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COUNCIL ON UNDERGRADUATE RESEARCH

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The Challenge of the Count

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Cover Photo:
Rachel Wright, fine arts and philosophy, experiments with plein air painting style and techniques pioneered by some of the Hudson River school painters and other European schools. Rachel participated in Buffalo State's summer research program in 2010.
photo credit: Used with permission from The Buffalo News (photographer: Derek Gee)

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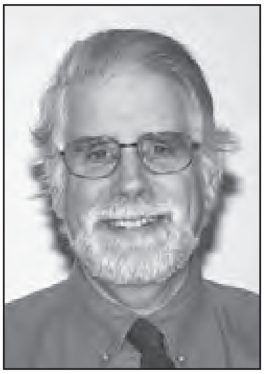

Last year I was speaking with a faculty member about undergraduate research—what a valuable learning experience it is for students, and how much fun it is for the instructor as well—when he interrupted me. "That may be true," he said, "but why should we spend all these resources on 80 students?" I was flabbergasted. This guy teaches at a regional comprehensive university, enrolling more than 6,000 students, with very active undergraduate research programs. I knew that, in fact, hundreds, if not thousands, of students participate in research, scholarly, and creative projects with faculty members on the campus every year. It turns out that this faculty member was counting only the students the university had sent to present their work at NCUR or other conferences. He had no idea how many additional students were involved.

Neither did I, and I should have. I had served that institution as Director of Grants & Research until I retired a couple of years ago. During my 20-year tenure I coordinated our various undergraduate research programs: travel to conferences, an on-campus celebration, support for summer research, small academic-year grants, and so on. When I expressed surprise at his earlier question, he asked, "So how many students participated altogether during your last year on the job?" I'm embarrassed to confess that I could not give him an answer. Counting the number of students who participate in research is very difficult.

Hence this issue of the *CUR Quarterly*. Issue Editor Linda Blockus' column lays out this compelling problem and all its ramifications. Contributors address various facets of the counting problem and place it in the correct frame: How should we evaluate and assess undergraduate research?

Colleges and universities have been wrestling with evaluation and assessment for many years, and so has CUR. Our institutes and conferences address various ways to evaluate research activities and assess the impact of undergraduate research. Many CUR publications include sections on

CUR Calendar

APRIL 2012

16-20 Undergraduate Research Week

MAY 2012

23-25 Initiating and Sustaining Undergraduate Research Programs Institute, University of Michigan, Ann Arbor, MI

JUNE 2012

23-26 The 2012 CUR Conference, The College of New Jersey, Ewing, NJ

JULY 2012

15-19 Proposal Writing Institute, University of Wisconsin- River Falls, River Falls, WI evaluation and assessment. There are no simple answers, of course, but we are about to launch a publication that lays the groundwork for better measurement. For more than a year, three CUR veterans have been working on a seminal document, *Characteristics of Excellence in Undergraduate Research,* or *COEUR*. Roger Rowlett, Linda Blockus and Susan Larson, have written a comprehensive summary of best practices to support and sustain highly effective undergraduate research. It is organized in sections that correspond to various functions or units of a typical college or university campus. In CUR's experience, successful programs exhibit many of the characteristics that are described in the document.

COEUR can be used by colleges and universities as a guide for creating or revising their undergraduate research programs or as a self-assessment tool. As I write this column, additional undergraduate research veterans, leaders of disciplinary associations, and college and university leaders are adding reactions and commentary. The entire volume should be hitting the streets this spring. *COEUR* promises to illuminate, if not settle, many of the foundational questions underlying our counting and assessment issues. Watch for it.

Bill Campbell
Director,
Grants & Research (Emeritus),
University of Wisconsin-River Falls
CUR President

IN THIS ISSUE OF CURQ on the web

CURQ on the Web, Spring 2012 edition
www.cur.org/quarterly/webedition.html

For three other approaches to counting undergraduate research engagement, please visit CURQ on the web. Examples from the University of North Carolina at Chapel Hill, The Ohio State University, and the Annual Biomedical Research Conference for Minority Students (ABRCMS) are provided.

From the CUR Issue Editor

The Challenge of "The Count"

Since assuming the position of director of the Office of Undergraduate Research at the University of Missouri, I have been asked each year, "How many students are doing research on our campus?" I have yet to be able to come up with a quick answer that satisfies my understanding of the complexities of the undergraduate research enterprise. I am reluctant to assign one static number each year to represent all of the varied opportunities that may define undergraduate research and creative activity. And that's assuming I can even figure out what that number might actually be!

In speaking with my program director colleagues across the country, most of them face the same dilemma: *How to count students in a way that provides both accountability and value to those using the derived number?* And this issue of "the count" has implications beyond our own campus borders. CUR, as the leading voice for undergraduate research, should be able to articulate in some quantitative form the national rate of student participation in the engaging experience of research and other creative endeavors. To be taken seriously as an educational movement, we need to be able to track increases at the micro and macro levels and compare students' participation among disciplines and institutional types. Right now, how many students are engaged in research activities on a national level is anyone's guess.

In theory, funding agencies should be able to count the numbers of students that they support specifically to do research. But collecting those data in a consistent manner can be a challenge. Finding those data can be a challenge. And figuring out what to make of those data can be a challenge. For example, in a given year a student may participate in the McNair Scholars Program at his or her home institution during the academic year and participate in a summer research program funded by the National Science Foundation. Should that student be counted twice? And what about those students supported by private funding or those who receive no funding at all?

Why is there pressure to count students' participation? There are many reasons, including in no particular order, the desire to use a number or percentage of the student body to impress high-school student applicants, their parents, the public, and the organizations that rank colleges based on comparing campus practices used to engage students. As colleges compete for students, donor dollars, and prestige, the ability to provide a higher number/percentage of student participants than a peer institution may give a competitive edge. Participation numbers are also useful for institutions' strategic planning and benchmarking to meet target goals. Research participation data, if detailed enough, can be used to determine if there is parity in participation across disciplines and undergraduate populations and to stimulate new programs to close any gaps. Participation information can also be used in grant proposals, either to demonstrate a rich undergraduate research environment deserving of funding or to point out low-performing areas that could benefit from external funding. Knowing which students participated in undergraduate research could be useful in gathering information on alumni who enter graduate programs. And information about the number of students a program impacts is always useful in demonstrating academic accountability, maintaining or increasing fiscal resources, and even saving programs from the chopping block. These are all excellent reasons to "count" participation; yet it remains a challenge for many institutions. What should we do?

First of all, we need to agree on a concrete definition of "undergraduate research participation." Do we only count those students who develop their own projects and do original work? Do we include students who engage in ongoing projects with faculty and graduate students as contributing members of the team? Certainly students working on a team benefit from the experience in some manner even though they may not yet have designed their own projects. How do we count students' participation in creative projects in the arts or in applied projects in professional programs such as business and journalism? Do community-based research projects count as part of undergraduate research or are they counted under the umbrella of service learning? How do we account for students who have authentic research experiences embedded in regular coursework? How should we consider students who engage in activities that support the research enterprise, such as coding data, making chemical solutions, or assisting with literature searches? Although such students may not have the same intellectual engagement as other students, they still are part of the developmental continuum of research.

Further, when should we count the students? Do we want to report the total number of students in a given academic year? (Where do we include summer research?) Students who participate in research for multiple years will be counted each year, and thus the annual data cannot just be added together to show participation for a student cohort. Or are we seeking to count the number of graduating seniors who have had a research experience (however it is defined) so we can report a percentage of research participants for each cohort? Yet we might also wish to account for the length or numbers of experiences students had during their time in college. Wouldn't we want to count a student who did a one-semester project differently than a student who worked with a faculty member for three years and in between had two different summer experiences at other institutions?

What information do we want for each student? The possibilities include academic and demographic information, the number and types of experiences and their length (hours per week, total weeks), credit hours earned and/or financial compensation, the number and types of resulting products (publications, presentations, awards, theses).

What about data on faculty mentors? We might wish to capture demographic information (including academic rank), academic discipline, the numbers of students an individual mentors each year, and faculty research products to which undergraduates have contributed, including preliminary data for grant proposals, assistance with publications, and new components for courses.

What should we do about undergraduates who are visiting researchers in summer programs at our institutions? Certainly these summer interns are also part of the undergraduate research community and deserve to be counted; however, we may want to keep those numbers separate from the numbers of students enrolled at the host institution. And how do we count and include our own students who conduct research in summer programs off-campus at other colleges, medical centers, field stations, government and non-profit labs, museums, industrial companies, or sites abroad? Students apply for these programs independently, and it always seems serendipitous to me when I find out in October that one of our students spent the past summer elsewhere doing research.

How do we go about trying to count students on our own campuses who are enrolled in coursework involving research? Some institutions, such as the University of Georgia (see the article by Webber, Fechheimer, and Kleiber in this issue), have worked out a course-numbering system to flag students enrolled in classes carrying research credit hours. However, students may not always choose to register for additional course credits after they have earned the maximum amount of useful credit. Some institutions have worked around this with a zero-credit hour option allowing students to register without earning credit or paying extra tuition. But this approach will not pick up students who are assisting faculty in a supporting role (such as transcribing interviews), and we may wish to include them somehow. We might consider counting students who are receiving

ABOUT the Editors

Meet the Book Review Editor

Amelia Ahern-Rindell, associate professor of biology at the University of Portland, recently became Book Review Editor of the *CUR Quarterly*. Currently the CUR Secretary, she has been actively involved in CUR for almost 10 years and is serving her third consecutive term as a Biology Councilor. She has been a member of the CUR Executive Board since 2007 when she became Chair of the Biology Division. She also has served as a CUR Facilitator and Coordinator for several CUR Institutes.

Ami has been a reviewer for several NSF programs, including the Course, Curriculum, and Laboratory Improvement Program, the Undergraduate Research and Mentoring in Biological Sciences Program, and the Graduate School Fellowship Program. Besides reviewing grant proposals, she has reviewed textbooks, journal manuscripts, and has written book reviews for several academic journals.

Ami received her BS in biology from the University of Illinois, Champaign-Urbana, and her MS and PhD in genetics and cell biology from Washington State University. She then trained as an NIH Postdoctoral Fellow at the Center for Molecular Genetics at the University of California, San Diego. In 1992, she received her first tenure-track appointment, in the zoology department at Weber State University in Ogden, Utah, and in 1997 she joined the faculty of the University of Portland.

Ami is involved in curriculum modernization and assessment, especially in undergraduate research and scholarship. She has an active research program in which she collaborates with students on the cell and molecular characterization of an animal model of a fatal genetic disorder. She teaches courses in cell and molecular biology, genetics, and evolution and has taught in her university's study abroad program. Her administrative activities at the University of Portland have included service as chair of the biology department and chair of the university's institutional review board, and she has served on numerous other committees. Ami is a member of the Columbia-Willamette Chapter of Sigma Xi and serves on its executive board as vice-president.

funds from external grants or who are listed as "lab assistants" in work-study jobs and approach counting students through financial/payroll tracking. However, receiving pay from a research account doesn't always ensure that students are actually engaged in research (either their own project or in a supportive role). We experimented with this approach at Missouri and found that students who were enrolled in research studies as *subjects* were included in our output data, because they received monetary compensation from research accounts for their role as test subjects (e.g., $100 for participating in a multi-session psychology experiment). Many students simply volunteer to help with research or continue their own projects without receiving academic credit or payment. Other students may receive a stipend or be a member of a research program and, in addition, earn academic credit. Thus they run the risk of being counted more than once!

Carefully worded student surveys might be an answer, assuming enough students complete an annual survey (or a senior exit survey) for administrators to make meaningful inferences from the self-reported participation. However, as demonstrated in the article in this issue by Angela Wilson examining the National Survey of Student Engagement (NSSE), student self-reports may lead to substantial overcounts or undercounts.

Would collecting data directly from individual faculty members be more valid and reliable? Are there systematic ways for faculty to report annually how many undergraduates they mentored? Getting faculty to report *anything* systematically may depend on the culture of the institution. For the data to be meaningful, mentors would need to report more than just a name of a student; they would need to report some quantitative and qualitative details about the engagement.

The University of Washington now has a successful method for collecting data about undergraduates' participation in research (in credit-bearing and non-credit-bearing experiences) from faculty in all colleges, which is tied back to the campus student-information system. This allows analysis to be done on the aggregated data to identify trends and places where further research opportunities need to be developed. It took the university ten years of collecting less-comprehensive data before it decided to invest in an online tool that provided more meaningful results. Another successful example of counting students via faculty reports is described in an online *CUR Quarterly* companion piece discussing the approach of the College of Arts & Sciences at the University of North Carolina.

Are there advantages to putting the reporting responsibility on department chairs instead of individual faculty members? Possibly, but collecting data at the departmental level also seems to have drawbacks, including the recognition that departments may not be aware when their own majors participate in research with faculty in other departments (for example, a history major doing a project with an education professor on effective methods of teaching high-school students about the U.S. Constitution). Some departments may not even have their own undergraduate programs and may not be included in a request for undergraduate data (for example, medical school departments with plenty of biology or pre-med students involved in research projects, but with no undergraduate teaching mission or perceived need to track students). And making the collection of data the responsibility of departments would probably miss students engaged in research off campus, in such venues as community-based research, research experiences abroad, and programs sponsored by museums, national laboratories, field stations, and medical institutions. These students should be included somewhere in our counts.

Should we count only those students who are conveniently countable? Students doing a senior thesis or honors project are easily defined and counted, but counting just those students is philosophically at odds with the ethos of a campus that strives to create opportunities for all interested students, not just seniors or honors students. Most campuses have some version of a student research celebration or symposium. Maybe a head count of student participation at the annual symposium is an easy approach? As suggested by Wilson's article in this issue, student presenters at such gatherings have engaged in research at a level that allows them to demonstrate accomplishment by virtue of having a project to present, thus providing a measurable threshold of participation. The drawback is that not all students who have completed projects may opt to present (although perhaps this could be mandated) and, further, students who don't have their own project, but are still part of the research enterprise, would be missed. Drilling down to the micro-level, a decision has to be made about how to account for students who present more than one project (I've seen double and triple majors with a project for each major!) or how to count team projects with more than one student per presentation. Those obstacles and others can be addressed on a campus level once a decision has been made on the overall approach to take.

The Ohio State University has taken a different approach to "counting." Rather than attempt to identify one concrete number, OSU includes a number of "indicators of participation" in its annual report. The indicators include symposium participation, senior honors theses, enrollments for research credits, and NSSE data. A link to the university's latest report can be found in the online companion pieces to this issue of the *CUR Quarterly*.

At the macro level, various funding agencies are working to collect data on student research participation and related information. For example, a system called XTrain is now being used to gather appointment and termination data for researchers supported by National Institutes of Health training grants, including data on graduate fellowships and undergraduate programs for minority-group students. The National Science Foundation has an online data-reporting system called WebAMP that program directors in its Louis Stokes Alliance for Minority Participation (LSAMP) use to record their student participants on an annual basis. All NSF REU (Research Experiences for Undergraduates) sites require directors to enter student demographic data in a system called FastLane as part of their annual report to the agency. Directors of projects funded by the McNair Scholars Program and the Howard Hughes Medical Institute are required to annually provide the names of student participants to these funding agencies. Based on personal experience and discussions with colleagues, some of the systems are challenging to use and extracting the collected data might not be possible. And even for some federal programs, finding participation data in an aggregated and useful form appears to be impossible.

CUR should consider pushing for greater accountability, at least from federal programs, and broad dissemination of aggregated data that is *already* being collected on undergraduate research participation. Perhaps CUR could take on the task of collecting annual program data from the programs I've mentioned, as well as others, and putting it into a meta-report each year to benchmark participation and provide a mechanism for accountability and dissemination. Gathering of these data would provide needed information and might illuminate model systems or data-collection problems of the type I've outlined above.

Admittedly, the examples I've cited of programs funded by external agencies only account for a fraction of the undergraduate research students in the country and are mostly oriented toward the STEM (science, technology, engineering, and mathematics) disciplines. And because the data systems don't "talk" to each other, it is impossible to know how many students who participated in one externally funded program also participated in another one. One theoretical, if perhaps impractical, solution would be to pick a "census date" in the summer and on that date have *all* programs (federal, state, private, and institutional) do a head count of participants, including both research location and funding source. In theory, students would not be in two programs on the same date and this would eliminate duplication. What would it take to conduct such a national census in a manner

ABOUT the Editors

Meet the Undergraduate Research Highlights Editor

Nicole Bennett is an associate professor at Appalachian State University. She received a PhD in organic chemistry from the University of Wisconsin-Madison in 1996 followed by work as an Assistant professor at Hope College in Holland, Michigan. Professor Bennett has mentored more than 40 undergraduates in a variety of organic synthesis projects. Her most recent work involves physical organic studies of microwave-induced synthesis of biodiesel (currently funded through a grant from the North Carolina Biofuels Center) and the Wittig reaction. Professor Bennett has received funding for undergraduate research through Pfizer Inc. the Merck/ American Association for the Advancement of Science Undergraduate Research Program, and several National Science Foundation Programs. She has also reviewed proposals for the Merck/AAAS program and the NSF. She was recently elected as a Chemistry Councilor for the Council on Undergraduate Research and was awarded the Indiana University Award for Excellence in Undergraduate Research (2002-2003).

that would provide useful data on summer interns? Is this a task for CUR?

