR model.

SAVE THE DATE

Windows of Opportunity: Undergraduate Research Conference

June 22-23, Chapman University, Orange, CA

This conference is an opportunity for undergraduate research program directors from all over the country to come together and share ideas, strategies, and best practices for undergraduate research. Seasoned program directors will share their knowledge and experiences about five specific themes:

- **Assessment**—Designing and implementing tools for assessment and evaluation.
- **Broadening Participation in Undergraduate Research**—Addressing core cultural, financial and policy issues that inhibit participation.
- **Marketing, Fundraising, & Public Relations**—Developing strategies for increasing awareness of research programs and financial resources.
- **Curricular Innovations**—Designing research-intensive assignments, courses, and curricula for a variety of programs.
- **Undergraduate Research Administration Nuts and Bolts**—Finding innovative administrative practices that maximize program success.

The conference format is intended to facilitate discussion, provide resources, and create networking opportunities. Breakout sessions will include panel presentations and facilitated roundtable discussions designed to help participants learn from each other and hear about best practices.

For more information contact MeLisa Zackery— mzackery@cur.org.

To register visit: www.cur.org.

SUBMISSION Guidelines

General Criteria —

The *CUR Quarterly* publishes articles relating to all aspects of undergraduate research that are of interest to a broad readership. Articles regarding the effects of the research experience on the development and subsequent endeavors of students, and how to initiate, support, or sustain undergraduate research programs are appropriate for this journal. The *CUR Quarterly* is not the appropriate venue for publishing results of undergraduate research.

Editorial Policies —

The *CUR Quarterly* is the voice of members of the Council on Undergraduate Research. All articles are peer-reviewed. Editorial judgment regarding publication of manuscripts and letters rests with the Editors. Concerns about editorial policies and decisions should be addressed to the Editors.

Manuscripts

Prepare to Submit —

• Copy of article (MS Word or compatible format, Times font, 12-point, double-spaced, 1 inch margins, and single-spacing between sentences). 2000-3500 words is the typical length of an article, but longer or shorter articles may be appropriate for certain topics.

• Key words for indexing (up to 10).

• Personal information

— Institutional title, mailing and email addresses for the corresponding author.

— Biographical sketch for each author (4-6 sentences).

• Proper Citations. Refer to the *Chicago Manual of Style* citation guidelines-author-date style (http://www.chicagomanualofstyle.org/tools_citationguide.html).

How to Submit —

Authors are encouraged to discuss disciplinary articles with the appropriate Division Editor prior to submission. Contact information for all Editors is listed at the front of every issue of the *CUR Quarterly*. Once you are ready to submit you will need to visit http://curq.msubmit.net and complete the online submission process.

Book Reviews

The *CUR Quarterly* publishes short reviews of books and other new publications the editors deem of interest to the undergraduate research community. Books or other publications will be reviewed within 12 months of publication. The Book Review Editor will select appropriate titles for review and solicit reviewers. In order to ensure that the reviews are as timely as possible, the Book Review Editor will expect to receive finished reviews within two months of assignment. Each printed issue of the *CUR Quarterly* will include one review.

Suggested titles for review and book reviews should be submitted via email to:

Book Review Editor
Ami Ahern-Rindell
ahernrin@up.edu

CUR Comments

The *CUR Quarterly* will consider for publication scholarly commentaries from readers on issues vital to the health and vigor of the undergraduate research enterprise. *CUR Comments* should be limited to 250 words, and must be on topics relevant to CUR's mission. *CUR Comments* will be published at the sole discretion of the Editors and will be edited if necessary. The writer will be shown the edited version for her/his approval.

Undergraduate Research Highlights

Highlights consist of brief descriptions of recent (past six months) peer-reviewed research or scholarly publications in scholarly journals. These publications must be in print and must include one or more undergraduate co-authors. A quarterly call for submissions will be sent to all members and posted on the CUR Web site.

Submissions should include:

• Title of the article and full journal citation (inclusive pages).

• A brief description (3-5 lines) of the research and its significance.

• Title and department or program affiliation of the faculty member.

• A brief description of the student co-author(s). Include the year of study in which the student(s) undertook the work, the opportunity through which the work was undertaken, (independent study project, summer project, REU program, senior thesis project, etc.), and the current status of the student (graduate school, employed, still enrolled, etc).

• The source of funding for the work.

For questions, contact:

Undergraduate Research Highlights Editor
Nicole Bennett
bennettns@appstate.edu

For questions, contact:

CUR Quarterly Editor-in-Chief:
Kelly McConnaughay
Associate Dean of Liberal Arts and Sciences
Bradley University
kdm@bradley.edu

Council on Undergraduate Research
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