

## Undergraduate Research at a Teaching-Oriented College: Seniors' Perspectives and Approaches to Consider

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*Abstract: This study examines the relationship of undergraduate research (UGR) participation on senior students' reported engagement, perceived gains, satisfaction with their educational experience and retention, and graduation status compared to peers that have not participated in UGR. Data were drawn from 1,472 senior students at a comprehensive, teaching-oriented public college, and collected from administration of the National Survey of Student Engagement (NSSE) from 2015 to 2019, along with institutional data. This examination uniquely investigates outcomes of UGR participation besides persistence and graduation (which are already well documented) and leverages the lens of senior students in particular. In addition, this study contributes to the literature on UGR at teaching-oriented colleges, which has been sparse most likely because there are many more opportunities for UGR at research institutions. In line with several conceptual frameworks of student engagement, data analysis revealed that relative to their peers who have not participated in UGR, UGR-participating students have higher levels of engagement, perceived gains, and overall satisfaction. UGR-participating students also continued enrollment and/or graduated at a higher rate after reaching their senior status compared to non-participating peers. The implications for teaching-oriented colleges, as well as suggestions for how these institutions can enhance their undergraduate research programming, are discussed.*

*Keywords: undergraduate research, senior, National Survey of Student Engagement (NSSE), engagement, perceived gains, satisfaction*

### Introduction

Participation in undergraduate research (UGR, hereafter) has been well documented to have an impact on student success. Rightfully designated a high impact practice (Kuh, 2008), working on novel research with a faculty member positively impacts student retention and graduation and increases a student's self-identification as a scholar/scientist, which may be critical in persistence into graduate-level study and future career choice (Eagan et al., 2013; Lopatto, 2010; Seymour et al., 2004). These outcomes are particularly notable in racial minority and first-generation populations (Carpi et al., 2017; Hurtado et al., 2010; Jones et al., 2010; Kuh, 2008; Lopatto, 2010; O'Donnell et al., 2015), which remain significantly underrepresented in the academy. Because of the reproducible data demonstrating the impact of UGR participation, institutions should expand opportunities for undergraduate research. This is easier at some institutions than others, however.

UGR normally operates in an apprentice model: a student spends a summer or semester working significant hours under a faculty member, postdoc, or senior graduate student and often earns a stipend to do so (Lopatto, in 2010, coins this “the epitome of the undergraduate research experience”). This apprentice model is standard at research universities but is expensive in both financial and human resources since stipends are required for both mentor and mentee, and mentors typically take on just a few undergraduate mentees at a time. It is also not easily replicated at teaching colleges where faculty frequently do not have the laboratory space, support to seek grant funding for staff/equipment to conduct research, or workload accommodations that would facilitate apprentice-based research (Hu et al., 2007; Marwick, 2012). In addition, there are questions of accessibility with the apprentice model. While there has not been extensive research about why some students *do not* participate in research, some research indicates that lack of time and the low pay for conducting research contribute to the decision (Stout, 2018). Therefore, accessing apprentice opportunities outside of dedicated for-credit class time is limited for first-generation and low-income students that frequently work significant hours while in college (Falcon, 2015; RTI International, 2019). This was confirmed in the national Survey of Undergraduate Research Experiences (SURE), where nearly two-thirds of students participating in research reported difficulty balancing time between research (in the apprentice model) with coursework and other activities (Lopatto, 2010). Despite this, little research has been done examining low-income student participation in UGR or the impacts of UGR for this population.

Teaching colleges (which represent a significant portion of the higher education market as community colleges, small liberal arts colleges, and undergraduate-focused regional comprehensive universities) have had to innovate alternative models for providing research opportunities (Wei & Woodin, 2011). Research partnerships with community organizations (e.g., research internships for credit) and course-based undergraduate research experiences (CUREs) are two such mechanisms. CUREs can take place in science labs conducting novel research, statistics classrooms (for example, a class can act as consultants for community organizations), as history projects (archiving materials at a local historical site), or education courses centered around teacher-as-researcher projects (students study the efficacy of reading interventions), etc. CUREs have the advantage of engaging an entire class in research as opposed to a select few apprentices (Auchincloss et al., 2014; Banger & Brownell, 2014), and yield similar positive results in building science identity, research skills, and intention to pursue graduate education/careers in research (Auchincloss et al., 2014; Harrison et al., 2011; Jordan et al., 2014; Shaffer et al., 2010). Students participating in class-based research also have higher skill gains than summer researchers for science writing, research ethics, and understanding primary literature (Lopatto, 2010).

Alternative forms of giving students access to research are especially important in that they are achievable at all kinds of teaching institutions, including community colleges where it is estimated that half of all college-going students get their start (Center, 2017). Community colleges have innovated a wide breadth of research opportunities for undergraduates (Cejda & Hensel, 2009; Marwick, 2012), with some emphasizing the scientific process (Brandt & Hayes, 2012), focusing on applied research in a technical area, or investigating topics/problems of local relevance (Cejda & Hensel, 2009). Importantly, the SURE data indicate that students engaging in alternative research experiences like these (compared to traditional apprentice programs) are just as likely to go to graduate school and go to graduate school at higher rates than peers who did not complete any UGR (Hathaway et al., 2002).

Despite the positive outcomes, there remains limited research on the outcomes of students engaging in UGR at teaching-focused institutions. Prior to this study, it has not been shown whether non-apprentice model UGR at teaching-focused institutions has similar impacts to student engagement, perceived gains, satisfaction or persistence/graduation, nor how these impacts manifest

in populations most underrepresented in the academy. In this study, we analyzed 2015-2019 National Survey of Student Engagement (NSSE) data from senior students at a public comprehensive institution that emphasizes teaching. Senior students are a relatively untapped source of feedback that can help campus communities learn about the meaningfulness of research opportunities and the impact such opportunities have on their success (Gardner & Veer, 1998). Surveys of senior students are important because research can occur at any level of the undergraduate experience, including during the senior year (a senior capstone, thesis, internship, project, or lab experience). We sought to examine whether there were differences in seniors' level of engagement, perceived gains, and overall satisfaction for those who did and did not participate in UGR. Further, we also wanted to examine the extent to which participation in UGR impacted persistence or graduation status after reaching senior status. This examination will help us understand the impact of research in this distinct setting and provoke greater discussion of how UGR can be implemented and leveraged at teaching-focused colleges.

## Methods

### *Study Context*

The study is situated in a comprehensive public teaching-oriented college (referred to as “the Institution” hereafter). The Institution has had a steadily growing baccalaureate population, reaching over 5,000 students in fall 2019. As a highly diverse, open-access campus, the Institution received designation from the Department of Education as a Title III & Title IV Minority Serving Institution (MSI) in 2013. In 2015, the Institution achieved its designation as a Hispanic Serving Institution (HSI). In fall 2019, 75% of the enrolled students were female, 63% were from ethnic and racial minority backgrounds, and over 47% were first-generation college students. The campus had a large portion (38%) of low-income, Pell recipient students. To address the needs of such a diverse student population and all students, the Institution offers a wide range of student support initiatives, programs, and inclusive practices to assist and support students (especially traditionally underserved racial and ethnic minority, first-generation, and low-income students) and enhance the students' educational experiences. Studies like this will shed light on the benefits of participation in UGR on student engagement, perceived gains, and satisfaction, especially for traditionally underrepresented college students in teaching-oriented colleges.

