Are All Undergraduate Research Experiences Created Equal?

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Introduction & Prior Perspectives from the Literature

Participation in undergraduate research has now become a "coin of the realm" among college engagement activities purported to facilitate positive student outcomes. Beginning with a number of studies in the early 1990s, undergraduate research was seen as a way to combine faculty-student interaction and active learning to promote persistence and achievement (e.g., Jonides, von Hippel, Lerner, & Nagda, 1992; Rayman & Brett, 1995; Sax 1994). Moreover, undergraduate research programs became popular in the late 1990s and early 2000s as a way of formally pairing students and faculty with similar interests on research projects. Student participation in such programs has been associated with: a) greater persistence, even after controlling for race/ethnicity and high school grades and test scores; b) pursuit of graduate and professional educational opportunities; and c) stronger self-efficacy in "learning how to think like a scientist" (Banta, 2004; Craney, et al., 2011; Hunter, Laursen, & Seymour, 2006; Lopatto, 2006; Russell, Hancock, & McCullough, 2007).

These early studies have led higher education leaders, researchers, and policymakers alike to promote undergraduate research widely. For example, the Association of American Colleges and Universities (AAC&U) has designated undergraduate research as a "high-impact practice," or a teaching and learning practice that they assert leads to a variety of positive student outcomes, including student engagement and retention (Kuh, 2008). Even more directly, the Boyer Commission on Educating Undergraduates in the Research University (1998) recommended that large research universities reorganize their entire undergraduate curriculum around the notion of a research-as-teaching model, emphasizing learning activities that are

experiential and inquiry-based. Chief among those types of activities, of course, are faculty-student collaborative research projects.

The 1998 Boyer Commission and 2008 AAC&U calls are clearly having an effect on college campuses across the U.S.. Results from the National Study of Student Engagement (NSSE) report that, nationally, 20.3% of undergraduates had performed some type of research by their senior year (Hu, 2012). Similarly, a follow-up study of 91 Research I and II universities (according to 1998 Carnegie classifications) by the Boyer Commission in 2003 noted that most or all undergraduates participated in some form of supervised research at 25.3% of the universities in the sample.

Purpose of the Study

Thus, it would appear that undergraduate research is ubiquitously accepted as an effective educational tool. And, numerous postsecondary institutions are promoting undergraduate research through a number of means. Yet, other than merely counting whether undergraduates are "doing" research, what do campuses know about the empirical processes that students engage with when conducting research? Is *any* kind of research done in *any* kind of fashion beneficial for students? While a growing body of research has documented the relationship between whether engaging in research as a whole is related to certain student outcomes, surprisingly little is known about what students typically are doing when they say they are involved with research.

In order to address this broad question, we conducted an exploratory study to examine if different types of research projects undertaken by undergraduates encompass similar kinds of research processes. In other words, are students equally as likely to progress through the various phases of a research study (e.g., form a research question, conduct a review of research, design

an appropriate methodology, collect and analyze data, form conclusions) no matter what type of research they are conducting—be it for a class project, for a cumulative project like a senior thesis, for an internship/work experience, or for a project they are working on with a professor. Active involvement in all facets of the research process is vital in producing skilled researchers who are able to apply those skills later on in different contexts. Students who conduct research but skip over certain facets of the research process may have subsequent difficulty in their graduate school work, job performance, and overall research self-confidence. Thus, in this study, we explored the following research questions:

1. What are the different ways that undergraduate students can get involved with conducting research?
2. What exactly are undergraduates doing when they say they are conducting research?
3. Are there strengths and limitations to the different ways in which students become involved with research?
4. What types of students are more or less likely to get involved in which types of research projects?

Review of Literature

Undergraduate research can be defined in a variety of ways. For the purposes of this study, we used Stocks et al.'s (2003) definition of undergraduate research as research, scholarly, or artistic activities that lead to the production of original work. Thus, undergraduate research includes a range of educational experiences and can result in output such as a collection of poetry, an agricultural field experiment, or an analysis of archival materials (Kinkead, 2003).

