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## Gender Differences and Roles of Two Science Self-Efficacy Beliefs in Predicting Post-College Outcomes

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### Abstract

The end of college is a key transition point when students prepare for the workforce or graduate school, and when competence beliefs that have been shaped throughout college play a particularly important role in decision-making processes. This study examined the roles of two competence beliefs, self-efficacy for scientific tasks and science academic self-efficacy, during the final year of college. A structural equation model was used to examine science research self-efficacy and science academic self-efficacy as predictors of post-graduation science career intentions and life satisfaction; prior achievement was also included as a predictor of competence beliefs and post-graduation outcomes. Findings indicated that both types of self-efficacy predicted career intentions and life satisfaction. To better understand the processes that contribute to gender gaps in certain science careers, gender differences in mean levels of self-efficacy and in the structural relations among the variables of interest were examined using multi-group analyses. Females reported lower academic self-efficacy, despite having similar levels of prior achievement and outcomes; structural relations also appeared to vary by gender. Results extend theoretical understanding of the roles of two distinct forms of self-efficacy and the potential mechanisms explaining gender gaps in science fields.

### Keywords

self-efficacy; post-secondary education; STEM; gender; career intentions

Social-cognitive theories, supported by decades of research, assert that competence beliefs, such as self-efficacy beliefs, are essential antecedents of achievement-related outcomes (Bandura, 1977; Eccles et al., 1983; Elliot & Dweck, 2005; Pekrun, 2006). These beliefs appear to be especially important in college science, technology, engineering, and mathematics (STEM) fields, where students face competitive climates and difficult coursework (Seymour & Hewitt, 1997). While prior research often focuses on achievement-related outcomes, motivational processes also have implications for outcomes in students'

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lives beyond academic achievement (Lent et al., 2005). Little research has examined competence beliefs near the end of college and their relations to important post-college outcomes. Examining both career-related outcomes and well-being after college in relation to two important self-efficacy beliefs can inform efforts to shape education to serve the broader community and promote adaptive lifelong development.

Men and women may also face different challenges and opportunities in STEM fields (Fredricks & Eccles, 2002; Murphy et al., 2007), both in shaping their competence beliefs in science and in how those competence beliefs relate to their well-being and desires to pursue science careers (Eccles & Wang, 2016). While gender gaps in STEM participation (Leslie et al., 2015; Penner, 2015) would suggest that women's motivation may not be well-supported in some STEM fields, there is a need for empirical research on motivational differences and important correlates of such differences during the transition from undergraduate to post-baccalaureate pursuits. Examining gender differences in levels and roles of competence beliefs at the end of college can provide a greater understanding of how men and women may experience STEM settings similarly or differently and thus how these environments may be designed to promote gender equity.

## Theoretical Framework: Social-Cognitive Views of Competence Beliefs

Social-cognitive theories (Bandura, 1977, 1983; Eccles et al., 1983) focus on the crucial role of individuals' competence beliefs in optimal human functioning. Competence beliefs, or individuals' appraisals about their abilities and likelihood of success on achievement tasks, include such constructs as self-efficacy, self-concept of ability, and outcome expectancies. Competence beliefs can refer to different domains and levels of measurement, including general academic success (e.g., Midgley et al., 2000), academic success in a particular domain (e.g., Perez et al., 2014), and specific skills and tasks within a domain or course (e.g., Chemers et al., 2011). Social-cognitive models link competence beliefs to a variety of outcomes across achievement and non-achievement contexts (Bandura, 1977; Eccles et al., 1983; Elliot & Dweck, 2005; Pekrun, 2006). Bong and Skaalvik (2003) highlight the links between competence beliefs and self-processes such as value, interest, self-satisfaction, and emotions. The theory of planned behavior (Ajzen, 1991) posits direct relations between competence beliefs and behavioral intentions, with intentions acting as an important, proximal mediator of future actions.

