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SERU Project and Consortium Research Paper*

UNDERGRADUATE RESEARCH ENGAGEMENT AT MAJOR US RESEARCH UNIVERSITIES

November 2013

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ABSTRACT

Bolstered by the recommendations of the 1998 Boyer Report, US federal agencies have put significant resources into promoting opportunities for undergraduates to engage in research. American universities and colleges have been creating support programs and curricular opportunities intended to create a "culture of undergraduate research." Yet our knowledge about the commonality of undergraduate research engagement—how it integrates into the educational experience, and its benefits or lack thereof—is still very limited. Universities exude the ideal of a pivotal link of teaching and research. We have assumed that personal interactions between active scholars and undergraduates—via traditional curriculum, research courses, working in a lab or doing fieldwork—have positive influences on students' maturation and their overall academic and social experience. The following exploratory study looks at data generated by the 2010 Student Experience in the Research University (SERU) undergraduate survey, an online census administered that year at fifteen major research-intensive universities. In this case study of mostly AAU campuses, we find that while some 83 percent of upper division students (juniors and seniors) students experience one or more courses with a significant research requirement like a research paper or project, many lower and upper division students do not – a disappointing finding that needs to be addressed by these campuses. At the same time, undergraduate research engagement outside of the traditional classroom is a relatively common experience. Among those students we find that research engagement leads to self-reported learning gains across many areas, but especially in the areas of field knowledge, how to present and communicate knowledge, research skills, higher levels of satisfaction, better use of time, and higher levels of non-quantitative skills. Yet not all research activities are created equally. Participating in student research and independent studies contribute much more to the learning gains across all dimensions than merely assisting faculty in research. Among the two research activities, participating in student research course is more effective than independent studies in enhancing student learning. Among the three activities involving assisting faculty research, assisting faculty research as a volunteer without credit tends to be connected to higher level of gains than for credit and for pay. Taken together, it appears that research activities that involve active learning contribute more to student learning. We offer a number of recommendations to SERU campuses, including: 1. We encourage member campuses to explore what are the causes for some students not engaging in a research paper or project and seek a path to have all students have this form of research engagement; 2. Use the SERU database to provide regular reports on undergraduate research engagement, and include those reports in Academic Program/Department reviews; 3. Expand existing efforts so that most, if not all, undergraduates have the opportunity for two or more non-classroom forms of research engagement, perhaps depending on the field of the major and discipline.

Keywords: Research Engagement, Undergraduate Education, Research Universities

Many critiques of America's higher education revolve around claims that students do not learn enough during the course of their university or college careers, that the curriculum should be more rigorous, and that students on average do not spend enough time studying.[1] The focus is often on a limited or narrow sense of the great range of experiences students gain from a

* Updated revised version as of November 6, 2013. A version of this paper was presented at the International Conference on Higher Education Student Learning and Development in a Globalizing Time, Tsinghua University, October 28, 2013. The Student Experience in the Research University Consortium is a collaborative of major research universities based at the Center for Studies in Higher Education at UC Berkeley and includes the administration of the SERU survey of undergraduates. For more information, see the SERU website: http://cshe.berkeley.edu/research/seru/. John Aubrey Douglass is Senior Research Fellow at the Center for Studies in Higher Education, UC Berkeley and SERU Consortium Berkeley PI; Chun-Mei Zhao is a SERU Research Associate and Director of China Programs, Stanford Center for Professional Programs, Stanford University. Thanks to Shelva Hurley, Gregg Thomson and Shannon Lawrence for reviewing and commenting on earlier drafts.

postsecondary education. While time in the classroom with peers and time studying are essential components of the learning process, there are a great variety of other educational and social opportunities students gain during a critical period in their maturation and transition from the home to the workplace, and to being responsible citizens.

Research universities in particular offer a rich amalgamation of experiences that do not easily conform to rigid ideas or measurements via standardized tests on "learning outcomes." Among the advantages of large, research-intensive universities are opportunities for students to be engaged in supporting or pursuing their own research. Having students engaged in knowledge production has always been a value in American higher education, an antecedent to the Humboldtian model of the modern university as a learning and research-focused community. Humboldt wrote that:

> Both teacher and student have their justification in the common pursuit of knowledge. The teacher's performance depends on the students' presence and interest - without this, science and scholarship could not grow. If the students who are to form [the teacher's] audience did not [gather round] of their own free will, he [or she] would have to seek them out in [the] quest for knowledge. The goals of science and scholarship are worked towards most effectively through the synthesis of the teacher's and the students' dispositions. The teacher's mind is more mature but it is also somewhat one-sided in its development and more dispassionate; the student's mind is less able and less committed but it is nonetheless open and responsive to every possibility.[2]

But this grand thought did not necessarily translate into ubiquitous chances for undergraduates to have research experiences. While valuing the researcher as a teacher who brought discoveries and inquisitive knowledge in their teaching, there was a growing sense that there was a gulf in which students were treated as pedestrians viewing from afar the world of scholarship.

Not until the 1998 Boyer Report entitled *Reinventing Undergraduate Education* did a focus return in earnest to the ideas of the "student as scholar." Building on one of the main concepts of the research university, Earnest Boyer and his colleagues emphasized the ideas of "research-based learning" and engaged scholarship, in and outside of the classroom, as an important component of the student experience.

What followed was an elevated sense by American universities that research engagement in various forms needed to be promoted in formal ways, such as designated courses, funding support, and organizations to help open opportunities for research in the lab and elsewhere. Further, it was recognized that opportunities for research experience is important for students to expand their networks of professional relationships key for deciphering their career goals, generating job opportunities, and making choices about graduate school.

Boyer Report (1998) – Summary "Making Research-Based Learning the Standard"

- Beginning in the freshman year, students should be able to engage in research in as many courses as possible.
- Beginning with the freshman year, students must learn how to convey the results of their work effectively both orally and in writing.
- Undergraduates must explore diverse fields to complement and contrast with their major fields; the freshman and sophomore years need to open intellectual avenues that will stimulate original thought and independent effort, and reveal the relationships among sciences, social sciences, and humanities.
- Inquiry-based courses should allow for joint projects and collaborative efforts.
- Professional schools need to provide the same inquiry-based opportunities, particularly in the early years.
- Provision of carefully constructed internships can turn inquiry-based learning into practical experience; internship opportunities need to be widely available.

In the following, we provide a profile of the research engagement of students within 15 member universities of the Student Experience in the Research University (SERU) Consortium. Each member institution administers a version of the SERU Survey to undergraduates—a census, online survey.

We seek to explore the degree to which students expect to be engaged in research. What are their real opportunities? Are there differences among disciplines, among campuses, among different socioeconomic groups? Then, among those that do gain research experience, can we see correlations: between academic and civic engagement? in students' self-assessed gains in writing, analytical, math, and other skills? in their sense of satisfaction?

The initial findings reported in this article yielded from a preliminary descriptive screening of the data. They do not fully answer all of these questions, but we do think that they are robust enough to advocate that major research universities consider integrating two or more designated research engagements or activities as a requirement of their undergraduate students. Member campuses of the SERU Consortium, in particular, should offer expansive chances for students to engage in research and scholarship. Institutions that form part of the SERU Consortium are large institutions, with a great array of disciplines and programs. Indeed, these robust research enterprises can expose students to the world of active learning that, one might surmise, forms an important component in student development.