Much of the literature on undergraduate research participation has focused on specific types of educational experiences and outcomes associated with these experiences (Bauer & Bennett, 2003; Campbell & Skoog, 2008; Ishiyama, 2002; Joyce, 2003). Many of these studies focus on educational experiences at a single institution. One such study (Campbell and Skoog, 2004, 2008) examined career and personal development outcomes (e.g., gains in self-confidence, increased motivation to pursue a science career, preparation for graduate school) associated with female students' participation in a biology undergraduate research program. Another (Joyce, 2003) explored outcomes reported by participants in a social science undergraduate research program, and found that students experienced gains in areas such as self-confidence and critical thinking. Indeed, the outcomes reported in these single institution studies have borne out in national studies, as well. Studies show, for example, that alumni of undergraduate research programs are significantly more likely to attend graduate school than peers with similar academic characteristics (Bauer & Bennett; Hathaway, Gregerman & David, 2004). In terms of career development, 68% of participants in science, technology, engineering and mathematics (STEM) undergraduate research programs reported an increased interest in pursuing careers in STEM fields (Russell, Hancock & McCullough, 2007).

National studies that included students from multiple disciplines provide more insight into the relationships between research experiences and outcomes. Analyses of NSSE data showed that students who gained significantly in critical thinking and oral communication skills were more likely to have taken part in particular kinds of research tasks such as contributing to research design, reviewing related research, interpreting findings, and collecting data (Buckley, Korkmaz & Kuh, 2008). In addition, students who analyzed data and interpreted findings were more likely to engage in higher order thinking (NSSE, 2007). Students were also more likely to

engage in integrative thinking if they contributed to study design, reviewed related literature, analyzed data, interpreted findings, wrote up findings, or submitted a paper or product (NSSE, 2007).

Findings from NSSE and other national studies shed light on levels of participation in undergraduate research, as well as disciplinary differences in undergraduate research participation. NSSE data reveals that students at research universities were less likely than students at baccalaureate colleges to collaborate on research projects with faculty members outside of course or program requirements (Kuh et al., 2007; NSSE, 2007). However, studies show that across institution types, students in laboratory sciences and engineering were more likely to participate in undergraduate research than students in business, social sciences, humanities, or the arts (NSSE, 2007; Russell et al., 2007). For example, national survey data shows that participation rates for chemistry (72%) and environmental sciences (74%) were higher than those in fields such as economics (38%) or political science (63%) (Russell et al.). Furthermore, the ways in which students became involved in research varied across disciplines (Buckley et al., 2008). Science students were more likely to pursue opportunities working on faculty members' research teams (Buckley et al.) and also more likely to work on projects that were assigned by mentors (Lopatto, 2006). In contrast, students in the arts and humanities, as well as the social sciences, were more likely to propose a research idea to a faculty member (Buckley et al.) and work alone (Lopatto).

Conceptual Framework

The Buckley et al. and Lopatto studies illustrate that undergraduates may engage in different types of research projects by major or discipline. But what is known about how students

engage with the *process* of research, or the various components of the research process? The only scholarship we found that references different ways in which undergraduates might engage with the process of research concerns a typology of ways in which students and faculty might partner on research projects. Multhaup et al. (2010) proposed three models for such projects: a) the traditional model, in which students worked on a professor's ongoing research project; b) the consultant model, in which students conducted a primarily independent project under a professor's guidance; and c) the joint-creation model, in which the faculty member and student collaborated to begin a new project jointly. In reflecting upon the limitations of each model, the authors noted that, for the traditional model, students may not see the comprehensive nature of research if they are only involved in one portion of the project or may feel like temporary laborers disconnected from the broad goals of the study. For the consultant model, drawbacks may include limited faculty time or expertise, and the likelihood that the research is not of a very sophisticated quality. Finally, the joint-creation model is the most labor intensive and requires the greatest investment of time and energy. For our study, we chose to focus on various forms of the traditional and consultant models, since they are likely the most popular forms of undergraduate research projects conducted on U.S. college campuses.

Methods

Institutional Setting

Data for this study were drawn from a project conducted at a mid-sized public research university in the Mid-Atlantic region that was commissioned by the International Baccalaureate (IB) Organization to study the research experiences of undergraduates and possible influences of the IB curriculum on those experiences. (The IBO sponsors an honors-type academic curriculum

for high school students similar to the Advanced Placement system. The IB curriculum is divided into six subject areas and includes an Extended Essay requirement, for which students must conduct an original research project under the supervision of a teacher of advisor at their high school.) The university from which this study's undergraduate sample is drawn is a Research Extensive university, and typically admits high-achieving traditionally aged students. The undergraduate student body at this institution varies by race/ethnicity (26 percent students of color), international student enrollment (over 130 foreign countries represented), and socioeconomic status (nearly 10 percent of students received full-grant packages from the institution for financial aid). The institution is highly competitive: approximately 33 percent of applicants are admitted each year, 94 percent of first-year students were ranked in the top 10 percent of their high school class, and the six-year graduation rate is 94 percent. One unique characteristic of the undergraduate enrollment is that it matriculates the highest proportion of IB alumni of all U.S. four-year postsecondary institutions.