Across these varying perspectives, theory and empirical research leave little doubt that competence beliefs are fundamental motivational processes that are necessary for students' success (Marsh et al., 2017; Muenks et al., 2018; Shavelson et al., 1976; Usher, 2016; Valentine & DuBois, 2005; Valentine et al., 2004). Indeed, competence beliefs have recursive relations with achievement; for example, prior successes predict self-efficacy (Bandura, 1997; Usher & Pajares, 2008), and self-efficacy subsequently promotes higher achievement via engagement in the activity. Thus, individuals are more likely to choose careers that align with domains in which they hold high self-efficacy beliefs (Brown & Lent, 1996; Lent et al., 1994, 2000). Furthermore, the relations between competence beliefs and achievement outcomes become stronger over time (Meece et al., 1990; Simpkins et al., 2006; Wigfield et al., 1997), which suggests that late college may be a critical period

when students especially need to feel confident in order to persist into science careers. Self-efficacy beliefs may be particularly important as students contemplate their likelihood of success on future careers while still completing coursework that prepares them to enter science careers or begin graduate studies.

Motivation theories as applied in education largely focus on competence beliefs in relation to achievement-related tasks (e.g., schooling, careers, etc.). However, competence beliefs also play a role in social-emotional processes (Kagen et al., 1995; Davis-Kean & Sandler, 2001; Marsh et al., 2002) including well-being (Elliot & Dweck, 2005; Marsh, Trautwein, et al., 2006). Indeed, social-cognitive models indicate that self-efficacy prompts productive engagement and success in valued tasks, and thus promotes both specific and general forms of well-being as evidenced through emotions and life satisfaction (Lent et al., 2009). In the social and personality psychology literature, well-being typically consists of three factors: positive affect, negative affect, and life satisfaction (Diener et al., 1999). We focus on life satisfaction in this study, which may be particularly salient for individuals settling into new routines in work or graduate school in the year following graduation from college.

However, relations of competence beliefs to well-being are not often examined in educational research. Such examinations are needed in STEM fields where the demands of difficult coursework and competitive climates may deteriorate students' sense of well-being both during and after college (Seymour & Hewitt, 1997). High competence beliefs may buffer students from these effects.

## Outcomes and Differential Roles of Self-Efficacy Beliefs

Scholars have empirically examined (Jansen et al., 2014; Marsh, Trautwein, et al., 2006; Valentine et al., 2004; Valentine & DuBois, 2005) and synthesized (Bong & Skaalvik, 2003; Marsh & Craven, 2006; Marsh et al., 2017) how different competence beliefs have varying developmental origins and relations to key correlates. Overall, this research indicates that various competence beliefs play different roles in predicting outcomes, including well-being. For example, Jansen and colleagues (2015) found that science self-concept and self-efficacy for scientific literacy skills showed differential relations to predictors and outcomes such as career aspirations, achievement, and big-fish-little-pond effects. Broadly speaking, this research suggests that stronger relations are observed when competence beliefs are measured at the same level of specificity as the outcome (e.g., Bong, 2006; Valentine & DuBois, 2005; Valentine et al., 2004), and that competence beliefs in one domain often show negative relations to achievement in a different domain (Marsh, Hau, et al., 2006). However, this prior work on competence beliefs has primarily focused on (a) different levels of measurement (e.g., global vs. domain-specific academic self-concept), (b) different forms of competence beliefs (e.g., self-concept vs. self-efficacy), or (c) how competence beliefs in different domains, but at the same level of measurement, predict overall and/or domain-specific outcomes.

In this study, we focus on two self-efficacy beliefs within the same domain: *science research self-efficacy*, which refers to students' confidence in their ability to complete authentic scientific tasks, and *science academic self-efficacy*, defined as students' confidence in their

ability to learn in their science courses (Mamaril et al., 2016; Midgley et al., 2000). Research comparing unique self-efficacy beliefs within the same STEM domain is scarce. However, existing research supports the empirical separability of theoretically distinct competence beliefs (self-concept and self-efficacy) in STEM fields (e.g., Jansen et al., 2015) and that self-efficacy beliefs in particular can be distinguished at general domain- and skill-specific levels (Mamaril et al., 2016).

