A Case Study of Evaluating Undergraduate Research Courses as High-Impact Practices Fostering Student Learning Outcomes

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Introduction

Student engagement in High-Impact Practices (HIPs) has been gaining the attention of higher education leaders and educational researchers. The practices are meaningful for achieving the pivotal role of higher education institutions' involving students in active academic and co-curricular endeavors. Institutions offer a variety of effective and purposeful programs and encourage college students to be more engaged in and integrated into campus activities. By participating in these activities, students can advance toward successful graduation in a timely manner. As such, we can restore America to its position as a world leader in college degree attainment, which has been a national priority of the White House (2010).

HIPs, as described by Kuh (2008), include: (a) first-year seminars and experiences; (b) common intellectual experiences; (c) learning communities; (d) writing-intensive courses; (e) collaborative assignments and projects; (f) undergraduate research; (g) diversity/global learning; (h) service learning, community-based learning; (i) internships; and (j) capstone courses and projects. The center of those practices is active student engagement, with the goal of successful learning outcomes (Kuh et al., 2006). Educational researchers have been exploring the factors that affect student retention and success and have provided theoretical foundations for college student behavior that leads to successful graduation. Tinto's (1987, 1993) integration model posits that academic and social integration are key to increasing retention. Students' persistence increases when there is the interaction of student commitment and an institutional environment that encourages them to be engaged in and integrated into academic and social activities. It is an educational practitioner's role to provide a positive campus environment and effective programs so that students become involved in academically and socially integrated activities, while Tinto explains the aspects and theories in terms of student retention and departure of institutions. In this regard, the HIPs practices suggested by Kuh make a functional connection between retention theory and educational practices in higher education institutions.

According to Kuh (2008), freshman seminars and learning community are a good choice for new students. The efficacy of freshman programs has been investigated by researchers (Clark & Cundiff, 2011; Moon et al., 2013), and findings have indicated that first-year students who participate in a freshman program are more likely to return for a second year and to successfully graduate. While freshman programs are good for increasing new entrants' persistence and successful graduation to maximize college impact, undergraduate research can be one of the HIPs in which juniors or seniors can participate in their major field before graduation. A student's conducting research in his or her major and developing a reflective understanding of his or her own field is an effective means to provide the undergraduate student with deep learning and engagement in research activities that are closely connected to those of faculty and advanced peers, including graduate students.

Undergraduate research experience encourages participants to aspire to enroll in graduate programs (Eagan et al., 2013). Student motivation and aspiration is encouraged by interaction with high-achieving peers and faculty in research programs (Carter, 2001), and research participants can accelerate their progress toward bachelor's degree attainment and graduate or professional programs. Educational

aspiration directs the students to search for and to enroll in graduate programs (Nevill & Chen, 2007). In a study that concerned the prediction of graduate program enrollment, Heller (2001) found that students' high degree expectations are positively related to high enrollment in advanced degree programs. As such, students who have experienced undergraduate research are more likely to pursue advanced degree programs than are those who have not (Slovacek, Whittinghill, Flenoury, & Wiseman, 2012). Institution-wide efforts to provide structured programs that encourage undergraduate students, particularly under-represented students, to participate in research can be an effective strategy to also encourage students to have a career in research career (Huartado, Eagan, Cabrera, Lin, Park, & Lopez, 2008).

Related to the motivational benefits of research participation, Vygotsky's (1978) notion of the zone of proximal development provides an understanding of interaction with advanced peers from a cognitive perspective and incorporates the notion that academic performance may be enhanced when students work in collaboration with more capable peers. Research participants continuously interact with faculty and graduate students, who make connections and share professional knowledge. Weidman's (1989) socialization theory posits that, once students enter college, they become socialized to a particular environment and are affected by the social norms of the college culture. They may associate themselves with their normative peers but also want to pursue the accomplishments of high-achieving peers in research programs. The benefits of research participation also can be understood by Lave and Wenger's (1991) communities of practice. They believe that a group of people who share a common interest or topic are more likely to learn and do better in that specific interest through the process of interaction. Research participants often have a shared topic and can collaborate as a team. In this way, student identities are formed through the social learning process of conducting research activities.

California State University, Fullerton, is a large, four-year public institution with over 38,000 students, of whom 37% of the undergraduate students are Hispanic. The institution has been serving a substantial number of Hispanic students as a Hispanic-Serving Institution (HSI) for past decade. Freshman learning communities and collaborative instructional settings are HIPs that the institution uses to maximize college impact and to produce constructive student change and have been found to be effective (Moon et al., 2013). The policy and practices that shape an institutional environment of active student engagement are culturally responsive practices that generate positive learning outcomes for all students and narrow the achievement gaps for underrepresented students. The underrepresented students gain more benefits from the collaborative group setting than do other students. Because over one-third of research participants in the College of Health and Human Development (HHD) are Hispanic students, it is important to provide educational programs that are consistent with their collaboratively disposed culture. Research has consistently indicated that most underrepresented students come from a collectivistic culture that values the needs of groups or family instead of those of individuals (Cabrera et al., 2002; LeMonda, 2008).

In the present study, we investigated the impact of an undergraduate research program, as one of the HIPs, on student learning outcomes. We sought to identify whether the research experience guides the students to graduate in timely manner and achieve a higher graduation GPA as a result of participation in research activities. Because transcripts are the most credible source of student data, as they do not "lie, forget, or exaggerate" (Adelman, 1999), we kept track of transcripts of research participants and non-participants to obtain their graduation timeline and graduation GPA. Additionally, post-baccalaureate enrollment was examined to determine whether research participation encourages students to pursue further study in graduate programs. We conducted a data extraction process through the National Student Clearing House to determine graduate program enrollment after students

participated in a research program and attained a bachelor's degree. Most research participants were juniors or seniors, and their background characteristics varied in terms of total units earned or college GPA since they entered college. To establish the comparable control group of non-participants in this quasi-experimental study, we utilized propensity score matching.

Purpose of the Study

The present study explores the effects of undergraduate research courses as one of the HIPs to maximize college impact and to have an influence on student learning outcomes. Because the undergraduate research participants have varied backgrounds, we also were interested in comparing those participants with non-participants who have similar characteristics at the beginning of the course. To investigate the value of undergraduate research, we kept track of the length of degree completion after a student took the research course, college GPA at the time of graduation, and his or her subsequent enrollment in a graduate degree program.

1. Does the *PSM* (*Propensity Score Matching*) method create a reliably matched sample in a non-randomized study to enable an examination of the effects of undergraduate research?
2. Do *UGRs* (*Undergraduate Research Courses*), as an effective high-impact practice, have a positive influence on students' timely graduation?
3. Do *UGRs* (*Undergraduate Research Courses*), as an effective high-impact practice, have a positive influence students' graduation GPA?
4. Do *UGRs* (*Undergraduate Research Courses*), as an effective high-impact practice, advance students' graduate program placement?