### *Data Sources and Participants*

Senior data from the Institution's 2015-2019 NSSE administrations, as well as institutional data, were used for this study. NSSE data were retrieved from NSSE through the designated institutional interface (NSSE staff administer its core survey in spring to first-year and senior-year students through a specific online survey link directly sent to eligible students and later provide each participating institution access to their data). One of the authors connected the NSSE data to the institutional data warehouse through student ID's and transferred the de-identified data to another author to conduct statistical analysis. The dataset allowed researchers to explore targeted variables related to student experiences with UGR, engagement, perceived gains, overall satisfaction, and other student success metrics.

Potential participants in this study were 1,673 senior-year students who responded to the NSSE core survey from 2015 through 2019. Of these respondents, 1,472 completed questions related to UGR and were included in the data analysis of this study. The majority of participants were female (80%), racial and ethnic minority (47%), first-generation (65%), and had received Pell support (53%).

The demographics of these NSSE seniors in this study is similar to the campus senior population of fall 2014 to fall 2018 in terms of gender (76% females), race and ethnicity (55% ethnic minority), first-generation status (64%), and receipt of a Pell grant ever in their time at the Institution (55%). Although the senior sample of this study is relatively representative of the campus senior population, caution should be practiced in interpreting and generalizing the findings.

### *Measurement and Variables*

The NSSE core survey was used to measure senior students' participation in UGR and engagement indicators, perceived gains, and overall satisfaction (see Appendix for example items for engagement indicators, perceived gains, and overall satisfaction in NSSE survey). After a significant revision of the NSSE core survey in 2013, the NSSE core surveys of 2015 through 2019 include the same questions related to UGR, engagement, perceived gains, and overall satisfaction. This makes the items comparable year over year.

*Undergraduate Research.* The UGR question in NSSE was not limited to the current school year at the time of data collection; therefore, seniors' responses included their participation for all the years since they attended the college. The question asked, "Which of the following have you done or do you plan to do before you graduate?" NSSE asked students to indicate whether they have done or were in progress of working with a faculty member on a research project with four possible responses: (a) have not decided, (b) do not plan to do, (c) plan to do, and (d) done or in progress. We re-coded "d" as "1", indicating UGR participation, and "a", "b", and "c" as "0" for no UGR participation.

*Engagement Indicators.* Student engagement was estimated by 10 engagement indicators constructed with 47 questions, which asked students to indicate how often they have done the related activities. The question stem asked, "During the current school year, about how often have you done the following?" and then provided a list of activities, such as "combined ideas from different courses when completing assignments." The NSSE core survey designated each question with four response options (1: never, 2: sometimes, 3: often, and 4: very often).

*Perceived Gains.* Perceived gains were measured by 10 questions, which asked students to indicate their gains in practical competence, personal and social development, and general education competency areas as a result of their undergraduate education. The prompt asked, "How much has your experience at this institution contributed to your knowledge, skills, and personal development in the following areas?" and then had areas such as "thinking critically and analytically" and "analyzing numerical and statistical information." Each area then had four response options (1: very little, 2: some, 3: quite a bit, and 4: very much).

*Overall Satisfaction.* Two NSSE items were used to measure what NSSE deems "Overall Satisfaction": "How would you evaluate your entire educational experience at this institution?" and "If you could start over again, would you go to the same institution that you are attending?" Both questions had four response options (1: poor, 2: fair, 3: good, and 4: excellent; or 1: definitely no, 2: probably no, 3: probably yes, and 4: definitely yes).

In order to facilitate comparisons over time and between groups of students, scores of engagement indicators, perceived gains, and satisfaction were first converted on a 60-point scale. Then, re-coded values for each component item were calculated and averaged as a composite score for each engagement indicator. Engagement indicators were pre-calculated by NSSE, while responses of perceived gains and satisfaction questions were re-coded with values of 0, 20, 40, or 60, for 1, 2, 3, and 4, respectively, following NSSE-recommended SPSS syntax (NSSE, n.d.). The higher scores mean more frequent engagement, more perceived gains, and high-level satisfaction.

*Persistence or Graduation Status.* We also collected two variables of persistence or graduation status drawn from institutional data for this study. First, we used persistence as one of the indicators

of senior student success, measured by a student *either* having graduated by summer after reaching senior status and completing the NSSE survey *or* continuing enrollment in the next fall at the Institution. A student either having graduated from or re-enrolled in the next fall at the Institution was coded as “1” for “persisted”. Otherwise, the student was coded as “0” for “not persisted”. Second, we included an institutional variable of “graduated by summer after reaching senior status and completing the NSSE survey” (senior status meaning the cumulative credit hours reached 90). Since these senior participants started their undergraduate career at different years, we believe that it is a fair comparison of graduation status after reaching senior status. Students were coded a “1” for “graduated by summer after reaching senior status and completing the NSSE survey” or a “0” for “not graduated by summer after reaching senior status and completing the NSSE survey.” This data was evaluated by minority status, first generation status, and low-income status. We defined minority as Black or African American, Hispanics of any race, Asian, two or more races, Native Hawaiian or other Pacific Islander, and American Indian or Alaska Native based on the Integrated Postsecondary Education Data System (IPEDS) definition. Those whose race and ethnicity was unknown were excluded from the analysis. First-generation students are those with neither parent having graduated with a bachelor’s degree from a 4-year college or university. Low-income students are those who have ever received a Pell Grant based primarily on the student’s or parents’ income for the previous year.

### *Data Analysis*

To address the research questions of this study, a quantitative method with several analytic approaches was adopted. Utilizing SPSS 26, we first examined the data before conducting data analysis to ensure the assumptions of multivariate analysis of variance (MANOVA) were met. Specifically, we checked multivariate normality, homogeneity of variance, outliers, and multicollinearity since multiple outcome variables were involved. Examinations of skewness and kurtosis (univariate and multivariate) were conducted for each engagement indicator, perceived gain, and satisfaction score. Analysis indicated no skewness or kurtosis appeared as skewness or kurtosis ranging from -3 to 3 (Kline, 2005). For homogeneity of variance, significance for Box’s M Test is determined at  $\alpha = 0.001$  because this test is considered highly sensitive. Following Tabachnick and Fidell’s suggestion (2013), we checked multicollinearity, and results indicated that neither of the two dependent variables of engagement indicators and perceived gains were correlated to each other above  $r = 0.90$ . The bivariate correlation coefficients ranged from 0.125 to 0.552 among 10 engagement indicators and ranged from 0.414 to 0.739 among 10 perceived gains. Therefore, there is no evidence that multicollinearity existed between the set of variables of engagement, perceived gains, and satisfaction.