Extant research also points to the importance of considering self-efficacy on both academic and disciplinary tasks due to the unique and complementary roles of each in predicting students' success. For example, Mamaril and colleagues (2016) found that academic self-efficacy in engineering and self-efficacy for authentic engineering tasks related similarly to mastery goals and task values, but the two self-efficacy beliefs related differentially to performance goals and achievement outcomes. Further, academic self-efficacy explained much more variance in GPA than skills self-efficacy. This study provides promising preliminary evidence; however, further research is needed to examine whether different self-efficacy beliefs referring to distinct tasks within science can exhibit differential relations to predictors and outcomes. Supports for different self-efficacy beliefs may require different interventions and have diverse implications for different outcomes in science.

### **Self-Efficacy Beliefs, Career Intentions, and Well-Being**

There is little longitudinal research examining how different self-efficacy beliefs within the same domain may play similar or different roles in individuals' career pursuits and well-being. Such knowledge is important for informing theoretical understandings of the nature of these constructs as well as practical efforts to support motivation in school. Links to career and life satisfaction outcomes are particularly interesting for understanding science persistence at the end of university studies. Prior research provides evidence of cross-sectional links between STEM major intentions and academic self-efficacy (da Silva Cardoso et al., 2013; Deemer et al., 2014; Lent et al., 2005; Soldner et al., 2012; Wegemer & Eccles, 2019) as well as between career intentions and research self-efficacy (Estrada et al., 2011; Syed et al., 2019). For example, Lent and colleagues (2005) found that for early college students, self-efficacy for doing well in their engineering major was significantly related to engineering major choice goals, controlling for interests and the perceived likelihood of achieving a desired career.

Not all studies have found significant links between self-efficacy and STEM pursuit, however. In one of very few studies examining research self-efficacy, Estrada and colleagues (2011) found that research self-efficacy did not significantly predict science career intentions at the same time point when controlling for science identity and scientific values. Interestingly, Syed and colleagues (2019) found that research self-efficacy predicted science career commitment assessed retrospectively in one survey among recent college graduates, but these relations did not hold for a longitudinal Study 2 among undergraduate students. These illustrated differences in self-efficacy's relations to STEM pursuit may be attributed to measurement differences, to the other predictors in the models, to differences between longitudinal vs. cross-sectional approaches, and importantly, to developmental differences in self-efficacy's relations to career goals at different stages of education (e.g., Wegemer &

Eccles, 2019). Self-efficacy beliefs are perhaps more well-informed at the end of college than at the beginning of college, which may lead to differences in relations to various outcomes, but empirical evidence is needed to address this question.

In addition to achievement-related choices, some research, mostly cross-sectional, provides evidence that academic self-efficacy is associated with well-being in adolescence (Diseth et al., 2012; Lent et al., 2009) and college (Coffman & Gilligan, 2002). It appears that students who feel capable of success in school also tend to have a sense of well-being in their broader lives, perhaps due to a sense that they are able to accomplish valued tasks that allow them to accomplish future goals. Limited longitudinal evidence supports these relations as well, with academic self-efficacy in early adolescence positively predicting life satisfaction five years later (Vecchio et al., 2007). Research is needed to examine whether these same relations hold for both academic and research self-efficacy at the end of college.

Students' success after graduating from college relies on both academic and task-specific competencies (Levin & Wyckoff, 1990). Thus, examining students' self-efficacy in both academic and career skill areas provides a more detailed picture of the multifaceted motivational demands facing students in their post-graduation decision-making processes. To our knowledge, no research has examined academic and research self-efficacy together in relation to post-graduation outcomes. It remains unclear how these two distinct and important beliefs within a single domain (efficacy in science classes vs. efficacy for engaging in scientific activities) similarly or differently support students in their career pathways and well-being after graduation. Indeed, when making important choices about their lives and careers after college, it is unclear whether students draw on their academic self-efficacy, their confidence on specific disciplinary tasks, or both. Comparing the roles of different self-efficacy beliefs for educational outcomes is particularly important to examine as students graduate and transition to adulthood and careers. Results of the present study may highlight whether it is most important to support students' self-efficacy in their science courses or self-efficacy for executing specific scientific tasks (or both) in order to support their science career pursuits and well-being after college.