Research Design & Methods

Data Source and Sample

The data were drawn from students who have taken undergraduate research courses in HHD between fall 2000 and fall 2011. Any research course takers in spring, summer, or fall semester for 11 years were drawn from the institutional data base and included in the data sample as participants. A total of 739 students participated in undergraduate research courses in HHD between 2000 and 2011. Student enrollment data for a total of 37 terms were employed to extract course taking, demographics, student major, and background characteristics. Because we had student degree and graduation data up to summer 2013, we included those students who graduated in two years after taking research courses. Approximately 90% of students attained a bachelor's degree in two years after participating in undergraduate research.

All of the students who did not participate in undergraduate research in HHD were considered the original comparison group. Non-participants were initially defined as all of the students who did not take undergraduate research courses in HHD but had enrolled in any other courses between fall 2000 and fall 2011. We had over 200,000 enrollment records of students who did not take HHD research courses but took any other courses. The initial comparison group of over 200,000 has been reduced to a matched sample of 739 using propensity scores, yielding students who had similar characteristics at the time of participants' research course enrollment.

The undergraduate research courses in HHD are taken by students who have already completed a minimum of 15 units of upper-division courses in their major field and who are of junior or senior standing. The research topic and study plan are prepared in cooperation with a faculty mentor, and the research culminates in a paper or project, with comprehensive performance. For example, some students who are enrolled in Health Science 499 and would like to participate in research activities work in teams on a physical activity intervention program at a community center in collaboration with the institution's Center for Healthy Lifestyle and Obesity Prevention. The research participants conduct intervention program classes, enroll subjects, administer/collect the survey questionnaire, and analyze the data. A series of research steps are advised by a faculty supervisor, and students are likely to work in teams on common intellectual interests or research topics.

Measures

Step 1. Propensity Score Matching (PSM)

Covariate Measures for PSM

The present study is a quasi-experimental design that does not use random assignment of participation in undergraduate research courses. Non-randomized groups include participants and non-participants who are dissimilar to each other based on a variety of covariates (Rosenbaum & Rubin, 1983a). To equate participant and non-participant groups, we employed the PSM method using logistic regression. The dependent measure for the logistic regression was participation versus non-participation in HHD undergraduate research. For this dichotomous measure, participants were coded as 1, while non-participants were coded as 0. We focused on the effects of research courses on student learning outcomes, and the dichotomous variable was chosen as dependent measure of major interest, indicating participation (or not) in the research activities.

To predict the likelihood of a student's research course taking, we selected covariates that could be related to the student's choice of research courses and estimated propensity scores for extracting a similar paired sample of non-participants. As such, the following variables were included in the analysis as covariates: student Pre-college GPA, Campus GPA, SAT score, Eligibility Index, Ethnicity, Total Units Earned at the term of taking research courses, Units Attempted at that term, Full-Time/Part-Time status, Entering Characteristics (as a First-Time Freshmen, or Transfer), Parent Education Level, Low Income Status, Major, College of Major, and Local Area Status, indicating whether a student is from the local area or from out of the area. Most students in undergraduate research courses are juniors or seniors who persisted at least two to three years since they started college, and we assume that the research participants are more likely to be successful in terms of getting close to graduation than are those who dropped out of college. Thus, some covariates were selected based on previous research and other relevant literature (Abraham et al., 2012; Moon et al., 2010, 2013), including factors related to student college success, such as student previous GPA, ethnicity, and parent education.

Some covariates were converted to binary variables using dummy coding, such as ethnicity and major. Matriculation term, enrollment term, and major were included, when using dummy coding, to find matched non-participants who had the most similar characteristics to the group who participated in undergraduate research. Any variables that could influence group membership were selected as covariates for statistical estimation to identify the binary measure of research participation or non-participation. In particular, enrollment term was selected as a covariate to establish the association

between the enrollment terms of research participants and those of non-participants as a means to keep track of longitudinal data for 11 years (Table 1).

Table 1. Variables for Logistic Regression to Obtain Propensity Score

Variable	Value of Variable
Dependent Variable	
Participation in HHD Research Courses during the college year	1: participants, 0: non-participants
Independent Variables	
Previous GPA (high school GPA or transfer GPA)	0 through 5
Campus GPA	0 through 4
EI (Eligibility Index)	440 through 5350
SAT Total (Verbal & Math)	430 through 1600
Units (Units attempted in a given term)	
Tot Units Earned (Total units earned in college)	
Sex	1: Female, 2: Male
Ethnicity	
AmInd	1: Yes, 0: No
Hisp	1: Yes, 0: No
Asian	1: Yes, 0: No
Black	1: Yes, 0: No
White	1: Yes, 0: No
Unknown	1: Yes, 0: No
Non-Res Int'l	1: Yes, 0: No
FTPT (Full-Time or Part-Time enrollment in a given term)	1: Full-Time, 2: Part-Time
Low Income	1: Low Income, 0: Not Low Income
Total Pell Grant Amount	0 through 36146
1st Generation (Parent Education Level)	1: No College, 2: Some College, 3: College Graduated
Local Area (came from local area)	1: Local Area, 0: Out of Area
Entering Characteristics	
As First-Time Freshman	1: as First-Time Frosh, 0: no
As Upper Division Transfers	1: as UDT transfer, 0: no
As Lower Division Transfers	1: as LDT transfer, 0: no
As 2nd BA	1: as 2nd BA, 0: no
College of Major	
College of Arts	1: Yes, 0: No
Mihaylo College of Business & Econ	1: Yes, 0: No
College of Communications	1: Yes, 0: No
College of Engineering & Computer Sci	1: Yes, 0: No
College of Health & Human Develop	1: Yes, 0: No
College of Humanities & Social Sci	1: Yes, 0: No
College of Natural Science & Math	1: Yes, 0: No
Major (HHD Research participants were from 35 different majors, and dummy coding was used for each major)	1: Yes, 0: No
Year Term (Study included longitudinal data for 34 terms from fall 2002 and fall 2011, and dummy coding was used for each year term)	1: Yes, 0: No
Matriculation Year Term (Matriculation year term for a total of 34 terms used dummy coding)	1: Yes, 0: No

Step 2. Measures for Post-Matching Analysis

Independent Measures

Once the PSM analysis was done, the pre-treatment covariates were controlled for, and the participants and matched non-participants were equated. Then, analysis of covariance (ANCOVA) was conducted to identify the effects of research participation (treatment effects) on Time-To-Degree and Graduation GPA, using the post-matched sample. Research participation, a dichotomous treatment variable, was entered as one of independent variables along with Low Income Status, Sex, 1st Generation Status, Total Units Earned, Units Attempted, Full-Time/Part-Time Status, Local Area Status, and Campus GPA. Similarly, logistic regression on enrollment in a graduate degree program was carried out with research participation and the same covariates as independent variables.