Sample

The sample population for this study included all of the IB alumni currently enrolled at the institution from the entering classes of 2008, 2009, 2010, and 2011 (n=1,045), as well as a comparison sample of Advanced Placement (AP) alumni at the same institution (n=1,046) for a total of 2,091 students. The AP comparison sample was created through random selection of all students at the institution who had transferred in at least one AP credit. While the sample in this study is not wholly representative of the undergraduate enrollment of the institution, it does represent an interesting group to study, in that one might expect that the undergraduates most likely to be involved with undergraduate research would be those who were high achievers in

high school, much like those who participated in accelerated high school curricula such as IB or AP.

Instrumentation

A survey instrument was created for the IB study, and consisted of 29 questions in four sections: a) background information; b) high school research experiences with the IB Extended Essay; c) college research experiences in a variety of contexts; and d) writing, mentorship, and resource usage in relation to research projects. Background information collected included socioeconomic status, perceptions of prior academic preparation, and educational, major, and career aspirations. College research experiences queried included research conducted as part of a class, as part of a cumulative project such as a senior thesis, in conjunction with a job or internship, as part of a professor's ongoing research, and as an independent endeavor. Activities undertaken as part of the research process were operationalized using a conceptual framework developed by Stokking, van der Schaaf, Jaspers, and Erken (2004):

1. Identify and formulate a problem using subject-specific concepts;
2. Formulate the research question(s), hypotheses and expectations (if any);
3. Make and monitor the research plan: research design and time schedule;
4. Gather and select information/data;
5. Assess the value and utility of the data;
6. Analyze the data;
7. Draw conclusions;
8. Evaluate the research;
9. Develop and substantiate a personal point of view;
10. Report (describe) and present (communicate) the research

Stokking et al. asserted that the above framework was applicable for empirical research universally (i.e., across all disciplines), and tested the applicability of the framework in the following subject areas: physics, biology, history, geography, economics, Dutch, and mathematics. For this study, we were primarily interested in learning how well students completed all of the above tasks when performing research in a variety of contexts (research

conducted for a class assignment, research undertaken as part of a professor's project, research performed as part of a thesis, etc.).

An earlier draft of the survey instrument was pilot tested for face validity by conducting cognitive interviews with several undergraduate students (n=5) in late January 2012. We used anticipated and emergent probing techniques during the cognitive interviews. Anticipated probes are predetermined based on anticipated problems with survey items, and emergent probes are flexible and unscripted, based on participants' responses to survey items (e.g., hesitation, facial expressions, see Beaty & Willis, 2007). Their feedback and suggestions for revision were incorporated, and the final version of the questionnaire was completed in mid-February 2012.

Data Collection

The final version of the survey instrument was converted to electronic form via Question Pro and was administered to the selected IB and AP alumni samples (n=2,091) from late February to mid-March 2012 via an Internet survey. Participants were sent an invitation email containing a link to the electronic version of the survey and initial non-respondents were sent up to three follow-up emails requesting their participation. Incentives to participate included the opportunity to win one of the following: one of two iPads or one of eight $25 gift cards. Institutional records for both the IB and AP alumni sample were drawn from the university's institutional research office and merged with the survey data.

Variables in the Study and Data Analyses

A list of all of the variables utilized in the study can be found in Table 1.

Table 1: Variables utilized in the study

Types of research projects respondents conducted while in college, including:
a. For a class assignment
b. For a cumulative project like a thesis
c. For a job/internship
d. For a professor's project
e. For an independent study, and
f. Other.

Respondents' self-reports concerning various facets of the research process they conducted in conjunction with the above types of projects, including the following 12 steps:
a. Identifying the research problem
b. Formulating a precise research question
c. Gathering and interpreting material from sources appropriate to the research question
d. Structuring a reasoned argument in response to the research question
e. Analyzing and synthesizing current knowledge on the topic
f. Making and monitoring a research plan (design and time schedule)
g. Gathering and selecting information/data
h. Assessing the value and utility of data
i. Analyzing the data
j. Drawing conclusions
k. Creating a reference list
l. Citing other literature using standard convention (MLA, APA, etc.).