Maybe the direction we wish to take is to count up the numbers of students presenting at undergraduate research conferences during the course of a year? This is a different type of data point, but it might at least provide a ballpark estimate of the number of students presenting projects. In the online *CUR Quarterly*, we have posted the participation demographics collected by the Annual Biomedical Research Conference for Minority Students (ABRCMS) as an example of the type of information we may wish to include in a comprehensive environmental scan of undergraduate research activity. More than 1,400 students presented at this conference in 2010, and the majority of them were funded by NIH programs, many at medical institutions that may not currently be part of the CUR network. If we counted the number of students who present each year at NCUR and conferences of external funders and honorary societies, as well as at other disciplinary and regional conferences, what would that number add up to be? There would certainly be duplications, but these are students that we can claim with certainty have reached a threshold of engagement that results in the tangible outcome of a presentation.

By now readers (and campus administrators) may be discouraged by the maddening complexities I've described or have found a magic bullet among the approaches I've discussed that might work for their situation. However, it is important to recognize the time it will take for institutional or program administrators to carefully define the data they wish to collect, determine how it will be collected, and decide for exactly what purposes the data will be used. Then they must ensure that the resources are available to implement their plan, which raises a host of new questions. Who is in a position to assist? What buy-in is needed from faculty, students, and/or administrators to collect enough data to be meaningful? It may be easy to send out an e-mail request to all students, but if only 10 percent respond, the data won't be too helpful. If and when adequately representative data are gathered, how will the information be sorted and assembled?

At the University of Missouri, we have started collecting student information from the directors of 20 different undergraduate research programs to put into a comprehensive spreadsheet. The graduate assistant assigned to this task has already spent more than 100 hours organizing the responses and making data tables. And we estimate our count, now at about 540, is missing students who are not part of a formal program or did not participate in our campus celebration. As we spend hours working on this project, which we hope will become more streamlined and part of the annual reporting culture as time goes on, we sometimes need to remind ourselves why we are putting in this effort— which brings us back to the need for accountability.

Two of the articles in this themed issue of the *CUR Quarterly* are included to provide alternate ways of looking at the concept of the count. In the May, Cook, and Panu article, the authors propose that there are other metrics of measurement besides student headcounts to which we should pay attention. Sims, *et al*, argue that emphasizing the number of heads counted can overshadow the importance of the "value added" to individual students by their research experiences. As educators we know that it is important to recognize the quality of the engagement. There are situations in which a head count doesn't adequately describe the transformative impact the undergraduate research experience can have on students, faculty, the institution, and the long-term welfare of the public. Yet we still must be accountable and that means counting.

I hope that this themed issue and the online companion pieces will illuminate the challenges and provide different approaches to consider as we look for solutions. I also hope that this issue inspires discussions and new ideas about how, as an organization, CUR can begin to address the need to collaborate to collect the data we need to bolster our individual programs and to further advocate for the undergraduate research enterprise.

Linda Blockus

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Linda Blockus is director of the Office of Undergraduate Research at the University of Missouri and serves in leadership roles in campus programs funded by the National Science Foundation, the National Institute of General Medical Sciences, and the Howard Hughes Medical Institute. During a leave of absence from the university (2008-2009), she was a Fellow at the Center for Advancing Science & Engineering Capacity at the American Association for the Advancement of Science and played a key role in organizing the Conference on Understanding Interventions that Broaden Participation in Research Careers (www.understandinginterventions.org). She served as Chair of CUR's Undergraduate Research Program Directors Division from 2009 through 2011.

CUR Focus

Angela Wilson, *University of Missouri-Columbia*

Using the National Survey of Student Engagement to Measure Undergraduate Research Participation

Many institutions rely on the National Survey of Student Engagement's (NSSE) *The College Student Report* as one measure of undergraduate research on campus. In this article I examine the usefulness of individual campus NSSE data concerning a particular question—item 7d, which asks students whether or not they have engaged in a research project under the direction of a faculty member or if they plan to. A thorough discussion is required to understand what exactly is being measured in that portion of the survey. I also offer one suggestion for a comparative method for counting undergraduate research: students' participation in undergraduate research celebration days. I outline the potential benefits of using this participation as a benchmark within and among institutions of similar types and sizes. No study of this approach as a method for counting undergraduate research has ever been conducted.

Introduction

Undergraduate research is a high-impact educational practice that emerges in countless ways, even across the same discipline (Finley 2011). In essence, the way the term is or is not defined will affect how a student will respond to the NSSE question about participation (Fechheimer, Webber, and Kleiber 2011). The Council on Undergraduate Research (CUR) uses this definition of undergraduate research: "An inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline" (Council on Undergraduate Research 2011). Many institutions use a variation of this definition on their campuses.

In reality, undergraduate research is a term used to describe an abundance of activities. Undergraduates may consider research to include: washing dishes in a lab, engaging in an immersive summer research program, writing a formal teaching plan for introductory percussion students learning marimba solos, data entry, website mining, conducting an innovative project on melanoma cells leading to a publication—among innumerable other options. At least some of these types of engagement ultimately lead to outcomes such as professional development, research design skills, and an understanding of data collection and analysis (Lopatto 2010).

Item 7d in *The College Student Report* is problematic because "research" is not precisely defined. What does the item actually measure? In 2000, NSSE conducted several focus groups to address measures of validity within the survey. Its report says the following about the item:

> ***Worked with a faculty member on a research project.*** *Some students were uncertain about what would be considered a "research project." Would a research paper be considered this? Or only things more akin to lab-work? The response options also posed a challenge because most students indicated "never". Response options were not all used, and it functioned more like a dichotomous yes/no answer* (National Survey of Student Engagement 2010).

The report discusses the changes in the instrument relating to issues discussed within the focus groups. The item relating to undergraduate research was shifted to a different area of the survey. The 2001 version of the survey item included an additional phrase: "outside of course or program requirements." The added phrase does not, however, seem to resolve the underlying problem concerning students' confusion about the term "research project." Changes to the instrument are scheduled for the 2013 version, but NSSE officials had not released any proposed changes for item 7d at the time of this publication.

NSSE and *The College Student Report* in Brief

NSSE is a project housed within the Center for Postsecondary Research at Indiana University. The Pew Charitable Trusts, a non-profit organization with a focus on public policy (Pew Charitable Trusts 2011), awarded funds to the center in 1998 for research on good student practices that result in positive outcomes for college students (National Survey of Student Engagement 2011). The grant was used to create and implement *The College Student Report*. According to the NSSE website, the report's survey was first administered in 2000 (National Survey of Student Engagement 2011). Since its inception, the survey has been used by 1,493 four-year institutions, which have administered it to more than 2.5 million students. Although technically labeled *The College Student Report*, the survey and the results are commonly called NSSE (pronounced "nessie").

The survey consists of 28 questions, some of which include multiple sub-questions. The sidebar on the following page provides information regarding the benchmarks of achievement used in the annual reports issued to individual institutions.

Five Benchmarks of the College Student Report

The items of the survey used to define the benchmarks are those that are considered impactful in the student experience.

- Level of Academic Challenge: Based on 11 items of the survey.
- Active and Collaborative Learning: Based on 7 items of the survey.
- Student-Faculty Interaction: Based on 6 items of the survey. (Question 7d is located in this benchmark for assessment.)
- Enriching Educational Experiences: 12 items of the survey.
- Supportive Campus Environment: 6 items of the survey

(National Survey of Student Engagement 2011).

The NSSE website states that the questionnaire takes approximately 15 minutes for students (samples of freshmen and seniors) to complete either online or in a paper version and that the 2010 version produced an average response rate of 37 percent of freshmen and seniors from participating institutions.

The survey has been extensively tested for reliability and validity. The strength of the survey is apparent in a benchmarking system that compares institutions (Kuh 2001; Chen *et al* 2009). The Center for Postsecondary Research at Indiana University provides extensive information regarding the psychometric measures used to ensure the reliability and validity of the survey for institutions and other consumers (National Survey of Student Engagement 2011). After the survey data is tabulated, a report is issued to each institution whose students participated, including their response rate. In addition, data from all other institutions of similar size with comparable missions can be found in the annual report or on the NSSE website.

NSSE officials state that the objective of the survey is to "provide data to colleges and universities to assess and improve undergraduate education, inform state accountability and accreditation efforts, and facilitate national and sector benchmarking efforts, among others" (National Survey of Student Engagement 2010). The goal is to provide institutions with the means to understand which areas on campus are performing well and which could use improvement (Kuh 2003). The survey, itself, is available to administrators to help them understand what the campus's results mean, so they can begin to take action in areas in which student engagement is lacking (Kinzie and Pennipede 2009). *The College Student Report* provides benchmarks (see sidebar) in five areas of student engagement for campuses to use for comparison with other institutions (Gordon, Ludlum, and Hoey 2008). The survey's results for a particular campus may provide the campuses with an overall understanding of students' perceptions about areas of engagement and how the campus situation can be improved (National Survey Student Engagement 2010). Comparative baseline data from other institutions can help campuses set goals for improvement.

Gathering Institutional and NSSE Data

In my data collection regarding item 7d of the NSSE survey on undergraduate research, 72 directors of undergraduate research were contacted by email requesting access to their NSSE data, particularly comprehensive raw data for question 7d of the survey. Fourteen directors responded, however, only seven responses fit the needs of the project. The directors were identified from a conference held by CUR in 2011. Regarding item 7d, the instrument allows students to select from the following four responses: "Done, Plan to do, Do not plan to do, Have not decided."

The responding directors also provided records of students' participation in sponsored symposia (or celebration showcases) for years corresponding to the available NSSE data. The campuses in this survey typically hold at least one annual student presentation event accessible to all students on campus. While the data I collected do not provide a comprehensive assessment of undergraduate researchers' participation in these events on a particular campus, the number of participants does indicate a measurable level of student activity that can be validated by a campus office of undergraduate research. Records of undergraduate enrollment were obtained through each university's website.

Data Analysis

In presenting my results, some data were manipulated with simple statistics to provide an overall understanding of seniors' participation in research at a single institution. The data presented below represent two measures of undergraduate research on individual campuses: self-reported responses to NSSE 7d and counts of students who participated in the campus symposium/celebration day. The second column in Table 1 illustrates the total undergraduate enrollment at the individual institution that corresponds to the year of the data collected by NSSE. Where possible, the spring enrollment data were used for the academic year instead of the fall enrollment. Spring enrollment data are a better indicator of the population of the institution because major symposia/celebration days are typically held in the spring, and the NSSE survey is distributed in the spring semester. Next, the reported number of seniors who responded in the NSSE survey that they had "done" research while an undergraduate is represented in column three, with the percentages these

Table 1: NSSE and Symposia Data *

Institution Name (Data Year)	Total Undergraduate Enrollment	NSSE Count of Seniors Responding Had "Done" Research	NSSE Percentages of Seniors Responding Had "Done" Research	Symposia Participation
The Ohio State University (2010)	41348	2434	22.4%	540 (~5.22% of senior class)
University of Missouri (2009)	23042	NA	27%	143 (~2.48% of senior class)
University of Nebraska-Lincoln (2010)	17627	265	26%	220 (~4.99% of senior class)
University of South Carolina (2009)	17874	531	14%	132 (~2.95% of senior class)
Utah State University (2008)	13179	NA	25%	100 (~3.03% of senior class)
University of Wisconsin – Eau Claire (2008)	10096	NA	25%	588(~23.3% of senior class)
Weber State University (2009)	23001	NA	17%	89 (~1.55% of senior class)

* A full list of references is available in Supplemental Materials in the Spring 2012 issue of the *CURQ on the Web*.

numbers represent of total campus enrollment provided in the fourth column. Rates of total student participation in undergraduate research symposia for the corresponding year are stated in the fifth column. Additionally, a percentage was calculated to approximate the total number of seniors participating in symposia. The percentage was obtained by dividing the total undergraduate enrollment at each institution into equal quarters. To roughly estimate the seniors' response rate, the percentage assumes all of the students participating in the stated symposium year are seniors. (Actual numbers were not gathered from the institutions in the interests of time and not imposing too great a burden on individual offices of undergraduate research.) This percentage was included in the data table as a crude scaling figure for the NSSE and symposia participation data.

NSSE also offers a new program on its website allowing individuals to build a comparative report concerning individual items based on institutional type. NSSE data were gathered from a total of 298,562 student responses (2009-2010) for this particular report with a total of 20.3 percent of these students indicating they had "done" undergraduate research (see Table 2).

Item 7d: What is actually measured?

Offices of undergraduate research and campus administrators use NSSE data as one measure of undergraduate research. Yet the NSSE question 7d simply asks whether or not the student has worked on a research project with a faculty member outside of class. As a result, students who primarily clean petri dishes in a lab, for example, may select "done" in response to this question. The NSSE question does not specify where on the undergraduate research experience continuum a "research" experience must fall. Instead, the survey may encompass students who have started the preliminary stages of undergraduate research but never completed a project or never presented information about their own research project. This may lead to an overestimation of undergraduate researchers on campus. Administrators who look to the survey results as a count of undergraduate research engagement may be misled by the quick and easy percentages offered.

NSSE also may exclude students from disciplines, such as arts and humanities, who may not define their scholarly and creative work as "research." The term "research" may be an unfamiliar one for some students who conduct scholarly activity such as analyzing Victorian-era art for feminist themes. In this example, an undercount of undergraduate research would result.

In conjunction with symposium participation numbers, NSSE may provide a clue to undergraduate research directors concerning the depth of engagement on campus. For example, in 2009 at the University of Missouri, 27 percent of students responded to item 7d by saying they had conducted research. However, the estimated percentage of seniors participating in the given year's symposium is only 2.48 percent. The University of Missouri has a clear disparity between the number of students who state they have participated in undergraduate research on NSSE and the number of students who present their research at the annual event sponsored by the undergraduate research office. This discrepancy in counts may lead to an interesting discussion of how

Table 2: Student Responses to Item 7d (2009-2010)

Type of Institution	Total NSSE Count of Seniors Saying Had "Done" Research	NSSE Percentages of Seniors Saying Had "Done" Research
Research Universities (very high research activity)	10164	25.3%
Research Universities (high research activity)	10147	20.7%
Doctoral/Research Universities	3441	17.7%
Master's Colleges and Universities (larger programs)	12808	16.1%
Master's Colleges and Universities (medium programs)	4888	19%
Master's Colleges and Universities (smaller programs)	122	20%
Baccalaureate Colleges—Arts & Sciences	7397	28.6%
Baccalaureate Colleges—Diverse Fields	3510	19.1%
Total	**54477**	**20.3%**

undergraduate research is perceived on this campus or it may point to a dramatic underutilization of the spring showcase event by students. Simply, students at the University of Missouri may consider undergraduate research to consist of any of the activities discussed earlier, including washing petri dishes or entering data. This is only one interpretation of the inconsistency in the separate counts. However, by comparing these numbers undergraduate research directors and administrators may gain considerable insight into how the term "research" is defined and disseminated on a particular campus.

The data from the University of Wisconsin at Eau Claire presented in Table 1 are unusual when compared with the data shown for other institutions. UW-Eau Claire reported an extremely high proportion of students engaged in undergraduate research symposia. The NSSE data perfect the same information reported by the institution. UW-Eau Claire promotes a campus-wide culture of undergraduate research and reports funding many students' research. Undergraduate researchers who are funded are required to either present at the system's undergraduate research celebration day, the campus poster event, or to produce a written report of the research completed. A portion of tuition is designated to fund high-impact practices such as undergraduate research. Students at UW-Eau Claire voted and approved a differential tuition fee to improve the institution's programs that promote "best practices." Further, the campus provides funding for students to present at professional conferences and meetings. Overall, the climate of the campus encourages students to participate in undergraduate research and to engage in campus or system-wide scholarly events (K. Havholm, personal communication, August 30, 2011).

Photo credit: Abbye Klamann

Summer Interns at the University of Missouri pose for a group photograph. These students were funded by seven different programs and represent 24 different institutions.

For most of the institutions in the sample, a disparity is evident between the symposia counts and the NSSE counts of students saying they had participated in research. The ambiguous language of the survey instrument appears to lead students to select "done" at a higher rate in institutions where the culture of undergraduate research is not well defined. In short, the instrument fails to provide a concrete measure of high-level engagement because the definition may not embrace all disciplines and does not require that an original contribution be made. As a result, the survey simply allows for students to define the term "research" for themselves. Although data collected from the instrument provides some insight to the institution about how undergraduate research is perceived or understood by students, the results of the survey do not provide an institutional method for reporting an undergraduate research count that is meaningful for undergraduate research program directors or administrators.

