PURM
Perspectives on Undergraduate Research & Mentoring

The Role of Self-Efficacy in the Relationship between Undergraduate Research and Graduation at a Hispanic Serving Institution

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Introduction

Institutions of higher education have been challenged to provide meaningful experiences to students that encourage active engagement and academic persistence. Undergraduate research is one such high impact practice that is beneficial for students' academic outcomes (e.g., GPA, retention, graduation; e.g., Collins et al, 2018; Nagda et al., 1998). This research defines undergraduate research broadly as any inquiry based activity that is mentored and contributes to the understanding of the student within a discipline. The type of activities can be within a course or outside of the curriculum. The mentors in our research are largely faculty members within our institution but can include faculty members from other institutions or industry professionals that are affiliated with our institution. Our prior research suggests that the odds of graduating for students who participated in research-related activity at a state Hispanic-Serving polytechnic university is almost twice those of students who did not participate in research-related activities (Dong et al., 2024). Research has examined the role of numerous mechanisms and psychological factors in the relationship between participation in undergraduate research and persistence, including self-efficacy (e.g., DeWitz et al., 2009; Ritchie, 2019), skill acquisition (e.g., Kilgo et al., 2015; Reissner & Armitage-Chan, 2024), sense of belonging (Estrada et al., 2018; Strayhorn, 2012), research identity (e.g., Merolla & Serpe, 2013), and faculty mentorship (e.g., Crisp & Cruz, 2009; Raposa et al., 2021).

It is important that research not only examines potential factors that underlie the relationship between participation in undergraduate research and graduation but also investigates the relative strength of each factor in driving this relationship. This information is of practical value to student-support programs with limited resources. This study specifically examined the role of sense of belonging, academic self-efficacy, mentor presence, mentor quality, and perceptions of the utility of education in the relationship between participation in undergraduate research and graduation.

Academic Self-Efficacy

Self-efficacy is a person's belief in their ability to perform a specific behavior or accomplish a particular goal (Bandura, 1977, 1986, 1997). When in reference to the academic domain, it is the learners' beliefs about their ability to successfully attain educational goals (Elias & MacDonald, 2007). Findings from meta-analyses indicate that academic self-efficacy is a determinant of academic performance, reporting moderate effect sizes (Richardson et al., 2012; Robbins et al.,

2004; Honicke & Broadbent, 2016). Academic self-efficacy is derived from mastery experiences, social learning (e.g., observing successful others), verbal persuasion (e.g., words of encouragement), and information conveyed by one's emotional reaction to a related situation (Bandura, 1997).

Undergraduate research often serves as an opportunity for students to develop self-efficacy through mastery experiences, social learning, and mentor encouragement (e.g., Chemers et al., 2011; Raposa et al., 2021; Sadler et al., 2010). Students who are engaged in an authentic research experience observe mentors and peers who conduct research and practice and master research-related skills. Authentic research experiences are generally defined as opportunities in which students "experience what scientists do, how science is done, and what science is" (Rowland et al 2017). This type of experience likely influences students' beliefs about their ability to succeed and grow. Indeed, there is research to suggest that undergraduate research experience is positively correlated with research skill self-efficacy (e.g., Bailey et al., 2020; Burke & Prieto, 2019; Chemers et al., 2011; Robnett et al., 2015). This study examines whether research experience is associated with students' beliefs about their ability to attain educational goals in general (rather than in research specifically) and to what extent academic self-efficacy underlies the relationship between undergraduate research and graduation.

Sense of Belonging

The need to belong or maintain social connections is a fundamental human motivation (e.g., Baumeister & Leary, 1995). Qualitative research by Ahn and Davis (2020) revealed four domains of sense of belonging including academic (i.e., curriculum, university, discipline engagement), social (i.e., student organizations, meaningful relationships), surroundings (i.e., culture, living space, and accommodations), and personal (i.e., life satisfaction, attitudes, identity, and personal interest). Sense of belonging in an academic domain reflects "the feeling that one fits or belongs, or is a member of the academic community in question…and the sense that one is valued and accepted by fellow members of the discipline" (Good et al., 2012, p. 700). In academic settings, sense of belonging in an academic discipline is a critical determinant of interest, achievement, and persistence in that discipline (Kandiko & Kingsbury, 2024; Rosenthal et al., 2013; Smith et al., 2013; Walton & Cohen, 2007).

Undergraduate research experience provides students with an opportunity to work with individuals with common interests (e.g., faculty research mentors, peers) toward a shared goal and become socialized into the community (NASEM, 2017). Both research training programs and curricula that include "authentic" research experiences are associated with students' greater experiences of belonging in the science community (e.g., Estrada et al., 2018; Jordan et al., 2014). Students who have positive interactions and guidance from faculty mentors and peers while engaging in research are likely to feel welcome in the field. This study examines whether research experience is associated with students' sense of belonging at the university in general (rather than in a specific discipline) and whether feelings of connectedness help explain the relationship between undergraduate research and graduation.

Mentoring

Although mentoring has been defined in numerous ways across the literature, in general, it is described as a relationship between individuals, whereby the more experienced individual provides varying forms of support to help the less experienced individual(s) develop and accomplish goals (e.g., Crisp et al., 2017). In a university setting, faculty, staff, and peer mentors can provide psychological and emotional support, degree and career support, academic / subject knowledge support, and serve as a role model (Crisp & Cruz, 2009; Raposa et al., 2021; Strayhorn & Terrell, 2007). Depending on the campus, mentoring may include informal and/or formal structured approaches, but one common theme is that the relationship is tied to demystifying, enriching, and

stretching the mentees' thinking in identity formation as a college student and student researcher. Thus, mentoring provides an opportunity for sharing social and cultural capital (Bensimon, 2007; Turner, 2015).