Outcome Measures

The concept of college success and learning outcome can be defined in multiple ways. We sought to investigate three outcome variables: time-to-degree and graduation GPA after research participation as a short-term outcome as well as graduate program placement after graduation as a long-term outcome. Time-to-degree is defined as unit of years, and time-to-degree of 1 year means that it takes 12 months to attain a bachelor's degree after taking research courses. Graduation GPA is another outcome measure that concerns the effects of research participation on college learning outcomes. Graduate program enrollment after research participation was tracked through the National Student Clearinghouse (NSC). We sent the research participant and post-matched non-participant information to the NSC and received their post-graduate data as a means to examine whether they entered master's or doctoral programs.

Analysis

Propensity Score Matching (PSM)

We employed PSM to investigate the effects of undergraduate research on student learning outcomes in the present study. PSM is a method of reducing self-selection bias in a quasi-experimental study. This statistical technique matches samples with similar observables first and then compares the treatment group with non-treatment groups who have the most similar pre-treatment characteristics (Guo & Fraser, 2010; Rosenbaum & Rubin, 1983). In PSM, the likelihood of group membership is estimated using logistic regression, and the propensity score of a participant is the probability of being a member in a treatment group. The treatment group and control group were equated and formed through PSM. As such, this technique simulates a randomized experimental study and estimates treatment outcomes (Austin, 2008; Shadish, Luellen, & Clark, 2006). The advantage of PSM methods have been validated in the literature across disciplines (Austin, 2007; Grunwald & Mayhew, 2008; Morgan & Harding, 2006; Schafer & Kang, 2008; Schnider et al., 2007); however, only a minimal number of publications in educational research have utilized PSM (Thomson Corporation, 2010).

Five steps of analysis were conducted by employing PSM in the present study. First, all of the variables that tend to associate with participants' characteristics were selected as covariates, so as not to leave out any confounding factors. Next, based on a set of covariates, logistic regression was conducted to estimate propensity score. Research participation as a treatment condition was used as a dependent

variable in this analysis process, and the covariates were entered as independent variables that predicted participation or non-participation. Then, the actual matching process was implemented, employing the *nearest neighbor matching* method, which is the simplest way to match. In this method, one single research participant was matched with one non-participant who had the closest propensity score. The SPSS macro (Painter, 2009) was used to implement this method in the matching process of the present study. After the matching process was complete, the balance of covariates was checked to verify whether the sample and matched sample had similar characteristics by way of estimating the standardized mean differences of covariates, generating graphical presentation, and conducting *t*-tests on the covariates between the two groups. Finally, outcome measures were compared between participant and non-participant matched groups to estimate the research participation effects.

Post-Matching Analysis

After the matching process was completed, and both sample groups were similarly extracted, a one-way ANCOVA was performed to estimate the effects of research participation on time-to-degree and graduation GPA, while adjusting for covariates described in the previous section. The major variable of interest, research participation, was employed as an independent variable, taking eight variables as covariates. This way, we could see the unique effects of research participation in terms of controlling for all other variables. Logistic regression was conducted to assess whether research participation and the other eight independent variables used in ANCOVA as covariates predicted graduate program enrollment after completing a bachelor's degree. The logistic regression analysis models event probability that predicts the presence or absence of an outcome based on a set of predictor variables. Enrolling in an advanced degree, including master's or doctoral, program is one of two learning outcomes. Participation in research was used as a dichotomous independent variable to determine the impact of research.

Results

Propensity Score

To obtain a propensity score, logistic regression was performed on research participation, based on a set of covariates. The results of logistic regression are described in Table 1. Campus GPA, Units Attempted in a given term, Total Units Earned, Sex, Full-Time/Part-Time status, and Local Area Status were found to be significant indicators that predict participation in research. A propensity score, which is the probability of being selected as a research participant, was calculated for each student. Later, it was transformed to a logit and was used for matching. Rubin (2001) indicated that logit transformation instead of propensity score works better for matching. As such, we created a simulated comparison group who were non-participants in undergraduate research.

Table 2. Logistic Regression on Research Participation based on a set of Covariates

Covariate Variables	*b*	Sig.
Independent Variables		
Previous GPA (high school GPA or transfer GPA)	-.097	.238
Campus GPA	1.053	.000
EI (Eligibility Index)	.000	.813
SAT Total (Verbal & Math)	-.001	.117
Units (Units attempted in a given term)	.247	.000
Tot Units Earned (Total units earned in college)	.023	.000

Sex	-.193	.016
Ethnicity		
AmInd	.286	.446
Hisp	-.188	.349
Asian	-.313	.138
Black	.119	.641
White	-.179	.373
Unknown	-.045	.835
FTPT (Full-Time or Part-Time enrollment in a given term)	.645	.000
Low Income	.102	.252
Total Pell Grant Amount	.000	.495
1st Generation (Parent Education Level)	.046	.296
Local Area (came from local area)	.323	.029
Entering Characteristics		
As First-Time Freshman	.071	.474
As Lower Division Transfer	.328	.123
College of Major		
College of Arts	-2.127	.997
Mihaylo College of Business & Econ	-1.390	.998
College of Communications	-1.250	.998
College of Engineering & Computer Sci	-7.071	.991
College of Health & Human Develop	-1.617	.998
College of Humanities & Social Sci	-1.641	.998
College of Natural Science & Math	-1.498	.998
Major (HHD Research participants were from 35 different majors, and dummy coding was used for each major)	Ranges from 10.890 to 15.800	Ranges from .936 to .983
Year Term (Study included longitudinal data for 34 terms from fall 2002 & fall 2011, and dummy coding was used for each year term)	Ranges from -13.791 to .565	Ranges from .030 to .977
Matriculation Year Term (Matriculation year term for a total of 34 terms used dummy coding)	Ranges from -15.687 to .969	Ranges from .012 to .999

Descriptive Statistics

Background characteristics of undergraduate research participants and pre/post-matched non-participants are presented in Table 3. Their previous GPA, including high school GPA or transfer GPA, was 3.25 for participants, 3.21 for non-participants before matching, and 3.27 for non-participants after matching. Pre-matched non-participants attained a campus GPA of 2.91, which was the lowest among the three groups. Campus GPA of post-matched non-participants was 3.29, which is slightly higher than that of participants. SAT composition score of verbal and math was 972 for both participant and post-matched non-participant groups. Sex composition indicated that women were 80% and men were 20% of the participant group, and women were 83% and men were 17% of the post-matched group. The pre-matched group shows that women were 38% and men were 62% of the group. The majority of participants in HHD research courses were females. Approximately 35% of the participants were Hispanic, 34% were White, and 15% were Asian, which is comparable to the composition of post-matched non-participants. Approximately 60% of participants and non-participants came from the local area, particularly from Orange County. One-third of the participants and post-matched non-participants entered college as first-time freshmen, whereas nearly two-thirds of those two groups came to college as upper-division transfers.