Photo credit: Abbye Klamann

Prairie View A&M University student Vivienne Echendu presents her summer research to a faculty member at the University of Missouri. Vivienne's summer internship was supported by the NSF Research Experience for Undergraduates program.

More than 110 undergraduate interns present posters after spending the summer conducting research at the University of Missouri in 2011.

Photo credit: Abbye Klamann

Measuring Research Day Participation

Many campuses have undergraduate research day celebrations, poster forums, symposia, or some other term used for an undergraduate research showcase. These showcases typically highlight students on campus who have completed their own research or scholarly/creative projects, analyzed their work, and prepared themselves to present the material to the community. The projects completed by students who participate in undergraduate research symposia land firmly within CUR's definition of undergraduate research.

Each campus implements this event in a different way. For example, the Office of Undergraduate Research at the University of Missouri holds two poster forums each year. All students on campus are encouraged to participate in the event. Some departments host a poster session exclusively for the students of the department. Other students outside a structured program may never formally present their work. Therefore, the count of undergraduate researchers based on the campus-wide poster events does not encompass all of the students who might be considered to have conducted research or engaged in other creative activities along the undergraduate research continuum. However, despite an anticipated undercount, using the numbers of students participating in a campus undergraduate research symposium is an easy and systematic way to tally actual students who have achieved a certain level of accomplishment.

Rather than using student responses to an ill-defined item on the NSSE survey as the measure of comparison among institutions, comparing the participation numbers at institutions' sponsored undergraduate research symposia might be a more salient measure for campuses to use. Presumably all institutions have similar challenges in ensuring students participate in such events, and therefore students will be similarly undercounted. Not all institutions have the resources and long-standing history of undergraduate research that UW-Eau Claire does, so the measure I've outlined may be a more accurate way to benchmark the quality and level of undergraduate research among campuses. In summary, an institution can benefit from comparing the number of students participating in campus-wide undergraduate research symposia or celebrations to the participation numbers at other similar-sized and Carnegie-categorized institutions.

Future Study

This article begins to scratch the surface of measuring student participation within and among campuses. Studies should be conducted concerning the reliability and validity of using data on undergraduate research symposia as a method for institutional benchmarking. The literature reflects a dearth of qualitative research exploring the ways students define "undergraduate research." Further understanding of how this concept is understood on individual campuses may provide the key for using national assessment tools like NSSE.

In the meantime, the NSSE survey results prompt some interesting questions for undergraduate research directors. How are students defining undergraduate research? How long does the engagement last? How can the campus's office of undergraduate research capture more students in symposia?

The NSSE survey results should not be the sole report provided to stakeholders and administrators as the campus undergraduate research count. Instead, the information should be used in concert with the physical participation counts of presenters at undergraduate research symposia. The latter information reports a tangible number of students who have achieved a defined level of undergraduate research experience.

Such information can be divided into useful data for undergraduate research offices and administrators. For example, a national database of statistics on numbers of students participating in undergraduate research celebration days, by institution, may provide a detailed and comparative measure of achievement and involvement that is lacking in the NSSE statistics. Data categories could include students' characteristics (year in school, major), mentor characteristics (department, rank), project information (broad academic discipline, poster/oral presentation or performance), and funding source, if any. This information is easy for undergraduate research administrators to gather and put into an online form. A centralized, searchable database accessible through an organization such as CUR would be an invaluable service for campuses to use in understanding participation numbers and how they compare with peer institutions. Further, open dissemination of such data could foster a collaborative and collegial atmosphere for promoting engagement in undergraduate research among institutions across the nation.

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Karen L. Webber, Marcus Fechheimer, Pamela B. Kleiber
The University of Georgia

Defining and Measuring Participation in Undergraduate Research at the University of Georgia

Many four-year colleges and universities are making solid progress in implementing the Boyer Commission (1998) recommendation to make "research-based learning a standard" in undergraduate education. However, the ways in which undergraduates are introduced to research and the methods by which we define and measure participation in undergraduate research (UR) vary widely. In our recent *CBE Life Sciences Education essay* (Fechheimer, Webber, and Kleiber 2011; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3105922/pdf/156.pdf), we described the dramatic increase in undergraduate research activities over a 10-year period at the University of Georgia (UGA). In addition, we analyzed achievement scores of 2005 baccalaureate graduates at UGA and, based on that data, our results confirmed that students' participation in undergraduate research contributes to their academic success. Reports of increases in participation rates in undergraduate research, both at our institution and at many other four-year colleges and universities (Hu, Kuh and Gayles 2007), have been most gratifying. The interpretation of these findings concerning participation, however, is hindered by differences in the methods used to measure students' participation in research, and these differences impact the ability to make comparisons about participation both within and between institutions. Here we present our approach to defining participation in undergraduate research in the hope that it might help other researchers arrive at a consistent definition of such participation.

We chose to define engagement in UR operationally, based on a strict definition, which is a student's enrollment at any point during baccalaureate study in specific courses designed exclusively for the conduct of UR. Credit hours generated from enrollment in such courses at Georgia served as the source of data in our recent *CBE* essay (see Figure 1). Because each course was identified with a program of study, we were able to further identify the increase in UR credit hours produced in each discipline across the entire university, which we then grouped into credit hours earned in the sciences, social sciences, humanities, and arts. This method also allowed us to assess the number of semesters of UR engagement for students. In addition to counting student credit hours generated, we also identified the number of students who participated in official UR activities such as presenting a paper at the annual campus UR symposium or students who completed a senior thesis (see Table 1). This information was based on data compiled by our university's Center for Undergraduate Research Office (CURO).

Table 1. Selected Capstone Student Outcomes from Undergraduate Research at UGA

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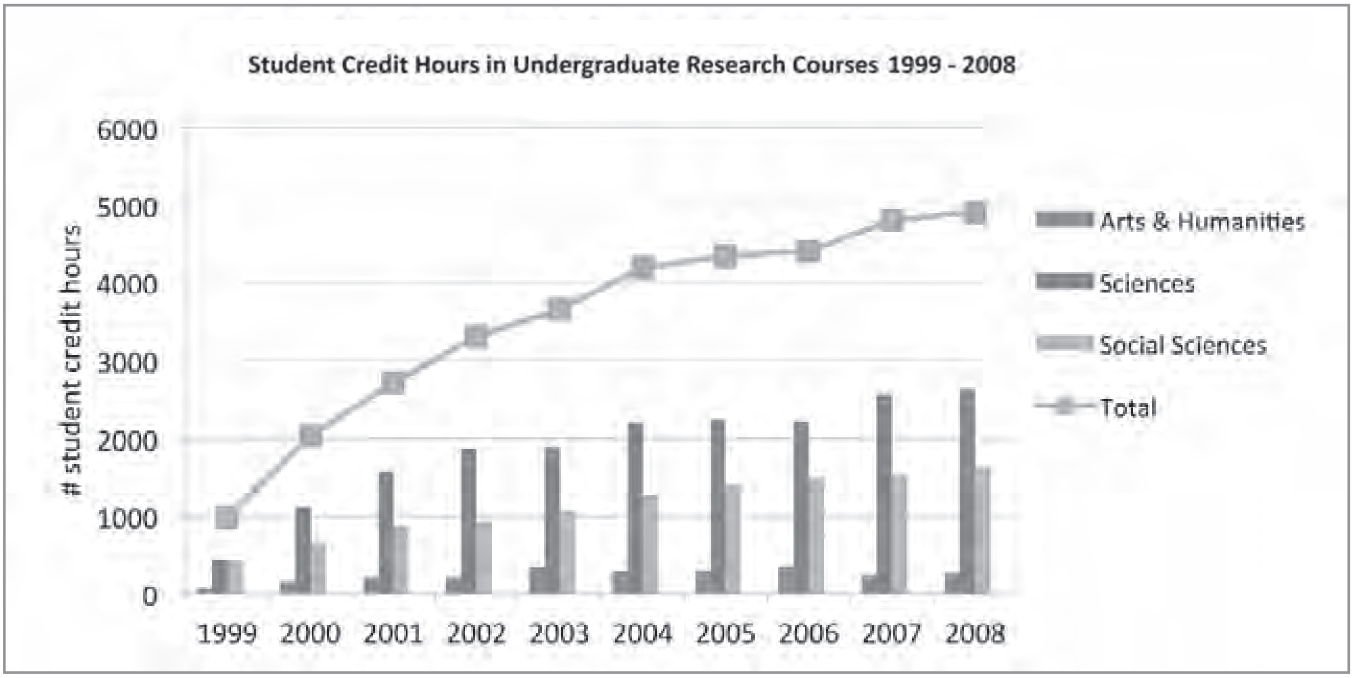
Year	# Students Presenting at CURO Symposium	# Students Submitting Honors Thesis	CURO Scholar Distinction
1997		19	
1998		23	
1999		46	
2000	68	63	
2001	67	68	
2002	138	69	6
2003	138	106	9
2004	115	89	12
2005	159	90	16
2006	143	104	35
2007	191	108	35
2008	211	67	35
2009	197	69	35

There are both advantages and disadvantages to our method of identifying participation in UR. The disadvantage of the method is that students participating in UR as a volunteer, a paid worker, or as an enrolled participant in courses not included in our operational definition were not counted. Thus it could be argued that our results underestimate the extent of participation in UR. However, the use of institutional data has advantages in that they cross all disciplines, allow measurement of the duration of engagement in research, identify the completion of "capstone" activities, and are amenable to retrospective as well as prospective study. Further, this method does not suffer from the problems of accuracy and low response rates that plague student surveys.

In addition to examining engagement in UR-related activities, we also sought to investigate the effect of students' participation in UR on their cumulative grade point average (GPA). After obtaining approval from our university institu-

FIGURE 1. Student Credit Hours in Undergraduate Research Courses at UGA 1999-2008
Reprinted with permission from *CBE-Life Sciences Education*.



tional review board, we examined demographic and student ability data from the university's student records system on all students from one recent baccalaureate graduating class (approximately 5,000 students). We identified participation in UR by the graduates' previous enrollment in designated UR courses, as described above. This retrospective analysis enabled us to examine enrollment in UR courses over students baccalaureate careers, to use their SAT scores to account for differences in student ability, and to examine differences in cumulative grade point averages based on the number of UR courses in which they enrolled. Statistical analysis of these data supported a relationship between UR and student success and a clear positive effect of extended engagement in UR.

We agree with Beckman and Hensel (2009) and Berkes (2008) that UR participation rates in the published research vary depending on the method or source of data used to determine the participation. For example, data on UR participation can be collected from institutional databases, faculty reports based on the number of students who work in their labs or other research programs, student reports from satisfaction surveys, or UR program records that document the number of students enrolled in a formal UR or honors program. Institutional database records can be very helpful in identifying UR participation at the current time or prospectively over multiple semesters or years, and can be especially helpful if one wants to examine UR participation across majors or disciplines. An institutional database may include a "flag" or indicator of UR activity, and this can be measured by student and/or faculty member. In addition, databases can effectively identify student enrollment in UR courses, and, if desired and approved by the institution's IRB, can include other relevant information on each student. Student enrollment, when combined with demographic data such as ability scores, grades earned, majors, credit hours completed, and cumulative number of UR experiences completed, can yield important information on the impact of UR participation.

In summary, there are a number of ways to define undergraduate research and to measure participation in this important activity. In addition to counting involvement by just the number of student participants, it is important to consider factors related to the breadth, depth, and duration of the activity. Our use of university database records, in combination with information on undergraduate research programs, offers numerous advantages, allowing for comparisons over time, between disciplines, and across institutions.

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For the online version of CBE Life Sciences Education, visit: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3105922/pdf/156.pdf

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Pamela B. Kleiber is the recently retired associate director of the Honors Program and Center for Undergraduate Research Opportunities at UGA. She is currently serving a three-year term as Councilor in the At-Large Division for the Council on Undergraduate Research (CUR). She directed the later stages of the Fund for the Improvement of Postsecondary Education grant that funded CURO and two National Science Foundation Grants to link high schools and a research university for CURO. Her research interests include undergraduate research. She is now a University of Georgia Emeriti Scholar who consults in higher education.

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CUR Focus

A Quantitative Model for Predicting Which Features of Undergraduate Research Aid Acceptance into Graduate Education

Major efforts are under way to increase students' participation in undergraduate research, primarily in the STEM (science, technology, engineering, and mathematics) disciplines, but in other disciplines as well. However, we also are entering a period of decreased funding for higher education from state sources, governmental agencies, and perhaps even private sources. This financial scarcity will impede the development of research-rich environments for undergraduate students unless we produce a powerful way to justify the extra expense in money and faculty time allotted to support undergraduate research. Evidence in support of undergraduate research is certainly accumulating, but we need more rigorous proof of which elements constitute effective student participation. Thus we are proposing a quantitative model, logistic regression, that can predict the relative usefulness of various components of the undergraduate research experience and thus advance our thinking about such opportunities—shifting undergraduate research from its current status as a moral imperative into a proven centerpiece of effective undergraduate training (see Paul 2011).

In the 1970s, proponents of undergraduate research began publishing documentation showing its importance. These efforts and a dozen papers in the 1980s were followed by the supportive report of the Boyer Commission on Education (1998), the National Science Foundation's Integration of Research and Education grants, and private funding of undergraduates' research participation. Calls for evaluation of undergraduate research programs began about a decade ago (Manduca 1997; Spilich 1997), and subsequently more than 50 articles have been published espousing the effectiveness of students' participation in undergraduate research (see Table 1 in Junge *et al*. 2010). Most of this evidence has been case studies and anecdotal reviews of student and faculty experiences, citing improvements in student learning outcomes, critical thinking, and personal motivation. There have also been useful before-and-after surveys and even a few large-sample studies that pool data from multiple undergraduate research settings (Mabrouk and Peters 2000; Merkel 2003; Lopatto 2004, 2007; Seymour *et al*. 2004; Russell *et al*. 2007). However, the vast majority of these studies do not compare undergraduate research participants with non-participants, and most lack methodological rigor in their designs (Adhikari and Nolan 2002; Bauer and Bennett 2003; Junge *et al*. 2010).

What is at stake is the ability of colleges and universities to provide effective undergraduate education across a wide spectrum of disciplines. If, in fact, undergraduate research is an absolutely important aspect of the recruitment, development, and retention of students majoring in STEM and other disciplines and their matriculation into graduate programs and subsequent careers, then institutions of all kinds need to understand the parameters of that participation.

The difficulties associated with providing this research experience have been addressed several times by articles in *The Chronicle of Higher Education*, which have outlined the pitfalls of undergraduate research at predominantly undergraduate institutions (see Guterman 2007). In spite of such admonitions, there has been a steady march toward undergraduate research programs in many higher education institutions. For example, at our institutions, Brenau University and Gainesville State College, there are shifts toward the research university model. The lack of "professor-extenders," such as graduate students and laboratory technicians, at predominantly undergraduate institutions can create a paradox in which there is a decrease in faculty teaching and advising in exchange for a focus mentoring on fewer students in the undergraduate research program (Malachowski 2010). Indeed, this problem almost certainly extends to research universities as well.

The technical need, then, is for the development of effective evaluation procedures using a statistical model that can predict the importance of the multivariate nature of undergraduate research participation. Rather than being critical of the significant quantity of studies that have been undertaken thus far to validate undergraduate research as an effective pedagogy, we are proposing to expand the inquiry using a more complex statistical approach employing multiple variables, and then focusing on a few significant ones if they are found to exist. We have also realized from the existing large-sample studies that pool data from multiple undergraduate research settings that there is a need to develop a framework that can be used to define the undergraduate research situation in a given university environment—one that can also be used as a predictive model for individual undergraduates who seek admission to graduate education and subsequent careers.

The Logistic Model

The choice of a methodologically rigorous assessment model to analyze the effectiveness of the amount and type of undergraduate research experience needs to include (1) multiple categorical variables, (2) indicators of the relative importance of each of the categorical variables, and (3) probability of a particular outcome. We have chosen a statistical approach called a logistic regression, or a logistic model, because it can incorporate several predictive variables that may be either numerical (e.g., cumulative GPA) or categorical (e.g., whether the student wrote or co-authored a publication). Conventionally, the variable *z* is used to represent the impact of the set of independent variables. Thus *z*, known as the logit, is a measure of the contribution of all the independent variables used in the model, and *f (z)* represents the probability of a particular outcome, running from 0 to 1.0. Our proposed logistic model is listed in Table 1.