One of the defining characteristics of undergraduate research is that the experience is "structured and guided by a mentor, with students assuming increasing ownership of some aspects of the project over time" (NASEM, 2017, p. 34). Mentoring is often the process by which the student is exposed and socialized into the culture of the research environment, their discipline and/or profession. Research suggests that high-quality mentorship within the context of undergraduate research is associated with self-reported gains in self-efficacy, research skills, retention, feeling integrated into the field, and a sense of belonging (e.g., Chemers et al., 2011; Crisp, 2010; Estrada, et al., 2018; Laursen et al., 2010; Linn et al., 2015; Sadler & McKinney, 2010). This study explores the role of mentoring in the relationship between participation in undergraduate research and graduation.

Utility Value

Expectancy-value theory posits that expectancies for success and perceived task value contribute to students' motivation and academic performance (e.g., Eccles-Parsons et al., 1983; Eccles & Wigfield, 2020). One type of task value is utility value, which refers to a task that is perceived relevant or useful for current or future goals. Research suggests that perceptions of utility value of learning tasks significantly predict students' interest, performance, and persistence in a field, particularly for students who are most likely to underperform (e.g., Canning et al., 2018; Hulleman et al., 2010; Harackiewicz et al., 2012). Although Eccles and colleagues (1983) define utility value as the usefulness of a task for one's own goals, interventions have used broader conceptualizations of utility value, such as having students relate learning material to their own life and the lives of others (Priniski et al., 2019).

High quality undergraduate research experiences are often designed to make content relevant and accessible, promote autonomy, emphasize collaboration, and make thinking visible (NASEM, 2017). Relevance in this context is analogous to perceived utility value. Undergraduate research experiences should help students recognize the utility value of course material by situating the research in the context of significant problems of interest to those in the field and in some cases to the broader community. Students who are made aware of how their research contributions fit into the big picture of the overall project are likely to see how their work is relevant and important in achieving the research objectives. This study examines the role of perceived utility in the relationship between participation in undergraduate research and graduation.

Current Study

The current study examines the roles of academic self-efficacy, sense of belonging, mentoring, and perceptions of utility of education in the relationship between participation in undergraduate research and graduation. In this study, participation in research is broadly defined – it spans beyond disciplinary boundaries and includes participation in research-related activities including internships and other career-initiating positions (e.g., activities that train students to be professionals in their disciplines). The current study also investigates the relative strength of each of these factors in explaining the relationship between undergraduate research and graduation rates.

Background/Motivation for Study

California State Polytechnic University, Pomona (Cal Poly Pomona) is located in the Inland Valley region of Southern California in northeast Los Angeles County. One of only six polytechnic universities nationwide, CPP is a comprehensive public university widely recognized for its polytechnic mission and learn-by-doing philosophy. The campus currently enrolls 26,973 students, with 23,748 (91%)

being undergraduates and 2,130 (9%) being graduate students. As a state university located in a multi-cultural urban metropolis, Cal Poly Pomona provides access to higher education for a large number of Hispanic and low-income students. Cal Poly Pomona is designated by the U.S. Department of Education as a Hispanic-serving institution (HSI) with Hispanic students accounting for nearly 50% (14,421) of the student body. Eighty-two percent (23,950) of its student population identifies themselves as non-white. Approximately 58% of the student population are first-generation college students and 46% are considered financially needy by federal standards (Pell-eligible).

Cal Poly Pomona is one of three polytechnic universities within the 23-campus California State University (CSU) system. As demand for accountability increases in higher education, the CSU system has responded through its Graduate Initiative (GI) 2025. GI 2025's goals are to increase graduation rates for all CSU students across its 23 campuses while eliminating opportunity and achievement gaps. The CSU system has identified several key factors that impact students' time to degree completion. Investment in the GI 2025 comes with the focus on addressing those factors: 1) Academic Preparation, 2) Enrollment Management, 3) Student Engagement and Well-Being, 4) Financial Aid, 5) Data-Informed Decision Making, and 6) Administrative Barriers. The campus has developed an institutional, coordinated strategy for student success efforts throughout campus resources to address the six GI 2025 factors that affect college completion.

Cal Poly Pomona's long-term plan to achieve GI 2025 goals includes scaling investments in high impact practices (HIPs; e.g., Kuh, 2008; Kuh et al., 2015) that focus on underrepresented students and work toward eliminating the equity gap. The Office of Undergraduate Research (OUR) is one of the targeted support services, and student engagement in undergraduate research has been identified as a HIP that can potentially increase graduation rates and narrow differences in graduation rates between various student populations. Indeed, based on a previous longitudinal study of 6,654 unique Cal Poly Pomona students between 2015 – 2018, it was found that undergraduate research, and related activities, have positive impacts on graduation rates at a large, public, urban HSI (Dong et al., 2024).

The purpose of this study is to determine what factors contribute to the increase in graduation rates for students who participate in undergraduate research and related activities. By understanding the most salient factors, universities will be able to enhance undergraduate research experiences by ensuring conditions that support the positive contributing factors such as sense of belonging, academic self-efficacy, etc. Additionally, universities can also ensure that these contributing factors are folded into other student engagement activities in addition to undergraduate research.

Three research questions guided our study:

1. How is research participation related to sense of belonging, academic self-efficacy, mentor presence, mentor quality, and perceptions of the utility of education?
2. To what extent do the variables of interest that differ by research participation predict graduation?
3. To what extent do the variables of interest mediate the relationship between research participation and graduation?

Materials and Methods

Materials and Procedure

This study employed data from several sources: two surveys (the multi-year Research Climate Survey and the one-time Supplemental Survey) and Cal Poly Pomona institutional data. Prior to data collection, this study was approved by the Cal Poly Pomona Institutional Review Board (eIRB #14-0410). Each of the data sources is described in detail below.