Second, we performed the General Linear Model (GLM) with two multivariate analyses of variance (MANOVAs) to examine the mean differences in engagement indicators and perceived gains between UGR participants and UGR non-participants since multiple composite scores of engagement indicators and perceived gains were examined (Stevens, 2002). The Bonferroni correction was applied to set the significance cut-off for alpha ( $\alpha$ ), in each case, at 0.005 (0.05/10) since there were 10 dependent variables (10 engagement indicators and 10 perceived gains). In addition, one univariate analysis of variance was conducted to examine the mean difference in overall satisfaction between UGR participants and UGR non-participants. Two conditions that emerged from NSSE data require weighting that must be considered when conducting secondary analysis. One condition is when the proportion of respondents within a particular demographic variable (e.g., gender, full-time/part-time, or adult students) differs substantially from their population percentages. The second condition involves when students within a subgroup differ substantially in the variables of interest (e.g., full-time and part-time students may show different patterns of engagement and participation). Therefore, two sets of weight variables were pre-computed by NSSE for first-year and senior students, respectively,

using gender and enrollment status information taken from submitted population files and were included in the data set released to the institution. In this study, weights for gender and full-time/part-time status for senior students were used for calculating means and standard deviations of engagement indicators, perceived gains, and overall satisfaction. The GLM over other procedures allowed the inclusion of sample weights when calculating means and standard deviations of the targeted variables and therefore was employed for the calculation (Chen et al., 2009; NSSE, n.d.).

Lastly, due to the categorical nature of persistence or graduation status (“persisted or graduated” versus “not persisted nor graduated”), we conducted the chi-squared test and logistics regression to address the fourth research question, “How does participation in UGR relate to persistence or graduation status controlling for gender, racial and ethnic minority, first-generation, and low-income status?” The chi-squared test can be used for testing dependence or homogeneity (Franke et al., 2012) and in this study was used to test the proportional differences between students who did and did not participate in UGR based on ethnic minority, first-generation, and low-income status. Hierarchical logistic regression was performed to test for the association of predictive variables with “persisted or graduated” status by adding them as a block to the model one at a time. We included the UGR participation status as one block of the variables, in addition to gender, race and ethnicity, first generation status, and low-income status as one block of control variables. These two blocks of variables were entered into the predictive equation in a hierarchical order to examine which variables significantly predict the outcome variable of persistence or graduation status with an additional block of variables introduced. For the chi-squared test and logistic regression, the alpha level for statistical significance was set at 0.05.

### *Limitations*

We acknowledge the limitations of the study. First, due to the lack of availability of institutional data from other similar campuses, the study focuses on the examination of UGR on student outcomes in one teaching-focused, minority-serving institution. Institutional collaboration for cross-institutional comparisons of student engagement in UGR would help illuminate the reproducibility of the results. Second, the small sample size of UGR participants (13% of the survey-takers) could lead to bias in the results, which means there are not large enough numbers of each racial and ethnic group to allow for the examination of individual racial and ethnic groups. Future examination of the participation patterns of each individual racial and ethnic group by including more participants from each group or merging multiple years of NSSE data will extend current findings. Third, the study relies on self-reported measures of UGR, engagement, perceived gains, and overall satisfaction. Although NSSE relies on self-reported data, we do see a difference between UGR participants and non-participants in terms of persistence and graduation, suggesting the self-reported data is valid and reliable. Validated measures of students’ actual participation were not available but would clearly add to the reliability of this study. Future studies may include data from other sources and/or collect more qualitative data to triangulate with quantitative measures (McNair & Finley, 2013). Fourth, although the data of this study were collected in participants’ senior year, the participation of UGR did not necessarily happen only in the senior year. However, this study provides an informative snapshot of student experience with UGR *by* senior year.

### **Results**

We organized the results into three sections. Section I presents the results of engagement by UGR participation. Section II follows with results of perceived gains and overall satisfaction by UGR participation. Section III presents persistence or graduation results by disaggregating and comparing

the results by UGR participation and minority status, first-generation status, and low-income status, respectively. This section also includes the logistic regression results of persistence or graduation status on UGR participation, controlling for gender, race and ethnicity, first-generation status, and low-income status.

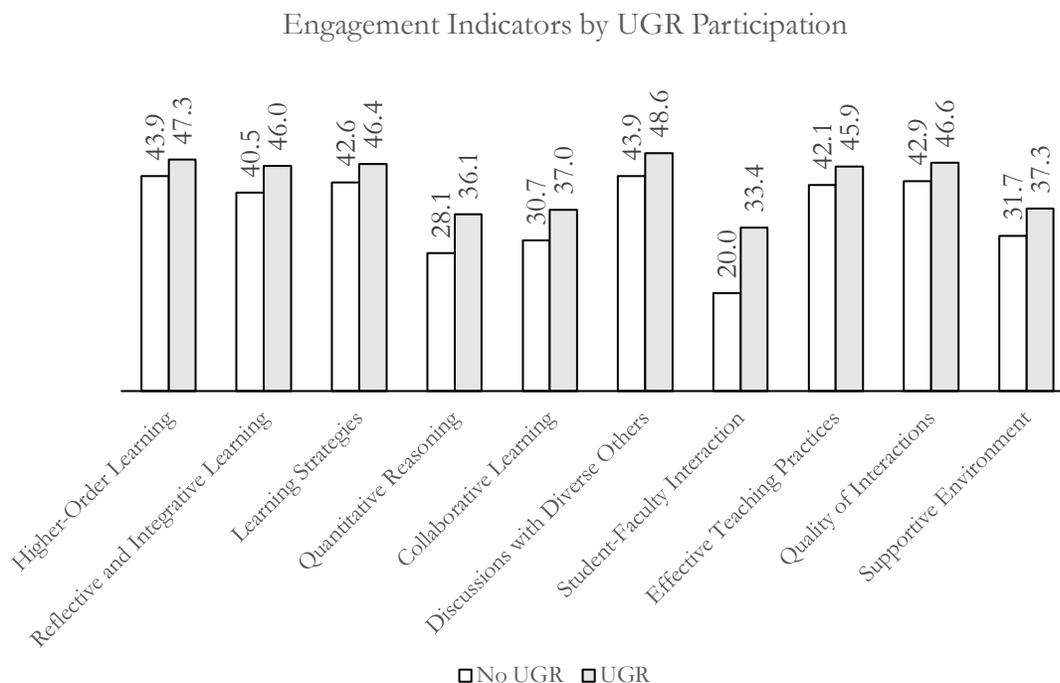
### *I. Engagement by UGR Participation*

In terms of engagement, there was a significant multivariate effect for engagement indicators between UGR participants and UGR non-participants,  $F(10, 1161) = 12.30, p < 0.001$ . UGR participants had significantly higher mean scores on all of the engagement indicators than their UGR non-participants,  $ps < 0.005$  (see Table 1 and Figure 1).