Respondents' background characteristics, including:
a. Gender
b. Race/ethnicity
c. Socio-economic status (combination of parents' educational attainment and household income)
d. Pell eligibility
e. SAT verbal and mathematics scores
f. High school GPA
g. Total AP or IB credits accepted by the institution
h. Major (split into six Holland codes)
i. Degree aspirations.

The data analyses included chi-square distributions to address the three first three, largely descriptive, research questions. For the final research question, we conducted logistic regression analyses to assess undergraduates' background characteristics and their likelihood to engage in different types of research projects (e.g., for a class, for a professor's research, etc.). The model

contained the following independent variables: gender (female); race/ethnicity (dummy coded); socioeconomic status; Pell grant eligibility; SAT scores; high school grade point average; major (by Holland type); and educational aspirations (dummy coded). The dependent variables, run as separate models, were: conducted research as part of a class; conducted research as a cumulative project or thesis; conducted research as an independent project; conducted research as a job/internship requirement; and conducted research as part of a professor's ongoing project. Chi-square analyses were utilized to assess the full model's ability to distinguish between respondents who did or did not pursue each type of research project (the dependent variables).

Results

A total of 1,008 undergraduates responded to the survey, for a 48.0% response rate. The obtained sample was majority female, White/Caucasian, from an advantaged socioeconomic background, and had very strong high school GPAs and SAT scores (see Table 2). The demographic makeup of the sample is no doubt influenced by the type of students who hailed from high schools offering either an IB or AP curriculum and who gained admission to this institution, but given the competitiveness of the institution in this study, this sample is not wholly distinct from the undergraduate population at-large. Indeed, while the sample in this study is slightly overrepresented by women, the racial/ethnic diversity is nearly the same as the entire undergraduate population at this institution. Moreover, the SAT Verbal and Mathematics scores of the students in this study are virtually identical to the undergraduate population at-large.[1]

[1] All information taken from the institution's fact book; however, in order to shield its identity, the name of the institution is not provided.

Table 2: Characteristics of the obtained sample

Gender (%)	
Female	65.6
Male	34.4
Race/ethnicity (%)	
White/Caucasian	59.2
Black/African American	4.1
Asian Pacific American	17.2
Hispanic/Latino	3.9
Native American	0.0
Multi-racial or ethnic	2.7
Non-resident alien	6.3
Unknown	6.6
Total household income (%)	
Less than $25K	2.1
$25-50K	6.7
$50-75K	7.7
$75-100K	13.0
$100-150K	20.1
More than 150K	30.8
Don't know	19.6
Average SAT scores	
Verbal	670.0
Mathematics	684.0
Writing	674.0
Average HS GPA	4.2
Major (via Holland code) (%)	
Realistic (e.g., engineering, environmental science)	18.1
Investigative (e.g., physical sciences, mathematics)	14.2
Artistic (e.g., English, foreign language, philosophy)	13.9
Social (e.g., education, human services)	31.3
Enterprising (e.g., business, communication, law)	14.9
Undecided	9.3

Educational aspirations (%)	
Attend college	0.9
Complete bachelor's degree	14.6
Complete master's degree	41.7
Complete professional degree or PhD	36.4
Don't know	6.4

Respondents' majors were spread across five of six of the Holland codes: 18.1% had majors classified under the "Realistic" code (e.g., engineering or environmental science); 14.2% had "Investigative" majors (e.g., physical sciences or mathematics); 13.9% had "Artistic" majors (e.g., English, foreign language, philosophy); 31.3% had "Social" majors (e.g., education, human services); 14.9% had "Enterprising" majors (e.g., business, communication, law); and 9.3% were undecided. Finally, again as one might guess, the sample had very high degree aspirations: 14.6% expected to finish a bachelor's degree, while 41.7% and 36.4% aspired to at least a master's or professional/doctoral degree, respectively.

The results of our study show that 69.2% of our sample conducted research of any kind while undergraduates (see Table 3). While this proportion is manifestly higher than the national average, this may be because we chose to include several different mechanisms through which students might engage with research. Indeed, further analyses show that 58.3% indicated that the research project they conducted was for a class assignment, while only 11.4% completed a cumulative research project such as a thesis, 12.0% conducted research as part of a job or internship requirement, 8.2% worked on a professor's ongoing research project, and 8.6% conducted an independent study. Students could select all applicable ways they were involved in research as undergraduates.