The college of the student major was of similar composition for both participants and post-matched non-participants, with 91% of participants and 89% of post-matched non-participants' having a College of Health & Human Development (HHD) major and 7.3% of participants and 7.8% of non-participants' having a College of Humanities & Social Sciences (HHS) major. Similarly, approximately 5% of both participants and post-matched non-participants consist of students with an HHS major. Their enrollment year term shows an analogous pattern; participants and post-matched counterparts, with approximately 7% having matriculated in fall 2009. Likewise, 9% of research participants matriculated in fall 2007, and 10% of their counterparts matriculated in the same year term. The similarities between the participant sample and paired matched sample signify that the confounding factors and pre-research elements of non-participants were well regulated and that the non-participant group became a simulated control group so that it could be compared to the participant group, which is the experimental group. It is particularly interesting that we can apply PSM to a longitudinal study that keeps track of those who have been enrolled in many different terms, matriculated in different years, and majored in a variety of programs.

Table 3. Descriptive Statistics of Sample and PSM Matched Sample

Variables	Participants	Non-Participants (before Matching)	Non-Participants (after Matching)
Outcome Variable	**Means**	**Means**	**Means**
Participation in HHD Research Courses during the college year	1	0	0
Independent Variables			
Previous GPA (high school or transfer GPA)	3.25	3.21	3.27
Campus GPA	3.25	2.91	3.29
EI (Eligibility Index)	3313	3290	3288
SAT Total (Verbal & Math)	972	985	972
Units (Units attempted in a given term)	13.37	11.13	13.78
Tot Units Earned (Total units earned in college)	107	106	110
Sex	1.20	1.3798	1.17
Ethnicity			
AmInd	.0095	.0052	.0149
Hisp	.3451	.2532	.3532
Asian	.1461	.2206	.1543
Black	.0338	.0264	.0338
White	.3437	.3498	.3180
Unknown	.0934	.1014	.1001
Non-Res Int'l	.0284	.0434	.0257
FTPT (Full-Time or Part-Time enrollment in a given term)	1.18	1.36	1.15
Low Income	.4682	.3702	.4601
Total Pell Grant Amount	3588	2650	3644
1st Generation (Parent Education Level)	2.02	2.18	2.02
Local Area (came from local area)	.62	.60	.60
Orange County	.6238	.5962	.5968
Los Angeles County	.2395	.2433	.2747
Riverside County	.0365	.0384	.0379
San Bernardino County	.0325	.0335	.0311
San Diego County	.0203	.0235	.0176
Entering Characteristics			
As First-Time Freshman	.3329	.3163	.3248
As Upper Division Transfer	.6428	.6576	.6441

As Lower Division Transfer	.0244	.0261	.0311
As 2nd BA	.0000	.0000	.0000
College of Major			
College of Arts	.0000	.0631	.0000
Mihaylo College of Business & Econ	.0027	.2835	.0095
College of Communications	.0095	.1451	.0135
College of Engineering & Computer Sci	.0000	.0264	.0000
College of Health & Human Develop	.9120	.1690	.8931
College of Humanities & Social Sci	.0731	.2732	.0785
College of Natural Science & Math	.0014	.0372	.0054
Other	.0014	.0024	.0000
Major (HHD Research participants were from 35 different majors, and dummy coding was used for each major)	.0000 to .5805 (Hum Serv: 5805)	.0004 to .1299	.0000 to .5250 (Hum Serv: 5250)
Year Term (Study included longitudinal data for 34 terms from fall 2002 & fall 2011, and dummy coding was used for each year term)	.0000 to .0677 (fa09: .0677)	.0000 to .0397	.0000 to .0744 (fa09: .0744)
Matriculation Year Term (Matriculation year term for a total 34 terms used dummy coding)	.0000 to .0920 (fa07: .0920)	.0000 to .0638	.0000 10 .1028 (fa07: .1028)

Balance Check

After the propensity score was estimated, real matching was processed utilizing the one-to-one nearest neighbor matching method (Rosenbaum & Rubin 1985). This matches each case in a treatment group (research participant group) with a case in a control group (non-participant group) based on the nearest distance of the propensity scores of the two cases. This technique is the most commonly used and is a straightforward matching procedure (Thoemmes & Kim, 2011). We validated a balance check for the matched sample group through employment of two methods, numerical and graphical techniques. First, a *t*-test as conducted on each covariate, and all the covariates, except two variables, indicated group differences between the treatment group and the post-matched control group. The only two covariates with significant *t*-values were "units attempted" in a given term and "total units earned" as of that term. To better control for these two covariates, an ANCOVA was performed in the last step of analysis, when we estimated the actual treatment effects. Standardized mean differences (effect size) also were verified on each single covariate between treatment and simulated control groups. All of the values of standardized mean differences of covariates were close to 0 after matching, as shown in Table 4.

In addition to the numerical balance checking described above, distribution and histograms of propensity scores of treatment group (participants) and pre-/post-matched groups (non-participants) were used to demonstrate the matching adequacy, as seen in Figures 1 through 4. The propensity score distribution of pre-matching and post-matching group considerably differ in Figures 2 and 4, while the post-matching distribution of the control group is almost identical to that of the treatment group. Similarly, the two box plots in Figures 5 and 6 illustrate how comparable the participant and post-matched non-participant groups are in terms of the propensity score. As such, the pre-existing and extraneous factors that the non-participants had were controlled for.