These institutions also have a strong ethic of being engaged and supportive of local and regional economies—the legacy of the Morrill Act that further expands research opportunities for students—characteristics that, when combined with the comprehensive nature of academic and professional programs offered by these universities as well as the presence of graduate students as models and mentors, makes them very different from small liberal arts colleges and many other teaching-intensive institutions.

A. PRIOR STUDIES ON RESEARCH ENGAGEMENT

It appears that the Boyer Report had a real impact on the efforts of American universities and colleges to become more organized in promoting undergraduate research engagement. Major research universities, for example, established campus and discipline-based programs, with staffing and institutional funds, and often-times monies from federal agencies such as FIPSE and the National Science Foundation's Research Experiences for Undergraduates (REU) program, and created a more coherent set of courses with and without credit to facilitate both paid and unpaid opportunities for students.

MIT is credited with starting the first formal program, the Undergraduate Research Opportunities Program, as early as 1969. Other institutions, like CalTech, also developed similar efforts and focused on the hard sciences and engineering.

The 1998 Boyer Report broadened the interest of research universities to create campus-wide, disciplinary and interdisciplinary programs across the spectrum of academic fields.[3] This has been accompanied by the establishment of a number of national organizations bent on supporting undergraduate research universities (see sidebar).

Many universities claim (and seem) to be making progress in creating "a culture of undergraduate research." The difference between the rhetoric and the reality, however, remains obscure.

Assumed Benefits of Undergraduate Research Engagement

- Skills development, including study design, data collection, computation, analysis of findings, and communication of results.
- Positive attitudes, habits, and intentions, including research ethics, perseverance, and professionalism.
- Clarification or confirmation of career plans (including postgraduate studies)
- Enhanced career preparation or preparation for postgraduate studies
- Greater networking opportunities – exposure to the world of active learning and potential career paths.
- Promotes links with regional economies and public services.

That there has been a marked expansion in Undergraduate Research (UR) Programs and activities, there is no doubt. A 2007 study by Shouping Hu, George D. Kuh and Joy Gaston Gayles concluded that between the early 1990s and 2004, "the frequency of student research experiences increased since 1998 at all types of institutions." But they also noted that students in research universities appeared not to be more engaged than those, for example, at liberal arts colleges.[4]

Yet this study was largely focused on frequency of engagement. What is known about the actual impact of engagement on the undergraduate experience? How ubiquitous is it? Does it vary differently between the sciences and the humanities in terms of frequency and impact?

There have been ongoing efforts to evaluate the effectiveness of UR Programs, many quantitative explorations based on small surveys with limited responses and some with a qualitative focus. A 2009 cross-institutional study by Tucson Lopatto included more than 100 institutions (but only 3000 students) and focused on the myriad of summer programs for students already in science majors. It is the hypothesis that UR promotes gains in skills, self-confidence, pathways to science careers, and active learning.[5] Participation in research activities also appears to increase retention in science majors, and improves the chances of minority students and women to apply and pursue graduate degrees in science programs.[6]

A more recent exploration of students in UR Programs by Marcus Fechheimer, Karen Webber, and Pamela B. Kleiber argued for more quantitative analysis and used institutional data, including credit hours and GPA among students at the University of Georgia. They

Leading Undergraduate Research Organizations

The Council on Undergraduate Research and its affiliated colleges, universities, and individuals share a focus on providing undergraduate research opportunities for faculty and students at predominantly undergraduate institutions. www.cur.org

Project Kaleidoscope is an informal national alliance working to build strong learning environments for undergraduate students in mathematics, engineering, and the various fields of science, with an emphasis on what works. www.pkal.org

The National Conference on Undergraduate Research promotes undergraduate research scholarship and creative activity done in partnership with faculty or other mentors as a vital component of higher education. www.ncur.org

The Reinvention Center is a national consortium of research universities dedicated to strengthening undergraduate education through networking, convening, and sharing. http://www.reinventioncenter.miami.edu/

concluded that "results show that extended participation in research for more than a single semester is correlated with an increase in GPA, even after using SAT to control for the initial ability level of the students."

There are few well-developed qualitative studies on research engagement. A 2004 study published in *Science Education* included seventy-six interviews with students who had some form of research engagement.[7] Some 91% reported various gains from their experiences, including:

- Personal/professional gains (28%)
- "Thinking and working like a scientist" (28%)
- Gains in various skills (19%)
- Clarification or confirmation of career plans (including postgraduate studies) (12%)
- Enhanced career preparation or preparation for postgraduate studies (9%)
- Shifts in attitudes to learning and research (4%)
- Other benefits (1%)

Another study looked at the effects on students after they graduated. Bauer and Bennett (2003) used alumni reports to assess the usefulness of undergraduate research experiences among 986 participants and their influence on students' post-graduation careers. They compared every person who had some form of research engagement with two students who did not. Alumni who had participated in research as undergraduates were matched as closely as possible with two alumni who shared the same academic major, year of graduation, and cumulative GPA. Those who participated in undergraduate research reported greater increases in their ability to carry out research, develop intellectual curiosity, acquire information independently, understand scientific findings, analyze literature critically, speak effectively, act as a leader, and possess clear career goals.

And finally, a recent study also published in *Science* focused on STEM majors and found that undergraduate research experiences where crucial for persistence, along with active learning techniques in introductory courses. They also found indicators that students who have research experiences directed by faculty at the freshman year correlated highly with students remaining in STEM fields and graduating.[8]

In light of the significant resources federal agencies have put into undergraduate research engagement, the number of UR Programs and the claims of an existing "culture of undergraduate research," the studies claiming that student research is common, how undergraduate research engagement integrates into the educational experience, and its benefits—or lack thereof—is still very limited.

In the following exploration of the SERU data, we offer a cursory look at what we believe is a tremendously rich data source that offers an opportunity to develop a larger, more comprehensive study. Part of the strength of this database is not only the grouping of top research-intensive universities, all with serious commitments and opportunities for undergraduate research, but also the comprehensive nature of the survey instrument and its link with institutional data. These combined factors allow the ability to drill down to the discipline (or major) level, along with various sub-populations.

B. A PROFILE OF RESEARCH ENGAGEMENT

The 2010 SERU Survey was administered at 15 major US research universities including all nine University of California campuses (where the survey is called the University of California Undergraduate Experience Survey or UCUES) and six top-25 public national universities: Rutgers University, the University of Pittsburgh, the University of Michigan, the University of Minnesota, the University of Oregon, and the University of Texas.[9]

SERU Survey: Question & Responses Related to Research Engagement" Over the Course of their Academic Studies

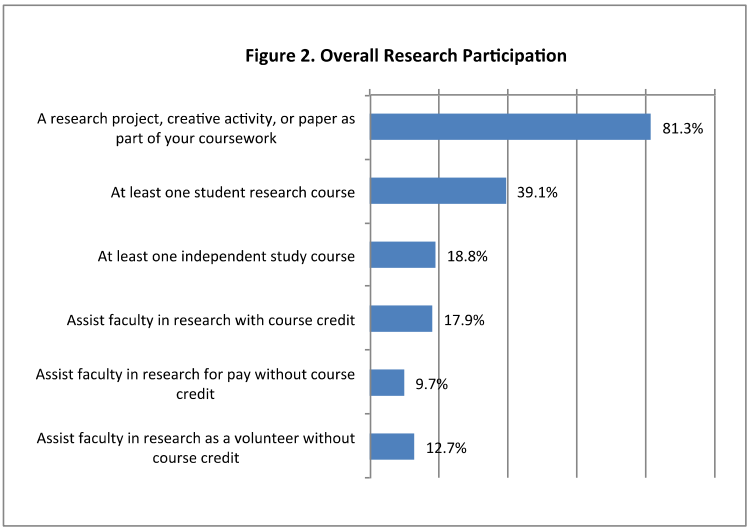
Indicate the following research and creative activities that you are currently doing or have completed as a student of this university.