Table 3: Percentages of sample who conducted various types of research

Percentage conducting research…	
…of any kind	69.2
…for a class assignment	58.3
…for a cumulative research project or thesis	11.4
…for a job or internship requirement	12.0
…for a professor's ongoing research project	8.2
…for an independent project	8.6

When we examined what specific research processes students undertook when conducting their research projects, we found that the different mechanisms through which undergraduates engage with research might profoundly affect their level of exposure to or experience with different components of the research process. For example, students conducting a research project for a class assignment nearly unanimously indicated that they performed all 12 facets of the research process. (See Table 1 for a list of the 12 facets.) Similarly, nearly all students producing a thesis or another type of cumulative project indicated that they performed all 12 steps. Yet, the profile for students working with professors on ongoing research projects was markedly different than the other types of projects: only 61.1% of students working on a professor's research reported ever formulating a precise research question; only 69.9% reported ever identifying the research problem to study or structuring a reasoned argument in response to the research question; and only 71.2% reported drawing conclusions about the data collected for the study. Conversely, the two steps students who worked on a professor's research project reported doing most frequently were gathering literature (87.5%) and performing data collection (97.3%). Thus, roughly 30-40% of students working on a professor's ongoing research project are not gaining exposure to several critical steps in the research process.

Table 4: Types of activities performed by type of research project (% "yes")

	For a class assignment	For a thesis	For a job or internship	For a professor's research	For an independent project
Identifying the research problem	97.9	99.1	89.1	69.9	94.8
Formulating a research question	96.4	99.0	81.8	61.1	90.8
Gathering and interpreting material from sources appropriate to the research	99.4	100.0	96.3	87.5	100.0
Structuring a reasoned argument in response to the research question	98.7	100.0	84.6	69.9	92.2
Analyzing and synthesizing current knowledge on the topic	98.7	99.1	91.8	83.6	98.7
Making and monitoring a research plan	86.9	96.2	82.4	82.2	92.2
Gathering and selecting information/data	97.4	98.1	97.3	97.3	92.2
Assessing the value and utility of data	95.9	99.1	92.5	86.3	89.5
Analyzing the data	96.8	99.0	93.6	84.9	90.7
Drawing conclusions	98.3	99.1	93.6	71.2	89.5
Creating a reference list	94.0	99.1	70.0	64.4	80.5
Citing other literature using standard convention (MLA, APA, etc.)	97.4	98.1	58.7	60.3	75.3

Given that our findings showed that students participating in different types of research projects tended to have different exposure to or experiences with the various facets of the research process, we investigated whether there may be distinct patterns regarding which types of students were more or less likely to participate in certain types of research projects. The logistic regression analyses revealed that the variables in the model were able to distinguish between respondents who did or did not a) conduct a research project for a class assignment (χ^2 (22, N=768)=64.12); b) produce a thesis or other cumulative research project (χ^2 (21, N=714)=47.62); or c) work on a professor's ongoing research project (χ^2 (22, N=755)=51.99).

Asian American students were 53% less likely (reference group: White students) and undergraduates aspiring to complete a professional degree were 48% less likely (reference group: complete a BA) to participate in a class research project assignment (see Table 5). On the other hand, undergraduates with Artistic and Social majors were 110% and 160% more likely, respectively, to complete a research project for a class assignment (reference group: undecided major). Meanwhile, undergraduates with Artistic, Realistic, and Enterprising majors all exhibited strong odds-ratios with being likely to conduct a senior thesis or other cumulative research project (odds-ratios=10.56, 10.20, 9.76, respectively; see Table 6). Finally, while Asian American students (odds-ratio=0.49) and students aspiring to a professional or doctoral degree (odds-ratio=0.52) were less likely to participate in a professor's ongoing research project, Realistic, Investigative, Artistic, and Social majors (odds-ratios=2.04, 2.21, 2.02, and 3.14, respectively; see Table 7) were all more likely to work with a professor on his or her research. (All odds-ratios reported were $p \leq .05$; see Table 7).