Table 1. Proposed Logistic Regression Model

$$f(z) = e^z/(e^z + 1)$$

where $z = \beta_0 + \beta_1 R + \beta_2 I + \beta_3 S + \beta_4 G + \beta_5 C + \beta_6 M + \beta_7 P + \beta_8 A$, and

β_0 = regression intercept

$\beta_1, \beta_2, \beta_3 \ldots$ = regression coefficients for the categorical variables

R = number of contact hours of primary research

I = number of contact hours of internship

S = number of contact hours of service learning

G = total number of contact hours of group or collaborative work

C = number of credit hours of STEM courses taken

M = number of professional meetings attended

P = number of student publications written and submitted

A = cumulative GPA

The proposed logistic model can demonstrate the relative importance of undergraduate research variables, as well as other predictors, in students' acceptance into a graduate degree program. Since this model is to be used in our study only for biology majors, we have selected acceptance into a graduate degree program as the predicted outcome variable of merit because nearly all careers in biological and biomedical fields require graduate training. We have adopted the analysis choices of Junge *et al*. (2010) and have included a number of graduate degree programs, including ones in life and natural sciences (MS, MA, PhD), health sciences (MPH, MSN, PsyD, MD, DMD, DPT, DNP, PharmD, DVM), and professional/trade/applied sciences (JD, MBA). In our model, the calculated *f (z)* will be the predicted probability of being accepted into one of these degree programs.

Choice of Categorical Variables

The choice of categorical variables starts with three types of undergraduate research experiences: primary research (defined as designed, executed, and analyzed original research projects), internships (defined as a shadowing experience or as working in a lab on someone else's already-designed projects using their research methods), and community-service learning (defined as projects that have a research component but are actually more rote in nature, such as conducting a survey).

Subsequent analyses may tell us whether research experience helps steer students towards pursuit of a PhD, while service learning may be found to be more important for other graduate-level studies, such as pharmacy and public health. In each case, we will determine the number of total contact hours that students spent on their projects, whether they undertook the projects individually or in a group, whether they attended or gave a paper at a professional meeting, and whether they co-authored a paper. We will also collect data on other variables not a part of the present model. These will include gender, ethnicity, presence of a disability, ratings of research mentorship, involvement of peer mentorship, and scores on three standardized tests: the Educational Testing Service Field Test in Biology, the California Critical Thinking Skills Test (CCTST), and the California Measure of Mental Motivation (CM3).

We realize that there are a wide variety of variables and that it is impossible to include all of them. However, a logistic analysis that starts with a reasonable number, say eight, and that ultimately focuses on a small number of variables that prove to be statistically significant is an advantage. During this process, non-significant variables may be discarded and new combinations tested in an iterative process.

Data will be collected using a survey form filled out by biology majors at the end of their senior year. Data from each categorical variable will be analyzed by means of a commercially available logistic regression model using a personal computer. Beta coefficients will be determined, and categorical variables not contributing significantly to the predictability of the model will be removed from the proposed model's equation. Variables not included in the original equation will be included and analyzed in an iterative fashion, until a final equation is selected. Beta values in the final equation can be used for the predictions and analyses concerning the model's potential usefulness.

Simulated Run of the Model

Although collecting data for a complete analysis and validation of the model will take more time, we have undertaken a simulation to determine whether the logistic model is generally workable for our goals. To generate a sample data set, we used the graduating biology majors from Brenau University in 2010, about half of whom had undergraduate research experiences and half did not, and repeated the same data up to a simulated total sample size of 403. Running both a general regression model and a logistic model showed that GPA overpowered everything ($P < 0.001$) in its prediction of graduate school admission. This is consistent with what we know about the importance of GPA in this process.

We then ran combinations of variables in the logistic model by trial-and-error and found that in this simulated sample, two other variables made a statistically significant contribution: the number of primary research contact hours ($P < 0.001$) and the number of credit hours of STEM courses taken ($P < 0.001$). None of the other variables, such as meeting attendance and paper writing, seemed to be significant in this sample. This shows that the design of obtaining data for many different parameters that might be involved in winning entry to a graduate program, and then using an iterative process to winnow them down to a statistically significant smaller group, is indeed a useable methodology for pursuing questions about the relative importance of those parameters using the logistic model.

Anticipated Challenges

One of the liabilities of the logistic regression model is that it may overestimate the beta coefficients or the relative importance of the categorical variables at sample sizes less than about 500. As the sample size increases, the accuracy of the statistic likewise increases (Nemes *et al*. 2009). So a significant effort to attain the needed sample size must be undertaken. In order to initiate a study of this magnitude, we have undertaken a collaborative effort, which will proceed over two or three years, to obtain data from the 870 biology majors at three predominantly undergraduate institutions in Northeast Georgia: Brenau University, Gainesville State College, and North Georgia College and State University.

Another challenge is pre-selection of only "top" students by the faculty to participate in undergraduate research experiences, particularly if those venues are outside the university (externships). Such externships are precious and protected by the faculty members who oversee the undergraduate research program. This is a challenge because it introduces a bias into the number of students who have an opportunity to show a graduate admissions committee they had a chance to do research. A third challenge is that in any given college or university setting, the opportunities for undergraduates to conduct research are seldomly abundant. Their rarity almost dictates that only the best, most motivated students will apply for them and be granted participation. These two challenges may be addressed by specifically designing research opportunities in such a way that other students without the highest GPAs have a chance to participate in research. With proper attention to mentoring, such less-than-top students may pose minimal risk to the program. Of course, all students in a cohort of data (graduating class), both outstanding students and all others included in undergraduate research, must apply for graduate education for the analysis to be valid.

Another challenge we have noticed is that of obtaining an accurate record of the number of hours students actually spend on research. This is best met by requiring students to keep a log of their research hours, as well as requiring them to meet frequently with their mentors. At these meetings, mentors can verify the hours and research activities listed in the log, since these mentors are actively overseeing the research.

Potential Usefulness of the Logistic Model

The significance of our efforts is that ultimately we may be able to determine predictably which elements of an undergraduate research experience are the most pivotal and effective in aiding students to advance in their educational and professional careers. It will enhance the current state of undergraduate research by validating a new statistical tool to be used in assessing its impact.

The practical applications of our predictive model are potentially threefold. First, we should be able to determine the specific parameters of the undergraduate research experience that are important for undergraduate education, including the type of research (primary research, internship/shadowing, or service learning) involved and the number of contact hours of experience that have an effect. We will also be able to determine whether students' experience is more valuable if undertaken as a group or individually. We can determine if undergraduate research participation causes students to take an increased number of courses in their own major and in related and supporting disciplines, as the paper by Junge *et al*. (2010) claims, and we can further test that finding. We also will be able to determine the relative importance of students' giving a presentation at a professional conference or writing a research paper. And we can set up a logistic regression analysis to determine the importance of items thought already to be influential in graduate school admission: GPA, *Graduate Record Examination in Biology* scores, content knowledge, critical thinking, and motivation.

Second, the formula we finally develop will help an individual university plan for appropriate undergraduate research experiences for its students in order to maximize the effectiveness of limited manpower and financial resources.

Photo credit: Rudi Kiefer

Jessi Shrout, assistant professor at Brenau University, provides guidance as Rebecca Jones, sophomore undergraduate research student, works in the laminar flow hood on a tissue culture project involving the endangered fern species Asplenium heteroresiliens.

Such a scientifically validated model for the prediction of success in undergraduate students' education will support university administrators in their quest for funds to support undergraduate research in this time of constrained budgets in higher education.

Third, in the case of particular students, the final equation can help students determine what types of experiences they might need to focus on to improve their chances of winning admission to graduate or professional programs. A corollary of this calculation is that the predictive power of the logistic regression model might be used to determine which undergraduate research variables play an important role in the success of underrepresented groups (by gender, ethnicity, or disability status).

Conclusions

A quantitative model predicting the relative usefulness of various undergraduate research experiences can advance our understanding of and advocacy for undergraduate research experiences. Here we have argued in support of choosing a logistic regression model to undertake such quantitative assessment. Its advantage is that it produces a probability estimate of whether a particular combination of undergraduate research experiences (type of experience, GPA, etc.), will result in admission to a graduate education program. It also can incorporate both numerical and non-numerical data into its analysis. Its major disadvantage is that it requires a relatively large sample size, probably 400 students. Its greatest strength, though, is that it may be able to settle the issue of the importance of undergraduate research experience, and it may do this at a time when limitations are being placed on higher education—financially and in faculty time and resources. It is probable that only a powerful quantitative analysis such as this will allow supporters to argue successfully for continued and even expanded support for undergraduate research programs.

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CUR Focus

Jeanetta D. Sims, Jimmy Le, Brittany Emery, James Smith, *University of Central Oklahoma*

Beyond the Quantitative Headcount: Considering the Un-Captured Qualitative Impact of Engaging Undergraduates in Research

"Knowledge—and particularly, knowledge of human beings–consists in the apprehension of qualities, which in their very nature elude the net of number, however fine its mesh" (Kaplan 1964, 206).

The success of any program is dependent upon a systematic evaluation of the program's ability to accomplish established objectives, and measurement of the undergraduate research experience is no different. The challenge of measuring the success of undergraduate research programs is the need to cast the net in such a way that what is caught provides an all-inclusive justification for the programs. While quantitative headcounts can be useful, this single approach to program impact fails to account for the multi-faceted influence of research involvement among undergraduate students. The purpose of this essay is not to argue in support of either side of the quantitative/qualitative debate about the proper way to evaluate the impact of research programs. In fact, we believe that both quantitative and qualitative approaches provide meaningful results legitimizing the benefits institutions receive through support of undergraduate research.

However, given the primary focus of this issue of the *CUR Quarterly* on counting undergraduate research participation, we wish to remind readers that "certain experiences cannot be meaningfully expressed by numbers" (Berg 2001, 3). As a result, we argue for the importance of moving beyond counting the quantitative impact (e.g., headcounts and participation numbers) to capturing the qualitative impact of undergraduate research. The omission of experiential, qualitative data may leave the essence, ambience, and quintessential aims of an undergraduate research program's impact un-captured by ignoring the impact of the undergraduate research experience on students' lives.

Maria Jimenez, David McKinney, and Tessa Chervenka taking a break while presenting at 2009 Oklahoma Research Day.

To illustrate the importance of capturing qualitative data for a more comprehensive account of an undergraduate research program, we first discuss the engagement of the faculty author (Sims) in such research and the quantitative headcounts generated within four academic years. We then discuss the qualitative impact of the experience not captured by the headcount, drawing on the perspectives of a few student participants. Finally, we briefly discuss the value of both types of assessments for those who seek stronger evidence of the multi-faceted effectiveness of their undergraduate research programs.

The Headcount for One Faculty Member

To better understand the faculty author's engagement with undergraduate research, it is helpful to explain the process by which students' research involvement occurs. First, the University of Central Oklahoma's academic focus on transformative learning, which is carried out through students being active and reflective participants in their own learning processes (University of Central Oklahoma 2011), served as the catalyst for the faculty author's commitment to engage undergraduates in her research activities. Sims announces during the first week of classes that students have the chance to work with her on research. This offer has been made in junior- and senior-level courses such as Business Communication, Interpersonal Communication, Integrated Marketing Communications, Social Marketing, and Digital Media and Content Marketing. Students are encouraged to express interest directly to Sims.

Students who need a three-credit marketing elective can enroll in independent study to work alongside the faculty author on business communication and marketing research. A sampling of past research projects include data collection for a study that examined how to protect value-in-diversity attitudes, transcription of focus group research, data collection for a study on message-sequencing success in integrated marketing communications, a literature review for a paper on technology and integrated marketing communications, and a content analysis of arguments examining the motivational forces associated with resistance to influence.

Typically, one to three students enroll for independent study credit each semester. The research projects are dictated typically by the faculty member's own pipeline of research on topics related to persuasion and social influence, organizational diversity, public relations, and marketing communications.

The student researchers commit to attend weekly research meetings and complete outside readings, data entry, or follow-up analysis while enrolled in the independent research study, and the faculty member commits to having at least one co-authored presentation as a result of their work. Most research students have chosen to continue working on research beyond the semester-long independent study, and in many cases, students have received an on-campus grant to have their own piece of research funded, with the faculty member serving as their mentor.

A few of the quantitative counts associated with this program of research are shown in Table 1. Within four academic years, 12 different students have participated in research that generated 15 three-credit independent research studies and 15 co-authored conference presentations with the faculty author. Four on-campus grants (one to the faculty mentor and three to undergraduate students) were awarded through the university's Office of Research & Grants, and one Top Paper Award was given to the faculty mentor and undergraduate student co-author at a national conference where the undergraduate student was also a co-presenter. All students who have participated in the undergraduate research program have either graduated from the university or are on track to do so within the next year.

Table 1: Quantitative Counts of Undergraduate Research Engagement

Year	Semester	Repeat Student Involvement	New Students Involved for the First Time	Students Enrolled in a 3-Credit Independent Study	Co-Authored Conference Presentations with Students
2007	Fall	1	1	1	1
2008	Spring	3	3	3	1
2008	Summer	2	0	0	0
07-08 Academic Year		**6**	**4**	**4**	**2**
2008	Fall***	3	1	2	4
2009	Spring	1	0	0	0
2009	Summer	0	0	0	0
08-09 Academic Year		**4**	**1**	**2**	**4**
2009	Fall	3	3	3	3
2010	Spring	1	1	1	1
2010	Summer	0	0	0	0
09-10 Academic Year		**4**	**4**	**4**	**4**
2010	Fall*	3	2	2	3
2011	Spring	4	1	3	2
2011	Summer	4	0	0	0
10-11 Academic Year		**11**	**3**	**5**	**5**
Grand Totals		**25**	**12**	**15**	**15**

** The presence of each asterisk denotes the number of student research assistantships awarded through on-campus grants funded by the University of Central Oklahoma's Office of Research & Grants, where three assistantships were awarded in fall 2008.*

Such quantitative counts could be accumulated for each faculty member and reported at the department, college, or university levels. While these types of counts may be the easiest and simplest to generate, as stand-alone measures, headcounts and participation numbers lack the nuance and rich evidence offered by qualitative measures.

Table 2: Qualitative Impact on Students of Research Engagement

Qualitative Impact	Quotes From Undergraduate Co-Authors' Reflections
Increased professionalism	It does not start to become truly beneficial for us to display appropriate behavior until we have a vested interest in the people around us. Working in research has given me this vested interest to not display childish behaviors. I learned how to carry myself in a more appropriate manner in different professional situations. I learned I need to filter myself more. Being able to observe how professionals interacted with each other was very beneficial to me.
Increased contacts and networks	I have increased my network by meeting new people within the university and beyond. I have had the pleasure of working with fellow students from different disciplines of business. I never could have known how many people I would meet through this [experience]. I was able to make connections with professionals that could help me in the future.
Better time management and responsiveness to deadlines	There is a lot of work that has to be done and managing this is only made more difficult by a full workload in [other classes]. I am confident that my ability to keep a tight schedule has significantly improved. Time management has always been a challenge for me, and I was able to learn to use a planner and get my tasks on an organized schedule. Working with other students on the same deadline created more pressure for me to have my part in on time.
Increased faculty expectations	I have seen an increase in faculty expectations of me due to the fact that they see me in local and regional events. By faculty expecting more of me, in turn, I expect more out of myself. The more time that we spend working with our professor, the more the other professors find out about our experiences. When instructors have heard about us through the grapevine, they look at us as model students and expect us to use this power of influence.
Increased self-efficacy and self confidence	[This] has allowed me to be able to speak in front of other people and [to become] a better writer. I have more confidence in myself. We are benefitted with more confidence than that of our [fellow] college students. This confidence gives us the energy and the focus to finish each project that we set our mind to.

The Qualitative Impact of Undergraduate Research

Certainly quantitative headcounts of the numbers of students working with faculty members on research projects can serve as evidence that a college or university is accomplishing its academic mission. For example, a university that claims to help students learn by "providing transformative experiences so that they may become productive, creative, ethical, and engaged citizens and leaders" (University of Central Oklahoma 2011) should be able to demonstrate this institutional value by showcasing transformative efforts using quantitative data from undergraduate research.

The challenge with this type of quantitative count is that the data fail to capture the depth and quality of students' experiences. As a result, the university administrator or program director receives only a partial picture of the program's influence on the participating students and on the university's espoused values.

To illustrate the importance of capturing qualitative data, the faculty author asked three student co-authors to reflect upon their participation in the faculty author's undergraduate research program. One student began working on research in spring 2010, and the other two students began in fall 2010. The three students' participation in research has resulted in eight co-authored presentations with the faculty author. After receiving the students' emailed comments, the faculty author distilled the students' reflections into key qualitative impacts, as shown in Table 2. The presentation of information is not designed to meet the rigors of assessment or the generalizability of experimental design. Instead, we simply wish to demonstrate contrasting examples of both how to count and what types of counts could be reported at the level of faculty engagement.

The student perspectives demonstrate that a qualitative approach is of equal importance to a quantitative one for a better understanding of the true influence that undergraduate research engagement exerts. The five qualitative impacts (increased professionalism, increased contacts and networks, better time management and responsiveness to deadlines, increased faculty expectations, and increased self efficacy and self confidence) would not manifest themselves in measures of quantitative headcounts or credit-hours generated. Yet many of these characteristics are influential enough to be of value to students throughout their careers as professionals. Thus, through qualitative insights the impact of undergraduate research can extend beyond the simple checklist of such categories as research assistantships, conference presentations, and independent research studies. Accounting for the qualitative, experiential aspects can reveal that undergraduate research alters students' thinking and feelings about themselves and their capabilities. This is meaningful information for helping to justify the worth of an undergraduate research program.