1. A research project, creative activity, or paper as part of our course work
2. At lease one student research course
3. At least one independent study course
4. Assist faculty in research with course credit
5. Assist faculty in research for pay without course credit
6. Assist faculty in research as a volunteer without course credit

SERU is a census, online survey. In 2010, a total of over 130,000 students answered the survey for a response rate of approximately 41%. Questions regarding research engagement are related to six response categories (see sidebar). The first response examines research as part of coursework and the others involve more research-focused projects or activities.

Overall Participation

SERU data indicate that a majority of undergraduate students engage in one or more forms of research in the course of their academic careers. The most common form of engagement is the requirement of collaborative research projects or research papers. As shown in Figure 1, some 81% of students reported this type of activity during the year of the SERU Survey on average, across the disciplines, and across the 15 campuses. However, the ideal is that students at all stages in their four-year or more path to a degree should be required to engage in some form of research.



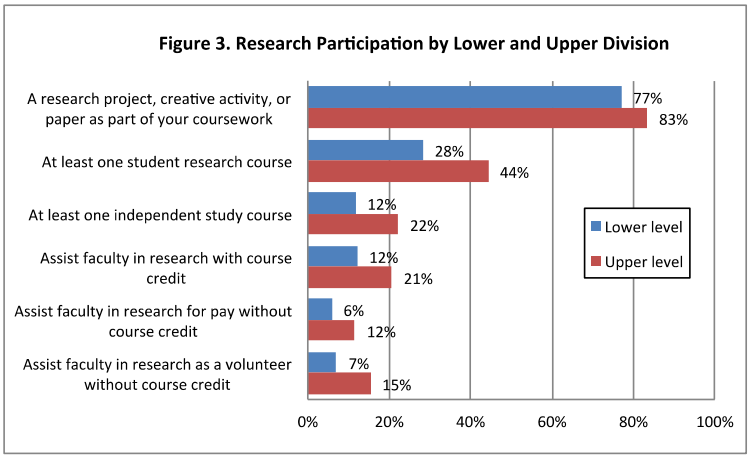
What would account for some 19 percent not having a course with a significant research component? Answering that question in comprehensive way is beyond the scope of this study, but we suspect it may relate to increasing student to faculty ratios at many of our SERU campuses in reaction to declining public investment, and perhaps differences between the disciplines. For example, requiring a research paper or project generally requires greater time and effort by university faculty who managing larger and larger classes on average. And students in STEM fields are less likely to have a course with a research component, but are more likely to participate in a research project for pay, or for credit, or as an independent study.

Figure 2: Occurrence of SERU Campus Research Engagement: Responses 2 through 6

Number of research activities engaged in	Lower Level			Upper Level			Total		
	N	%	Valid %	N	%	Valid %	N	%	Valid %
0	19216	45.8	60.1	28413	32.6	42.3	47732	36.7	48.04
1	7597	18.1	23.8	17844	20.5	26.6	25500	19.6	25.66
2	3415	8.1	10.7	10491	12.0	15.6	13953	10.7	14.04
3	1018	2.4	3.2	5726	6.6	8.5	6764	5.2	6.81
4	302	0.7	0.9	3041	3.5	4.5	3351	2.6	3.37
5	401	1.0	1.3	1655	1.9	2.5	2064	1.6	2.08
Missing	10040	23.9		20075	23.0		30808	23.7	
Sum of 1 to 5	12733	30.3	39.9	38757	44.4	57.7	51632	39.7	52.0
Total	41989	100.0		87245	100.0		130172	100.0	

At the same time, a majority of students are engaged in some form of research outside of the classroom. A total of 39.7% of all students in the survey (or 52% if disregarding the missing values) are currently doing or have completed at least one of five research activities (options 2 through 6 shown in Figure 2, not including traditional course requirements listed in option 1).

About 44.4% of all upper-division students (or 57.7% if disregarding missing values) are engaging in these research activities; in contrast, only 30.3% (or 39.9% if disregarding missing values) of all lower-division students are engaging in one or more of these five research activities.



As a reference point, a previous SERU study that focused on the UC system indicated that in 2008 some 33% of upper-division students participated in research outside of the traditional classroom.[10] Data from the National Survey of Student Engagement in

2009 indicated that only one in five of senior students engaged in research outside of the classroom at four-year colleges and universities overall.

Although we need to unpack the SERU data (for example, UC campuses versus other SERU AAU campuses), this may indicate that research engagement has increased and now forms a significant component in the undergraduate experience among students attending SERU institutions.

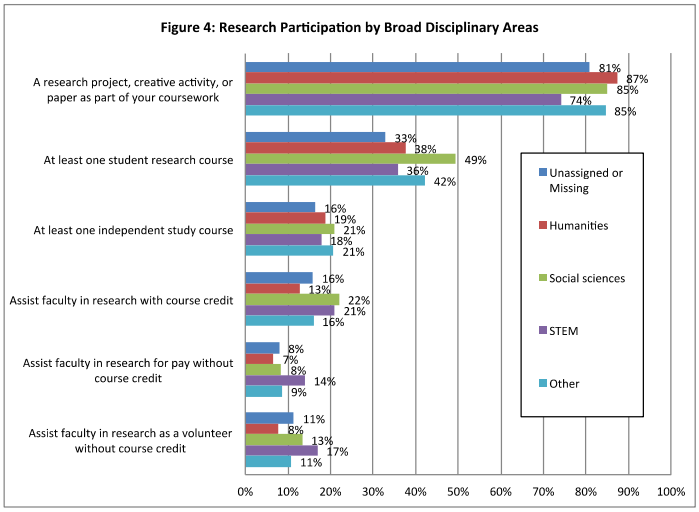
Another indicator of the pervasiveness of research engagement by undergraduates, and rising expectations among students and faculty, is indicated in Figure 2. Of the students that responded to the SERU Survey at the 15 SERU member campuses, nearly 40% of all students participate in research through at least one student research course; 18.9% of students participate in at least one independent study course or assist faculty in research with course credit; and 9.7% and 12.7% of all students assist faculty in research without course credit either for pay or as volunteers respectively.

Research participation differs by class levels. Upper-division students (third year and above) have significantly more experience in both classroom and out of class research (see Figure 3). One would expect this pattern, with upper-division students already fulfilling all or most of the general education requirements, and gaining experience and the desire for engaged scholarship.