Research Climate Survey
Beginning in fall 2015, the OUR administered the annual Research Climate Survey, designed to measure campus-wide undergraduate student research participation (see Dong et al., 2024). On the survey, students were asked to indicate the types of research activities they participated in during the previous academic year (excluding those as part of coursework).

During the fall 2018 survey administration, students were also asked if they would like to participate in additional surveys or focus groups, with the opportunity to receive incentives. Students who selected "yes" were prompted to provide a contact email address.

Supplemental Survey
The Supplemental Survey instrument was designed to measure hypothesized constructs that may connect research participation to graduation. The sampling frame was derived from students who indicated interest in participating in additional surveys during the fall 2018 Research Climate Survey. Students were contacted in November 2018 via an email from the OUR to their provided email address. The survey remained open for four weeks and students who had not yet completed the survey received weekly email reminders. Students who completed the Supplemental Survey were offered entry into a drawing for a $100 gift card.

Institutional Research Data
Student academic and demographic data were requested from Cal Poly Pomona's Institutional Research, Planning, and Analytics (IRPA) office in fall 2020. The student IDs of respondents to the Supplemental Survey were provided to the office and used to link survey responses to institutional data.

Measures
Research Participation. On the Research Climate Survey, students could select all of the activities they had participated in during the previous year from the following list:

- Internship with professional in their academic field of interest
- Training under professional in their academic field of interest
- Internship with industry
- Research or project with a Cal Poly Pomona faculty member
- Research or project outside of Cal Poly Pomona
- Participation in other activities that trained them to be a professional in their discipline (e.g., relevant off-campus employment, community service)
    - Students were asked to provide an example (open-ended)
- None

Sense of Belonging. Sense of belonging was measured in the Supplemental Survey by Walton and Cohen's (2007) eight-item scale (rated from 1 = "Strongly disagree" to 5 = "Strongly agree"). The scale was adapted to reflect sense of belonging at Cal Poly Pomona (e.g., I feel like I belong in my major at Cal Poly Pomona). The internal consistency of the scale as measured by Cronbach's α (.92) was closely aligned to the published α (.91).

Academic Self-Efficacy. Academic self-efficacy was measured on the Supplemental Survey by Pintrich & DeGroot's (1990) nine-item Strategies for Learning Questionnaire (MSLQ) self-efficacy subscale (rated from 1 = "Not at all true of me" to 7 = "Very true of me"). Items were adapted to reflect beliefs about success in the student's major at Cal Poly Pomona (e.g., Compared with others

in my major at Cal Poly Pomona, I think I'm a good student). The internal consistency of the scale as measured by Cronbach's α (.95) was slightly higher than the published α (.89).

Utility and Intrinsic Value of Education. Beliefs about of the utility of education were measured on the Supplemental Survey using three scales (value to self, value to society, and intrinsic value). The first was Hulleman et al.'s (2010) three-item utility value scale (rated from 1 = "Strongly disagree" to 7 = "Strongly agree"). Items were adapted to reflect the value of what students are learning in their major courses at Cal Poly Pomona (e.g., What I am learning in my major courses at Cal Poly Pomona is relevant to my life). The internal consistency of the scale as measured by Cronbach's α (.91) was closely aligned to the published α (.88). The second was Jackson et al.'s (2016) four-item prosocial affordances scale (rated from 1 = "Not at all" to 7 = "Very much"). The observed α (.91) was higher than the published α (.76). The third was Pintrich and DeGroot's MSLQ nine-item intrinsic value subscale (rated from 1 = "Not at all true of me" to 7 = "Very true of me"). The observed α (.91) was closely aligned to the published α (.87).

Mentor Presence and Quality. On the Supplemental Survey, students reported if they have had a mentor during their time at Cal Poly Pomona (mentoring was defined for participants as "when a more knowledgeable person helps to guide a less knowledgeable/experienced person"). Students could select all of the following options that applied: faculty/staff member at Cal Poly Pomona; faculty/staff member at another institution; professional in my field; student/peer mentor; other mentor (please specify [open ended]); or I have not had a mentor during my time at Cal Poly Pomona.

If students indicated that they had at least one of the types of mentors, they were asked to complete the 19 mentoring items comprising Nora and Crisp's (2007) "Educational/Career Exploration and Goal Setting" scale factor (rated from 1 = "Strongly disagree" to 5 = "Strongly agree"). The observed internal consistency of the scale as measured by Cronbach's α (.96) aligned to the published α (.96).

Student Demographic Information

The following demographic variables were obtained from the university's IRPA office:

- Sex (male or female)
- Undergraduate admission basis (first-time freshman [FTF] or transfer)
- First-generation status (first college degree, first Bachelor's degree, or not first-generation)
- Pell award recipient status (yes or no)
- IPEDS (Integrated Postsecondary Education Data System) ethnicity
- Underrepresented minority (URM) status (yes or no)[1]

Student Academic Information

The following academic variables were obtained from the university's IRPA office:

- Prior GPA (high school GPA for FTF; transfer GPA for transfer students)
- Cal Poly Pomona matriculation term
- Fall 2018 enrollment (yes or no)
- Fall 2018 academic level (freshman, sophomore, junior, or senior)
- Fall 2018 academic college (Agriculture; Business; Education & Integrative Studies; Engineering; Environmental Design; Hospitality; Letters, Arts, and Social Sciences; Science)
- Graduation as of summer 2020 (yes or no)

Data Cleaning

[1] Students in the following IPEDS ethnicity categories are considered URM: American Indian or Alaska Native, Black or African American, Hispanic or Latino.