While the qualitative impacts students described may not be generalized to the experiences of *all* student participants in *every* undergraduate research program, the information does elucidate the need to cast multiple nets that can capture different types of data for a more comprehensive understanding of undergraduate research.

Key Considerations

What then does the quantitative headcount truly accomplish for assessment of undergraduate research? This type of data provides evidence of the amount or volume of research activity under way, which is inextricably linked to the justification of a program's existence. An educational institution that claims to have developed a premier undergraduate research program but has no count of research activity to support this claim, lacks sufficient evidence to bolster its argument. Thus, counts and measures of the research activities, outcomes, participants, grants, and funding levels associated with undergraduate research programs are undeniably important. However, too often individuals provide quantitative counts without acknowledging what is and is not being captured.

If undergraduate research is taking place on a university campus at levels sufficient enough to provide meaningful quantitative data from headcounts and participation levels, we argue that administrators, program directors, and others should also ask for and strive to capture the qualitative meanings and experiences that accompany this type of quantitative data. Unless a different type of net is cast to capture these experiences (e.g., exit interviews with undergraduates at the conclusion of their funded research grants, comment areas within self-report surveys designed to understand the student research experience), individuals will overlook the very perspectives that can provide the greatest insights about an undergraduate research program's influence—its depth, its essence, and its impact.

Brittany Emery, James Smith, Dr. Jeanetta Sims, and Jimmy Le headed to set up poster presentations at 2010 Oklahoma Research Day.

As a result, we argue for the use of both types of nets (e.g., quantitative headcounts and qualitative indicators) for a more comprehensive picture of undergraduate research. The themes discovered from qualitative inquiry (e.g., student comments and reflections about their experiences) could be used to identify concepts that could be measured on a larger, quantitative survey. In addition, qualitative methods could add clarification and nuance to the reports of quantitative data. The challenge of the count is to adequately capture both types of data for a multi-faceted valuation of the undergraduate research program.

Conclusion

Quantitative headcounts express the amounts associated with various facets of undergraduate research. These counts and measures are essential data points with strong explanatory power for revealing the spectrum of undergraduate research activities. However, the intensity and magnitude of the impact of undergraduate research programs are not fully captured using quantitative headcounts alone. The qualitative, experiential nature of undergraduate research further demonstrates the breadth of what student research experiences mean for professional conduct, time management, and self-efficacy well into students' post-academic careers. To capture this type of information, it is our hope that individuals will move beyond the quantitative headcount.

Atoya Sims and Dr. Jeanetta Sims receiving a Top Paper Award from Dr. Michael Smith at the 2008 National Communication Association conference.

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Jonathan Parker, *Keele University*

From the International Desk

International Comparisons of the Integration of Research into Undergraduate Degrees in the Social Sciences

Undergraduate research can take many different forms (Healey and Jenkins 2009), but to what extent do different disciplines, universities, and even countries embed such research into their undergraduate degrees? When discussing research at the undergraduate level, the best way to compare activity is to look at degree requirements. The specific outcomes that are expected of all students across the entire curriculum provide the clearest and most valid indication of overall research participation. However, there has been little research comparing the extent to which universities integrate research throughout undergraduate degrees, from the perspective of disciplines or countries. In this article we analyze the place of research in the undergraduate degree by examining its role in the mainstream curriculum of the social science disciplines.

While many universities proclaim that their teaching is "research-led", there is little evidence that undergraduate research is systematically taught or practiced. Most high-quality experiences of undergraduate research are limited in enrollment and overall impact. The senior thesis or research project is the most prominent example of undergraduate research at most institutions in the U.S., but rarely required and usually restricted to a small, elite group of students. Capstone courses or other activities, while they play an important role, often have no formal research component even when they are required. Further, a degree program needs to prepare students to make the most of their research experiences. Students must understand what research is and how to do it before carrying out a major project, so the teaching of research design and methods should be taken into account in any measure of undergraduate research.

We conducted a study analyzing the integration of research into undergraduate degrees by surveying the extent of required research-methods training, as well as research experiences, in five social science disciplines across eight countries. In the United States, for social science and humanities disciplines the senior thesis is most often associated with liberal arts colleges because they have a more highly defined core curriculum and progression of requirements that culminate in a research project in the student's final year (Ishiyama and Hartlaub 2003; Pascarella and Terenzini 2005; Seifert *et al* 2008). The research project is a widely accepted part of many European undergraduate degrees, involving an intensive three-year progression of skills and preparation that constitutes a large portion of the overall degree. In some cases, research is not limited to the final act of an undergraduate degree but occurs throughout. Integration of research into a curriculum should be measured by the full extent to which the curriculum coherently builds research skills into students' coursework in a coherent sequence.

There are many institutional forces fragmenting the curricula for social science and humanities degrees in the United States. The profusion of student curricular choices through electives, the transfer of many students from community college to four-year institutions, and the lack of control over when students take compulsory courses have long undermined attempts to develop a strong structure in curricula for degrees, both for the first two years of general college requirements and for the final years in which the major is usually pursued. Critics in the 1980s noted that many degrees required simply a full year's worth of courses taken from a single department, with the courses having little else in common (Zemsky 1989).

In the 1990s, a set of reports by the Association of American Colleges challenged this lack of structure in the American undergraduate curriculum. Reports from 12 disciplinary societies all recommended specific structures to make the curriculum "coherent." First, a common course should introduce students to a discipline. Second, the curriculum for a major in a discipline should require an early course in research methods. Third, the curriculum for the major should provide sequencing of courses through prerequisites to systematically develop students' skills and knowledge. Finally, students needed a final summative experience at the end of their degree program (AAC 1991a; 1991b). These types of experiences have been endorsed by further research evidence demonstrating that the more connected and integrated types of learning provided by such structures do, in fact, lead to improved student outcomes (Schneider 1996; Schneider and Green 1993; Astin 1993; Ishiyama and Hartlaub 2003; Ratcliff and Associates 1995).

The preparation for and practice of undergraduate research occurs through requirements for training in research methods, as well as through research projects or experiences themselves. Some studies have analyzed individual disciplines in this regard, but few have generalized across universities, and the use of different analytical methods prevents comparison across studies (Parker 2010). In the United States, some data on undergraduate research can be extracted from the National Survey of Student Engagement, but its primary relevant question asks whether a student has worked "on a research project with a faculty member outside of course or program requirements." This question excludes those research experiences that are required as part of the degree.

Compulsory forms of undergraduate research in the U.S. can still be captured in its question about whether a student has a "senior experience," but this question mixes the senior thesis with other activities such as capstone courses and comprehensive exams that have no required research component. Further, many of these opportunities are limited to small numbers of students, particularly on large campuses or are offered to students on a voluntary basis (Kuh 2008). Overall, only 33 percent of seniors report any type of senior experience, so the proportion engaging in a senior thesis must be lower than that figure (National Survey of Student Engagement 2010). International comparisons of undergraduate research requirements are even scarcer.

Social science disciplines in the United States vary widely in their approaches. Political science has generally neglected education in research methods, with no recommendations on a model curriculum from professional associations and few requirements for research in curricula for undergraduate degrees, particularly at research-intensive universities (Parker 2010). This lack of attention and consensus over a common standard is not shared by other disciplines, however. Psychology and sociology, whose national associations have frequently commissioned reports on the undergraduate degree, have made detailed recommendations on the content and structure of the undergraduate degree (Halonen *et al*. 2007; McKinney *et al*. 2004).

Requirements for research in undergraduate degrees would be expected to follow certain patterns based on university structures and on how undergraduates are taught about conducting research. Research develops high level educational outcomes in students (Kuh 2008), but achieving these ambitious outcomes requires sustained training and practice which can only be accomplished through an explicit sequencing of skills in the curriculum. The disciplines that have a stronger professional consensus about what should be taught will have more detailed guidance on curriculum standards. Such disciplines will be more able to develop and embed research into their degrees than those without clear standards. In the United States, psychology and sociology have more detailed guidance from their national associations on curricular standards than some other social science disciplines, so they should be more likely to provide undergraduate research than other disciplines that lack strong definitions of curricular standards.

Further, the most prominent form of undergraduate research, the honor's thesis or dissertation, is closely associated with liberal arts colleges but rarely found in more research-oriented institutions because of the perceived heavy workload created by this type of teaching (Parker 2010). If research institutions generally resist this more intensive approach to teaching, there should be a portion of universities in every country that have few requirements for undergraduate research.

Study Data and Methods

We surveyed degree requirements in five social science disciplines (business, economics, political science, psychology, and sociology) in eight countries— Australia, Canada, Finland, the Netherlands, Norway, Spain, Sweden, and the United States. The survey examined the extent to which degrees require training in research methods and research experiences by identifying mandatory courses in quantitative or qualitative research methods and courses in general research methods, as well as requirements for student research projects, theses, or dissertations.

Except for the United States, the survey included all universities in the target countries—30 in Australia, 66 in Canada, 7 in Finland, 4 in the Netherlands, 6 in Norway, and 14 in Sweden. The sample from the United States consisted of the top 100 institutions designated "national" universities in *U.S. News and World Report*'s annual rankings in *2006*.

Mandatory course requirements in each subject were obtained from university catalogs and websites, which provide an efficient and relatively accurate way of obtaining information about the structure and requirements of a degree, which are much less likely to change than particular course offerings (Ishiyama 2005).

"Research" consisted of courses in which students design and engage in their own research. This activity can be called a thesis, dissertation, research project, capstone course, or senior seminar. This designation was not applied to every course fulfilling senior writing requirements or senior capstone seminars, as writing a paper is not the same as engaging in an independent research project. Only courses dedicated to the practice of research and the research process, including designing and conducting research or participating in a research project and writing a report on the results, were counted. These courses could occur at any point in the degree program.

Course data were used to construct simple distribution tables. A quick rule of thumb was adopted that a full load for a student should be eight to 10 courses per year, to provide consistency both within and across countries.

Table 1: Percentage of Degrees Requiring Quantitative Methods

	Australia	Canada	Finland	Netherlands	Norway	Spain	Sweden	Unite States
Business	64	91	43	100	100	95	33	59
Economics	43	85	75	100	100	95	73	89
Political Science	0	21	14	75	50	75	7	15
Psychology	18	81	85	100	100	38	54	87
Sociology	0	45	43	100	60	100	31	79

Research Results

The results show consistencies across disciplines and countries, suggesting a number of trends.

Clear differences appear across disciplines. Economics and business degrees stand out as the most consistent in requiring students to take courses in quantitative research methods. Almost all universities in Canada, the Netherlands, Norway, and Spain require majors in economics and in business to take quantitative research methods courses. Only for business degrees in Finland and Sweden and for economics degrees in Australia are quantitative research methods courses not required by most universities. Psychology shows a similar pattern. Almost all universities in Canada, Finland, the Netherlands, Norway, and the United States require undergraduates to take a course in quantitative methods, and a majority of universities in Sweden require this. Only in Australia and Spain do most universities not require this.

Sociology and political science stand out as having the fewest requirements for students to learn quantitative research methods. In sociology, only the Netherlands, Norway, Spain, and the United States require quantitative methods courses for most undergraduate degrees. A majority of universities in Canada, Finland, and Sweden do not require undergraduate majors in sociology and political science to take a quantitative methods course, and no Australian university requires this. Political science appears to have the fewest requirements for undergraduate majors to take quantitative methods courses, with only a majority of universities in the Netherlands, Norway, and Spain requiring them. Such courses are rarely required for majors in the discipline in Australia, Canada, Finland, Sweden, and the United States.

While there is much variation across disciplines, national cultures and systems of higher education have a clear effect on undergraduate requirements. The Netherlands and Norway appear consistently strong in their quantitative requirements for undergraduates, regardless of subject.

Australia and Sweden appear to require much less quantitative undergraduate coursework across all subjects, with the United States and Canada also having lower quantitative requirements in many disciplines than the Netherlands and Norway.

Compared with requirements for students to take courses in quantitative research methods, classes are more often required that provide general training in the conduct of research. With only a few exceptions, all countries require general methods courses in an overwhelming majority of degree programs for disciplines other than business and economics. Business degrees require undergraduates to study general research methods in a majority of universities in Australia, the Netherlands, and Sweden. Psychology and sociology majors are required to take general research methods courses at almost all universities in the countries surveyed. Psychology degrees in the United States are the least likely to require such training, with 72 percent of universities requiring this. Clearly, psychology and sociology have a strong collective sense of what students need to know. The same does not hold for political science, which requires training undergraduates in general research methods more consistently than disciplines such as business and economics, but nowhere near as consistently as psychology and sociology. Training in general research methods is required in political science in a majority of universities in Finland, the Netherlands, Norway, Spain, and Sweden, but fewer than one third of universities in Australia, Canada, and the United States require such training.

Country differences in students' involvement in research projects appear very strong, with only Finland, the Netherlands, and Sweden requiring such involvement consistently across disciplines. Very little participation in research projects is required of undergraduates in Australia, Canada, Spain, and the United States across all subjects. Clearly, some countries' systems of higher education and academic cultures promote or require the inclusion of a research project as part of their undergraduate curricula. Despite the profusion of endorsements for undergraduate research, it remains a largely exclusive or elective element of many degrees in most countries we studied.

The United States compares poorly to other countries' requirements for research training and experience at the undergraduate level. One of the reasons for such low results

Table 2: Percentage of Degrees Requiring General Research Methods

	Australia	Canada	Finland	Netherlands	Norway	Spain	Sweden	United States
Business	64	14	43	86	33	25	58	18
Economics	73	5	50	67	0	50	0	5
Political Science	25	21	71	88	67	100	79	30
Psychology	91	84	83	100	100	100	92	72
Sociology	79	88	100	83	100	100	77	90

is that the sample of universities in the United States was taken from research institutions, which are much less likely than others to require research methods courses and undergraduate research projects, but this factor only accounts for a small proportion of the difference. An earlier study of political science using a representative sample of 200 universities found that 25 percent of research institutions required quantitative methods courses at the undergraduate level, while 20 percent of universities overall had the same requirements. Research-methods courses were required of undergraduate majors by only 13 percent of research universities compared to 24 percent of all universities in the U.S. overall, and only 6 percent of research universities required research projects of undergraduates, compared to 17 percent of all U.S. universities (Parker 2010). This previous research suggests that the results in this study may slightly underestimate overall requirements in the U.S., but the general conclusions would remain the same.

Research-intensive universities in the United States, though they have more staff, resources, and expertise than many other colleges, have been shown to be less likely to include undergraduate research in their undergraduate curricula compared to all universities. Research-intensive institutions may choose to avoid the large commitments of teaching and administrative resources needed to include undergraduate research in their curricula because fostering more undergraduate research would impinge upon other priorities, namely faculty and staff research. Ironically, the more intensive effort and planning required to teach and supervise undergraduate research is seen as a much higher priority by non-research-intensive universities. American undergraduate degrees still lack consistent requirements for student training and practice in undergraduate research compared to the requirements in other, particularly northern European, countries (Parker 2010). Few disciplines and few countries consistently require students to train in research methods and apply them in doing research projects.

Conclusion

Clear disciplinary differences emerge from our survey results. Not unexpectedly, business and economics proved much more likely to require undergraduates to study quantitative research methods, with an overwhelming majority of universities requiring such coursework in most countries. These same disciplines proved less likely to require training in general research methods. Political science also proved less likely than psychology and sociology to require research methods coursework of any kind, standing out as the least likely to provide research training of any social science discipline.

In terms of requirements for actual participation in research, there was very little variation among the disciplines. This result was unexpected, since the clear variation in research training should result in similar variations in research practice. However, the reason for this lack of variation can be seen in the results across countries. The impact of the aca-

Table 3: Percentage of Degrees Requiring A Research Project or Equivalent

	Australia*	Canada	Finland	Netherlands	Norway	Spain	Sweden	United States
Business	0	5	71	86	67	5	83	0
Economics	0	5	38	67	40	10	91	4
Political Science	0	0	57	100	33	8	100	2
Psychology	0	7	43	100	100	0	100	4
Sociology	0	0	71	100	60	10	100	10

* Approximately 12 percent of Australian students take an additional year to complete an honors degree, which does require a thesis.

demic culture and expectations within particular countries overwhelmed any differences in disciplinary requirements.

The provision of quantitative methods courses differed strongly by country, with the Netherlands, Norway, Spain, and the United States appearing stronger in this area than the other countries in our study. Offerings of general research methods courses were most prevalent in Finland, the Netherlands, Norway, Spain, and Sweden. Undergraduates' participation in research was strongest in Finland, the Netherlands, Norway, and Sweden. The variation by country in requirements for undergraduate participation in research was more striking than for research-methods training, because research tended to be required in most, if not all, universities in some countries and barely at all in the others. Research requirements seem to be all or nothing, which is unexpected. If requirements for undergraduates to participate in research place heavy teaching burdens on staff, then there should be more variation in which universities impose such requirements. Instead, the results show that many countries require all students to do undergraduate research—specifically northern European countries that score highly in rankings by the Organisation of Economic Co-operation and Development (OCED) of higher education participation. Large research universities in those countries seem able to require large research projects from their students without losing control of faculty workloads.