**Table 1. Means and standard deviations of engagement indicators by UGR participation status**

Engagement	No UGR		UGR		<i>F</i>	<i>p</i>
	<i>M<sup>a</sup></i>	<i>SD</i>	<i>M<sup>a</sup></i>	<i>SD</i>		
<i>Higher-Order Learning</i>	43.87	13.20	47.26	10.85	9.78	0.002*
<i>Reflective and Integrative Learning</i>	40.53	12.18	45.97	11.21	28.93	0.001**
<i>Learning Strategies</i>	42.62	13.85	46.43	11.84	11.10	0.001**
<i>Quantitative Reasoning</i>	28.12	16.03	36.10	16.02	35.08	0.001**
<i>Collaborative Learning</i>	30.71	14.89	37.03	13.98	25.95	0.001**
<i>Discussions with Diverse Others</i>	43.86	16.44	48.64	14.23	12.42	0.001**
<i>Student-Faculty Interaction</i>	20.01	15.18	33.44	16.86	107.32	0.001**
<i>Effective Teaching Practices</i>	42.11	14.54	45.86	12.08	9.86	0.002*
<i>Quality of Interactions</i>	42.88	13.28	46.60	11.07	11.64	0.001**
<i>Supportive Environment</i>	31.70	14.78	37.25	14.62	20.07	0.001**

a. Weighted Least Squares Regression - Weighted by Gender, FT/PT weight for FY, SR within the institution. \*  $p < 0.005$  (alpha was set at 0.005, which is 0.05 divided by the number of ANOVAs conducted. It equals to the number of dependent variables, 10 in this case), \*\*  $p < 0.001$ .



**Figure 1. Engagement indicators by UGR participation.** Average response scores to each question of the NSSE related to engagement is shown.

*II. Perceived Gains and Overall Satisfaction by UGR Participation*

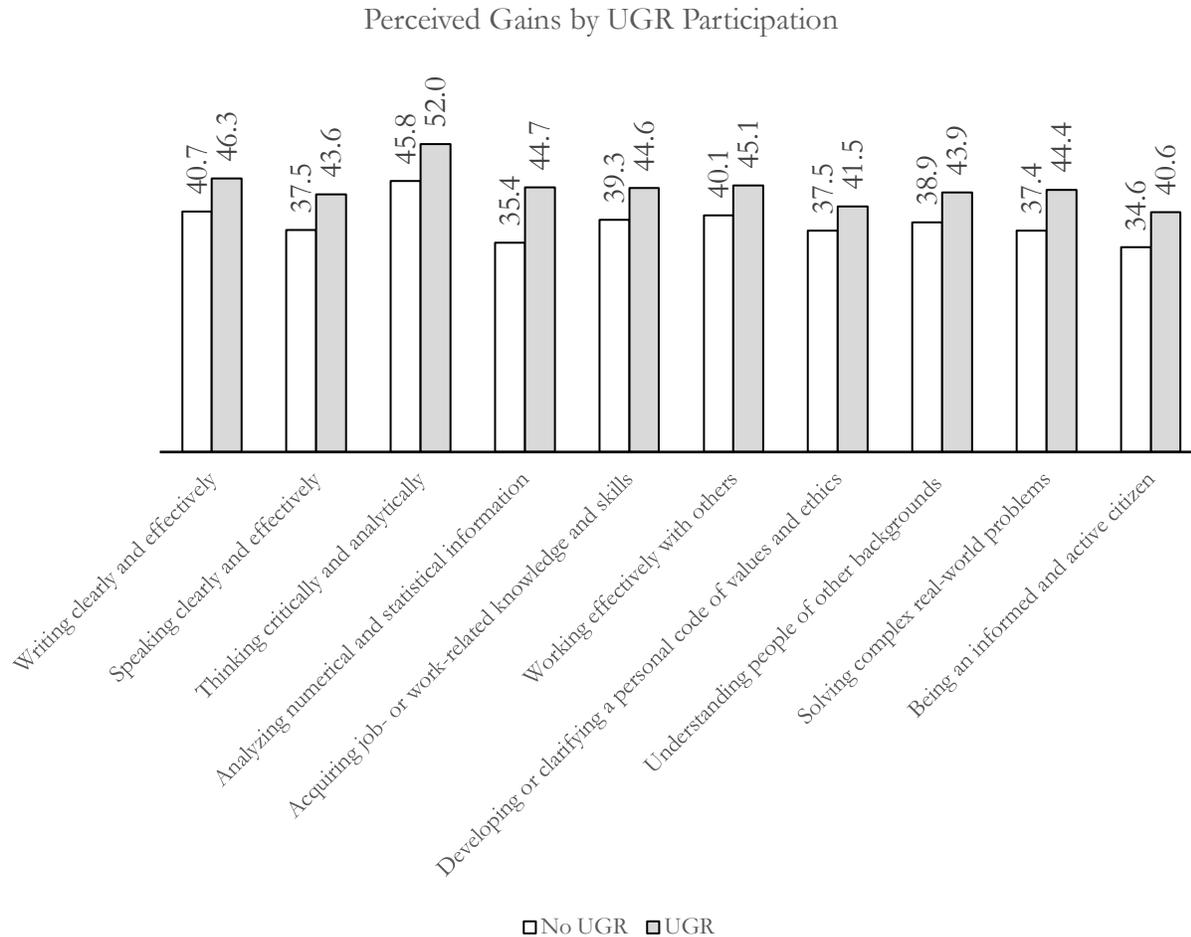
Regarding perceived gains, there was a significant multivariate effect for perceived gains between UGR participants and UGR non-participants,  $F(10, 1322) = 4.64, p < 0.001$ . UGR participants reported significantly higher scores on almost all of the perceived gains than their UGR non-participants,  $p < 0.001$ , except “*Developing or clarifying a personal code of values and ethics*” (see Table 2 and Figure 2). Similarly, there was a significant multivariate effect for perceived gains between UGR participants and UGR non-participants,  $F(1, 1394) = 12.33, p < 0.001$ . UGR participants reported a significantly higher level of overall satisfaction than their UGR non-participants,  $p < 0.001$  (see Table 2 and Figure 2).

**Table 2. Means and standard deviations of perceived gains and overall satisfaction by UGR participation status**

Perceived gains	No UGR		UGR		F	p
	M <sup>a</sup>	SD	M <sup>a</sup>	SD		
<i>Writing clearly and effectively</i>	40.69	17.73	46.25	15.96	15.71	0.001**
<i>Speaking clearly and effectively</i>	37.52	18.96	43.56	16.87	16.25	0.001**
<i>Thinking critically and analytically</i>	45.85	15.96	52.05	11.58	25.10	0.001**
<i>Analyzing numerical and statistical information</i>	35.37	19.97	44.72	16.88	35.53	0.001**
<i>Acquiring job- or work-related knowledge and skills</i>	39.31	19.67	44.63	17.63	11.72	0.001**
<i>Working effectively with others</i>	40.06	18.09	45.06	16.39	12.22	0.001**
<i>Developing or clarifying a personal code of values and ethics</i>	37.47	20.11	41.53	19.15	6.44	0.011

<i>Understanding people of other backgrounds</i>	38.87	18.98	43.93	17.12	11.35	0.001**
<i>Solving complex real-world problems</i>	37.43	19.30	44.38	16.88	20.88	0.001**
<i>Being an informed and active citizen</i>	34.60	20.21	40.59	18.20	14.06	0.001**
<i>Overall satisfaction</i>	47.97	13.93	51.86	11.20	12.35	0.001**

a. Weighted Least Squares Regression - Weighted by Gender, FT/PT weight for FY, SR within the institution. \*\*  $p < 0.001$  (alpha was set at 0.005, which is 0.05 divided by the number of ANOVAs conducted. It equals to the number of dependent variables, 10 in this case).