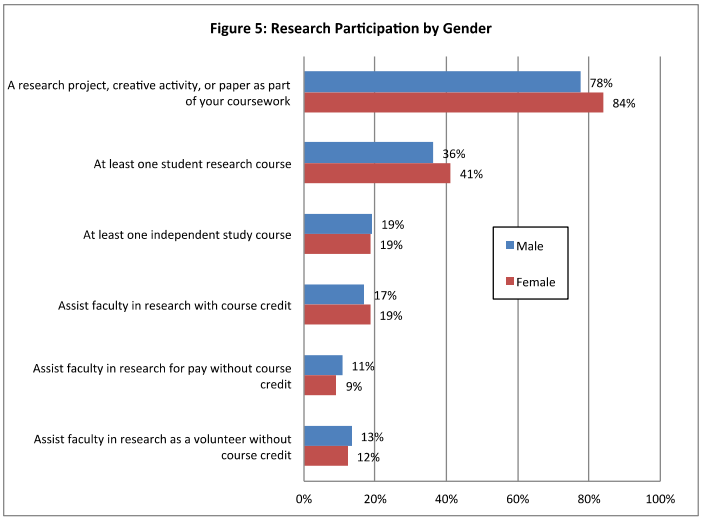
The Disciplines

How broadly is research experience spread across the disciplines, with an expectation that Science, Technology, Engineering and Math (STEM) fields would afford more or at least different types of opportunities for undergraduates? It is plausible to consider that the research-grant prowess of STEM fields, plus the team and laboratory nature of research activities, might generate more research-for-pay activity among undergraduates.

Figure 4 provides data that focuses on students who have declared their major in the humanities, social sciences, STEM, and professional fields, plus students who have not yet declared their major. In the first two categories of student research engagement, research related to coursework and a student research-specific course, STEM fields show no significant integration of research experience when compared to other fields and undeclared students. Indeed, the Social Science disciplines, at 49%, have a significantly higher participation of students.



Reflecting the pedagogy and laboratory or field nature of research, STEM fields do have a higher percentage of students assisting faculty for pay and volunteering, at 14% and 17% respectively, compared to the humanities at 7% and 8%. At the same time, the differences are not huge and indicate that regardless of major, students are engaged in research outside of the traditional classroom.



Based on the aforementioned studies, which note overall increases in undergraduate research engagement during the past few decades, we can assume that the humanities and social science fields have and will continue to increase their support of student research activities if major universities continue to expand their efforts to integrate undergraduate research experiences. For any campus or any discipline, the question should be asked: What percentage of students should have one or more of the five categories of experiences we analyze here during their academic careers?

Gender

Women now represent over 50 percent of all undergraduate enrollment among SERU member campuses. Are there differences in engagement by gender?

The data suggest that there is a slightly different pattern in research participation between male and female students (see Figure 5). While on par with their male counterparts when it comes to participating in at least one independent study course and assisting faculty members in research, female students appear to be more engaged in a research project, creative activity, or paper as part of their coursework and in at least one student research course than their male peers. Again, differences between the disciplines, and where students are majoring, may have an influence in categories, including the correlation of male students in STEM fields (with notable exceptions such as Biology) with research experience for pay and volunteering to work with a faculty member.

Ethnicity

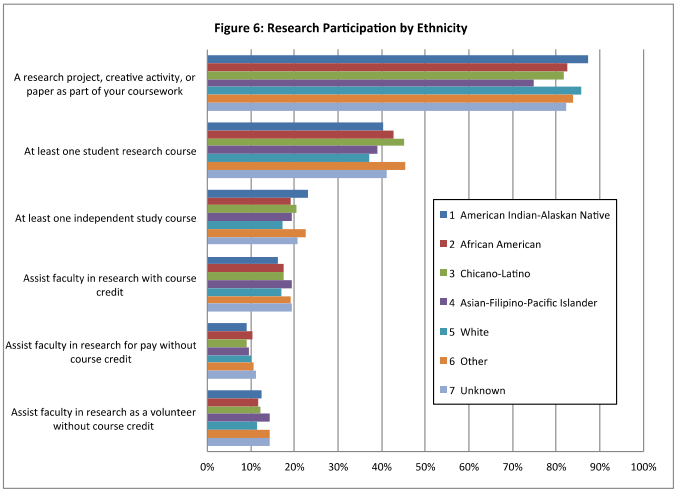
Are there differences in research participation between ethnicities? Asian students tend to engage less in research as part of their course work—again, perhaps reflecting their choice of majors. Chicano-Latino and African American students are more likely to participate in student research courses than their white and Asian counterparts. (See Figure 6.)

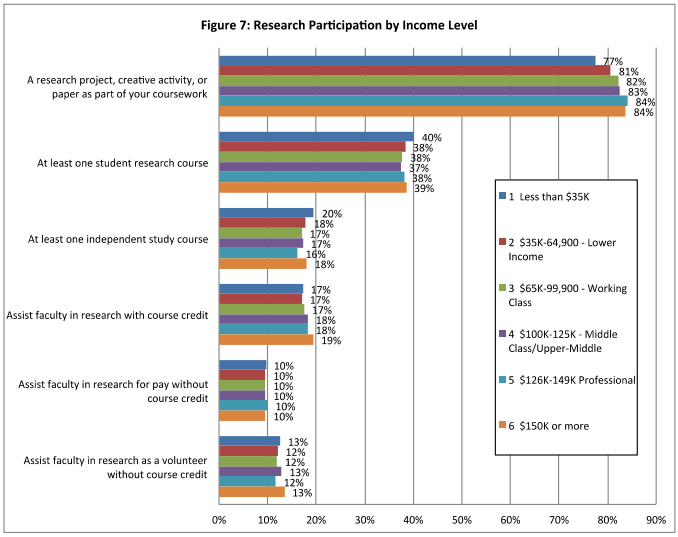
Different ethnic groups are similar to one another in terms of assisting faculty research, although Asian students are slightly more engaged in assisting faculty in research with course credit or as volunteers without course credit.

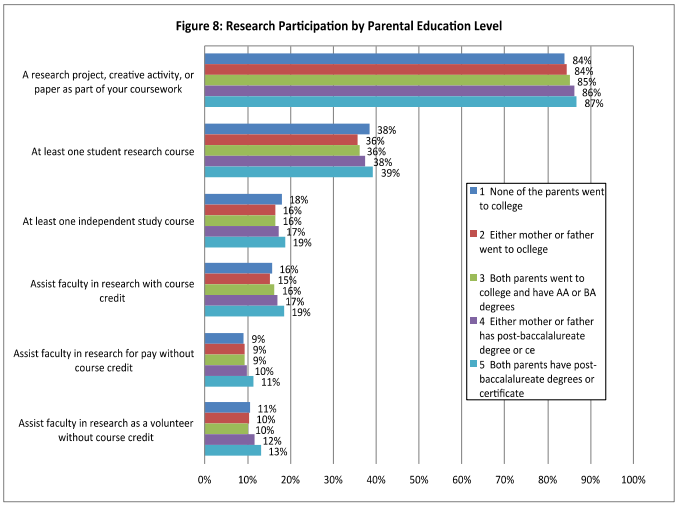
Income and Parental Educational Background

Are there differences in the rates of engagement between socioeconomic groups? We find that undergraduate research engagement is similar across the self-reported income levels of students (see Figure 7).

One exception is that students from higher income backgrounds tend to engage more in conducting research activities as part of coursework. On the other hand, students from the lowest income group are slightly more engaged in all the other research activities than their wealthier peers.