Data cleaning was performed to exclude students who met any of the following criteria from the sample: students matriculating in fall 2018 (as they cannot accurately report on research conducted at Cal Poly Pomona in the 2017-18 academic year), students who were not enrolled in fall 2018, students without demographic data, non-undergraduate students, students who did not answer any of the Supplemental Survey questions, and students who did not respond to the fall 2018 Research Climate Survey. Responses to each scale were inspected to ensure they did not violate the assumption of normality. Responses to all scales were within the acceptable range with skewness < |1| and kurtosis < |2|. Research Climate Survey responses from the 2015, 2016, 2017, 2018, and 2019 administrations were used to determine whether a student had participated in research.

Participants

A total of 3,093 students who responded to the fall 2018 Research Climate Survey indicated interest in participating in future surveys. Of these students, 881 responded to the Supplemental Survey for a 28.5% response rate. After data cleaning, 544 students remained in the final sample.

The distribution of demographic characteristics in the sample differs somewhat from the demographic characteristics of the Cal Poly Pomona undergraduate population in fall 2018 (see Table 1). The largest difference between the sample and the campus population was sex: survey respondents were 67.8% female compared to 47% campus-wide. This distribution of male vs female respondents is consistent with Research Climate Survey responses across years (Dong et al., 2024). Other demographic characteristics more closely mirrored campus-wide demographics, including Hispanic/Latino (44.9% in the sample compared to 45% campus-wide) and first-generation (56.1% in the sample compared to 58% campus wide).

Table 1. *Final Sample Demographic Characteristics*

		n	Percent
Sex	Male	175	32.3%
	Female	369	67.8%
Race/Ethnicity	Hispanic/Latino	244	44.9%
	Asian	139	25.6%
	White	75	13.8%
	Black/African American	18	3.3%
	Two or More Races	22	4.0%
	Other	33	6.1%
	Unknown	13	2.4%
URM Status	URM	272	50.0%
	Not URM	272	50.0%
First-Generation Status	First Generation: First College	181	33.3%
	First Generation: First Bachelors	124	22.8%
	Not First-Generation	214	39.3%
	Unknown	25	4.6%
Admission Group	First-Time Freshman	343	63.1%
	Transfer	201	36.9%
Socio-Economic Status	Low Income/Pell	324	59.6%
	Not Low Income/Non- Pell	220	40.4%
Academic Level as of Fall 2018	Freshman	36	6.6%
	Sophomore	101	18.6%
	Junior	113	20.8%
	Senior	294	54.0%

Data Analysis

Research Question 1

To determine whether there were differences for each of the constructs (i.e., sense of belonging, academic self-efficacy, mentor presence, mentor quality, perceptions of the utility of education) between students who participated in research and students who did not participate in research, multiple linear regressions were conducted. Each regression controlled for sex, URM status, first-generation status, admission basis, Pell grant eligibility (a proxy for socio-economic status), academic college as of fall 2018, academic level as of fall 2018, prior GPA (high school GPA for FTF, transfer GPA for transfer students), and number of Research Climate Surveys completed. The mentoring analysis also controlled for the number of types of mentors students reported.

Research Question 2

To test whether the supplemental survey measures that differed by research participation predicted likelihood of graduation, a series of binary logistic regressions were conducted. The regressions included only students who could have reasonably graduated by summer 2020 (i.e., matriculated in fall 2018 or earlier for transfer students, matriculated in fall 2016 or earlier for FTF) for a sample of 431 students (FTF n = 230, transfer n = 201). Regressions controlled for sex, admission basis, first-generation status, Pell status, URM status, and prior GPA.

Research Question 3

Constructs that significantly differed by research participation and predicted graduation were tested as potential mediators of the research participation and graduation relationship. Mediation models were run in SPSS Version 28 using the PROCESS macro and ordinary least squares path analysis (Hayes, 2022). All mediation models controlled for sex, admission basis, first-generation status, Pell status, URM status, prior GPA, and number of Research Climate Surveys completed. For each model, a bootstrapped confidence interval based on 5,000 samples was used to estimate the indirect effect. Only students who could have reasonably graduated were included in the analysis.

Results

Research Participation

The proportion of students who participated in research was greater in the supplemental survey sample (54.4%; see Table 2) than Dong and colleagues' (2024) larger Research Climate Survey sample (44.8%). The type of research activity with the greatest reported participation in the supplemental sample was "other activities that trained me to be a professional in my discipline" (23.0%), which was also the activity with the greatest reported participation in Dong et al. (13.4%). See Dong et al. (2024) for details on the open-ended types of "other" activities reported by students.

Table 2. *Student Research Participation by Research Type*

Activity	n	Percent of research participants	Percent of total sample
Internship with a professional in my academic field of interest	99	33.4%	18.2%
Training under the supervision of a professional in my academic field on interest (not for credit)	83	28.0%	15.3%
Research with Cal Poly Pomona faculty member (not for credit)	83	28.0%	15.3%
Internship with industry (including the Cal Poly Pomona Co-Op program)	79	26.7%	14.5%
Research outside of Cal Poly Pomona	38	12.8%	7.0%

Other activity that trained me to be a professional in my discipline	125	42.2%	23.0%
Total	296	-	54.4%

N = 544

To examine whether research participation predicted graduation for the supplemental study student sample, a chi-square analysis was employed. While Dong et al. (2024) employed a binary logistic regression, the supplemental sample size was too small to conduct the exact same analysis. Of the 544 students in the supplemental sample, 431 were eligible to graduate based on the criteria of 2 years from matriculation for transfer students (i.e., matriculating fall 2018 or earlier) and 4 years from matriculation for first-time freshmen (i.e., matriculating fall 2016 or earlier). A chi-square was conducted to compare research participation through spring 2010 (yes/no) with graduation (yes/no) for the 431 students eligible to graduate. Students who participated in research were significantly more likely to graduate than students who did not participate in research ($X^2 = 7.91$, $p < 0.01$).