Table 4. Standardized Mean Differences of Participants and Matched Non-Participants

Variable	Effect Size (*d*) (Participants vs. post-matching non-participants)	*t* (*t*-test) (Participants vs. post-matching non-participants)
Independent Variables		
Previous GPA (high school GPA or transfer GPA)	0.0473	.909
Campus GPA	0.0772	1.484
EI (Eligibility Index)	-0.0364	-.699
SAT Total (Verbal & Math)	0.001	.020
Units (Units attempted in a given term)	0.1168	2.245
Tot Units Earned (Total units earned in college)	0.1137	2.186
Sex	-0.073	-1.404
Ethnicity		
AmInd	0.0493	.948
Hisp	0.017	.327
Asian	0.0227	.437
Black	0	.000
White	-0.0052	-.1.00
Unknown	0.0229	.440
Non-Res Int'l	-0.0166	-.320
FTPT (Full-Time or Part-Time enroll in a given term)	-0.0767	-1.474
Low Income	-0.0163	-.313
Total Pell Grant Amount	0.0102	.196
1st Generation (Parent Education Level)	0.0007	.013
Local Area (came from local area)	-0.0555	-1.066
Orange County	-0.0555	-1.066
Los Angeles County	0.0805	1.548
Riverside County	0.0071	.137
San Bernardino County	-0.0077	-.148
San Diego County	-0.0198	-.381
Entering Characteristics		
As First-Time Freshman	-0.0173	-.332
As Upper Division Transfer	0.0028	.054
As Lower Division Transfer	0.0412	.792
As 2nd BA	n/a	n/a
College of Major		
College of Arts	n/a	n/a
Mihaylo College of Business & Econ	0.087	1.672
College of Communications	0.038	.731
College of Engineering & Computer Sci	n/a	n/a
College of Health & Human Develop	-0.0639	-1.228
College of Humanities & Social Sci	0.0204	.393
College of Natural Science & Math	0.0699	1.344
Other	-0.052	-1.000
Major (HHD Research participants were from 35 different majors, and dummy coding was used for each major)	Ranges from -0.1117 to 0.2022	Ranges from -2.147 to 3.886
Year Term (Study included longitudinal data for 34 terms from fall 2002 & fall 2011, and dummy coding was used for each year term)	Ranges from -0.0801 to 0.0652	Ranges from -1.539 to 1.254
Matriculation Year Term (Matriculation year term for a total of 34 terms used dummy coding)	Ranges from -0.0647 to 0.0748	Ranges from -1.243 to 1.438