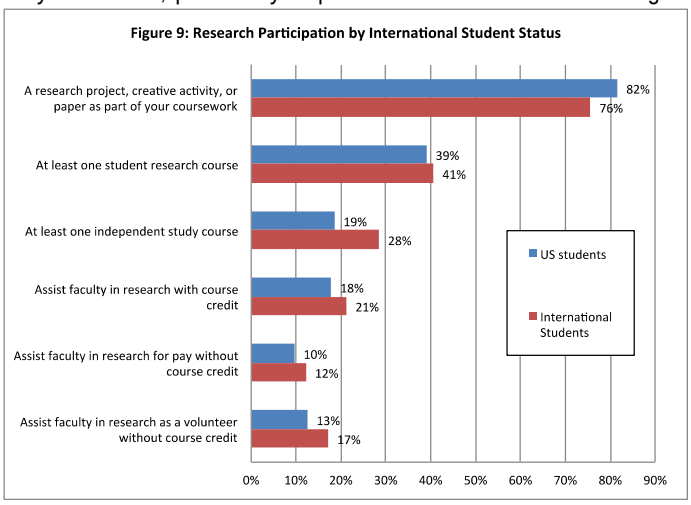




Similar results are found by categorizing the data by parental education level (see Figure 8). There are marginal differences among the six SERU-identified areas of research engagement when comparing students whose parents went to college or have professional degrees with those with parents with no postsecondary experience.

International Students

International students are a growing component of university enrollment, particularly at public universities that are striving to become global players, and as a source of income in an era of declining public funding (see Figure 9). On average, across 15 SERU member campuses, international students are more engaged in all the other research activities than their US counterparts, and particularly in categories 3 through 6.



This may reflect the high percentage of international students in STEM fields (see the SERU Brief on International students).

Student Aspirations

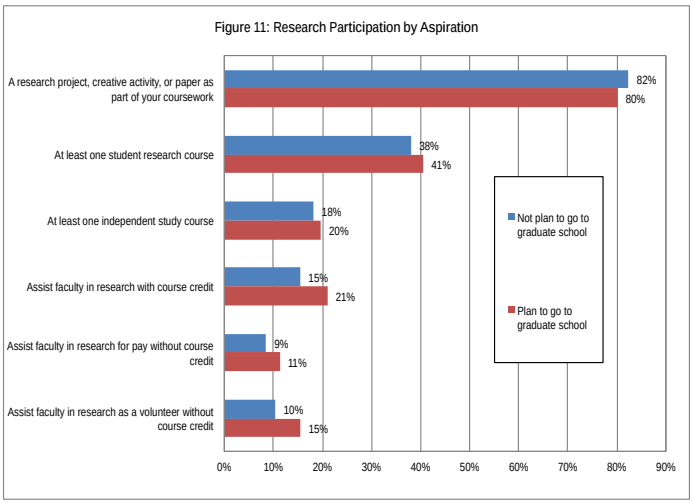
Student aspiration to go to graduate school seems to be connected to their research engagement patterns, particularly in categories 3 through 6. Overall the students who plan to go to graduate school show more engagement in various research activities. But it should be noted that students at the various SERU campuses generally have high expectations to go on to some form of graduate education.

The following analysis categorizes research engagement into two "Indexes" to help analyze the relative interests of students in the fields and professions they aspire to pursue (see table below). Factor loadings are provided in Appendix 1.

Figure 10: Research engagement index 1: Assist faculty in research	
RUC0RESFACSCH	Assist faculty in research with course credit
RUC0RESFACPAY	Assist faculty in research for pay without course credit
RUC0RESFACVOL	Assist faculty in research as a volunteer without course credit
Research engagement index 2: Conduct research	
RUC0CMPLTDRES	A research project, creative activity, or paper as part of your coursework
RUC0RES99	At least one student research course
RUC0RES199	At least one independent study course

Students who aspire to careers in artistic, creative professions, education, law, and psychology are more likely to engage in conducting research. Students who strive for careers as researchers, scientists, and psychology are more likely to assist faculty in research. Students aspiring to a business career and students who have no idea about their career paths show below average engagement across both of the research activity types.

In terms of the relation between students' aspiring degrees and their research engagement, a general pattern emerges: the students aspiring to higher degrees are connected with a higher-level engagement in assisting faculty research. In addition, students aspiring to master's level professional degrees are linked to a higher level of engagement in conducting independent studies.



It may be useful to correlate these ambitions with discipline/major, and with other variables. The conjecture noted previously is that research experience—perhaps the very nature of it—leads students not only to gain in various analytical skills but expands their knowledge of and interest in future endeavors.

These data seem to indicate that this is true (see Figure 11); but the question remains whether those students who engage in research outside the classroom are a self-selected population—that they are already ambitious and academically engaged lower-division students.

So how does the aspiration of students with some form of undergraduate research engagement match up with the realities of their later careers? This is a good question that the SERU database cannot help us attempt to answer at present. We can, however, point to a 2006 evaluation of the National Science Foundation's support for undergraduate research opportunities in the United States by SRI International. That study found that undergraduate research opportunities increased the likelihood and expectation of obtaining a PhD.

About eight in ten postgraduate students who expected to obtain a PhD reported that their research experiences were fairly or extremely important in their decision to pursue postgraduate studies, their decision about their field of study, and their acceptance as a PhD student.[11]

SERU Data by Campus

Among SERU campuses, are there significant differences in the six categories used here to decipher research engagement? If there are, might this relate to the general importance placed by faculty and the institution in supporting undergraduate research opportunities, or perhaps specific programs and offices for linking and supporting students to pursue experiences and careers in research?

Most of the SERU universities have campus-wide offices to support this activity, and many academic departments have programs. The University of North Carolina, for example, established a campus-wide Office of Undergraduate Research in 1999. Analysis on the correlation between formal programs and actual activity is beyond the scope of this brief, but the data we do provide indicates marginal differences among most of the campuses in the occurrence and type of engagement—although there are patterns that indicate that some campuses are leaders in supporting and encouraging research engagement.

At this stage in our research, we have are just beginning to explore campus-level data. We can note, however, that, generally, UC campuses have few students participating in classroom research projects when compared to non-UC campuses—perhaps a subject for the UC campuses to return to. This may be a result of increasing student-to-faculty rations, and the mix of disciplines. UC now has a systemwide average of 24 students for each faculty person, one of the highest among the AAUs.

C. CORRELATING RESEARCH ENGAGEMENT WITH OUTCOMES

In the following, we provide two initial efforts to explore the correlation of various types of research engagement with other indicators of academic engagement.

1. Relations between research engagement and other engagement activities, time use, and satisfaction

The following correlation analysis confirms that there is a relationship between research engagement and satisfaction. Our regression analysis examines the impact of research engagement on the engagement factors and satisfaction, controlling for major, level, and aspiration to study in graduate school. The most significant impacts of research engagement are on three areas—engagement with studies, current skills self-assessment and gains in non-quantitative areas, and time use.

Figure 12 shows the connection between the two research indexes and a broad array of engagement factors. As shown in the table, assisting faculty research is significantly and positively corrected with student engagement with studies and effective use of time. It is also significantly corrected with quantitative professions.

Conducting independent research has a powerful connection with many aspects—including enhanced satisfaction with educational experience, current assessment of non-quantitative skills, engagement with studies, gains in non-quantitative skills.