**Figure 2. Perceived gains by UGR participation.** Average response scores to each question of the NSSE related to perceived gains is shown.

### III. Persistence and Graduation Outcomes by UGR Participation

Table 3 presents whether a student persisted (re-enrolled or graduated) (see Table 3 Column 4) and whether they graduated by summer after reaching senior status (see Table 3 Column 5) by UGR participation and race and ethnicity, first-generation status, and low-income status. Overall, there is a significantly larger proportion of UGR participants (95.4%) still enrolled or graduated than their peer counterparts of UGR non-participants (88.3%). The trends hold true when disaggregating the results

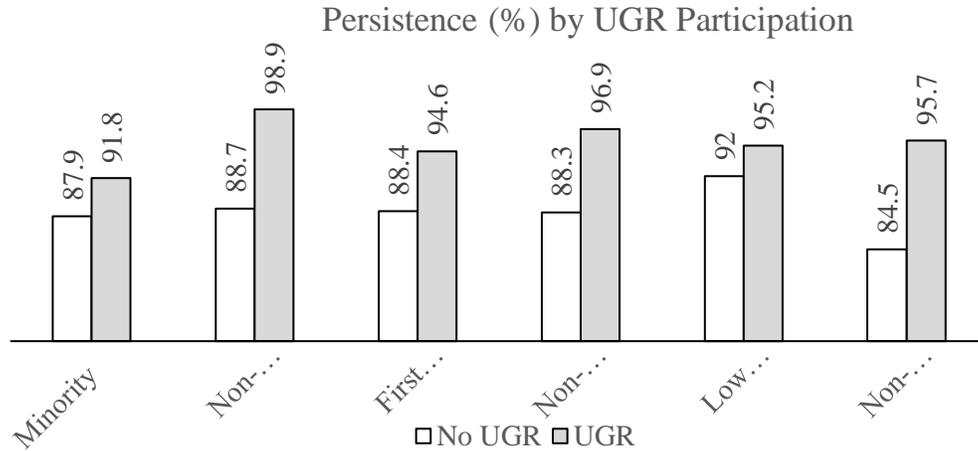
by minority, first-generation, and low-income status. A significantly larger proportion of UGR-participating students graduated compared to their non-participating peers, regardless of first-generation status or low-income status. Although ethnic minority UGR participants persisted at a higher rate (91.8%) than UGR non-participants (87.9%) (see Table 3, Column 4), the proportional difference was not significant.

**Table 3. Persistence or graduation by UGR participation, race/ethnicity, first-generation, and low-income status**

	UGR Participation	Total	Persisted (Re-enrolled or Graduated)	Graduated
Overall	No	1,278	1129 (88.3%)	441 (34.5%)
	Yes	194	185 (95.4%)	117 (60.3%)
	Total	1,472	1,314	558
	Statistical test		$\chi^2(1) = 8.66, p < 0.01$	$\chi^2(1) = 47.64, p < 0.01$
Minority	No	569	500 (87.9%)	196 (34.4%)
	Yes	97	89 (91.8%)	48 (49.5%)
	Total	666	589	244
	Statistical test		$\chi^2(1) = 1.22, p > 0.05$	$\chi^2(1) = 8.07, p < 0.01$
Non-Minority	No	672	596 (88.7%)	238 (35.4%)
	Yes	92	91 (98.9%)	65 (70.7%)
	Total	764	687	303
	Statistical test		$\chi^2(1) = 9.33, p < 0.01$	$\chi^2(1) = 41.98, p < 0.01$
First-Generation	No	825	729 (88.4%)	293 (35.5%)
	Yes	129	122 (94.6%)	76 (58.9%)
	Total	954	851	369
	Statistical test		$\chi^2(1) = 4.47, p < 0.05$	$\chi^2(1) = 25.75, p < 0.01$
Non-First-Generation	No	453	400 (88.3%)	148 (32.7%)
	Yes	65	63 (96.9%)	41 (63.1%)
	Total	518	463	189
	Statistical test		$\chi^2(1) = 4.45, p < 0.05$	$\chi^2(1) = 22.68, p < 0.01$
Low-Income	No	652	600 (92.0%)	257 (39.4%)
	Yes	124	118 (95.2%)	75 (60.5%)
	Total	776	718	332
	Statistical test		$\chi^2(1) = 1.48, p > 0.05$	$\chi^2(1) = 18.89, p < 0.01$
Non-Low-Income	No	626	529 (84.5%)	184 (29.4%)
	Yes	70	67 (95.7%)	42 (60.0%)
	Total	696	596	226
	Statistical test		$\chi^2(1) = 6.42, p < 0.05$	$\chi^2(1) = 26.90, p < 0.01$

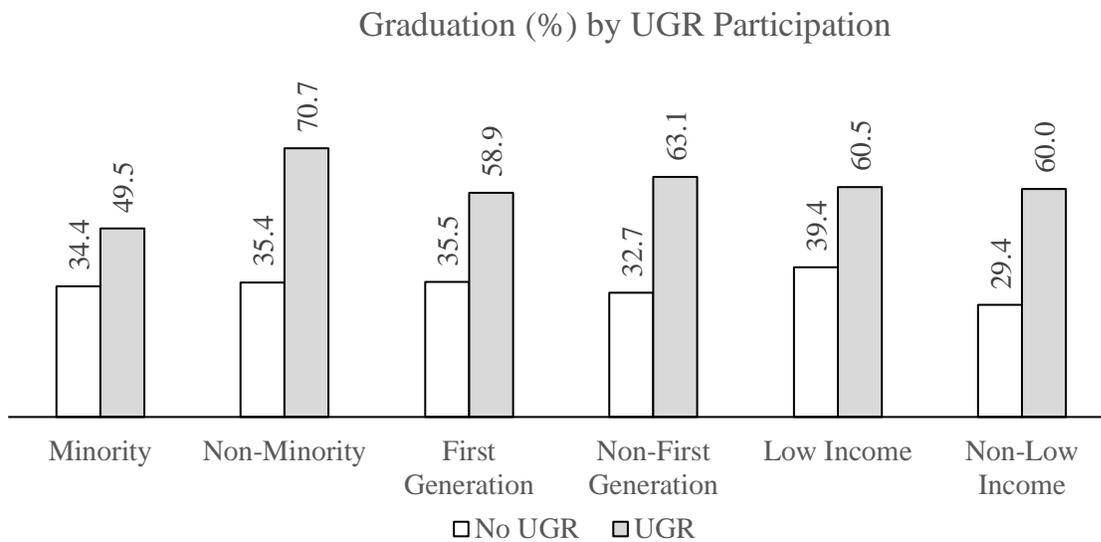
Regarding institutional outcomes, overall, we observed an increase in persistence for UGR participants vs. UGR non-participants. For seniors who participated in UGR, a significantly larger proportion graduated by summer after reaching senior status or re-enrolled in the next fall (95.4%) compared to their peers who did not participate in UGR (88.3%),  $\chi^2(1) = 8.66, p < 0.01, \phi = 0.07$ . The overall persistence boost is 7.1% for UGR participants against UGR non-participants (see Table 3 Column 4). The trends hold true for all subgroups examined, including minority, first-generation, and low-income students. A significantly higher proportion of students who participated in UGR

persisted or graduated than their UGR non-participants, regardless of race and ethnicity, first-generation status, and low-income status (see Table 3, Column 4 and Figure 3).