Table 3. *Research Participation and Graduation*

	Graduated		Did not graduate	
	Percent	n	Percent	n
Participated in research	80.7%	205	19.3%	49
Did not participate in research	68.9%	122	31.1%	55

N = 431

Mentor Presence

Students only responded to the mentoring quality scale if they indicated that they had a mentor. Approximately two thirds (67.5%) of students reported they had a mentor during their time at Cal Poly Pomona (see Table 3). "Other" types of mentors reported included family members, friends, graduate students, and Cal Poly Pomona alumni. Students could select all types of mentors that applied, and most students had either zero (32.5%), one (26.1%), or two (28.7%) types of mentors. A small number of students reported three (9.4%) or four (3.3%) types of mentors.

Table 3. *Frequency of Mentor Type*

Mentor type	n	Percent of students with mentors	Percent of total sample
Faculty/staff member at Cal Poly Pomona	270	73.6%	49.6%
Student or peer mentor	244	66.5%	44.9%
Professional in my field	108	29.4%	19.9%
Faculty/staff member at another institution	51	13.9%	9.4%
Other mentor	16	4.4%	2.9%
Total	367	-	67.5%

Note: Students could select all that applied. N = 544.

RQ1: How is research participation related to sense of belonging, academic self-efficacy, mentor presence, mentor quality, and perceptions of the utility of education?

Sense of Belonging

The overall model predicting sense of belonging from control variables was not significant, $R^2 = 0.053$, $F(18, 523) = 1.62$, $p = 0.050$. However, the model with the addition of research participation was significant, $R^2 = 0.066$, $F(19, 522) = 1.95$, $p = 0.009$. Controlling for academic and demographic variables, students who participated in research reported a greater sense of belonging

at Cal Poly Pomona (M = 4.02, SD = 0.75) than students who did not participate in research, (M = 3.80, SD = 0.77, p = 0.006). Research participants had a predicted sense of belonging score 0.19 points higher than non-participants and the addition of research participation to the model explained additional variance in sense of belonging scores (ΔR^2 = 0.13).

Academic Self-Efficacy
The overall model predicting academic self-efficacy from control variables was significant, R^2 = 0.150, $F(18, 524) = 5.14$, $p < 0.001$, as was the model with the addition of research participation, R^2 = 0.165, $F(19, 523) = 5.44$, $p < 0.001$. Controlling for academic and demographic variables, students who participated in research reported greater academic self-efficacy (M = 5.37, SD = 1.14) than students who did not participate in research (M = 5.06, SD = 1.18, p = 0.003). Research participants had a predicted academic self-efficacy score 0.30 points higher than non-participants and the addition of research participation to the model explained additional variance in academic self-efficacy scores (ΔR^2 = .015).

Mentor Presence and Quality
Overall, students who participated in research were more likely to report that they had a mentor during their time at Cal Poly Pomona (75.3%) than students who did not participate in research (58.1%; χ^2 (1, N = 544) = 18.34, $p < 0.001$). In addition, among students who had mentors, research participants reported more types of mentors (M = 1.92, SD = 0.85) than students who did not participate in research (M = 1.74, SD = 0.82; $t(365) = 1.98$, p = 0.049).

The overall model predicting mentoring quality from control variables was not significant, R^2 = 0.076, $F(19, 355) = 1.60$, p = 0.053. The model with the addition of research participation was significant, R^2 = 0.084, $F(20, 354) = 1.62$, p = 0.046, however the p value changed only slightly. Within the model, research participation alone was not a significant predictor of mentoring quality (B = 0.11, p = 0.172).

Utility and Intrinsic Value of Education
The overall model predicting utility to self from control variables was significant, R^2 = 0.086, $F(18, 522) = 2.74$, $p < 0.001$, as well as the model with the addition of research participation, R^2 = 0.092, $F(19, 521) = 2.77$, $p < 0.001$. Within the model, research participation alone was not a significant predictor of utility to self (B = 0.20, p = 0.083).

The overall model predicting utility to society from control variables was significant, R^2 = 0.085, $F(18, 524) = 2.70$, $p < 0.001$, as well as the model with the addition of research participation, R^2 = 0.087, $F(19, 523) = 2.63$, $p < 0.001$. Within the model, research participation alone was not a significant predictor of utility to society (B = 0.12, p = 0.249).

The overall model predicting intrinsic value from control variables was significant, R^2 = 0.087, $F(18, 524) = 2.77$, $p < 0.001$, as well as the model with the addition of research participation, R^2 = 0.094, $F(19, 523) = 2.85$, $p < 0.001$. Controlling for academic and demographic variables, students who participated in research reported greater intrinsic value (M = 5.69, SD = 0.94) than students who did not participate in research (M = 5.50, SD = 1.01 $p < 0.044$). Research participants had a predicted intrinsic value score 0.17 points higher than non-participants and the addition of research participation to the model explained additional variance in intrinsic value scores (ΔR^2 = .007).

RQ2: To what extent do the variables of interest that differ by research participation predict graduation?
Three supplemental survey measures differed by research participation: sense of belonging, academic self-efficacy, and intrinsic value. Sense of belonging was a significant predictor of

graduation, Wald $\chi^2(1) = 11.27$, $p < 0.001$. For each one-point increase on the sense of belonging measure, the odds of a student graduating were 1.71 times greater. Academic self-efficacy was also a significant predictor of graduation, Wald χ^2 (1) = 21.24, $p < 0.001$. For each one-point increase on the self-efficacy measure, the odds of a student graduating were 1.62 times greater. Intrinsic value was not a significant predictor of graduation, Wald χ^2 (1) = 3.55, $p = 0.060$.

RQ3: To what extent do the variables of interest mediate the relationship between research participation and graduation?