Figure 12: Correlation of Research Engagement with Other Forms of Academic Engagement

	Satisfaction with Educational Experience	Current Skills Self-Assessment (Nonquantitative)	Engagement with Studies	Campus Climate for Diversity	Quantitative Professions	Use of Time (Academic and Employment)
	Beta	*Beta*	*Beta*	*Beta*	*Beta*	*Beta*
Research: Assist Faculty	0.028 ***	0.039 ***	0.334 ***	-0.017 ***	0.030 ***	0.130 ***
Research: Conduct Research	0.075 ***	0.115 ***	0.330 ***	-0.007	-0.014 **	0.044 ***
Humanities	0.070 ***	0.071 ***	0.085 ***	-0.027 ***	-0.255 ***	-0.002
Social Sciences	-0.011 *	0.030 ***	-0.051 ***	-0.038 ***	-0.143 ***	-0.046 ***
Stem	-0.038 ***	-0.065 ***	-0.092 ***	0.007	0.144 ***	0.032 ***
Plan to go to grad school	0.050 ***	0.051 ***	0.066 ***	0.040 ***	0.065 ***	0.027 ***
Upper class level	0.037 ***	0.102 ***	0.040 ***	-0.079 ***	-0.080 ***	0.163 ***
Female	0.012 **	0.016 ***	-0.042 ***	-0.011 *	-0.119 ***	0.042 ***
Asian	-0.146 ***	-0.136 ***	-0.063 ***	-0.015 *	0.027 ***	-0.045 ***
White	-0.007	0.015 *	0.063 ***	0.064 ***	0.015 *	0.011
African American	-0.022 ***	0.019 ***	0.028 ***	-0.034 ***	0.007	0.017 ***
American Indian	-0.011 *	0.002	0.009 *	-0.003	-0.009 *	0.000
Other_race	-0.017 ***	0.003	0.024 ***	0.003	0.003	0.008
Unknown Race	-0.040 ***	-0.009	0.007	-0.001	-0.007	-0.008
SAT	0.036 ***	0.021 ***	-0.045 ***	-0.031 ***	-0.043 ***	-0.055 ***
Family income	0.037 ***	0.078 ***	0.038 ***	0.057 ***	0.049 ***	-0.063 ***
Parental Education	0.043 ***	-0.002	0.033 ***	-0.001	-0.054 ***	-0.001
International Student	-0.034 ***	-0.057 ***	0.017 ***	-0.001	0.028 ***	0.005
Model Adjusted R^2	0.056	0.088	0.276	0.023	0.192	0.063

2. Relations between research engagement and student self-reported learning gains

Here we focus on only the five research activities (responses 2 through 6), not including traditional classroom research-related assignments) to look at the link between various research activities and student self-reported learning gains. The SERU asks students to evaluate their levels of proficiencies across 19 dimensions of desired educational outcomes at two points: when they entered the university and at the time of their survey. These outcomes include critical thinking, reading, writing, research skills, and social skills, etc. A detailed listing of all of the 19 areas is included in Appendix 2.

We compared the two time points of the student university career and derived learning gains on the learning outcome dimensions (the difference between the current and the beginning scores). Figure 13 shows the highest correlations between the research activities and learning gains. As shown, the top learning gain dimensions contributed by the research activities include: other research skills (all research other than library research skills), presentation skills, skills about a specific field of study, reading skills, and library research skills.

Figure 13: Highest Correlations between Research Activities and Learning Gains

At least one student research course		At least one independent study course		Assist faculty in research with course credit		Assist faculty in research for pay without course credit		Assist faculty in research as a volunteer without course credit	
Other research skills	0.234	Other research skills	0.147	Other research skills	0.164	Other research skills	0.111	Other research skills	0.134
Library research	0.182	Presentation	0.133	Presentation	0.108	Presentation	0.096	Presentation	0.101
Presentation	0.161	Reading	0.099	Reading	0.090	Knowledge about major	0.071	Reading	0.080
Critical thinking	0.129	Critical thinking	0.099	Knowledge about major	0.088	Reading	0.068	Knowledge about major	0.077
Knowledge about major	0.126	Library research	0.097	Library research	0.077	Computer	0.061	Library research	0.062
Reading	0.126	Speak in English	0.090	Critical thinking	0.064	Math	0.056	Speak in English	0.059
Writing	0.118	Internet Skills	0.089	Internet skills	0.055	Internet skills	0.051	Internet skills	0.058
Internet Skills	0.114	Knowledge about major	0.089	Computer skills	0.050	Critical thinking	0.043	Critical thinking	0.056

In addition, we ran a series of regression analyses to further explore the connection between research activities and learning gains. The five research activities are independent variables; the 19 dimensions of learning gains (calculated by the difference between the current score and the beginning scores) are dependent variables. Control variables are also included: broad disciplinary areas, academic class levels, gender, race, and other student background characteristics.

A summary of the regression models is shown in Appendix 2. Overall, research engagement is positively linked to learning outcomes, especially in the development of research skills, presentation skills, and understanding a specific field of study.

Participating in student research and independent studies contribute much more to the learning gains across all dimensions than merely assisting faculty in research. Among the two research activities, participating in student research course is more effective than independent studies in enhancing student learning. Among the three activities involving assisting faculty research, assisting faculty research as a volunteer without credit tends to be connected to higher level of gains than for credit and for pay. Taken together, it appears that research activities that involve active learning contribute more to student learning.

D. CONCLUSIONS

Universities are built around an ethos of a virtuous link between teaching and research. Personal interactions between active scholars and undergraduates via the traditional curriculum—a research course, working in a lab or doing fieldwork—all have been assumed to have positive influences on students' maturation and their overall academic and social experience. This exploratory look at the SERU data among 15 major research universities provides evidence of this effective link—that it is not simply bravado. Specifically, among this case study of mostly AAU campuses, there is evidence that research engagement outside of the traditional classroom is a common experience. Further, we can presume that the research engagement leads to:

- Self-reported learning gains across many areas but especially in areas of field knowledge, how to present and communicate the knowledge, and research skills.
- Higher levels of satisfaction about educational experiences.
- Better use of time.
- Higher levels non-quantitative skills.
- Other engagement of activities.

Yet not all research activities are created equal. We identified two different types of research—those research activities that mainly involve assisting faculty research, and those that mainly involve conducting independent and personal research. The former is more prevalent in STEM fields, while the latter is more likely in the humanities, social sciences, and in professional majors. Further, lower-division students also tend to assist faculty research more than their upper-division peers, who are more likely to engage in independent research. Depending on the discipline, assisting faculty research is significantly and positively corrected with student engagement with studies and effective use of time. It is also significantly corrected with quantitative professions. Conducting independent research has a powerful connection with many aspects—including enhanced satisfaction with educational experience, current assessment of non-quantitative skills, engagement with studies, gains in non-quantitative skills.

Although the participation rate has increased over the years, less than 50% of students participate in research activities, and research engagement is uneven for students from different groups (major, class level, gender, race, etc.). Lower-division students participate significantly less than upper-division students. Further, aspiration matters: students with different career and postsecondary degree aspiration approach research engagement differently.

SERU campuses have embraced the ideal of continually reviewing and revising what they offer undergraduate students and how they do it. Research engagement, we think, offers a significant area of potential institutional improvement that will further shape productive and creative graduates. We hope the SERU Consortium can more fully investigate research activities of students by different disciplines and at the campus level to help identify good practice and the effects of institutional efforts at promoting greater academic and civic engagement of students.