## Gender Differences in Self-Efficacy Processes

Compared to men, women may face unique barriers to pursuing science, as evidenced by low representation in certain STEM fields in the United States (Koenig, 2009; Myers & Pavel, 2011; National Science Board, 2016). In particular, the basic science workforce that drives knowledge creation in the U.S. (i.e., science researchers) showed only minor progress toward gender equity from 1993 to 2013, with women still making up less than 30% of the basic science and engineering workforce (National Science Board, 2016). Various factors are assumed to explain such underrepresentation and many have been explored in the expectancy-value literature (e.g., Eccles, 2005; Wang et al., 2013; Wegemer & Eccles, 2019). In particular, gender disparities in STEM research participation may be due in part to women's lower levels of competence beliefs and differential paths to the development of competence beliefs in STEM (e.g., Antunes & Fontaine, 2007; Jansen et al., 2014; Linver & Davis-Kean, 2005; Simpkins et al., 2006; Zarrett & Malanchuk, 2005). Social-cognitive theories, in particular expectancy-value theory (Eccles et al., 1983), indicate that social

and societal messages about gender shape individuals' beliefs about their competence in academic and professional pursuits. Although the expectancy-value literature has largely examined self-concept of ability rather than self-efficacy, findings inform our examination of gendered self-efficacy processes due to similarities between these constructs (Bong & Skaalvik, 2003).

Indeed, some prior research has documented lower academic self-concept for female students relative to males in STEM domains such as mathematics (Jacobs et al., 2002; Nagy et al., 2010; Simpkins et al., 2006; Watt, 2004; Wigfield et al., 1997; Watt et al., 2012), despite women generally achieving at similar levels as men. Some evidence suggests that gender gaps in STEM self-concept become narrower with age (Fredricks & Eccles, 2002) and gender gaps in self-efficacy may not exist at the beginning of college (Robinson et al., 2019). However, competitive and demanding climates in college science settings, which may activate stereotypes that threaten women's sense of belonging (Murphy et al., 2007), may lead to a widening of the gender gap in science self-efficacy during college. Thus, near the end of college, women's science self-efficacy may again be lower than men's.

Women may also differ from men in how their self-efficacy beliefs are shaped (Usher, 2009) and how they relate to career- and broader life-related outcomes. Research on this issue among college students is scant; however, research on middle school students and adults in STEM careers provides some initial, although mixed, evidence. Some research suggests that women may rely more on social information than on their own prior achievements to inform their academic self-efficacy (Linver & Davis-Kean, 2005; Usher & Pajares, 2006; Zeldin et al., 2008; Zeldin & Pajares, 2000). Further, Heffner and Antaramian (2016) found that life satisfaction differentially related to math outcomes for middle school boys and girls. Life satisfaction appeared to be less important for girls' future goals than it was for boys'; however, it appeared to be more important for predicting girls' achievement than boys'. Thus, self-efficacy may also relate to life satisfaction and career intentions differently for men versus women. However, Simpkins and colleagues (2006) found no gender differences in the relations of science self-concept to predictors and outcomes among 6<sup>th</sup> and 10<sup>th</sup> grade students. Further, and perhaps most relevant to the current study, Syed and colleagues (2019) also found no gender differences in the cross-sectional relations of research self-efficacy to science career commitment. Thus there is little evidence on which to base hypotheses about potentially differential roles of both academic and research self-efficacy across genders at the end of university studies.

These inconsistencies in the research on gender and competence beliefs may reflect the variety of constructs examined in addition to some important developmental differences in the roles of competence beliefs (Wegemer & Eccles, 2019). Research is needed to examine whether women adjust their science career goals and feel less satisfied after pursuing science due to differences in self-efficacy, despite being equally capable. Further, extant literature does not provide guidance as to whether there are mean-level and structural gender differences for academic and research self-efficacy in science. It is possible that men and women differ in the areas in science in which they feel confident in (academic work vs research skills). There may also be differences in how these two self-efficacy beliefs relate to different outcomes for men and women. Such understandings are critically important for

developing supports designed to retain more women in basic science careers, and current literature is lacking on these issues. We address this gap in the literature to further illuminate which specific processes may be subject to differential socialization processes in science.