The logistic analyses involving majors (coded as Holland types) revealed some interesting non-significant findings as well. Because the referent category for academic majors was "undecided," and the overwhelming majority of undecided students in our study were first or second year students, it is not particularly surprising if students who had declared a major (i.e., one of the other Holland types) were more likely to participate in some type of research given that they were typically third or fourth year students and had identified a focus of study. However, Realistic, Investigative, and Enterprising majors were not significantly more likely than undecided students to participate in a research assignment for a class. Similarly, Investigative and Social majors were not more likely than undecided students to work on a

cumulative research project or thesis, and Enterprising majors were not more likely than undecided students to participate in a professor's ongoing research project.

Table 5: Results for logistic regression: Predictors of student participation in a classroom research project

Independent Variable	*Odds Ratio*	*(SE)*	*z-value*
Female	0.91	(0.16)	-0.51
Race			
Black	1.73	(0.79)	1.19
Asian	0.47	(0.10)	-3.52***
Hispanic	2.13	(0.87)	1.85
Multiracial	1.31	(0.64)	0.54
Unknown	0.89	(0.28)	-0.36
Socioeconomic Status	1.01	(0.02)	0.41
Pell Eligible	0.89	(0.27)	-0.39
SAT Verbal	1.00	(0.00)	-1.15
SAT Math	1.00	(0.00)	-0.67
High School GPA	1.16	(0.31)	0.55
Total Test Credit Received	1.00	(0.01)	0.32
Holland Codes			
Realistic	1.60	(0.53)	1.42
Investigative	1.26	(0.43)	0.68
Artistic	2.10	(0.70)	2.21*
Social	2.60	(0.78)	3.17**
Enterprising	1.32	(0.48)	0.76
Uncategorized	3.46	(2.24)	1.92
Expected Educational Attainment			
Some College	0.76	(0.68)	-0.31
Master's Degree	0.72	(0.18)	-1.36
Professional or Doctoral Degree	0.52	(0.13)	-2.53*
Don't Know	0.36	(0.13)	-2.84**
Number of Observations	768		
Pseudo R-Squared	0.0626		
F-statistic (likelihood ratio)	64.12***		

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

Table 6: Results for logistic regression: Predictors of student participation in a thesis or other cumulative research project

Independent Variable	*Odds Ratio*	*(SE)*	*z-value*
Female	0.93	(0.25)	-0.26
Race			
Black	1.82	(1.02)	1.07
Asian	1.11	(0.38)	0.30
Hispanic	0.79	(0.46)	-0.40
Multiracial	0.42	(0.45)	-0.82
Unknown	2.10	(0.81)	1.91
Socioeconomic Status	0.99	(0.04)	-0.17
Pell Eligible	0.79	(0.39)	-0.48
SAT Verbal	1.00	(0.00)	-0.24
SAT Math	1.00	(0.00)	0.41
High School GPA	0.34	(0.14)	-2.56**
Total Test Credit Received	1.01	(0.01)	1.20
Holland Codes			
Realistic	10.20	(10.78)	2.20*
Investigative	2.19	(2.49)	0.69
Artistic	10.56	(11.22)	2.22*
Social	5.09	(5.33)	1.55
Enterprising	9.76	(10.53)	2.11*
Uncategorized	17.40	(20.78)	2.39*
Expected Educational Attainment			
Some College	3.79	(3.64)	1.39
Master's Degree	1.36	(0.50)	0.85
Professional or Doctoral Degree	1.61	(0.63)	1.23
Don't Know	(omitted)		
Number of Observations	714		
Pseudo R-Squared	0.0880		
F-statistic (likelihood ratio)	47.62***		

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

Table 7: Results for logistic regression: Predictors of student participation in a professor's ongoing research project

Independent Variable	*Odds Ratio*	*(SE)*	*z-value*
Female	0.85	(0.16)	-0.83
Race			
Black	1.46	(0.70)	0.78
Asian	0.49	(0.11)	-3.23***
Hispanic	1.48	(0.61)	0.96
Multiracial	0.99	(0.51)	-0.02
Unknown	1.04	(0.36)	0.12
Socioeconomic Status	1.01	(0.03)	0.22
Pell Eligible	0.72	(0.23)	-1.03
SAT Verbal	1.00	(0.00)	-0.99
SAT Math	1.00	(0.00)	-0.61
High School GPA	1.06	(0.31)	0.20
Total Test Credit Received	1.01	(0.01)	0.89
Holland Codes			
Realistic	2.04	(0.69)	2.10*
Investigative	2.21	(0.77)	2.25*
Artistic	2.02	(0.69)	2.08*
Social	3.14	(0.97)	3.71***
Enterprising	1.56	(0.59)	1.19
Uncategorized	2.85	(1.84)	1.62
Expected Educational Attainment			
Some College	0.52	(0.47)	-0.73
Master's Degree	0.62	(0.81)	-1.74
Professional or Doctoral Degree	0.56	(0.42)	-2.04*
Don't Know	0.30	(0.001)	-3.22***
Number of Observations	755		
Pseudo R-Squared	0.0563		
F-statistic (likelihood ratio)	51.99***		