**Figure 3. Persistence Outcomes by UGR Participation.**

Similarly, overall, we observed higher rates of graduation for UGR participants compared to non-participants. For seniors who participated in UGRs, a significantly larger proportion graduated by summer after reaching senior status and completing the NSSE survey (60.3%) compared to their peers who did not participate in UGR (34.5%),  $\chi^2(1) = 47.64, p < 0.01, \phi = 0.18$  (see Table 3 Column 5). This was true across all subgroups examined, regardless of minority, first-generation, or low-income status (see Figure 4).



**Figure 4. Graduation Outcomes by UGR Participation.**

A logistic regression was conducted for persistence (fall to fall re-enrollment or graduation by summer after NSSE administration) on UGR participation controlling for gender, race and ethnicity, first-generation status, and low-income status. After controlling for other variables, the results indicated that UGR participation was a significant predictor of persistence, Wald  $F(1) = 6.93, p < 0.01$  (see Table 4). This indicates that there is a positive relationship between UGR participation and persistence. If a student participated in UGR, the odds of this student persisting would increase by 155 percent. First-generation status was also a significant predictor of persistence status, Wald  $F(1) = 16.11, p < 0.01$  (see Table 4). Being a first-generation student, the odds of that student being retained or graduated would increase by 105 percent. Gender, race and ethnicity, and low-income status were not significant predictors of retention or graduation status, Wald  $F(1) = 2.77, 1.788, \text{ and } 0.186, p > 0.05$ , respectively (see Table 4).

**Table 4. Regression results of retention or graduation status on UGR participation (controlling for other variables).**

	B†	SE‡	Wald§	df**	p††	Exp(B) ‡‡
Gender	-0.336	0.202	2.770	1	0.096	0.715
Ethnic Minority	-0.232	0.173	1.788	1	0.181	0.793
First-Generation Status	0.718	0.179	<b>16.11§§</b>	1	<b>0.001</b>	<b>2.050</b>
Low-Income Status	-0.079	0.183	0.186	1	0.666	0.924
UGR	0.935	0.355	<b>6.928</b>	1	<b>0.008</b>	<b>2.548</b>
Constant	1.934	0.183	111.272	1	0.001	6.920

\* Hierarchical linear regression is a statistical technique that tests for the influence variables by adding them to the model one at a time.

† B lists the partial logistic regression coefficients for each independent variable.

‡ S.E. or standard error measures the accuracy with which a sample represents a population.

§ Wald is a way of testing the significance of independent variables in a statistical model.

\*\* df or degree of freedom is the number of values in the study that are free to vary.

††  $p$  is an estimate of the probability that the result occurred by statistical accident. A low level of  $p$  indicates a high level of statistical significance.

‡‡ Exp(B) list the odds ratios, which are used to assess the isolated impact of each independent variable.

§§ Bold indicates statistically significant results.

## Discussion

### *The Relationship between UGR Participation and Engagement*

UGR participants reported significantly higher scores on all of the engagement indicators compared to their UGR non-participants. Their multiple and positive experiences with the four NSSE engagement themes (i.e., being academically challenged, learning with peers, working with faculty, and having a supportive environment to thrive) were reflected in their responses. Notably, students reported higher scores of student-faculty interactions, quantitative reasoning, and collaborative learning experiences (13.4, 8.0, and 6.3 higher for UGR participants compared to non-participants, respectively, see Table 1 and Figure 1). This is important because these represent relationship-building and skills-development that can contribute to persistence, completion, and improved performance in graduate school or the workforce. UGR opportunities promote teamwork where students can learn from one another and employ collaboration and communication skills in authentic situations that they wouldn't otherwise practice in a classroom, and this is reflected in the 6.3 increase of reported experience with collaborative learning. Students must contribute collectively, as well as be held

accountable to accomplish tasks independently when engaged in research teams (Madan & Teitge, 2013). Whether students choose to go on to graduate school or join the workforce upon graduation, knowing how to work in teams and communicate with diverse colleagues are highly valued skills (Baird & Parayitam, 2019).

In addition, these results confirm that UGR requires participants to use higher order thinking and metacognitive skills (UGR participants reported 3.4 higher gains in higher order learning and 5.5 gains in reflective and integrative learning, respectively, compared to non-participants). In conducting research, students have to collect, apply, analyze, and synthesize, as well as interpret and evaluate information that is being studied. The direct impact of UGR on metacognition has been reported by Dahlberg et al. (2019) and Kortz and van der Hoeven Kraft (2016), but this NSSE data from seniors implies that the gains are recognized by the student participants and persist to the senior year, even if the research happened previously. Too often institutions of higher education are criticized for not facilitating the development of higher order thinking skills among students (Arum & Roksa, 2011), but UGR may be a way to ensure students hone these skills.

Lastly, the 13.4 gain in UGR participants reports of student-faculty interaction compared to non-participants is worth celebrating. One of the most important factors in students' success in college is their interactions with faculty (Anaya & Cole, 2001; Campbell & Campbell, 1997; Chickering & Gamson, 1987; DeAngelo et al., 2016; Eagan et al., 2013). Students who participate in UGR have *regular* and *meaningful* interactions with faculty (Taraban & Logue, 2012). Students who work with a faculty mentor achieve higher academic performance, gain networking opportunities and feel welcomed into the discipline, and develop confidence (DeAngelo et al., 2016). These interactions are especially important for underrepresented minority students who may have an increased sensitivity to mentoring relationships (Jones et al., 2010; Lopatto, 2004). That UGR facilitates such increased perception of these interactions at a teaching institution, where research is likely occurring in non-traditional ways, is note-worthy.