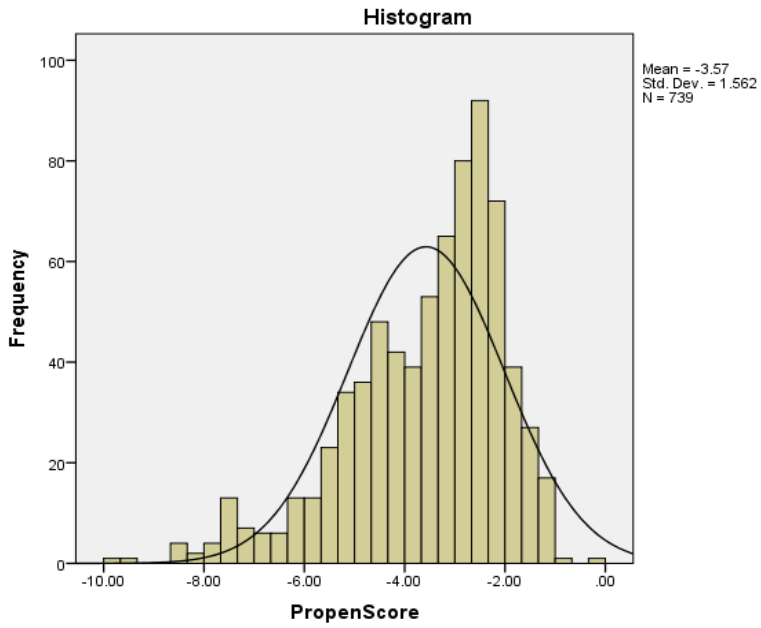

Figure 1. **Treatment = 1 before matching.**

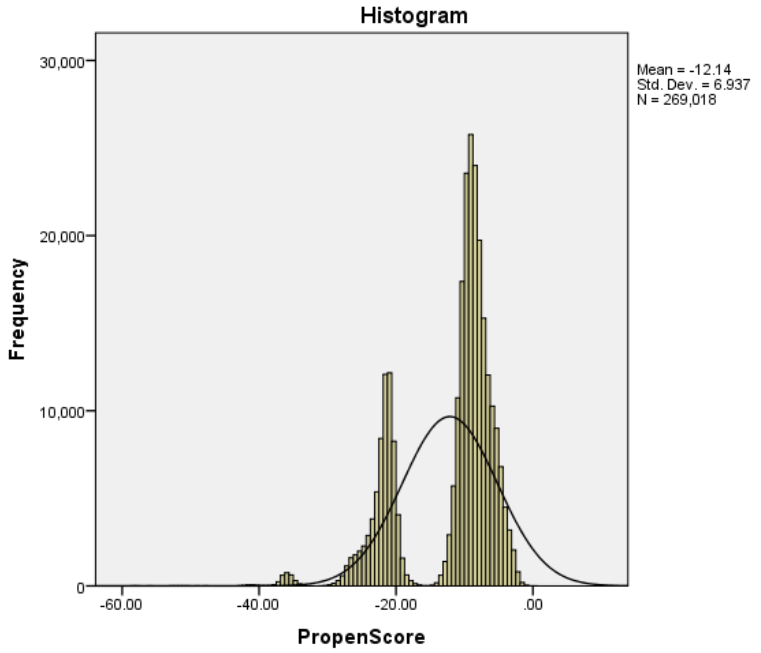

Figure 2. **Treatment = 0 before matching.**

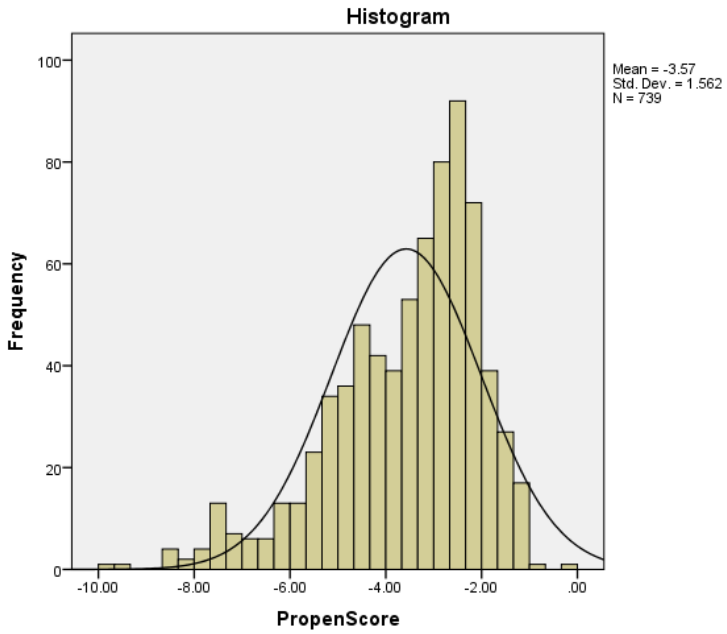

Figure 3. **Treatment = 1 after matching.**

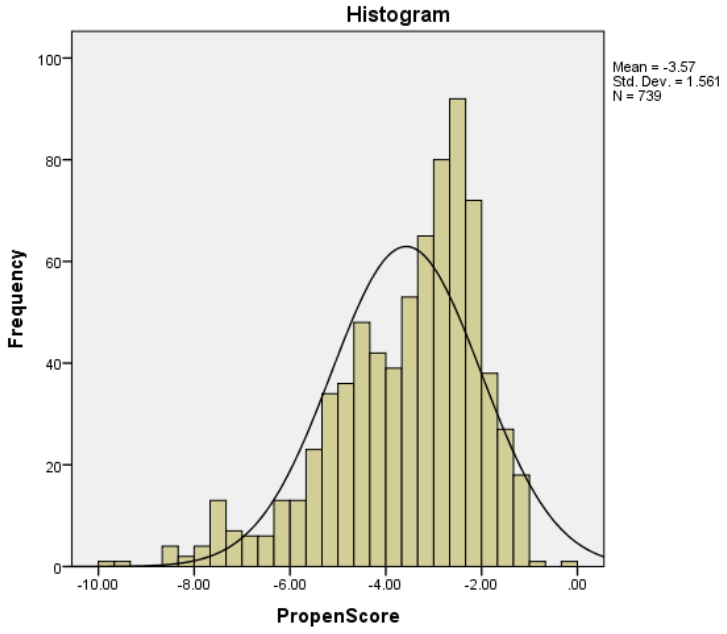

Figure 4. **Treatment = 0 after matching.**

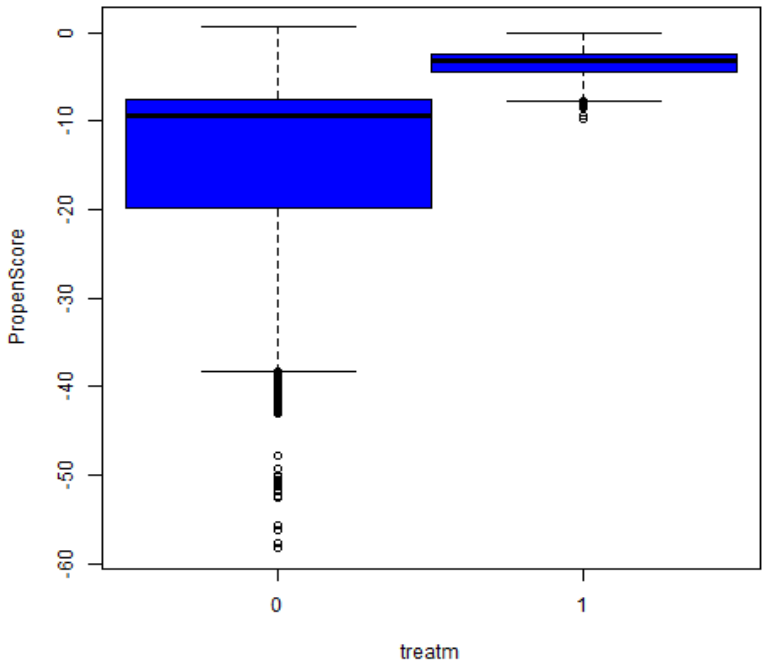

Figure 5. **Box plots before matching for treatment and control groups.**

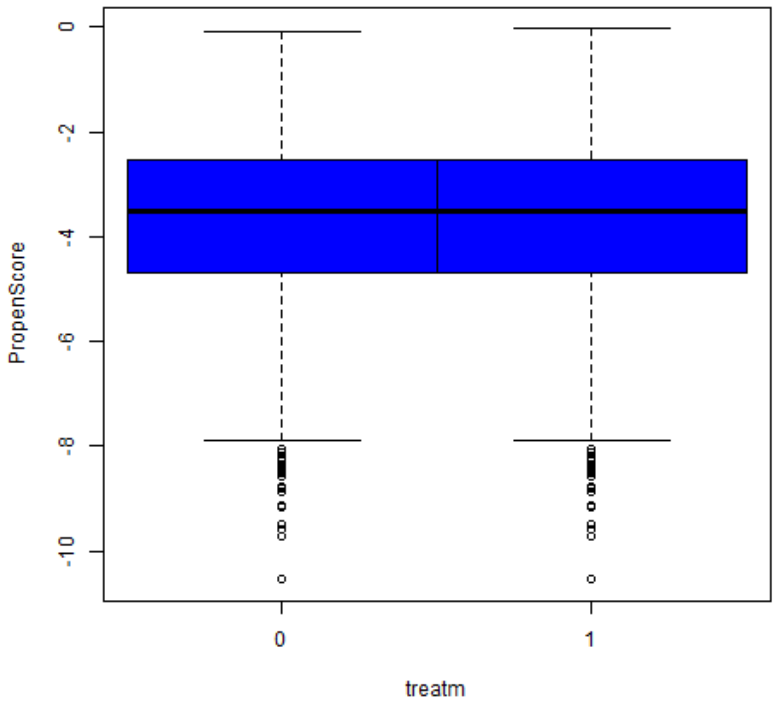

Figure 6. **Box plots after matching for treatment and control groups.**

Estimating Effects of Research Participation on Student Learning Outcomes

As a post-matching analysis, an ANCOVA was conducted to investigate the effectiveness of undergraduate research participation in reducing the time to graduate (Table 5). Research participation was the independent variable that predicted the dependent variable of time-to-degree. Significant differences were found in time-to-degree between participants and non-participants. Instead of one-way analysis of variance, an analysis of covariance was employed to compare group means more precisely, controlling for covariates. The covariates used in the ANCOVA were the independent variables that were significant in logistic regression to extract propensity scores. Using the same covariates, we endeavored to maximize controlling for the extraneous effects of confounding variables that might be strongly related to treatment effects and decrease any remaining bias as a result of limited matching. As such, we tried to reduce within-group error variance and separated the differences attributable to the covariates and maximized the precision of between-group variance. The total variance of explained (R^2) was 19%.

Table 5. One-way Analysis of Covariance on Length of Graduation after Research Participation

Source	Sum of Squares	*df*	Mean Square	*F*	Sig.
Low Income	.073	1	.073	.386	.534
Sex	1.621	1	1.621	8.569	.003
1st Generation	.118	1	.118	.626	.429
Total Units Earned	60.172	1	60.172	317.973	.000
Units Attempted	.121	1	.121	.642	.423
Full-Time/Part-Time	.022	1	.022	.114	.736
Local	.130	1	.130	.687	.407
Campus GPA	5.623	1	5.623	29.714	.000
Participation	2.536	1	2.536	13.401	.000
Corrected Total	346.909	1477			

Note. R2 = .199 (Adjusted R2 = .194).