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

Discussion

Limitations

Clearly, this study relies heavily on student self-reports and was conducted at a single institution with a unique sample: the participants in this study attended a highly competitive university and were themselves from a high social capital and academically achieving

background (although one might argue that this is precisely the type of student who would choose to conduct research at the undergraduate level). Nevertheless, replication of the findings with a national sample of undergraduates, and preferably including a data collection strategy that incorporates observational data as well as faculty input, is needed. Moreover, it may be beneficial to conduct a qualitative study of students and their research experiences that uses interviews with follow-up probes in order to ascertain whether undergraduates can accurately identify and differentiate the various phases of the research process.

Summary and Discussion

It would appear that not all research experiences are inherently equal: students participating in a professor's ongoing research project may not be exposed to or gain experience in some critical elements of the research process, such as formulating a research question or drawing conclusions from the data. Instead, their experiences may be somewhat disjointed—perhaps only gathering materials for a literature review or collecting data—thus offering these students an incomplete snapshot of the research process, which is consistent with observations made about the traditional model by Multhaup et al. (2010).

After learning that students participating in different types of research projects have disparate experiences, we investigated which types of students were more or less likely to participate in certain types of research projects. The results of the logistic regression analyses showed that students majoring in different subject areas (with undecided majors serving as the referent category) were not equally as likely to engage in different types of research: students with Artistic majors (e.g., English, foreign language, philosophy) or Social majors (e.g., education, human services) were more likely to conduct research as part of a class assignment. Meanwhile, Artistic, Enterprising (e.g., business, communication, law), and Realistic (e.g.,

engineering, environmental science) majors were more likely to conduct a cumulative research project or thesis. Finally, students in almost all of the major categories—Artistic, Realistic, Social, and Investigative (e.g., physical sciences, mathematics)—were more likely to perform research as part of a professor's ongoing research.

Given the strong emphasis that the institution in this study places on working on a faculty member's research project, it is perhaps not that surprising that students from various majors were more likely to join a professor's research team. It is somewhat surprising, though, that Enterprising majors were not more likely to work on a professor's research project. One might speculate that Enterprising students are generally more inclined to continue their education at a professional school (e.g., business school, law school) and not go on for a doctorate, and thus students in Enterprising majors found it less strategically advantageous to work on a professor's research team than those students whose graduate school plans included doctoral studies in more purely academic (i.e., not professional) fields. It is also curious that students in Investigative and Social majors were not more likely to engage in research for a cumulative project or thesis, while students in Realistic, Artistic, and Enterprising majors were more likely to do so. Perhaps the requirements for the latter three types of majors include a senior thesis or capstone, while the requirements for Social or Investigative majors do not.

Indeed, it is important to consider the quality of the research experiences for Investigative majors. The results of the logistic regression analyses indicate that they are only more likely to conduct research as part of a professor's ongoing research project and not any other type of research. Given that prior analyses in our study have shown that 30-40% of undergraduates who work on a professor's research team may not become involved with several critical steps in the research process such as formulating a research question or drawing conclusions from the data, it

is troublesome to know that Investigative majors may be having incomplete research experiences that may not be supplemented through other means. This becomes especially important when considering that a high percentage of Investigative majors in our study (66.9%) planned on pursuing professional or doctoral study, where a complete set of research skills will become extremely important.

Similarly, there were other student characteristics that were associated with a decreased likelihood of conducting some type of research at the undergraduate level. For example, Asian American students were less likely to become engaged with a class research project assignment or ongoing research with a professor. Likewise, and somewhat surprisingly, students aspiring to a professional or doctoral degree were also significantly less likely to work on a class research assignment or professor's research project. Ancillary cross-tabulation analyses revealed that Asian American students were severely underrepresented among Artistic majors, and Artistic majors were somewhat underrepresented among those who aspired to a professional or doctoral degree. Moreover, Artistic majors were more likely to pursue research through class assignments, cumulative projects or theses, or professors' research studies. Thus, the above negative relationships among Asian Americans and aspiring professional/doctoral degree seekers may be partially explained as a function of their chosen majors.