### *The Relationship between UGR Participation and Perceived Gains and Overall Satisfaction*

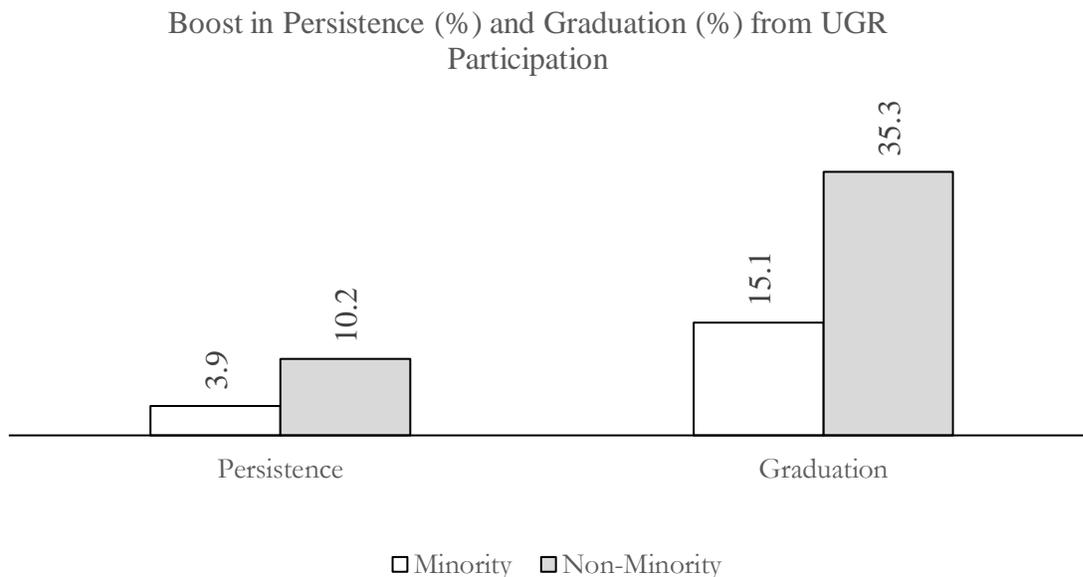
UGR participants reported significantly higher scores on almost all of the perceived gains compared to UGR non-participants and had significantly higher levels of overall satisfaction (the only gain that was not significantly increased was “developing or clarifying a personal code of values and ethics”, see Table 2). Notably, UGR participants had higher gains compared to their non-participant peers in analyzing numerical and statistical information (9.3 point gain), solving complex real-world problems (7 point gain), thinking critically and analytically (6.2 point gain), and being an informed and active citizen (6 point gain) (see Table 2). In today's day and age, we think all efforts that increase these metrics in students should be employed.

Students who participated in UGR positively evaluated their educational experiences, said they would go to the same institution if they had to start over, and reported positive relationships with peers, advisors, faculty, staff, and students (data not shown). Participating in UGR promotes perceived gains in personal (e.g., understanding people of different backgrounds), practical (e.g., working effectively with others), and general education competency (e.g., solving complex real-world problems) areas, as well as higher satisfaction in their educational experience. These types of gains had been documented in both an apprentice-type research experience and a CURE (Kinner & Lord, 2018; Williams et al., 2016), though both these previous reports focused exclusively on self-reported gains immediately after a single STEM course or summer research experience at a research university. We demonstrate that these gains occur at teaching institutions and potentially persist far beyond the actual UGR experience.

*The Relationship between UGR and Persistence and Graduation Disaggregated by Race and Ethnicity, First-generation Status, and Low-income Status*

Participating in UGR positively impacts persistence (re-enrollment or graduation by the fall following NSSE administration) or graduation. In this study, a significantly higher proportion of students who participated in UGR graduated within one year of becoming a senior (60.3%) than non-participants (35.4%). This trend was true regardless of minority, first-generation, or low-income status. These findings corroborate studies noted earlier in the paper; working on novel research with a faculty member positively impacts student retention and graduation (Eagan et al., 2013; Lopatto, 2010; Seymour et al., 2004).

It is worth noting that we did observe a significant racial equity gap in the impact of UGR when it comes to persistence and graduation. While an admirable 91.8% of UGR participating racial and ethnic minority students persisted, the percent of non-minority UGR participants that persisted was 98.9% (Table 3 Column 4, and Figure 3). Even more startling is the fact that only 49.5% of minority UGR-participants in our data set graduated by summer after reaching their senior status, compared to 70.7% non-minority UGR-participants (Table 3 Column 5, and Figure 4). The “boost” in persistence and graduation rates for non-minority students is significantly higher than it is for minority students (see Figure 5). While we cannot eliminate the possibility that there were compounding factors that could impact this data, such as unique disciplinary differences, we suspect the data is straightforward: minority students face additional obstacles that opportunities like UGR are not sufficient in eliminating. Interestingly, there was almost no gap in graduation rates between low-income and non-low-income UGR participants (60.5% compared to 60.0% respectively, see Figure 4), so the racial equity gap may not be due to intersecting economic barriers. Similarly, there was only a small difference in the percent of UGR-participating first-generation students that graduated within a year of starting their senior year (58.1%) compared to non-first-generation students (63.1%). As teaching institutions develop additional UGR opportunities, it is critical that faculty and administrators evaluate the literature on how best to support, retain, and graduate minority students.



**Figure 5. Persistence and Graduation Boost by UGR Participation for Minority and Non-Minority.**

### *Overall Impact of UGR*

UGR is positively associated with higher perceived gains, satisfaction, persistence, and graduation. We recognize that we cannot conclude that UGR causes improved outcomes, as students that are more likely to be engaged or satisfied or likely to persist/graduate could be more likely to participate in UGR. Indeed, Webber and colleagues (2013) reported that some students (i.e., students in STEM, students participating in Greek life, students attending full-time, and students with higher GPAs) were somewhat more likely to participate in UGR. However, Fechheimer and colleagues (2011) have shown that participation in research-based classes at a research university led to significant increases in academic success outcomes, even when they controlled for SAT scores - a measure of academic ability prior to the UGR experience. This contradicts an explanation of more engaged or capable students selecting UGR and thus performing better. Although we cannot claim causality, there is clearly a positive relationship between UGR and academic success/completion, and this has implications at different levels. As stated earlier, there is a dearth of literature on why students *do not* participate in research. Lack of time (Stout, 2018), working a significant number of hours outside of school (Falcon, 2015; RTI International, 2019), and challenges balancing between time and research are cited in the literature. Because the gains for students are so large and so consistent, we would argue that teaching colleges continue to find ways to involve more students in UGR or reduce/eliminate barriers to these activities (several suggested mechanisms are discussed below). Still, the impacts of these activities at this institution were higher for non-minority students, and thus additional interventions to support these students must be considered. Future studies should increase the sample size so individual racial/ethnic groups can be examined. In addition, qualitative interviewing/focus groups of minority students to understand why gains from UGR participation are not equal in terms of persistence and graduation would be useful.

### *Approaches Teaching-Centered Colleges Can Take to Enhance UGR*

One of the easiest ways for teaching-centered colleges to curate additional UGR opportunities is to embrace existing CUREs that are intended to be reproduced and in fact leverage crowd-sourced data from multiple institutions. These are most commonly in the sciences and are aimed at introductory-level courses, making them accessible even at community colleges. For example, the Howard Hughes Medical Institute's Science Education Alliance (SEA) has both a PHAGES program and subsequent GENES program to characterize novel bacteriophages and is open to all 2-year and 4-year institutions (<https://www.hhmi.org/science-education/programs/science-education-alliance>). Yale University created the Small World Initiative, [www.smallworldinitiative.org](http://www.smallworldinitiative.org), which boasts an international network to curate the world's next highly-needed antibiotics. These programs offer resources and support for faculty joining these projects. While limited, some entities are trying to curate existing CURE projects, such as CureNet (<https://serc.carleton.edu/curennet/index.html>), which can be a resource for teaching institution faculty, as well.