The absence of research requirements or their restriction to a small, elite group of students in higher education systems appears to be caused more by cultural differences or a lack of will rather than shortages of resources or administrative feasibility. Our results demonstrate that an exclusive, restricted, or elite approach to teaching undergraduate research is not the only model in higher education. Universal requirements for undergraduate research can be found in a few, highly respected systems of higher education

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Recruiting Students into Science: Evaluating the Impact of the North Dakota IDeA Network of Biomedical Research Excellence

The primary goal of the North Dakota IDeA Network of Biomedical Research Excellence (NDINBRE) is recruitment of students into science careers. The National Institutes of Health (NIH) support the development of research through IDeA (Institutional Development Awards) to academic institutions in 23 states. One important component of NDINBRE is building the research capacity of the four baccalaureate institutions in this rural state. North Dakota is sparsely populated, with 9.3 persons per square mile, compared with the national average of 79.6 persons per square mile (U.S. Census Bureau 2010). Recruiting students into science from rural high schools is particularly challenging, given common difficulties among rural schools with recruitment and retention of science teachers and limited access to resources (Monk 2007; National Comprehensive Center for Teacher Quality n.d.).

Initially, the NDINBRE program supported infrastructure development, including funding for research facilities and relationships among scientists at the four public baccalaureate institutions and the two graduate-degree-granting institutions in the state. With improved science facilities at baccalaureate institutions, attention then turned to increasing faculty and student research productivity while recruiting students into science. NDINBRE undergraduate students have participated in a variety of research activities, such as collecting plants and animals in the field and conducting laboratory experiments in cell and molecular biology, biochemistry, organic chemistry, microscopy, and physiology.

Measuring the effectiveness of the NDINBRE program's efforts to recruit students into science is necessary to provide feedback for further program development and to answer the key question: "What impact does a science-intensive research experience have on students' educational and career paths?"

First, the method used to evaluate the program's operations and outcomes is described. The evaluation tracked students after their participation in the program. The method and results for tracking and evaluating these students provide insight into their outcomes and the impact the program has had on their educational and career paths. The discussion presents implications for future evaluation based on a larger conceptual framework and makes recommendations for testing components of that framework.

Research on Career Decision Making

Previous research has focused on various aspects of students' educational and career aspirations, ranging from identifying influential factors such as family influences and the impact of secondary education (Gloria and Robinson Kurpius 2001, 95; Jolly, Campbell, and Perlman 2004, 7-8) to differences based on sex and race (McWhirter 1997; Scott and Mallinckrodt 2005, 268). Aspirations are generally defined as a malleable psychological outcome or construct that is influenced by a variety of contextual factors (Wang and Staver, 2001, 313). Grounded in social cognitive career theory (Lent, Brown, and Hackett 1996), research on career development investigates the behaviors, self-efficacy beliefs, outcome expectations, and goals that influence career choices (Mau 2003).

Additionally, a number of previous studies have demonstrated the impact of a research or educational program on students' academic and career outcomes (Bauer and Bennett 2003; Gonzalez-Espada, Wilson, and LaDue 2006). However, those studies rarely address recruitment of students from rural, frontier, and tribal areas into careers in science. Given the recommendations of previous research for tracking students over time, the lack of longitudinal studies, especially on students in rural areas, and the need to evaluate the effectiveness of the NDINBRE program, the current research aimed to locate students who had previously or were currently participating in the program, determine their current educational and career status and future intentions, and investigate the impact the program has had on their educational or career paths.

Methodology

This study, using a staggered prospective multiple-cohort design (Fienberg and Mason 1985), addresses the research question: What impact does a science-intensive research experience have on students' educational and career paths? Current and former participants were asked to describe: (1) their experiences in the program, (2) their current educational and career status and aspirations, and (3) the program's impact on their education and career.

The primary criterion for participation in INBRE is that a student be enrolled in a rural academic institution; all of the four baccalaureate institutions participating in NDINBRE are located in rural areas. Initially, a list was created of all students who had participated in the program since its inception in 2003, drawing from a variety of data sources: college faculty members' student lists, conference participation lists, and financial records of the program's payments to students. The list was revised further based on feedback from students and faculty. Faculty at each of the four baccalaureate institutions confirmed the list of students. At these four institutions, 180 students participated in the program; 74 (41 percent) provided in-depth information during the collection of data.

Instrumentation and Data Collection, Management, and Analysis

Tracking students. Longitudinal data collection is the most accurate way to report program outcomes and efficacy, especially when considering changes that may take place over a period of time. Maintaining accurate contact information is essential for longitudinal data collection, particularly when the sample includes individuals likely to relocate, such as young adults who often move to pursue educations and careers. Although many studies investigate the impact of an educational experience by following students over time (e.g. Pugnaire, Purwono, Zanetti, and Carlin 2004), information on the methods for finding and tracking students after high school is rarely articulated.

Over the past twenty years, a growing and rapidly changing body of literature has provided recommendations for increasing the effectiveness of telephone surveys as a data collection tool. Such literature has evolved as technologies, such as cell phones and caller ID, have increased, and authors now recommend multiple calls at varied times of the day over a relatively brief period of time. For example, in a review of the literature, Sangster (2003, 2-3) found that the best time to call was evenings and weekends, with only one weekday call during the day time in the first five attempts. More recently, Carley-Baxter, Triplett, Evans, *et al*. (2006) confirmed this conclusion for adults, but found that the best times to contact college students differed. Calling during the workweek, either day or night, was more successful in reaching college students than calling on the weekends.

The current study employed a variety of methods to identify and contact students, including faculty contacts, visits to colleges, attendance at workshops where students presented, phone, e-mail, mail, and social networking sites such as Facebook. A letter explaining the project and inviting participation was sent to all students for whom addresses were available. When possible, students were contacted via phone, as that is the desired method for completing surveys because of the accuracy and speed allowed. Inquiries of faculty members at the baccalaureate institutions and phone calls to the students' permanent addresses, usually their parents' homes were also successful methods for locating students. In some cases when accurate contact information (phone or email) was not available, Facebook or Internet searches were fruitful.

Data collection. Approval by the participating colleges' institutional review boards (IRBs) was obtained prior to data collection. Students were invited to complete a survey collecting academic, employment, productivity (publications and presentations), demographic, and contact information. Students also reported their academic majors and degree information, if relevant, and their employment history. Students described their experience, for instance, who their mentor was, the type of compensation they received, and activities in which they participated. They were asked an open-ended question regarding the impact the program had on their academic and professional careers. The survey concluded with a request for recommendations for further development of the program. The same questions were asked whether the survey was completed by phone, e-mail, mail, or in person, although the format varied slightly according to the method of collection.

Students remembered and reported their research productivity inconsistently, that is, how many articles, presentations, and posters in which they had participated; therefore, an additional step was taken to obtain this information. All faculty members at the baccalaureate institutions were asked to create a list of products on which students were co-authors and/or for which NDINBRE resources were used.

Data management and analysis. Information from the surveys was recorded in an ACCESS database designed specifically for this study, which allowed easy data entry and confidential storage. Qualitative information was transferred into a Microsoft Word table for content analysis. First, phrases, the unit of analysis, were identified in each comment through an iterative process. Two researchers independently isolated the phrases, then compared and reached agreement about them. Because one comment could have contained several phrases, the total number of phrases is greater than the number of students who made comments.

Then, categories were developed through a similar iterative process, during which the two researchers developed the initial list of categories by coding a sample of comments independently. They compared results, revised the categories, and recoded independently until the final coding scheme emerged for each question. The categories in the final coding schemes were mutually exclusive; each phrase could only be coded in one category. The total number of phrases is reported for each question, frequencies and percentages are calculated by category, and comments for each category are provided, to explicate the meaning of the category.

Table 1. Opportunities Provided by the NDINBRE Program as Reported by Participating Students

Opportunity	N	%	Example Comments
Research Experience (lab)	33	3.0	I know way more about research than I would have had INBRE not been around.
Research Experience (general)	32	31.7	Gave me a chance to see research and I really liked it.
Faculty Mentors	15	14.9	Dr. XXX was EXCELLENT to us as students. Allowed the professors to be more available for research. Ended up getting more one-on-one, deeper level of attention.
Dissemination of Research	8	7.9	Got to travel to different meetings; travel and networking at meetings. I presented at those conferences, which was a big deal for my resume when I applied to graduate school.
Financial Assistance	7	6.9	It allowed me to earn money. Paid well.
Organization of Opportunity	5	5.0	It was well organized.
Collegiality with Fellow Students	1	1.0	I also enjoy working with fellow students on certain projects.
Total Responses	101	100	

Findings

To answer the question about the impact of a science-intensive research experience, students were asked to provide information about opportunities afforded them by NDINBRE, what their current educational and career status was, and their opinion about the impact of the program. They also were given the opportunity to make recommendations for changes in the program.

Opportunities

When asked to note opportunities available to them as a result of the program, students commented positively on their opportunities for research lab experience and general research experience (see Table 1). They also commented positively about their faculty mentors.

Although only a few students' comments identified the opportunity to disseminate research as an important opportunity, network students and faculty members were prolific, creating 352 products, including posters, presentations, abstracts, and articles. The most common products were posters (see Table 2). Faculty and students presented at local, regional, and national venues, including the 100th Annual Meeting of the North Dakota Academy of Science, the 12th Annual American Society for Biochemistry and Molecular Biology Annual Meeting, the 1st Biennial National IDeA Symposium of Biomedical Research Excellence, the CUR Conference, the 2010 CUR Posters on the Hill, the 236th National Meeting of the American Chemical Society, American Association of Pharmaceutical Scientists, American Indian Consortium, the Society for Toxicology Annual Meeting, and the Louisiana State University Health Sciences Center Graduate Student Research Day.

Table 2. Products Resulting from Students' Research

Type of Product	N
Poster	216
Presentation	94
Abstract	17
Article	22
Grant	3
Total Products	352

Education and Career Status

Of the 64 students who had graduated from one of the four primarily undergraduate institutions, 47 were pursuing or had obtained an additional degree (see Table 3). Almost half (n = 21) were in health professions programs. Three had graduated from an advanced program; one was in a post-doctoral position, one worked as a medical illustrator, and one was a veterinarian. Academic institutions attended include private and public institutions in ND, Iowa, Louisiana, Arizona, Kansas, Minnesota, Arizona, Oregon, Washington, Wisconsin, Canada, and England.

Program Impact

The NDINBRE program had an impact on students' employment and academic aspirations, as well as them personally (see Table 4). The three major themes, each had three subthemes. Forty-two percent of the comments highlighted the influence that the program had had on employment, primarily career aspirations. Many students indicated that

Table 3. Current Status of Graduates (Applying or Enrolled in Another Program)

Status	N	%	Type of Program
Applying to graduate program	2	3.1	
Applying to health professions program	3	4.7	Medicine, physical therapy
In graduate program	18	28.1	Archeological conservation, biochemistry, biomedicine, chemistry, microbiology, molecular biology, psychology, public health, science
In health professions program	21	32.8	Chiropractic, dentistry, medicine, nursing, optometry, pharmacology, pharmacy, physical therapy, physician assistant, social work, veterinary science
In other professional program	1	1.6	Law
In undergraduate program	2	3.1	Science
Not pursuing a graduate degree	17	26.6	
Total	64	100	

Table 4. The Positive Impacts of the Network Research Experiences

Themes	Subthemes	N	%	Examples of Comments
Career	Influenced career aspirations	26	23.9	Changed major to clinical lab science because of it. I was at a point where I picked a major when I didn't think I could pick one.
	Current science-based employment	12	11.0	Job wise, the internship helped me get into a lab position that I am in now.
	Improved career opportunities	8	7.3	Opened up job opportunities, contacts.
Academic	Future academic aspirations and opportunities	20	18.4	It helped me gain experience and allowed me to get insight into what graduate school would be like in learning various techniques.
	Enhanced awareness	11	10.1	It showed me a different side of education that I hadn't been exposed to before. I never knew about doing research under a professor.
	Enhanced academic experience	10	9.18	It was to actually get involved in research that was beyond a textbook setting, developing protocol, conducting experiments that haven't been done.
Individual Impact	Increased skills	15	13.8	Learned a lot of applications and processes beyond class work.
	Confidence	5	4.6	Good because of knowledge and confidence.
	Enjoyment	2	1.8	I enjoy the research part of science more.
Total		**109**	**100**	

the research experience prepared them for graduate school. Students mentioned that they enjoyed the science laboratory experiences and appreciated the increased confidence they had gained, especially with presentations at conferences. Participation in the program also influenced students academically, through enriching their current experience and their future career choices. Finally, the experience positively impacted students' knowledge, skills, self-confidence, and enjoyment of research.

Suggestions for Program Changes

Students made recommendations for program development. Most were about the need for increased resources (see Table 5). Other issues included better communications, increased

Table 5. Recommendations for Change

Themes	Subthemes	N	Examples of Comments
Resources	Lab	8	More money for lab I was working in.
	Student funding	2	Not enough grant money for students to be paid. Had to work, didn't have time to participate.
Communication	Cross-institution collaboration	7	A little more intercommunication between principal investigators and the administrators of the program. Cooperation of the different research programs. You could compare each other's research.
	More student input	1	More input from the students.
Recruitment		7	Wish more students from the reservation would participate in it.
Organization of experience		6	We went through all the stuff, but each of us was given a specific, different task so we weren't told about the process. We just learned about the specific part. I didn't know really what we were doing overall.
Flexibility in research topics		6	I would try to broaden and expand the topics.
Increased participation	More group work	1	Maybe more group stuff.
	More meetings & presentations	4	I would have liked to be able to present.
Duration		2	Try to make it extend over entire school year.
Nothing		31	I don't think I would change anything.
Total		**75**	

recruitment efforts, the organization of the experience, the need to inform students more about the bigger picture, and increased opportunities, such as making research presentations. It is important to remember that student experiences occurred over a range of years, from the early 2000s to the present, and at several institutions. Therefore, some of the recommended changes may have already been implemented since the early years of the program.

Discussion

Overall, students were pleased with the opportunities they had while participating in the NDINBRE program, especially the opportunity to learn research skills and to learn from faculty mentors. Students were very productive and were able to present at local, regional, and national conferences and publish articles. A high number of the participants who had graduated from their baccalaureate institution continued their education in a science or health-related field. The program's positive impact on students' confidence, their current academic success, future career aspirations, and employment was clear. The few suggestions for change centered on the need for even more resources; increased cross-institutional collaboration; recruitment of students, especially American Indian students; and the way in which their particular experience was organized. Taken together, these results support the positive impact of the program and the fulfillment of its goals. The recommendations for change provide guidance for examination of the current program to identify ways to further enhance students' research experiences and the impact of the program.

Not all the former participants have been located. Although attempts will continue to be made to locate them, this will be an ongoing issue, as with all longitudinal studies. The use of new technologies, such as Facebook, should increase our capacity to achieve a high response rate. The initial methodology did not include a mechanism for determining what factors other than the NDINBRE program might have influenced students. Therefore, one cannot rule out the possibility that other factors besides this program might have influenced students' career choices. The evaluation does not have a comparison group; given the circumstances of the program, neither a national or local control group is a possibility. However, as additional data are collected, the prospective cohort analyses of this research design will compensate for the lack of a control group.

Further Research

Students participating in the NDINBRE program will be surveyed annually. The number of methods used to locate each student will be recorded, to better determine the most successful tracking methods. Based on information gained from the process of data collection and student and faculty input, the next step will be to address the question, what factors, in addition to the program, might have influenced students' academic and career paths. Some research suggests that factors in three areas (engagement, continuity, and capacity) are needed for student success (Jolly, Campbell, and Perlman

2004; Symonette 2008, 1). In this "trilogy model," engagement refers to individual student factors such as interest; capacity reflects individual ability; and continuity reflects the impact of external institutions and opportunities. Future plans to combine this "trilogy model" with the bioecological approach (Bronfenbrenner and Ceci 1994), which considers factors at various levels of the social ecology, such as individual, family and societal factors, will allow a better delineation of the impact of the program on students. As the broader body of research regarding the impact of recruitment efforts grows, comparisons can be made across types of programs and regions regarding successful outcomes.

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Jill Singer, Bridget Zimmerman, *SUNY-Buffalo State*

Evaluating a Summer Undergraduate Research Program: Measuring Student Outcomes and Program Impact

At SUNY-Buffalo State we have undertaken a multi-year effort aimed at developing and field-testing an evaluation methodology for measuring student learning and related outcomes in our summer undergraduate research program. Our goal was to extend the findings of the many valuable studies that had already been done on the impact of undergraduate research on participating students (Gregerman *et al*. 1998; Alexander *et al*. 2000; Merkel 2001; Bauer and Bennett 2003; Seymour *et al*. 2004; Lopatto 2004; and Hunter *et al*. 2007). As described in Singer and Weiler (2009), our aim was to obtain reliable independent assessments of program impact without creating a measurement burden, and at the same time provide information to participating students that could help them gain new insights into their academic strengths and weaknesses. We also were interested in obtaining information from faculty mentors on how the summer undergraduate research program influenced their teaching.