Sense of belonging and academic self-efficacy were identified as potential mediators of the relationship between research and graduation, as both differed significantly by research participation and both significantly predicted graduation. A simple mediation model found that sense of belonging mediated the relationship between research participation and graduation (see Figure 1). Research participants who reported greater sense of belonging and were in turn more likely to graduate (*ab* = 0.13; 95% CI [0.03, 0.28]). The direct effect of research participation on graduation was significant after accounting for the mediating effect of sense of belonging ($p = 0.035$). The indirect effect accounted for 20% of the total effect of research on graduation.

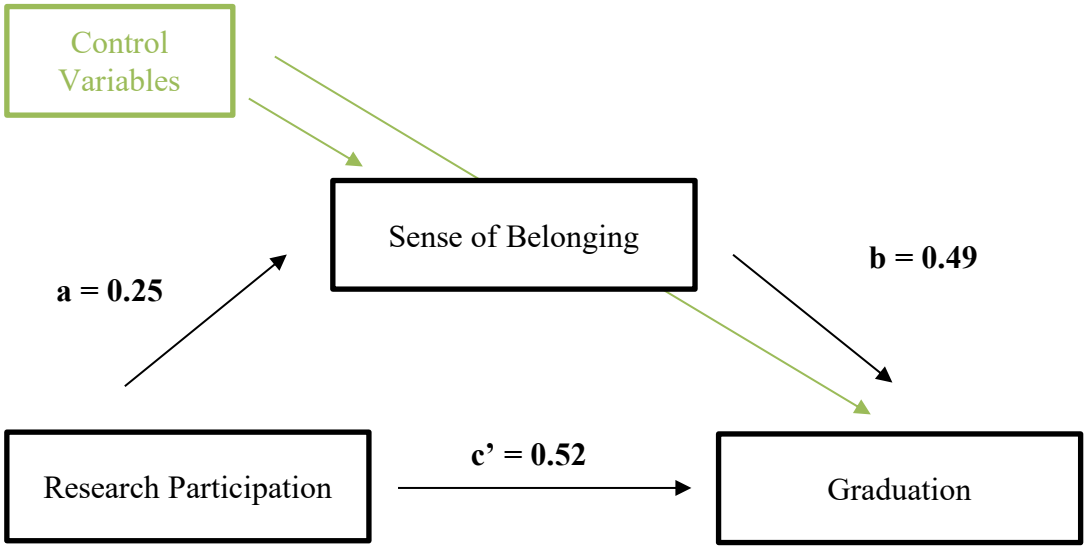

Figure 1. *Sense of Belonging Mediation Model*
Note: a, b, and c' represent unstandardized regression weights within the path model.

A simple mediation model found that academic self-efficacy also significantly mediated the relationship between research participation and graduation (see Figure 2). Research participants reported greater self-efficacy and were in turn more likely to graduate (*ab* = 0.18; 95% CI [0.07, 0.34]). The direct effect of research participation on graduation was not significant after accounting for the mediating effect of self-efficacy ($p = 0.051$). The indirect effect accounted for 27% of the total effect of research on graduation.

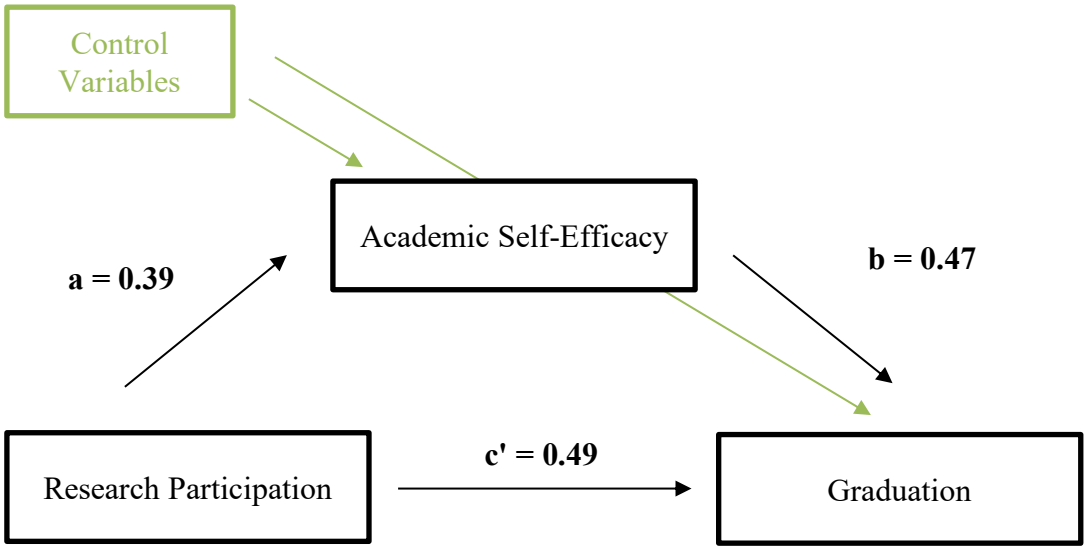

Figure 2. *Academic Self-Efficacy Mediation Model*
Note: a, b, and c' represent unstandardized regression weights within the path model.

As both sense of belonging and academic self-efficacy demonstrated significant mediating effects alone, they were placed into a single model as multiple parallel mediators to determine if one construct represented a stronger mediational relationship than the other (Figure 3). While sense of belonging was not a significant mediator in the parallel model (ab_1 = 0.04; 95% CI [-0.06, 0.17]), academic self-efficacy was a significant mediator (ab_2 = 0.15; 95% CI [0.05, 0.31]). There is overlap between the constructs of belonging and self-efficacy (r = 0.55), and results suggest that the academic self-efficacy construct better captures what connects research participation to graduation. The mediating effect of academic self-efficacy accounted for 24% of the total effect. The direct effect of research participation on graduation was not significant after accounting for the mediating effects (p = 0.071).