There are promising opportunities for the humanities and social sciences to embed research in their courses, as well. For example, for those in psychology, the Collaborative Replications and Education Project (<https://osf.io/wfc6u/>) strives to find groups, such as classes, to reproduce highly-cited studies, and the Emerging Adulthood Measured at Multiple Institutions project (<https://osf.io/te54b/>) seeks new collaborators to help investigate attitudes, behaviors, and beliefs related to emerging adulthood. General faculty can visit Zooniverse.org to find 25 crowd-sourced data projects that their students can engage with and discuss, from transcribing supreme court justice's hand-written notes or tracking the life histories of historical criminals to classifying baby speech sounds (Zooniverse.org). The Council on Undergraduate Research ([www.cur.org](http://www.cur.org)), while requiring

membership, has archived highlights of collaborative undergraduate research projects in broad disciplines from the arts and humanities to social sciences to engineering. Others have published about course-based methods in community-based surveys for social science courses (Crowe & Boe, 2019), as well as the use of existing databases or community-generated data for research in introductory statistics courses (Le, 2020). At our Institution, faculty in Psychology leverage methodology courses to implement short but authentic research projects among student groups.

Inspiration can be found nationally and locally for increasing research opportunities. Community colleges can gain inspiration from the Community College Undergraduate Research Initiative (<https://www.ccuri.org/>), which has established a large network across the country to develop opportunities for research. Research experiences range from field work and laboratory investigations to interview transcription, recording and data entry, or basic analyses requiring what would be expected in a collegiate statistics course. Even the use of student workers as research assistants can be a modern modification to the traditional apprentice model. In all disciplines, there is also the opportunity for local collaboration to undergird novel experiences for students: community colleges can partner with local research institutes, and professional school faculty (such as those in Education or Nursing) can collaborate with local organizations (schools, hospitals, non-profits, etc.) to engage in action research.

Administrative support is also critical to the initiation and success of undergraduate research at teaching-centered colleges. At our institution, the Provost provided seed-funding awards for faculty scholarship that involved students and provided compensation for several faculty to engage in a summer institute to construct/revamp courses to embed scholarly research. For example, this enabled a history faculty member to develop a collaboration with a local fire department to create a multi-semester project for students to archive and research unique materials, untouched for fifty years, from firehouse storage. Centralized support for grant writing and submission, library resources with sufficient staff and adequate access to materials, travel support for sharing work, and recognition and compensation for faculty mentoring of undergraduate researchers are also ways administration can facilitate growth in UGR at teaching-centered institutions and community colleges (Marwick, 2012). While curriculum is a product of the faculty, there are certainly ways in which the administration can collaborate with faculty on curricular requirements for UGR and support faculty in course redesign. Policies can be generated that allow faculty to leverage independent study projects with students into future course releases. Studies have shown faculty are willing and eager to engage with students in activities like UGR, but in the end, administrators are key in ensuring that the *benefits to faculty* reflect the subsequent benefits to students and facilitate their choices to make greater UGR opportunities a reality (Eagan et al, 2011).

## Conclusion

In this study, we sought to examine whether there were differences in seniors' level of engagement, perceived gains, and overall satisfaction relative to their participation in UGR in a regional, comprehensive institution. Additionally, the extent to which participation in UGR impacted persistence and graduation after reaching the senior year was explored. The findings yielded positive results in all outcomes, demonstrating the importance of UGR at teaching-centered institutions.

Undergraduate research can be implemented and leveraged at teaching-focused colleges to enhance the student experience, as well as assist in critical persistence and graduation imperatives. Teaching colleges can and should embrace a variety of UGR methods, from CUREs to modified credit-bearing apprenticeship models with flexibility for diverse student needs. Faculty across disciplines could be encouraged to embed authentic inquiry experiences in their classes to increase their students' knowledge and skills in research. While selected disciplines in teaching colleges, for

example education and nursing, might have a more difficult time embedding research into their courses due to the high number of required clinical hours in the field and other licensure requirements, targeted professional development and mentoring could assist faculty in embedding meaningful research opportunities for students in their courses that would enhance the overall learning experience. While historically UGR has been more prominent at research institutions, many types of UGR can be adapted to teaching institutions, including CUREs, research internships for credit, and modified apprentice models where small numbers of students work directly with a faculty member on a study for credit. Colleges should find and fund mechanisms to help train faculty to build these kinds of courses and programs and support these programs with space and administrative support. The return on investment is clear: enhanced engagement, gains, satisfaction, persistence, and graduation, all of which will lead to more adaptive, qualified, and fulfilled alumni.

### Appendix

	Question in NSSE	Example Items
<b>I. Student Engagement Indicator</b>		
<b>Higher-Order Learning (HO)</b>	<i>During the current school year, how much has your coursework emphasized the following</i> (Very much, quite a bit, some, very little)	Applying facts, theories, or methods to practical problems or new situations Analyzing an idea, experience, or line of reasoning in depth by examining its parts
<b>Learning Strategies (LS)</b>	<i>During the current school year, how often have you</i> (Very often, often, sometimes, never)	Identified key information from reading assignments Summarized what you learned in class or from course materials
<b>Quantitative Reasoning (QR)</b>	<i>During the current school year, how often have you</i> (Very often, often, sometimes, never)	Reached conclusions based on your own analysis of numerical information (numbers, graphs, statistics, etc.) Used numerical information to examine a real-world problem or issue (unemployment, climate change, public health, etc.)
<b>Collaborative Learning (CL)</b>	<i>During the current school year, how often have you</i> (Very often, often, sometimes, never)	Asked another student to help you understand course material Prepared for exams by discussing or working through course material with other students
<b>Discussions with Diverse Others (DD)</b>	<i>During the current school year, how often have you had discussions with people from the following groups</i> (Very often, often, sometimes, never)	People from a race or ethnicity other than your own People from an economic background other than your own
<b>Student-Faculty Interaction (SF)</b>	<i>During the current school year, how often have you</i> (Very often, often, sometimes, never)	Talked about career plans with a faculty member Worked with a faculty member on activities other than coursework (committees, student groups, etc.)
<b>Effective Teaching Practices (ET)</b>	<i>During the current school year, to what extent have your instructors done the following</i> (Very much, quite a bit, some, very little)	Clearly explained course goals and requirements Used examples or illustrations to explain difficult points
<b>Quality of Interactions (QI)</b>	<i>Indicate the quality of your interactions with the following people at your institution</i> (1: Poor to 7: excellent)	Students Academic advisors Faculty
<b>Supportive Environment (SE)</b>	<i>How much does your institution emphasize the following</i> (Very much, quite a bit, some, very little)	Providing support to help students succeed academically Using learning support services (tutoring services, writing center, etc.)
<b>II. Perceived Gains (PG)</b>		
	<i>How much has your experiences at this institution contributed to your knowledge, skills, and personal development in the following areas?</i> (Very much, quite a bit, some, very little)	Writing clearly and effectively Acquiring job- or work-related knowledge and skills
<b>III. Overall Satisfaction (OS)</b>		

<b>Evaluation (EV)</b>	<i>How would you evaluate your entire educational experience at this institution?</i>	Excellent, good, fair, and poor
<b>Whether go to the same institution (SI)</b>	<i>If you could start over again, would you go to the same institution you are now attending?</i>	Definitely yes, probably yes, probably no, definitely no

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