## Present Study

Science students nearing the end of their university studies are at a key point in the science career “pipeline,” where beliefs about their ability to succeed in science will have vital implications for their future career trajectories and well-being. Understanding and supporting self-efficacy in college requires a nuanced understanding of (1) which self-efficacy beliefs may be more or less important for students’ success and well-being, (2) how these beliefs may be shaped, and (3) how self-efficacy beliefs may function differently for men and women. There is little empirical evidence examining these questions, particularly in science, and even less comparing two different self-efficacy beliefs side by side. Most prior studies have examined younger students and only one competence belief. None to our knowledge have investigated mean and structural differences of self-efficacy beliefs at the end of college, nor have prior studies examined mean and structural differences of two unique beliefs. Science academic and research self-efficacy are particularly important to examine, as they reflect the competencies necessary for progressing to basic science careers, including further studies and/or training in research settings. Accordingly, we examined the following research questions (hypothesized model presented in Figure 1):

1. Does prior achievement predict both science research self-efficacy and science academic self-efficacy in the final year of college? And, do the two forms of self-efficacy differentially predict post-graduation science career intentions and post-graduation life satisfaction?
2. Do men and women differ in their mean levels of science research self-efficacy and science academic self-efficacy in the final year of college?
3. Do men and women show differential patterns in the relations among prior achievement, self-efficacy beliefs, and post-graduation outcomes?

Our first research question focused on prior achievement related to the two forms of self-efficacy at the end of college and how, in turn, these two self-efficacy beliefs related to life satisfaction and science career intentions after college. Self-efficacy beliefs are shaped by a variety of processes, including seeing others fail or succeed at similar tasks, receiving encouragement from others, or physiological reactions (Bandura, 1977). Perhaps the strongest influence on students’ self-efficacy beliefs is prior success or failure on similar tasks (Bandura, 1997; Usher & Pajares, 2008); if a student has historically done well on their science exams, they will likely feel confident about their chances of success on future science exams. We expected that prior achievement (year 3 science GPA) would more strongly predict science academic self-efficacy than self-efficacy for research tasks; prior research has demonstrated that relations are stronger when the target of the measure and outcome are matched (Valentine et al., 2004). However, because students likely also complete science tasks as part of their coursework and at least partially rely on prior course performance to judge their efficacy in scientific tasks, we also expected that prior achievement would positively predict science research self-efficacy.

Based on theory and research demonstrating links between various competence beliefs and career intentions (da Silva Cardoso et al., 2013; Deemer et al., 2014; Lent et al., 2005; Soldner et al., 2012), we expected that both academic and research self-efficacy would predict science career intentions. However, due to inconsistent findings in past literature, these hypotheses were tentative. We focused in particular on research-related science career intentions, as our sample consisted of students originally intending to pursue science and engineering majors, and non-research careers in science (e.g., medicine, public health) are not as plagued by issues of gender representation as are research-related careers (National Science Board, 2016). In addition, research self-efficacy may become more important compared to academic self-efficacy as students consider the skills needed in their future careers. Thus, we hypothesized that research self-efficacy would more strongly predict research career intentions. Due to the lack of theory or empirical evidence about potential differential relations to life satisfaction, we did not make strong hypotheses about how the two types of self-efficacy might similarly or differently predict life satisfaction. We considered this portion of the analysis to be exploratory. However, because both academic and scientific skills are presumably important for engaging in valued activities and achieving valued goals, we tentatively predicted that both beliefs would predict life satisfaction.

The second research question addressed mean differences in prior achievement, academic and research self-efficacy, life satisfaction, and science career intentions across gender groups. Based on prior research in math and science domains (Marsh & Yeung, 1998; Robinson et al., 2019), we hypothesized that men and women would have similar levels of science GPA in the third year of college. However, we expected that in the last year of college, women would report lower academic and research self-efficacy beliefs than men, on average, due to the competitive climate, instructional cues about women's capabilities compared to men's, and low representation in some science majors (Leslie et al., 2015; Murphy et al., 2007). Because women often report negative experiences in science fields, we also expected that women would have lower life satisfaction and science career intentions than men.