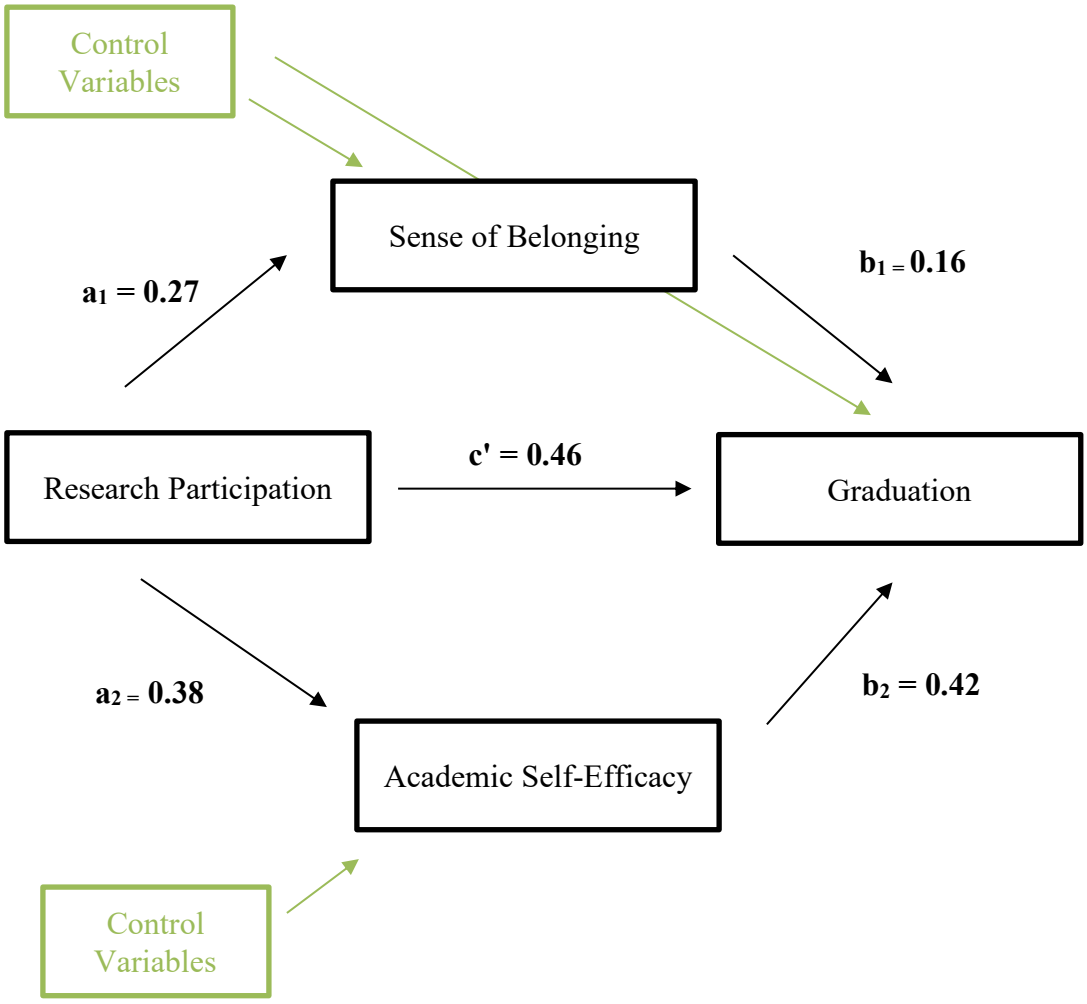

Figure 3. *Multiple Parallel Mediators Model, Sense of Belonging and Academic Self-Efficacy*
Note: a_1, a_2, b_1, b_2, and c' represent unstandardized regression weights within the path model.

Discussion

Results indicate that students who participate in undergraduate research report greater academic self-efficacy and sense of belonging than students who do not participate in undergraduate research. When examined in separate models, both academic self-efficacy and sense of belonging partially mediated the relationship between undergraduate research and graduation. However, when both factors were included in a single mediation model, academic self-efficacy was the only significant mediator of the relationship. This suggests that academic self-efficacy is a stronger predictor of the relationship between undergraduate research and graduation than sense of belonging. An important caveat is that we cannot determine if participation in undergraduate research predicts self-efficacy or if self-efficacy leads students to participate in undergraduate research. However, since there is evidence that an increase in the sense of self-efficacy leads to increased graduation rates, providing resources and interactions that can increase the sense of self-efficacy in undergraduate research experiences will benefit all participants.

This study suggests that undergraduate research programs can best support students on their journey toward graduation by helping students feel academically self-efficacious – that they can succeed and grow. In addition, participating in undergraduate research provided students more

opportunities to interact with mentors and with more types of mentors (faculty, peer, staff, etc.) Combining these two findings indicate that mentors can play a crucial role in the students' outcomes if they are aware of and have the tools to help students develop their sense of self-efficacy. According to the literature, previous mastery experiences, observation of successful others, and words of encouragement are crucial sources of self-efficacy (Bandura, 1982). Given our findings, undergraduate research experiences should include these key elements in both the programming and mentor training to support student growth.