Another possible research question: Are there positive effects of inter-disciplinary academic programs? This is an area in which the link between institutional culture and effort might allow us to more fully understand the role of research engagement for enhancing learning.

Understanding the limitations of this study, we do offer preliminary recommendations:

- Our data analysis indicates that there is a significant cohort of students who do not have classes with a research component of some sort, such as a research paper or course directed research project. We encourage member campuses to explore what are the causes for this and to seek a path to insure that research engagement is more thoroughly integrated into courses in all disciplines.
- SERU Campuses should consider using the SERU database to provide regular reports on undergraduate research engagement, and include such reports in Academic Program/Department reviews.
- SERU campuses should consider expanding their efforts so that most, if not all, undergraduates gain two or more non-classroom forms of research engagement, perhaps depending on the field of the major and discipline. Campuses should consider amending their current curricular requirements to this end.
- Faculty should incorporate active learning techniques (that focus on research in the discipline) into introductory courses, particularly in STEM fields that have been found to correlate with persistence.
- AAU institutions should further encourage student-led "learning communities" focused on offering opportunities for students to engage in research both within and outside their major.

Ultimately, AAU institutions need more evidence that there is a causal link between participation in undergraduate research programs and improved academic engagement and performance, as well as career outcomes. The SERU dataset offers an opportunity for an expanding inquiry, perhaps combined with focus groups and other qualitative methods. In the end, it appears that the transition of undergraduate research engagement into a mandatory part of the students experience would have significant benefits. And, in so doing, AAU partners, with their wide breadth of fields of study, will better meet the needs of students as well as their teaching, research, and public service mission.

REFRENCES

Alexander, B. B., Foertsch, J., & Daffinrud, S. (1998). The Spend a Summer with a Scientist Program: An evaluation of program outcomes and the essential elements for success. Madison: University of Wisconsin-Madison. Spend a Summer with a Scientist Program website: http://www.crpc.rice.edu/CRPC/SaS/

Bauer, K. W. (2001). The effect of participation in undergraduate research on critical thinking and reflective judgement. AIR 2001 Annual Forum Paper.

Brint, Steven, John Aubrey Douglass, Gregg Thomson, and Steve Chatman (2010). *Engaged Learning in a Public University: Trends in the Undergraduate Experience*. SERU Project and Consortium, Center for Studies in Higher Education.

Graham, M. et al (2013). "Increasing Persistence of College Students in STEM," *Science*, vol. 341, September 27: pp. 1455-1456.

Hathaway, R. S., Nagda, B. A., & Gregerman, S. R. (2002). The relationship of undergraduate research participation to graduate and professional education pursuit: an empirical study. *Journal of College Student Development*, 43(5) 614-31. UROP website: http://www.lsa.umich.edu/urop/

Humboldt, Wilhelm von (reprint 1970). On the Spirit and the Organisational Framework of Intellectual Institutions in Berlin, *Minerva* VIII: 2 (April 1970), 243f.

Hu, Shouping & George D. Kuh & Joy Gaston (2007). "Engaging Undergraduate Students in Research Activities: Are Research Universities Doing a Better Job?" *Innovation in Higher Education*, v32 n3 p167-177 Oct 2007: http://www.eric.ed.gov/ERICWebPortal/detail?accno=EJ784935

Hunter, A. B., Laursen, S. L., Seymour, E. (2006). Becoming a scientist: the role of undergraduate research in students' cognitive, personal, and professional development. *Science Education*, 91, 36-74.

Kardash, C. M. (2000). Evaluation of an undergraduate research experience: perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology*, 92(1) 191-201.

Katkin, W. (2003). The Boyer Commission Report and its impact on undergraduate research. *New Directions for Teaching and Learning*, 93, 19-38.

Kremer, J. F., Bringle, R. G. (1990). The effects of an intensive research experience on the careers of talented undergraduates. *Journal of Research and Development in Education*, 24(1) 1-5.

Landrum, R. E., Nelson, L. R. (2002). The undergraduate research assistantship: an analysis of the benefits. *Teaching of Psychology*, 29(1) 15-19.

Lopatto, D. (2003). The essential features of undergraduate research. *Council on Undergraduate Research Quarterly*, 23(2) 139-142.

Lopatto, D. (2004). Survey of Undergraduate Research Experiences (SURE): first findings. *Cell Biology Education*, 3, 270-277.

Lopatto, D. (2006). Undergraduate research as a catalyst for liberal learning. *Peer Review*, 8(1) 22-25.

Merkel, Carolyn Ash. (2001). "Undergraduate Research at Six Research Universities – A Pilot Study for the Association of American Universities, May 1, 2001.

Nagda, B. A., Gregerman, R. S., Jonides, J., Von Hippel, W., & Lerner, J. S. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education*, 22(1) 55-72. UROP website: http://www.lsa.umich.edu/urop/

Ruekert, (2006). Council on Undergraduate Research biennial meeting. PowerPoint presentation retrieved 20th July 2007 from: http://www.neiu.edu/%7Elruecker/rsrchassess.ppt

Russell, S. (2006). Evaluation of NSF support for undergraduate research opportunities: Draft Synthesis Report. SRI International.

Ryder, J., Leach, J., & Driver, R. (1999). Undergraduate science students' images of science, *Journal of Research in Science Teaching*, 32(2) 201-219.

Seymour, E., Barrie-Hunter, A., Laursen, S. L., & Deantoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: first findings from a three-year study. *Science Education*, 88(4) 493-534.

Skoog, Campbell A. (2008). Transcending deficits and differences through undergraduate research. In: Taraban R, Blanton RL, editors. Creating Effective Undergraduate Research Programs in Science: The Transformation from Student to Scientist. New York: Teachers College Press; 2008. pp. 206–214.

APPENDIX 1

Factor Loadings

	Research: Assist Faculty	Research: Conduct Research
Assist faculty in research as a volunteer without course credit	0.752	
Assist faculty in research for pay without course credit	0.747	
Assist faculty in research with course credit	0.630	
A research project, creative activity, or paper as part of your coursework		0.754
At least one student research course		0.749
At least one independent study course		0.556