Our final research question focused on gender differences in the structural relations among the variables of interest. Because there is little research examining these relations, we had no strong hypotheses about how the relations may differ for men and women. Rather we expected that in general, relations would be the same for men and women. However, self-efficacy beliefs might be especially salient for women if they encountered stereotype threat, belonging threat, or discrimination in science, so we had a tentative hypothesis that self-efficacy beliefs might more strongly predict life satisfaction and career intentions for women compared to men.

## Method

### Participants and Procedure

The sample consisted of three cohorts of undergraduates followed longitudinally at a highly selective, private, medium-sized, research-intensive university<sup>1</sup> in the United States ( $N=874$ ; 65% female; 7.7% Black/African American, 5.6% Hispanic or Latino/a, 0.3% Native American, 29.9% Asian, Pacific Islander, or Asian American, 49.7% white non-Hispanic;

6.3% first-generation college students). Participants were originally recruited as part of an intervention study in their first year of university (2010, 2011, and 2012 for each cohort, respectively) from introductory chemistry courses for science and some engineering majors. Students who participated in the intervention ( $n = 193$ ) were excluded from the sample for this study because the intervention was designed to influence science self-efficacy, among other related motivation variables (Godin et al., 2015; Linnenbrink-Garcia et al., 2018). Students who were recruited for the study but did not participate in the intervention were used as the pool from which a comparison group was randomly selected to take yearly follow-up surveys. Thus, the sample for this study is comprised of comparison group students who were invited to take follow-up surveys as part of the larger study.

For the data reported in the present study, participants completed online self-report surveys about their self-efficacy for research and academic tasks in the spring of their final year of college (Time 1) and completed surveys on the outcome measures one year later, in the spring after graduation (Time 2). Students were paid \$10 and \$20 for completing the senior and post-graduation surveys, respectively. Of the original sample recruited in their first year of college ( $N = 1,766$ ), 1,298<sup>2</sup> students were invited to take the senior year survey and 1,541 students were invited to take the post-graduation survey; 605 students (46.6% of those invited) completed the senior year survey, and 728 students (47.2 % of those invited) completed the post-graduation survey, for a total of 874 participants who took at least one of the two surveys. Of these 874 participants, 458 (52%) completed both surveys and 613 (70%) took science courses in their third year. Participants with data on either the senior year survey or the post-graduation survey were included in the study ( $N = 874$ ). Missing data analyses are included below.

## Measures

Surveys included measures of science research self-efficacy, science academic self-efficacy, science career intentions, and life satisfaction. A full list of survey measures is included in the appendix.

**Science Research Self-Efficacy**—During their final year of college (Time 1), students reported how confident they were about their ability to successfully complete authentic scientific tasks (Estrada et al., 2011; 6 items,  $\alpha = .88$ ) on a Likert-type scale from 1 to 5, with 1 = *Strongly disagree* and 5 = *Strongly agree*. A sample item is, “I am confident that I can generate a research question to answer.”

**Science Academic Self-Efficacy**<sup>3</sup>—Also during their final year of college (Time 1), students answered questions assessing their confidence in their ability to complete academic tasks in science classes using a scale adapted for science from PALS (Midgley et al.,

<sup>1</sup>This university has consistently ranked among the top twenty U.S. higher education institutions and has acceptance rates between 10 and 15% over the past ten years (2010–2019), compared to a national average acceptance rate of approximately 65% between 2012 and 2017 (Clinedinst, 2019). We provide these additional details in order to contextualize the nature of the sample and potential generalizability concerns.

<sup>2</sup>As noted above, a randomly selected sub-sample of original baseline comparison group participants were invited to take the survey each year. In 2015, we received additional funding to expand the comparison group (partway through data collection), thus the entire original baseline sample was invited to participate in follow-up surveys for the senior year survey for Cohort 3 and the post-graduation survey for Cohorts 2 and 3.