The difficulty in achieving our goal originates mainly from the fact that the outcomes of undergraduate research generally are not measurable by objective tests. Rather, they encompass independent student projects whose results often are a written paper, a new work of art, a laboratory or field experience, or a range of other experiences. As a result, outcome assessments largely rely on perceptions and judgments by faculty mentors. These assessments are subject to challenge on the grounds that faculty may have had inadequate exposure to students' work, that assessment parameters rarely are made explicit, and/or that assessments are not comparable across different disciplines or across different faculty and student participants. We engaged in a multi-year effort to design an evaluation that could overcome these concerns. It is worth noting that it is not ordinarily practical to conduct evaluations of undergraduate research that rely on classic comparison-group designs, given the difficulties of matching students who have not applied or not been accepted into a program with "comparison" students, as well as the difficulty of asking faculty mentors to assess "comparison" students without being able to meet with and observe them.

Our strategy for developing the evaluation began with a two-day retreat during the summer of 2006. Faculty representing a range of disciplines (including arts, humanities, social sciences, and sciences) identified 11 student outcome categories of interest. Each outcome category included lists of specific outcome components (see Table 1). In addition to the 11 categories, it was decided that mentors and students would be able to add more outcomes as appropriate to their specific research interests.

Next we discussed and designed an assessment procedure that uses a five-point scale linked to an explanatory rubric to denote that a student always (5), usually (4), often (3), seldom (2), or never (1) displays a given outcome for each component in the 11 outcome categories. Faculty mentors rate students on each component, and students evaluate their own progress using an identical instrument. As a result of these and other decisions about the design of the evaluation, described more fully below, the evaluation now has six essential features:

- Repeated assessments (pre-research, mid-research, and end-of-research);
- Assessments in which faculty mentors and students all use the same outcome categories and components;
- A scoring rubric, used by all mentors and students, that defines the meaning of each assessment score on the five-point scale;
- A "confidence" judgment in which mentors are asked to indicate their level of confidence in the accuracy of each of their assessment scores, using a five-point scale ranging from "very confident" to "not confident at all";
- Student self-assessments and mentors' assessments of students, performed independently; and
- Student-mentor discussions to compare their independent assessments following each of the three assessment periods.

The first four of these features are designed to overcome the concerns about faculty assessments summarized above by ensuring that (1) faculty mentors have multiple opportunities to familiarize themselves with student work; (2) assessments are conducted according to standards that are explicit and uniform across disciplines and across different student-faculty pairs; and (3) assessments are weighted to reflect the amount and quality of information underlying the scores. The last two evaluation features outlined above are designed to provide opportunities for students to improve their understanding of their academic strengths and weaknesses.

During the summer of 2007 we conducted a pilot implementation of the evaluation methodology that included both first-time and experienced mentors familiar with the summer research program. At the end of the summer, focus groups composed of student researchers and faculty mentors provided feedback on the evaluation methodology and on the clarity of the overall process. Based on this feedback, modifications were made to the evaluation instruments and the overall process was simplified to help mentors and students better understand the sequence of steps involved

Table 1: Evaluation Outcome Categories and Components

Communication
Uses and understands professional and discipline-specific language.
Expresses ideas in an organized, clear, concise, and accurate manner.
Writes clearly and effectively in discipline-specific formats.
Creativity
Brings new insights to the problem at hand.
Shows ability to approach problems from different perspectives.
Combines information in new ways and/or demonstrates intellectual resourcefulness.
Effectively connects multiple ideas/approaches.
Autonomy
Demonstrates the ability to work independently and identify when input, guidance, and feedback are needed.
Accepts constructive criticism and applies feedback effectively.
Displays high level of confidence in ability to meet challenges.
Uses time well to ensure work gets accomplished and meets deadlines.
Ability To Deal With Obstacles
Learns from and is not discouraged by setbacks and unforeseen events.
Shows flexibility and a willingness to take risks and try again.
Practice And Process Of Inquiry
Demonstrates ability to formulate questions and hypotheses within the discipline.
Demonstrates ability to properly identify and/or generate reliable data.
Shows understanding of how knowledge is generated, validated, and communicated within the discipline.
Nature Of Disciplinary Knowledge
Shows understanding of the way practitioners think within the discipline (e.g., as an earth scientist, sociologist, or artist) and view the world around them.
Shows understanding of the criteria for determining what is valued as a contribution to the discipline.
Shows understanding of important current individuals within the discipline.
Critical Thinking And Problem Solving
Trouble-shoots problems, searches for ways to do things more effectively, and generates, evaluates, and selects between alternatives.
Recognizes discipline-specific problems and challenges established thinking when appropriate.
Recognizes flaws, assumptions, and missing elements in arguments.
Understanding Ethical Conduct
Shows understanding and respect for intellectual property rights.
Predicts, recognizes, and weighs the risks and benefits of the project for others.
Recognizes the severity of creating, modifying, misrepresenting, or misreporting data, including omission or elimination of data/findings or authorship.
Intellectual Development
Demonstrates growth from basic to more complex thinking in the discipline.
Recognizes that problems are often more complicated than they first appear to be and the most economical solution is usually preferred over convoluted explanations.
Approaches problems from a perspective that there can be more than one right explanation or model or even none at all.
Displays accurate insight into the extent of his/her own knowledge and understanding and an appreciation for what isn't known.
Culture Of Scholarship
Is involved in the scholarly community of the discipline and/or professional societies.
Behaves with a high level of collegiality and ethical responsibility.
Content Knowledge Skills/Methodology
Displays detailed and accurate knowledge of key facts and concepts.
Displays a thorough grasp of relevant research methods and is clear about how these methods apply to the research project being undertaken.
Demonstrates an advanced level of requisite skills.

in completing the various instruments. For a more complete description of the evaluation-development process and methodology, see Singer and Weiler (2009).

A full-scale implementation of the evaluation has now been conducted with three groups of student researchers and their faculty mentors. This article reports on evaluation findings for the period 2008 to 2010. Static versions of all instruments referred to in this paper and data tables supporting our findings can be found at: http://www.buffalostate.edu/undergraduateresearch/x561.xml.

Implementation of the Evaluation Methodology

Evaluation Stages

Table 2 shows the summer research program and its evaluation divided into three stages: Pre-to-Early Research, Mid-Research, and End-to-Post Research.

Pre- to Early Research

The summer research program starts with the student-faculty mentor teams attending a two-hour group orientation session. The orientation includes a thorough explanation of the evaluation that emphasizes its dual purpose of assessing program outcomes and providing a means for students to learn more about their academic strengths and weaknesses. Following the orientation session, students complete an online survey that asks them about their motivation for participating in the undergraduate summer research program, their knowledge and expectations, and their current understanding of their academic strengths and weaknesses. The survey provides students with a structured opportunity to explore their goals, knowledge, and readiness for the summer research program, and it provides mentors with insights into student knowledge and thinking as an aid to completing their pre-research assessments.

After the mentors review students' survey responses, students and mentors meet in order to give mentors an opportunity to query students on their survey responses and to formulate preliminary student assessments. The mentors' version of the survey shows the relationship between each survey question and relevant student outcomes, as delineated in the assessment categories and components. Following this meeting, the students and mentors each independently complete the pre-research assessment. They then meet to discuss why their scores on outcome components of interest were the same or different. These procedures provide both students and mentors with an environment in which they can be unbiased in their scoring and open and forthcoming in discussing their rationale for assigning a particular score. Following completion of the pre-research assessment and student-mentor meetings, the students begin their research projects.

Mid-Research

To help students and mentors keep track of their experiences and progress, we encourage them to keep a journal. An electronic form (with access restricted to user only) is available. In the absence of a formal journal (electronic or paper), we recommend that students and mentors keep track of the experience by noting times when particular obstacles were encountered or when a particular accomplishment was achieved. About halfway through the summer, students and mentors complete a short report that responds to several questions about research progress, changes from original research plans, and plans for the second half of the summer. In addition to answering these questions, students and mentors each complete the mid-research assessment and meet to compare their scores on each outcome component and discuss scores that changed from their initial assessments. A feature of the online assessment allows students and mentors to review their scores from the pre-research assessment and asks them to reflect on the reason(s) for any score changes. As with the pre-research assessment, students and mentors cannot directly review one another's assessment scores before meeting to discuss their respective assessments. Student research then continues for the remainder of the summer.

End- to Post-Research

At the conclusion of the summer research program, the students and mentors complete a final report. This is longer than the mid-summer progress report and students provide a short (3-to-4 page) report on their project, including their methods/approach, findings, and suggestions for places where they might present their work. The report is uploaded as a document, and often includes figures, data tables, and illustrations. Mentors are asked about their project experiences and the extent to which the program has helped them reconsider their approach to classroom teaching. Both students and mentors complete the post-research assessment and meet one final time to discuss how they each scored the outcome components. As before, students and mentors can review their pre- and mid-research assessment scores but cannot see each other's scores prior to their final meeting.

Evaluation Modifications

Based on interim findings following our experiences in 2009, we made four significant modifications to the evaluation:

Orientation was improved. To ensure that program participants followed each step of the evaluation in the proper order and at the appropriate time in the research experience, clearer instructions were provided to better prepare students and mentors to follow the sequence of steps (summarized in Table 2).

Student confidence scores were dropped. Students' responses in 2008 and 2009 supported the elimination of the "confidence" score from all three stages of students' self-assessments. The confidence scores were replaced by a single question at the end of the assessment that asks students how certain they are about their skill levels and responses.

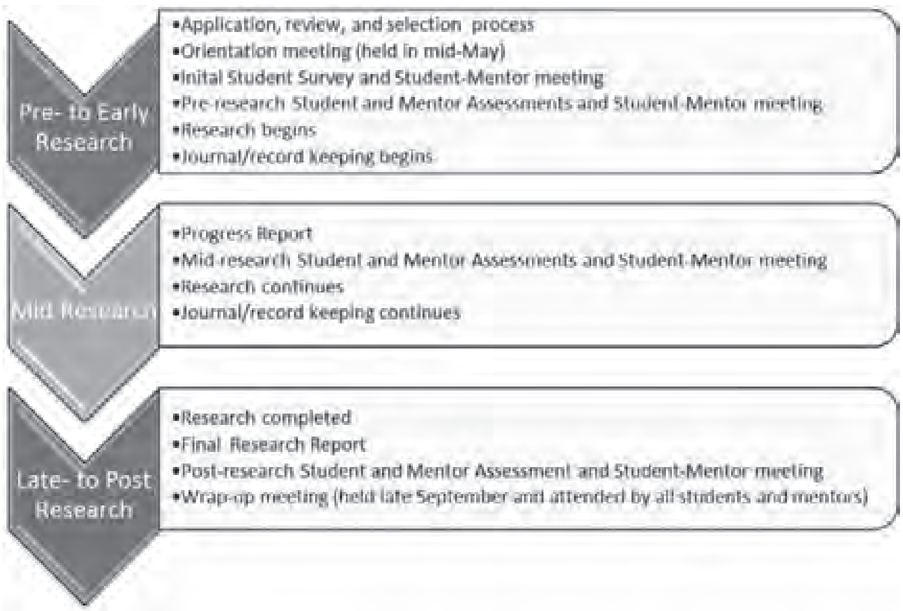
One mentor confidence score was dropped. Mentors' responses in 2008 and 2009 supported the elimination of "confidence" scores from the mid-research assessments. The measure is retained in both the pre- and post-research assessments.

The format of the instrument was improved. The assessment instrument was simplified so that additional optional outcomes now are identified at the end of the instrument rather than after each outcome category.

Analysis of Assessment Instruments

In order to ensure that we had obtained a realistic measure of program outcomes, we began by making certain that our assessment instruments provided reliable and valid impact measures. First, Cronbach's alpha was used to determine

Table 2. Stages of Summer Research Program and Evaluation



the strength of association of the individual assessment components. This measure was calculated for the 34 component questions for 2008 (n=17), 2009 (n=20), and 2010 (n=24) data, to determine how well the items hold together as the scales currently are defined. The mentor assessment (N= 61, three years combined) had an overall coefficient alpha of .964. The student self-assessment (N=61, three years combined) had an overall coefficient of .951. These alpha coefficients are evidence that the measured items have high internal consistency. The high coefficient scores suggest that the categories and components represent the multiple facets of one holistic construct—student intellectual and professional growth.

We also were sensitive to the overall length of the assessments and wanted to eliminate possibly redundant and non-discriminating items in order to reduce response fatigue for mentors and students. To this end, we completed a factor analysis/principal components analysis for all three years combined (n=61) for both the mentors and the students. This was done to ascertain whether all the questions added value to defining the summer research program's impact on the participants. The 34 items were highly correlated with each other. The analysis suggested a minor reduction in the number of questions, but there were differences between the mentor and student assessments regarding the particular questions that could be eliminated.

Given the lack of persuasive statistical evidence to support a reduction in the length of the assessments and our desire to keep the mentor and student versions of the assessments the same, only minor modifications in format were made, as noted above. This decision was further supported by two central characteristics of the evaluation: (1) The assessment instrument's contents pertained to issues that faculty had identified during the program's initial retreat as important potential outcomes of students' education and research experience, and (2) the assessment categories and components were being used strategically (not just as an exercise in psychometrics) in the student-mentor discussions to help students understand their own strengths and weaknesses and thus help them grow academically and think professionally.

Findings

In order to understand the impact of the summer research program, we first applied a repeated measures analysis of variance (ANOVA) test to student and mentor pre-, mid-, and post-research assessments (N =61, 2008–2010). Mentors' confidence scores were analyzed with a paired samples T-test, as there were only pre- and post-research assessment confidence measures.

We found that the mentors' largest adjustments in appraisals of their students' abilities—with the strongest confidence levels—took place between the pre- and mid-research assessments, with few additional assessment differences and little additional growth in confidence between the mid- and post-research assessments. This finding is consistent with the expectation that the greatest gain in mentors' understanding of students' abilities would likely take place within the first half of the summer research program as the mentors began to work with the students, and that additional gains in understanding would be minimal because most of their knowledge about the students had already been gained by mid-summer.

In their pre-research assessments, student self-ratings were on average somewhat higher than mentor ratings of their students on the same outcome components. This finding suggests that many students at first over-estimated their academic strengths. This is confirmed by many students' comments on the post-research assessment form, where they wrote that they thought they knew "a lot" at the outset of their research experience, but that by the time they concluded their research, they realized how much they didn't know. One student wrote:

> *"I was glad to see that there was more than one assessment survey given over time. In this way, people can see the change (for better or worse) they underwent. We (mentor and student) found that I had improved in some areas but declined in others because I over-scored myself in the beginning."*

Table 3. Pre-Post Mean Scores for Students and Mentors

Scale: Always (5); Usually (4); Often (3); Seldom (2); and Never (1)