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

APPENDIX 2

Regression Results A: Column Dependent variables; Rows: Independent variabkes

Dependenet Variables	Critical thinking		Writing		Reading		Foreign Language		Understanding of a specific field of study		Math		Speak English		Understand international perspective		Computer Skill	
	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.
RUC0RES992	0.081	0.000	0.087	0.000	0.070	0.000	0.011	0.004	0.062	0.000	0.021	0.000	0.064	0.000	0.061	0.000	0.041	0.000
RUC0RES1992	0.045	0.000	0.044	0.000	0.041	0.000	0.026	0.000	0.021	0.000	0.021	0.000	0.050	0.000	0.023	0.000	0.041	0.000
RUC0RESFACSCH2	0.004	0.375	0.001	0.805	0.029	0.000	-0.007	0.091	0.027	0.000	-0.003	0.385	-0.003	0.480	-0.001	0.843	0.003	0.514
RUC0RESFACPAY2	0.011	0.003	-0.003	0.396	0.024	0.000	0.003	0.357	0.028	0.000	0.029	0.000	0.004	0.309	-0.001	0.835	0.031	0.000
RUC0RESFACVOL2	0.015	0.000	0.008	0.039	0.030	0.000	0.009	0.025	0.020	0.000	0.024	0.000	0.028	0.000	0.000	0.980	0.010	0.009
hum	0.033	0.000	0.055	0.000	0.022	0.000	0.126	0.000	0.024	0.000	-0.059	0.000	0.004	0.364	0.017	0.000	-0.025	0.000
soc	0.033	0.000	0.042	0.000	0.025	0.000	0.056	0.000	0.052	0.000	0.011	0.014	0.005	0.273	0.072	0.000	-0.020	0.000
stem	-0.012	0.015	-0.036	0.000	-0.014	0.006	-0.051	0.000	0.024	0.000	0.120	0.000	-0.022	0.000	-0.063	0.000	0.057	0.000
other	0.032	0.000	0.042	0.000	0.006	0.201	0.002	0.685	0.071	0.000	0.035	0.000	0.015	0.002	0.041	0.000	0.047	0.000
Grad_School	-0.006	0.120	0.001	0.829	0.008	0.032	-0.011	0.003	-0.014	0.000	0.021	0.000	0.001	0.881	-0.036	0.000	-0.042	0.000
Upper level	0.128	0.000	0.046	0.000	0.124	0.000	0.034	0.000	0.218	0.000	0.000	0.920	0.067	0.000	0.118	0.000	0.088	0.000
Female	-0.021	0.000	-0.037	0.000	-0.037	0.000	0.003	0.379	-0.026	0.000	-0.088	0.000	-0.064	0.000	0.000	0.995	-0.026	0.000
Model R Square	0.039		0.026		0.041		0.027		0.075		0.038		0.022		0.041		0.028	

Regression Results B: Column Dependent variables; Rows: Independent variabkes

Dependenet Variables	Internet skill		Library Research Skill		Other research skill		Presentation Skill		Interpersonal skill		Appreciate racial diversity		Appreciate arts		Apprecaite global diversity		Understand personal responsibility		Self Awareness	
	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.	Beta	Sig.
RUC0RES992	0.072	0.000	0.146	0.000	0.157	0.000	0.095	0.000	0.038	0.000	0.045	0.000	0.041	0.000	0.049	0.000	0.047	0.000	0.049	0.000
RUC0RES1992	0.041	0.000	0.028	0.000	0.041	0.000	0.056	0.000	0.027	0.000	0.025	0.000	0.021	0.000	0.028	0.000	0.025	0.000	0.023	0.000
RUC0RESFACSCH2	-0.004	0.373	0.006	0.105	0.058	0.000	0.026	0.000	0.014	0.001	0.002	0.676	-0.008	0.045	0.001	0.731	0.000	0.931	0.008	0.048
RUC0RESFACPAY2	0.019	0.000	0.000	0.943	0.036	0.000	0.043	0.000	0.007	0.078	0.006	0.118	-0.002	0.630	0.010	0.006	0.007	0.062	0.007	0.064
RUC0RESFACVOL2	0.020	0.000	0.020	0.000	0.047	0.000	0.032	0.000	0.016	0.000	0.004	0.350	0.016	0.000	0.004	0.288	0.007	0.075	0.016	0.000
hum	0.015	0.001	0.042	0.000	0.025	0.000	0.019	0.000	0.008	0.095	0.008	0.093	0.028	0.000	0.010	0.032	0.008	0.098	0.029	0.000
soc	0.016	0.000	0.047	0.000	0.042	0.000	0.014	0.002	0.011	0.016	0.013	0.004	0.017	0.000	0.023	0.000	0.027	0.000	0.027	0.000
stem	0.022	0.000	-0.020	0.000	0.009	0.051	0.025	0.000	0.024	0.000	-0.032	0.000	-0.028	0.000	-0.033	0.000	-0.019	0.000	-0.011	0.025
other	0.039	0.000	0.041	0.000	0.036	0.000	0.100	0.000	0.042	0.000	0.020	0.000	0.020	0.000	0.020	0.000	0.025	0.000	0.031	0.000
Grad_School	-0.037	0.000	0.001	0.700	0.015	0.000	-0.029	0.000	-0.014	0.000	-0.007	0.069	-0.012	0.001	-0.020	0.000	-0.013	0.000	-0.021	0.000
Upper level	0.120	0.000	0.077	0.000	0.132	0.000	0.159	0.000	0.063	0.000	0.038	0.000	0.030	0.000	0.065	0.000	0.058	0.000	0.098	0.000
Female	0.018	0.000	0.031	0.000	0.019	0.000	-0.032	0.000	-0.048	0.000	0.032	0.000	-0.034	0.000	0.019	0.000	-0.001	0.676	0.015	0.000
Model R Square	0.034		0.047		0.089		0.074		0.014		0.01		0.008		0.015		0.012		0.022	

ENDNOTES

[1] See Babcock & Marks 2010 study "Leisure College: Decline in Student Study Time:" http://www.aei.org/article/education/higher-education/leisure-college-usa/

[2] Wilhelm von Humboldt (reprint 1970). On the Spirit and the Organisational Framework of Intellectual Institutions in Berlin, *Minerva* VIII: 2 (April 1970), 243f.

[3] Carolyn Ash Merkel. "Undergraduate Research at Six Research Universities – A Pilot Study for the Association of American Universities, May 1, 2001.

[4] Shouping Hu & George D. Kuh & Joy Gaston (2007). "Engaging Undergraduate Students in Research Activities: Are Research Universities Doing a Better Job?" *Innovation in Higher Education*, v32 n3 p167-177 Oct 2007: http://www.eric.ed.gov/ERICWebPortal/detail?accno=EJ784935

[5] Lopatto D. Tucson (2009). "Science in Solution: The Impact of Undergraduate Research on Student Learning," The Research Corporation for Science Advancement

[6] Campbell A, Skoog GD. Transcending deficits and differences through undergraduate research. In: Taraban R, Blanton RL, editors. Creating Effective Undergraduate Research Programs in Science: The Transformation from Student to Scientist. New York: Teachers College Press; 2008. pp. 206–214.

[7] Seymour, E., Barrie-Hunter, A., Laursen, S. L., & Deantoni, T. (2004). "Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First findings from a Three-Year Study. *Science Education*, 88(4) 493-534.

[8] Mark J. Graham, Jennifer Frederick, Angela Byars-Winston, Anne-Barrie Hunter, and Jo Handelsman, "Increasing Persistence of College Students in STEM," *Science*, vol. 341, September 27, 2013: pp. 1455-1456: http://www.sciencemag.org/content/341/6153/1455.short

[9] The SERU Consortium currently consists of 18 major research universities in the US, and beginning in 2011 six international universities located in China, Brazil, Europe, and South Africa. For more information, see the SERU website at: http://cshe.berkeley.edu/research/seru/

[10] Steven Brint, John Aubrey Douglass, Gregg Thomson, and Steve Chatman (2010). *Engaged Learning in a Public University: Trends in the Undergraduate Experience*. SERU Project and Consortium, Center for Studies in Higher Education.

[11] Susan Russell (2006). "Evaluation of NSF support for undergraduate research opportunities: Draft Synthesis Report." Prepared for the Directorate for Education and Human Resources, Division of Research, Evaluation and Communication, SRI International: http://chemsrv1.uwsp.edu/fire/rbadger/URO_2004_ExecSummary.pdf