2000; 5 items,  $\alpha = .91$ ). The 5-point Likert scale was the same as for the science research self-efficacy measure. A sample item is “I can do almost all the work in science classes if I don’t give up.”

**Outcomes**—One year after graduation (Time 2), students responded to a single item assessing their science-research career intentions (Estrada et al., 2011; “To what extent do you intend to pursue a research-related career in science?”) on a scale from 1 to 10, with 1 = *definitely will not*, 10 = *definitely will*. Students also completed the Satisfaction with Life Scale at Time 2 (Diener, 1985; 5 items,  $\alpha = .87$ ) on a 5-point Likert-type scale as described above. A sample item for this scale is, “In most ways, my life is close to my ideal.”

**Prior Achievement and Demographics**—GPA from science courses completed in the year prior to the Time 1 survey (third year of college) was obtained from university records and served as an indicator of prior achievement.

## Analyses

Structural equation modeling in Mplus version 8 (Muthén & Muthén, 1998–2017) was used to examine academic and research self-efficacy as predictors of post-graduation science career intentions and life satisfaction for the overall sample, and prior achievement as a predictor of self-efficacy, career intentions, and life satisfaction (RQ1; see Figure 1). Next, we used multigroup models to compare means and structural relations among the variables across gender groups (RQ2 & RQ3). All models included first-generation college student status (vs. continuing-generation college student status) and race/ethnicity (underrepresented racial/ethnic group vs. overrepresented racial/ethnic group<sup>4</sup>) predicting all variables in the models to control for potential demographic differences in these processes (e.g., Ramos-Sánchez & Nichols, 2007; Robinson et al., 2019). Full Information Maximum Likelihood estimation was used to handle missing data. Model fit was evaluated using the comparative fit index (CFI; values  $\geq .90$  for adequate fit; close to .95 for excellent fit; Hu & Bentler, 1999) and root mean square error of approximation (RMSEA; values close to .08 for adequate fit; close to .06 for excellent fit).

## Results

### Preliminary Analyses

Correlations and descriptive statistics for the sample are presented in Table 1. Results indicated that all study variables were positively and significantly correlated with one another. These relations were consistent with expectations from theory and prior research.

<sup>3</sup>In our prior work, we have referred to this construct as academic perceived competence. In order to increase alignment between our own conceptualization and findings with those in the broader literature (e.g., Mamaril et al., 2016), we now refer to this construct as academic self-efficacy.

<sup>4</sup>Following typical demographic distributions of STEM participation in the United States and at this institution, Black, Hispanic/Latino/a, and Native American students were included in the “underrepresented racial/ethnic group” category; white and Asian students were included in the overrepresented racial/ethnic group category. Racial/ethnic proportions in our sample were similar to those of national participation rates in STEM majors (Snyder et al., 2019).

**Confirmatory Factor Analyses**—First, a two-factor model of research and academic self-efficacy at Time 1 showed acceptable fit to the data,  $\chi^2(43) = 184.68^{***}$ , RMSEA = .074, CFI = .964, TLI = .954, which provided evidence that students viewed research self-efficacy and academic self-efficacy in science as distinct constructs.<sup>5</sup> A one-factor model for life satisfaction also exhibited acceptable fit to the data,  $\chi^2(5) = 35.38^{***}$ , RMSEA = .083, CFI = .986, TLI = .971.

**Measurement Invariance**—Because of our interest in comparing gender groups, we also conducted tests of measurement invariance across gender groups for the latent variables (Widaman & Reise, 1997). The configural model assumed the same model structure across groups. Next, we specified the weak invariance model constraining factor loadings to be equal across groups. Next, strong invariance assumed item intercepts to be equal, and lastly, strict invariance involved constraining unique variances of items to be equal. Invariance was inferred when the change in CFI was equal to or less than .01 (Cheung & Rensvold, 2002). Results are presented in Table 2 and support strict measurement invariance for the latent variables across gender groups. This provides evidence that men and women interpreted the survey items similarly and mean differences can be attributed to true differences in study variables rather than measurement differences (Widaman & Reise, 1997). The strict measurement invariance constraints were retained in the multigroup models.