Outcome Components	Student			Mentor		
	Pre	Post	Significance	Pre	Post	Significance
Uses and understands professional and discipline-specific language	3.87	4.19	***	3.92	4.28	***
Expresses ideas in an organized, clear, concise, and accurate manner	3.80	4.14	**	3.93	4.23	**
Writes clearly and effectively in discipline-specific formats	3.77	4.13	**	3.77	3.70	
Brings new insights to the problem at hand	3.70	4.13	***	3.83	4.26	***
Shows ability to approach problems from different perspectives	3.82	4.22	**	3.92	4.25	***
Combines information in new ways and/or demonstrates intellectual resourcefulness	3.89	4.18	*	3.95	4.28	**
Effectively connects multiple ideas/approaches	3.87	4.03		3.88	4.30	***
Demonstrates the ability to work independently and identify when input, guidance and feedback are needed	4.31	4.53	*	4.32	4.54	**
Accepts constructive criticism and applies feedback effectively	4.36	4.60	*	4.35	4.62	**
Displays high level of confidence in ability to meet challenges	4.10	4.22		4.23	4.34	
Uses time well to ensure work gets accomplished and meets deadlines	4.08	4.05		4.27	4.23	
Learns from and is not discouraged by set-backs and unforeseen events	4.13	4.25		3.92	4.41	***
Shows flexibility and a willingness to take risks and try again	4.28	4.35		4.14	4.61	***
Demonstrates ability to formulate questions and hypotheses within discipline	3.77	3.95	***	3.71	4.07	*
Demonstrates ability to properly identify and/or generate reliable data	3.43	3.97	**	3.10	4.05	***
Shows understanding of how knowledge is generated, validated and communicated within the discipline	3.72	4.10	*	3.77	4.07	
Shows understanding of the way practitioners think within the discipline and view the world around them	3.90	4.15		3.85	4.21	**
Shows understanding of the criteria for determining what is valued as a contribution in the discipline	3.95	4.07		3.78	4.10	**
Shows understanding of important current individuals within the discipline	3.38	3.63		3.30	3.82	***
Trouble-shoots problems, searches for ways to do things more effectively, and generates, evaluates and selects between alternatives	3.85	4.20	*	4.02	4.30	**
Recognizes discipline-specific problems and challenges established thinking when appropriate	3.69	3.92		3.45	3.84	**
Recognizes flaws, assumptions, and missing elements in arguments	3.79	3.73		3.52	3.82	**
Shows understanding and respect for intellectual property rights	4.62	4.67		4.12	4.44	**
Predicts, recognizes, and weighs the risks and benefits of the project for others	4.02	4.27		3.44	3.74	
Recognizes the severity of creating, modifying, misrepresenting, or misreporting data including omission or elimination of data/findings or authorship	4.48	4.62		3.97	4.48	
Demonstrates growth from basic to more complex thinking in the discipline	3.85	4.13		4.17	4.43	*
Recognizes problems are often more complicated than they first appear to be and the most economical solution is usually preferred over convoluted explanations	3.82	3.93		3.75	4.10	*
Approaches problems from a perspective that there can be more than one right explanation or model or even none at all	3.98	4.22		4.02	4.15	
Displays accurate insight into the extent of his/her own knowledge and understanding and an appreciation for what isn't known	4.03	4.17		4.08	4.35	*
Is involved in the scholarly community of the discipline and/or professional societies	3.39	3.67		3.23	3.35	
Behaves with a high level of collegiality and ethical responsibility	4.41	4.50		4.65	4.74	
Displays detailed and accurate knowledge of key facts and concepts	3.80	4.02		3.90	4.34	***
Displays a thorough grasp of relevant research methods and is clear about how these methods apply to the research project being undertaken	3.38	3.98	***	3.67	4.16	**
Demonstrates an advanced level of requisite skills	3.54	3.78		4.02	4.23	

** p <.05, ** p <.01, *** p <.001*

Another student reported:

> *"I thought I was good at research until I actually started doing it and then I realized how little I knew."*

One mentor captured this realization with the comment:

> *"Every student is different and one thing I believe I learned this summer was that very good students assess themselves more poorly than I do and moderately good students with a more naive approach assess themselves better than I do. I didn't really anticipate this and found it interesting and something I need to take into account while mentoring."*

Students reported growth on all 34 outcome components from pre- to mid-research assessment and again from mid- to post-research assessment. However, actual differences between student pre- and post-research assessments were statistically significant less frequently than were the comparable mentors' assessments. Student self-assessment scores showing pre- to post-research academic growth on 13 of 34 assessment components were statistically significant at $p < .05$ or better, which is strong evidence of knowledge growth on the 13 items. Student's open-ended comments also focused on the impact of the program on gains in their knowledge, their contribution to the discipline, value for future endeavors (e.g., applying to graduate school, and listing the research program on their resume), and knowledge gained above and beyond the classroom setting.

Table 3 shows average student self-assessment and mentor pre-research and post-research scores for each of the 34 outcome components. Pre- to post-scores shown in asterisks were statistically significant at $p < .05$ or better.

As noted above, mentors tended initially to rate the students lower than the students rated themselves, but by the end of the program, the mentors' assessment scores of students were, on average, higher than the students' self-assessment scores. Twenty-four of 34 items showing these higher ratings were statistically significant at $p < .05$ or better, providing strong evidence that the mentors saw growth in student knowledge on the 24 items. Two items with decreased scores ("writes well" and "is involved in the community") suggest that the mentors may have initially over-rated their students on these outcomes and, after more experience with the students, adjusted for this by lowering the scores. On the other hand, the decreased scores on these items could have masked any improvement the students actually may have made in these areas. Mentors' confidence in assigning scores from pre-research to post-research assessments were statistically significant at $p < .05$ or better for 33 of 34 items.

In their responses to open-ended questions on the assessment forms, a number of students wrote about the value of the program's emphasis on blending assessment and educational goals (as described at length above). Students said, for example:

About the orientation:

> *"It helped me to realize the nature of research and that things don't always turn out as you planned. This made me more open to learning new things and making more connections between ideas."*

> *"It prepared me for the amount of work this really is, as well as getting me even more motivated seeing how prestigious this program is and the standards you are held to."*

About the assessment:

> *"It was useful in that it allowed me to compare my own perception of my strengths and weaknesses to my mentor's interpretation of the same."*

> *"I was able to see if I was improving /declining in any areas and just gave me the ability to assess myself and set a new goal of where I wanted to be by the end of the summer."*

> *"Meeting to review our responses allowed me to understand another perspective. It also allowed me to view weak areas that I needed to research and improve upon."*

About the journals:

> *"During the summer I kept a full journal of my notes, research and plans to develop a final installation piece incorporating historical paper cutting, and the integration of industrial processes. This journal was very important and still is very important to my future goals and plans for graduate school."*

> *"I did keep a very detailed journal about the process I went through this summer. ... It really allowed me to organize my thoughts and keep track of exactly what I had done already and what still needed to be completed."*

Comments made by mentors on their assessment forms often focused on the growth in their confidence about students' skills, abilities and limitations, and on the value of a collegial working relationship with their students. On the latter point, for example, one mentor noted:

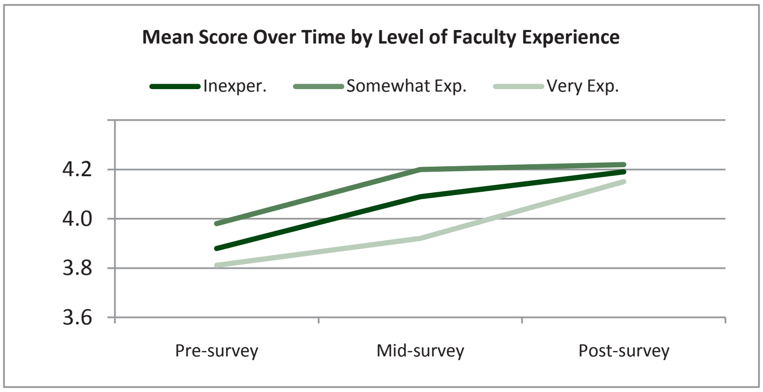
> *"We were able to get a better grasp on what we thought of each other and the project. The questions were not discipline-specific, so they were useful in getting to know the student's personality better and also the student's abilities, likes and dislikes, and aptitudes."*

Mentors also reflected on how the program influenced their teaching practices. For example:

> *"This experience reinforces the fact that each student is an individual and that one size does not fit all"*

> *"This year I had to mentor at a higher level because my student's knowledge base has grown. I had to learn to*

Table 4. Mean Score Over Time by Level of Faculty Experience



take less of a role and really stand by and monitor and advise during all phases of the research. This was difficult at times because I am used to being more hands on with students because they typically need more help."

"I think that I learned more about assessment/evaluation of student progress—especially in a student who is very desirous of doing well but doesn't necessarily have the tools yet to do so. That is, I think I am better able to pinpoint weaknesses and address them more quickly and effectively."

Students and mentors both commented, as well, on the value of the pre-research survey and follow-up conversation between student and mentor. Many reported that even when a student and mentor had worked together before and the mentor knew the student fairly well, the survey revealed information that was very helpful in establishing a "starting point" for the balance of their collaboration.

Other Findings

The evaluation data were analyzed to ascertain whether or not either mentor experience or academic discipline contributed to differential assessment of student outcomes. First, we coded the mentors as belonging to one of three experience categories: relatively inexperienced (less than three years mentoring undergraduates who are conducting research, n=25), somewhat experienced (between three and six years of mentoring, n=25) and very experienced (more than six years of mentoring, n=10). The data for the period 2008 to 2010 showed little difference either in the scores or patterns of scoring among inexperienced, somewhat experienced, and very experienced mentors. Very experienced mentors tended to be more conservative in their scoring on all three assessments than did inexperienced or somewhat experienced mentors. Taken as a whole, however, the mean scores from all mentor experience levels increased over time. Overall mean scores for all 34 items over time, coded by mentor experience, illustrate these trends, none of which were statistically significant. Mean differences were small. There also were no statistically meaningful differences in how the students of inexperienced, somewhat experienced, and very experienced mentors scored themselves on any of the 34 outcome components.

It is possible that differences in mentoring experience would ordinarily have shown up as marked differences in mentors' assessments of their students, although there is no way to be sure of this. If so, the structure of the summer research program evaluation may have helped to compensate for such experience effects. The program's monitoring of student and mentor progress, combined with regular communications with mentors by one of us (Singer), seemed to have helped ensure that all mentors, regardless of their level of experience, were able to implement the evaluation instruments effectively and use them to provide meaningful feedback to their students. This observation is based on personal communications between Singer and the program mentors and on comments made by some mentors on their assessment forms.

The data for the period 2008 to 2010 showed little difference either in the scores or patterns of scoring among inexperienced, somewhat experienced, and very experienced mentors. The mean scores from all mentor experience levels increased over time.

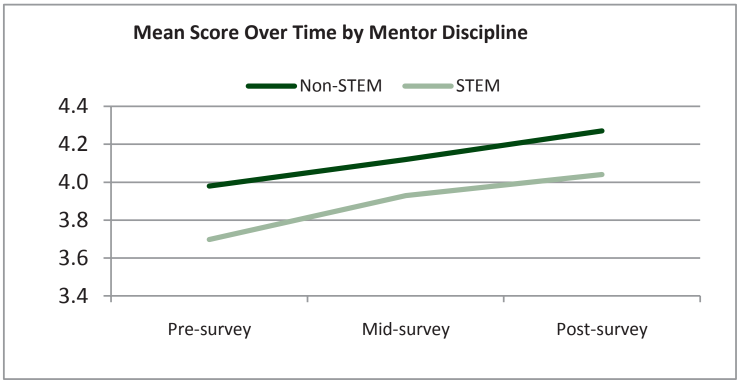
The finding (although not statistically significant) that very experienced mentors scored more conservatively (assigned lower scores) than did inexperienced or somewhat experienced mentors suggest that very experienced mentors may have questioned students more closely in order to learn more about them and make them more self-aware.

We also coded the mentors according to whether they were in a STEM or non-STEM academic discipline. When comparing STEM discipline mentors (n=23) to non-STEM discipline mentors (n=37), there was a modest difference in how mentors, regardless of experience, scored students. On 28 of the assessment's 34 items, non-STEM mentors gave their students slightly higher ratings than did the mentors in STEM disciplines. Ten items were statistically significant at $p < .05$ or better, and two other items were close to significance. STEM discipline mentors rated students higher on three items in the assessment, but the differences were not statistically significant. An overall mean score for all 34 items over time, by mentor's discipline, illustrates the trend. Note that mean differences are small. These findings suggest that the assessment instrument is, in fact, applicable to all disciplines. There were no statistically significant differences between student self-assessment scores for students in STEM disciplines and students in non-STEM disciplines.

Concluding Remarks

The evaluation of the SUNY-Buffalo State summer research program achieved its dual goals of providing a reliable assessment of program impact and helping to advance student

Table 5. Mean Score Over Time by Mentor Discipline



intellectual and professional growth. Our data—including comments from students and mentors on the assessment forms and participants' personal communications with one of the authors (Singer)—confirm that participating in the student research and evaluation processes fostered meaningful reflection by both students and mentors and encouraged frequent, constructive student-mentor dialogue. While the students were the primary beneficiaries of these activities, our data confirm that mentors also gained from the experience. Asking mentors to reflect on how much confidence they had in their assessment scores and asking them to explain why they raised or lowered their ratings from one assessment to the next appeared to help them become more effective mentors, no matter how much prior experience they brought to the program. It also appears that asking students about why they raised or lowered their self-assessments helped them gain a more realistic understanding of their abilities and identify areas they desired to improve.

We are continuing this evaluation and will look for ways to refine and enhance the assessment instruments themselves, while being mindful of the educational opportunities the evaluation and its assessment components provide. We intend to further explore the dynamics of mentoring and its impact on students. Alumni surveys also will be implemented to assess the long-term impact of the research experience on plans for graduate school, employment, and the undergraduate experience in general.

Acknowledgments

The authors gratefully acknowledge Daniel Weiler for the role he has played throughout the years. He has provided encouragement and much feedback as we progressed from the pilot evaluation effort to full-scale implementation. We thank Buffalo State for its continuing strong support for this program. We also thank the students and faculty who participated in Buffalo State's Undergraduate Summer Research Program and embraced our efforts to evaluate the impact of the program.

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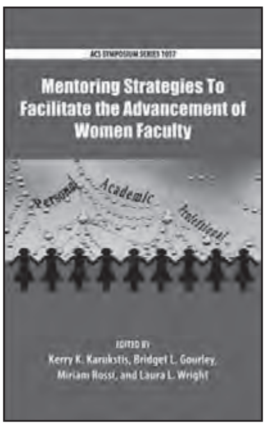
CUR Book Review

Mentoring Strategies to Facilitate the Advancement of Women Faculty

Editors, Kerry K. Karukstis, Bridget L. Gourley, Miriam Rossi, Laura L. Wright

Reviewed by Amelia J. Ahern-Rindell, University of Portland



Oxford University Press,
978-0-8412-2592-3,
208 pp, $150, 2010.
(American Chemical Society)

For most of us involved in higher education, there was a pivotal time in our lives when we made the decision to pursue a career in academe. For me, it was the realization that I could continue my education indefinitely, while at the same time helping a younger generation learn how to acquire knowledge. This may sound selfish and laudable at the same time.

In retrospect, the first inkling I had of teaching as a career was back in high school. I had a great biology teacher who fascinated me with his engaging style and enthusiasm for the subject. I recall telling him that I baby-sat for a family in which all three children were suffering from a fatal, inherited disorder and that I wanted to learn what I could about genetics. What he did next was important to laying the groundwork for my career trajectory: he offered to help me with a genetics research project. That day, he became my first research mentor and started me on a path of inquiry and problem solving that would be populated with other giving mentors along the way.

Some of these mentoring relationships were quite formal, such as the research mentors I had as an undergraduate and graduate student and as a postdoctoral fellow. However, I also have had many informal mentoring relationships that I was not really cognizant of at the time but from which I also have benefitted. I can look back now and realize that simply by chance, pieces of advice and guidance turned out to be critical in helping me to advance my career. I now find myself in the role of mentor for my students and colleagues. I have learned that there are many forms that mentoring can take, and no one type is necessarily best. The point is that we all need help along our professional path.

This is the same message conveyed in *Mentoring Strategies to Facilitate the Advancement of Women Faculty,* which is part of the American Chemical Society's published symposium series. The editors and contributors of this volume shed light on the various mentoring strategies that have been utilized for "enhancing the leadership, visibility, and recognition of academic women scientists." Although the book was targeted on broadening "the participation and advancement of women in science and engineering," it has the potential to impact all types of mentoring relationships and thus is a worthy book for all academicians regardless of gender, career stage, or institutional category.

This book is divided into sections based on different organizational levels of mentoring. The first few chapters describe mentoring initiatives at the institutional level, providing insights on building supportive networks with individuals who can act as role models, sounding boards, and advocates. This section also explains how a "small wins" approach—focusing on providing the most impact with the least cost—can promote "incremental changes" that can have a transformational effect on institutions, with minimal expense. The example provided describes how one institution conducted a "faculty climate survey" and a cost-benefit analysis of best practices at other institutions that had received funding from the National Science Foundation's ADVANCE program. The purpose of this program is to increase participation and advancement of women in science and engineering careers. What the analysis found was that more than half of the highly ranked practices evaluated were classified as mentoring activities.

The second section concentrates on how similar types of institutions, such as small liberal arts colleges, create mentoring alliances by pooling the efforts of their senior women faculty, who then share their unique challenges and demands and learn from one another. This "horizontal peer mentoring" is a recurring strategy, in fact, throughout the book. It complements the more traditional vertical mentoring, but is more variable in structure and therefore more flexible.

The third section of the volume offers a national perspective by looking at two mentoring initiatives that provide lessons for informing institutional policy on issues such as paid leave and split appointments, while alerting readers to problems that still need to be addressed. The final section provides recommendations for individuals that transcend career stage or institutional type—recommendations on topics that many of us continue to wrestle with, such as how to achieve an appropriate balance between work and personal life and how to effectively advocate for oneself.

How to maintain one's professional productivity but still have time for "personal satisfaction" is important for well-being; it includes finding strategies for mitigating stress and dealing with time constraints. I had to laugh when I read the opening quote in this chapter from the late multimillionaire Malcolm Forbes, which put this time issue into appropriate perspective: "There is never enough time, unless you're serving it." However, faculty, for the most part, can set their own priorities and divide their time and energy among their various roles; they should do so without feeling guilty.

In sum, this book illustrates how mentoring relationships can help us achieve personal and professional balance without reinventing the wheel and how such relationships can help us be better mentors to our students and colleagues and design a productive, sustainable lifestyle for ourselves.

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• 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.

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