Even after holding all other confounding covariates constant, there were significant positive effects of research participation on student time-to-degree (F = 13.401, p =.000). Participating in research activity was the second significant factor that predicted time-to-degree, followed by campus GPA (F = 29.714, p = .000). The adjusted average time-to-degree of research participants was nine months after they took research courses, while that of non-participants was 11 months (Figure 7). The results of a second ANCOVA on graduation GPA indicated the effectiveness of research participation as well. We controlled same covariates used in a previous ANCOVA to investigate effects of research on graduation GPA. The results, as seen in Table 6, indicated that research participation contributed to improving student college GPA (F = 11.315, p < .01) at the time of graduation, although campus GPA at the term of research participation was the strongest predictor for graduation GPA (F = 11868.083, p = .000). The adjusted average graduation GPA was 3.30 for research participants and 3.28 for their non-participant counterparts (Figure 8).

Table 6. One-way Analysis of Covariance on Graduation GPA after Research Participation

Source	Sum of Squares	*df*	Mean Square	*F*	Sig.
Low Income	.015	1	.015	.834	.361
Sex	.045	1	.045	2.602	.107
1st Generation	.033	1	.033	1.888	.170
Total Units Earned	.174	1	.174	9.960	.002
Units Attempted	.003	1	.003	.198	.657
Full-Time/Part-Time	.020	1	.020	1.122	.290
Local	.002	1	.002	.134	.714
Campus GPA	207.145	1	207.145	11868.083	.000
Participation	.197	1	.197	11.315	.001
Corrected Total	241.181	1332			

Note. R2 = .904 (Adjusted R2= .904)

In terms of graduate program enrollment after bachelor's degree attainment, we accessed NSC data to keep track of those who were research participants or post-matched non-participants. These student data were coded as dichotomous variables, depending on enrollment in advanced degree programs, including master's or doctoral. The eight independent variables used in ANCOVA and research participation were included in the logistic regression equation to separate out the unique effects of each predictor variable, particularly the unique effects of research participation on graduate program enrollment. The logistic regression results show that research participation (χ^2 = 7.663, p < .01), followed by campus GPA (χ^2 = 6.278, p < .05) are significant predictors of advanced degree program placement (Table 7). The predicted odds of the independent variable, research participation, are 1.45, indicating that the odds of graduate program enrollment for research participants are 1.45 times higher than for the non-participants. That is, holding all other independent variables constant, the odds of advanced degree program placement for research participants is 45% more than the odds of advanced degree program placement for non-participants. Campus GPA also was a significant predictor, and the predicted odds of campus GPA were 1.43. That is, for every one-unit increase in college GPA (for every additional one point of GPA), we expect a 1.43 increase in the odds ratio of graduate degree enrollment, controlling for all other predictor variables. Figure 9 shows that 162 out of 739 research participants enrolled in advanced degree program, while 122 non-participants did in advanced degree program.

Table 7. Logistic Regression on Graduate Program Enrollment after Research participation

Effects	Coefficient (B)	Wald χ^2	*p*	Odds Ratio
Low Income	.174	1.526	.217	1.189
Sex	-.179	.962	.327	.836
1st Generation	.033	.131	.717	1.033
Total Units Earned	-.004	1.541	.215	.996
Units Attempted	.016	.332	.565	1.016
Full-Time/Part-Time	-.190	.459	.498	.827
Local	-.047	.115	.735	.954
Campus GPA	.362	6.278	.012	1.437
Participation	.373	7.663	.006	1.452

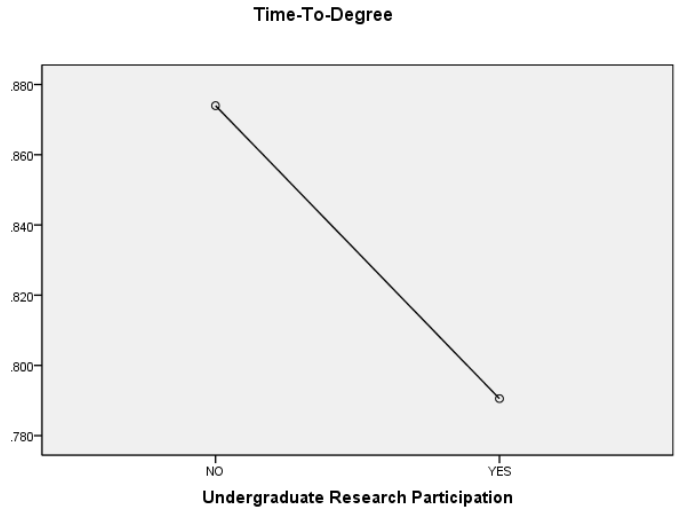

Figure 7. **Time-To-Graduation between Participants and Non-Participants.**

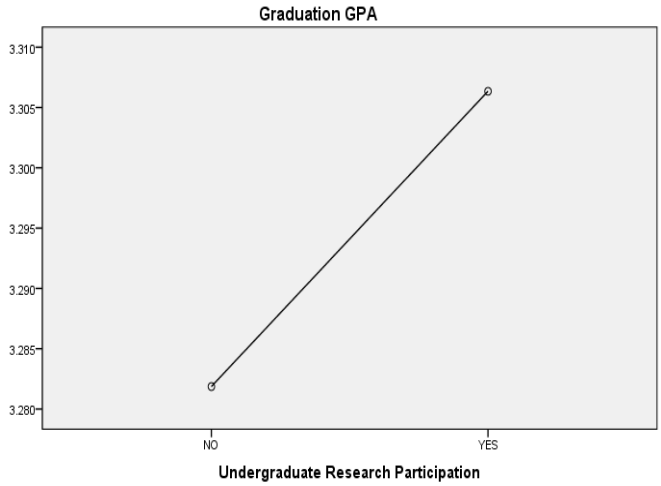

Figure 8. **Graduation GPA between Participants and Non-Participants.**

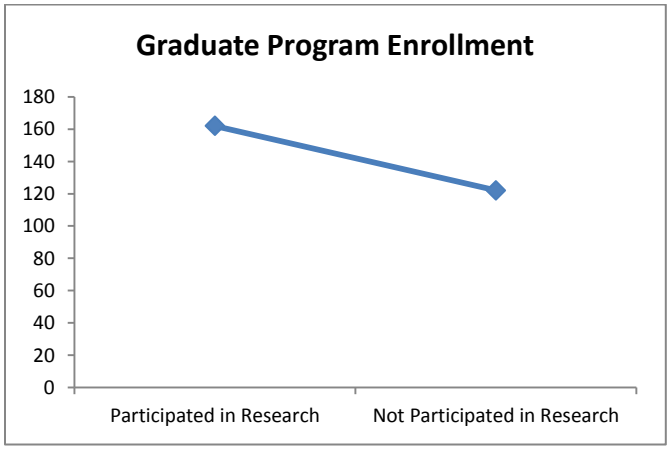

Figure 9. **Graduate Program Enrollment between Participants and Non-Participants.**