Undergraduate research experiences are generally structured to provide students the opportunity to learn, practice, and master research-related skills (e.g., Beasley et al., 2024). Other elements to specifically include in faculty mentor training are instruction and practice with metacognitive skills and self-regulation strategies. Specifically, instruction in metacognitive skills (e.g., elaboration, spaced practice, retrieval practice) has been shown to increase students' self-efficacy in STEM and end of semester grades (Graham et al., 2019), while goal setting and goal management strategies are associated with increased engagement and higher levels of self-efficacy (Burns et al., 2019; McMichael et al., 2022; Pop & Tiba, 2019). Students with strong metacognitive skills know how to set goals, choose an effective strategy to approach a new problem, and adjust the strategy when needed to successfully complete the task. Students who draw on experiences of persisting to achieve a goal when faced with obstacles are likely to feel self-efficacious about their abilities. Given this research and our finding of the important role of academic self-efficacy in supporting graduation, undergraduate research programs may benefit from requiring students to complete metacognitive skills training in addition to acquiring technical skills.

Observation of exemplars and words of encouragement are also key sources of self-efficacy (Bandura, 1982). Given the critical role of mentoring in the research experience, mentors are strongly positioned to provide these sources of self-efficacy (e.g., Holloway-Friesen, 2021). Mentors should demonstrate research skills, offer opportunities for student to practice skills, and provide feedback to encourage persistence (e.g., skills can improve with experience and practice). Research indicates that incremental beliefs (e.g., intelligence is malleable, growth mindset) predict higher STEM efficacy (e.g., Lytle & Shin, 2020; van Aalderen-Smeets & Walma van der Molen, 2018), suggesting mentors can model and encourage this way of thinking in their mentees to boost their self-efficacy (Canning et al., 2019; Yeager et al., 2022). To support students' self-efficacy, mentors can scaffold tasks so that they are appropriately challenging to the mentees' abilities, emphasize hard work and persistence, and provide encouraging feedback (e.g., Shin et al., 2016). Mentors can also model their own thinking when working through a research-related task, help students to set optimally challenging goals and visualize their success, and provide clear constructive feedback to students to help them meet their goal.

Institutions can maximize the benefits of undergraduate research by providing scaffolded resources and workshops that support students in developing self-efficacy through their research experience. These can include workshops on overcoming the imposter phenomenon, developing strong mentor-mentee relationships, and workshops on skills related to research, such as communication, professional presentations, etc. Mentors should be made aware that a significant benefit to undergraduate research experiences for students is the increase in self-efficacy and that the mentoring students receive plays a role in the development of self-efficacy. It is important for universities to provide mentor training on effective strategies that build mentees' self efficacy, such as modeling behavior, scaffolding tasks, providing constructive feedback, etc.

Limitations

One limitation to this study is that we did not account for characteristics that likely relate to who chooses or chooses not to participate in undergraduate research. Students who participated in

research-related activities likely differed from those who did not participate in research-related activities in important characteristics not accounted for in this study, such as motivation. Characteristics that were unaccounted for likely influence the observed relationship between research and student outcomes. Future research will benefit from accounting for these factors.

A second limitation of the current study is that the design did not allow for us to determine causality or be certain about the directionality of the relationship between undergraduate research and academic self-efficacy. Both variables were assessed concurrently; thus, we cannot determine if participation in undergraduate research predicts self-efficacy or if self-efficacy leads students to participate in undergraduate research. Future research will benefit from building on this study to assess the constructs using a more rigorous research design (e.g., pretest posttest design).

A third limitation of this study is the conceptualization and assessment of mentoring. Only students who indicated that they had a mentor responded to the mentoring scale however, the scale is designed in such a way that those without formal mentors can respond. If the study design was modified to have all students respond to the mentoring scale, the level of mentoring support between research participants and non-participants could have been compared and the impact on graduation could be assessed. Future research will benefit from refining the methods to accurately assess the potential mediating role of mentoring.

Future Directions

To ensure high-quality research-related experiences, institutions and programs should support, and evaluate and monitor students' academic self-efficacy as well as variables associated with it (e.g., metacognitive skills). Future research should investigate other ways that students can increase their academic self-efficacy in research-related tasks as well as other domains where students can improve their mastery of specific skills that prepare them for work.

Given that in our study sense of belonging mediated the relationship between undergraduate research and graduation and was highly correlated with self-efficacy, future studies should further examine the relationship and potential overlap between sense of belonging and academic self-efficacy. A recent study by Thacker et al., 2022, coined the term competency belonging, defined as a feeling of inclusion in a course, major, or field by drawing on mastery experiences in previous courses and by demonstrating high levels of competency in the subject matter. This suggests that feelings of belonging derive from feelings of competency. Additional research suggests that uncertainty about one's ability to "fit in" intellectually is negatively correlated with academic self-efficacy (Lewis & Hodges, 2015). Consequently, the concept of belonging is also multi-faceted and should be investigated with respect to how students develop their intellectual belonging through academically-related experiences. Since there are conceptual similarities between competency and academic self-efficacy, this finding suggests more research is needed to investigate the relationship between the two variables.

Another avenue for future research is exploring the role of disciplinary or professional identity (e.g., identity as a scientist) in the relationship between self-efficacy and graduation. Studies by Sayed et al. 2018 and Chemers et al. 2011 found that identity as a scientist partially mediated the relationship between science self-efficacy and commitment to a science career. Given our finding that academic self-efficacy explains the relationship between undergraduate research and graduation, further research is needed to examine how academic self-efficacy leads to graduation. Identity as a researcher may be one factor worth further investigation.

This study represents a step forward in understanding the benefits of undergraduate research and research-related experiences on both short-term (e.g., academic self-efficacy) and long-term (e.g.,

graduation) student outcomes. Future work can expand upon the findings presented here with the goal of better informing the design and conduct of undergraduate research programs to maximize student benefits. Empowering students to take charge of their academic progress can provide benefits beyond simply graduation and can set students up for success in their careers and beyond.

Acknowledgments
This work was supported by the Office of Undergraduate Research at [University].

Declaration of Interest Statement
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The authors received no financial support for the research, authorship and/or publication of this article.

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