Implications for Future Policy and Practice

We see the above negative relationships, as well as the absence of a relationship between Investigative majors and participation in research projects other than those with a professor, to be missed opportunities. For Asian American students and students who aspire to complete a doctoral education (or for Asian American students with doctoral education aspirations, of which there are many in this study), the institution can emphasize why conducting research is a useful

skill that would be advantageous to undertake at the undergraduate level. After all, the very institution at which this study was conducted includes participation in undergraduate research as one of its central opportunities for student learning in its accreditation requirements. For those undergraduates in Investigative majors, the curricula in these students' disciplines might consider adding more opportunities to conduct research—for example, as a formal class assignment or as a cumulative project or thesis.

Although the predominance of the empirical and scholarly literature strongly promotes working on a professor's research project as a high-impact endeavor (Banta, 2004; Craney, et al., 2011; Hunter, Laursen, & Seymour, 2006; Lopatto, 2006; Russell, Hancock, & McCullough, 2007), our study preliminarily shows that this type of research experience may not be the most optimal—at least in terms of learning about the entire research process or becoming socialized as a scientist. Thus, students in Investigative majors should supplement their research experiences to include more than exclusively working with a professor. Again, this is a particularly important consideration because students in these majors—such as biology, chemistry, physics, etc.—may opt to pursue a graduate education or professional work setting that requires a comprehensive research skill set and not a partial one.

On the other hand, a different approach to addressing the incomplete nature of undergraduates' exposure to the research process when working on professors' ongoing projects might be to require that students take a research methods and design course *before* they work on a professor's research project. For some majors, such a research methods course is already required. However, timing students' enrollment in the course prior to their exposure to a professor's research project may not only help make students more aware of the entire process of research and where their contributions to the professor's project might fit into that process, but it

may also enhance students' research skills and capabilities and thereby make them more competent to fulfill more roles on a professor's research team.

A third approach might be to offer training opportunities to faculty members, to aid them both in helping them more effectively involve undergraduates in all facets of the research process, and in helping undergraduates see how their involvement in the research process contributes to the larger research "picture." Faculty may be motivated to be more inclusive and comprehensive regarding their research when they consider that today's undergraduates are tomorrow's graduate students and, ultimately, the next generation of scholars in their fields. Doing so might be a step toward making this type of undergraduate research a more comprehensive learning opportunity for students. Furthermore, the National Science Foundation and the National Institutes of Health have both incentivized the inclusion of undergraduates in their requests for proposals, so an undergraduate research experience—as long as it is comprehensive and inclusive—can be beneficial for some faculty as well.

Implications for Future Research

As was mentioned previously, this study was exploratory in nature and utilized a unique sample. Thus, this study's findings should be treated as preliminary, and additional investigations are warranted. In those future investigations, we encourage future researchers to delve more deeply into students' epistemological beliefs about the nature of research and how research is conducted. This study relied heavily upon students' self-reports of their research activities, but students' perceptions of their research experiences are shaped largely by their fundamental understanding of what they believe research is and does. Second, this study should be expanded to include students beyond those who participated in the International Baccalaureate or Advanced Placement programs. It is important to learn if undergraduate research is the

exclusive domain of high-achieving students, or if participation is more broadly distributed across ability levels. Moreover, if participation in undergraduate research is found to improve the outcomes of lower achieving students, then such findings might inspire more intentional outreach on the part of postsecondary institutions to bring lower achieving students into the research "pipeline."

Finally, this study revealed differential patterns of involvement in research endeavors, with some groups of students (e.g., Asian Americans, students with stronger high school GPAs, students aspiring to professional or doctoral degrees) being less likely to participate in certain research projects, and some groups of students (e.g., Artistic majors) being more likely to participate in a broad range of research endeavors. If these patterns of engagement are consistently uncovered in future empirical studies, it will become important to examine the real and perceived supports and barriers to research participation among these groups. At the very least, though, the results from this initial study may imply that one of the high-impact "coins of the realm" should be revisited or further investigated.

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