Conclusions and Implications

The present study was an investigation of how undergraduate research participation maximizes college impact in a comprehensive university that prioritizes HIPs as effective strategies to improve student learning. The efficacy of college students' participation in research was examined in HHD research courses that enroll students from diverse cultural backgrounds; more than one-third of research participants were Hispanic students. The findings of this study indicated that an undergraduate research program brings about positive student change, including timely graduation, improved GPA, and future placement of college graduates in advanced degree programs.

Undergraduate research is an academic activity in which juniors or seniors are engaged in developing a deeper understanding of their major fields. At the time they took research courses, the students had a variety of backgrounds, including different college GPAs, total units earned, and majors. To regulate for these extraneous factors, which might influence the efficacy of research participation, we employed a quasi-experimental design and developed a simulated control group utilizing a matching process to equate both the treatment group (participants) and their counterpart (non-participants). The PSM technique was used to perform the matching process, and the post-matched control group was found to be sufficiently reliable. Both the numerical and graphical analyses of the treatment group and post-matched sample indicated that the two groups are analogous and comparable with regard to background characteristics. As such, the first research question was answered in the present study, in support of previous research (Austin, 2008; Grunwald & Mayhew, 2008; Morgan & Harding, 2006; Rosenbaum & Rubin, 1983; Schafer & Kang, 2008; Schnider et al., 2007). The next three research questions in this study also were answered using post-matching analysis.

For the second research question, which concerned student success and timely graduation, post-matching analysis showed that undergraduate research decreased the time to graduate for participants. Students who participated in research courses could complete a bachelor's degree in a shorter time than those who did not. The results were even significant when controlling for all other confounding variables that might have an effect on research participation. Undergraduate research was found to be an effective and purposeful academic activity that deepens student engagement in learning and enhances student success as one of the HIPs. As Kuh (2009) indicated, engagement in productive learning activities, such as conducting research, lead to college student success.

We also investigated the effects of undergraduate research on graduation GPA as a third research question. Participation in research activities was one of the significant predictors for improving graduation GPA. The research participants graduated college with higher GPAs than did non-participants. The previous college GPA, before the students took research courses, already had been controlled for, and we made the assumption that the participants and non-participants achieved similar college GPAs at the time of enrollment in undergraduate research courses. Undergraduate research participation encouraged students to improve their college GPA during and even after participation in the research activities.

The two outcome measures of timely graduation and college GPA were significantly predicted by undergraduate research participation, supporting the notion of the efficacy of HIPs to generate positive student change in college. These findings were consistent with a previous study on HIPs as strategies to promote student learning outcomes (Moon et al., 2013). Cognitive learning outcomes, such as successful timely graduation and GPA enhancement, can be explained by Vygotsky's (1978) notion of

the zone of proximal development, as the students work in groups with advanced peers when they explore research topics. The positive effects of undergraduate research also support the socialization theory of undergraduate students in higher education (Weidman, 1989). The undergraduate research participants might assess and alter their norms in social contexts as they socialize and interact with more capable peers and faculty mentors.

Students' positive experience in research activities might motivate them to advance toward graduate program enrollment. The fourth research question concerns the influence of undergraduate research on enrolling in advanced degree programs, such as master's or doctoral. We kept track of research participants and non-participants through the NSC to identify in which college and program they enrolled after completing their bachelor's degree. Undergraduate research participation was the strongest predictor of graduate program enrollment. The participants in research courses were more likely to advance toward graduate degree programs than were non-participants. This finding provides support for the theory of communities of practice (Lave & Wenger, 1991), that is, a group of people who share a communal theme do better in that specific field as they interact and collaborate. Further, the findings of the present study also are consistent with earlier research that found that the undergraduate research experience can encourage students to aspire to enroll in advanced degree programs with high expectations (Eagan et al., 2013; Heller, 2001).

The prevalent component in the theories noted above, including Vygotsky's (1978) zone of proximal development and communities of practice, is "working in groups with collaboration and engagement," which is part of undergraduate research and is a substantial part of the HIPs proposed by Kuh (2008). Tinto (2003) also noted the advantages of learning communities as an effective practice in higher education institutions, ascribable to their collaborative pedagogy, active involvement, and mutual interaction of students. HIPs are specifically beneficial for underrepresented students (Kuh, 2008; Kuh et al., 2008; Moon et al., 2013; Pascarella & Terenzini, 2005) because cultural characteristics are collaboratively disposed (Moon et al, 2013).

The findings of the present study are promising and support those of previous research (Kuh, 2008; Kuh et al., 2008; Moon et al., 2013), that HIPs are effective in improving student learning and maximizing college impacts. In particular, undergraduate research is good for upper level students who have already declared their majors, and it is academically valuable for those who strive to complete college and explore their future careers in major fields. The results of this study are meaningful in that they showed that HIPs produce not only in-college learning outcomes but also post-college future placement outcomes. Reducing the graduation time span and improving college GPA were tracked as in-college outcomes, and advanced enrollment in graduate degree programs were tracked as post-college placement outcomes.

Now that we know the benefits of undergraduate research, it is time to inspire college students to participate in research activities. Advancing our students to successful graduation is not only a matter of the students themselves but also a matter of all campus constituencies, including administrators, faculty, staff, and even parents. As such, the culture of an institution is a vital means to lead our students down the right path, and we *all, as a team,* should work in close collaboration with each other. For example, raising external funding to support undergraduate research is one of the HIPs that will encourage both students and faculty to be engaged in research activities. Faculty development also could make a contribution by facilitating faculty-to-mentor relationships for undergraduate students for research activities and by providing research workshops and positive incentives to faculty for participation. Public universities in California have been experiencing a budget deficiency for the past

decade, and external fundraising will be an important additional revenue source to decrease the student-to-faculty ratio so that faculty will have more opportunities to conduct research with undergraduate students. In this way, faculty will have more interaction with students and can engage in mentoring and advising students at the same time. Campaigning for active engagement and its efficacy can make campus constituencies aware of the benefits to students. It is time for all of us to be engaged, as a community, in student and college success.

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