**Missing Data Analyses**—Among the analytic sample, missing data at the item level ranged from 16.8% to 32.5%, with an average missing rate of 24.6%. We examined a variety of variables as correlates of missing data in order to understand potential biases introduced by patterns of missing data. Participants with missing data (missing any data = 1) vs. complete data (missing no data = 0) on survey and grade data were compared using t-tests for continuous variables and chi-square analysis for categorical variables. Analyses indicated that women,  $\chi^2(1) = 8.72, p = .003$ , pre-medical students,  $\chi^2(1) = 34.18, p < .001$ , higher achievers (cumulative GPA),  $t(872.38) = 2.24, p = .009$ , students with higher achievement in Year 1 STEM courses,  $t(749.65) = 4.46, p < .001$ , and students in Cohort 1,  $\chi^2(2) = 19.20, p < .001$ , were less likely to have missing data compared to men, students not intending to pursue medical school, lower achievers, and students in Cohorts 2 and 3. Race/ethnicity,  $\chi^2(1) = 0.73, p = .395$ , and first-generation college student status,  $\chi^2(1) < .001, p = .99$ , were not associated with missing data.

As we identified correlates of missing data, our analyses provided evidence supporting the missing at random (MAR) assumption for FIML estimation (Enders, 2010). As a result of these analyses, we included gender, pre-medical status, 1<sup>st</sup>-year STEM GPA, 4<sup>th</sup>-year cumulative GPA, and cohort as auxiliary variables to aid with FIML estimation and reduce potential bias in the estimates due to systematic missing data patterns (Enders, 2010, pp. 127–163).

<sup>5</sup>A one-factor model of overall self-efficacy, including all items from the academic and research self-efficacy scales, resulted in poor model fit,  $\chi^2(44) = 1305.32$ , RMSEA = .22, CFI = .68, TLI = .60.

## Main Results

Our first research question concerned the relations of two different self-efficacy beliefs with prior achievement and key post-graduation outcomes in science, controlling for race/ethnicity and first-generation college student status. The specified model using latent factors (see Figure 2) fit the data well,  $\chi^2(153) = 343.81^{***}$ , RMSEA = .038, CFI = .967, TLI = .960. Consistent with our hypotheses, third year science GPA positively predicted both science research self-efficacy ( $\beta = .13, p = .009$ ) and science academic self-efficacy ( $\beta = .26, p < .001$ ) in the fourth year. Comparing  $R^2$  values revealed that the model explained significant variance in academic self-efficacy ( $R^2 = .06, p = .003$ ) but not research self-efficacy ( $R^2 = .02, p = .19$ ).

Science academic self-efficacy significantly predicted post-graduation life satisfaction ( $\beta = .22, p = .001$ ) and research-related science career intentions ( $\beta = .24, p < .001$ ). Similarly, research self-efficacy predicted post-graduation life satisfaction ( $\beta = .17, p = .008$ ) and research career intentions ( $\beta = .12, p = .03$ ). Overall, the model explained a moderate amount of variance in life satisfaction ( $R^2 = .16, p < .001$ ) and a small amount of variance in career intentions ( $R^2 = .12, p < .001$ ). Our second and third research questions asked whether men and women differed on means of the key variables as well as on the relations among the variables in the model. Multigroup models, again using latent factors, included a baseline model with parameters constrained to be equal across groups (Table 3, Model 0), as the null hypothesis posited that the model would not differ across gender groups. The next model allowed only the means (intercepts) of the focal variables to estimate freely across gender groups (Model 1). Next, we estimated a model with only the regression coefficients estimating freely across gender groups (intercepts equal across groups). Each of these models was compared to the baseline, all constrained model. Significant differences in model fit were evaluated using chi square difference tests, with significant tests indicating that the model parameters differed significantly across gender groups. Results of model comparisons are presented in Table 3. Results indicated that both the means-free and regression coefficients-free models (Models 1 and 2) fit the data significantly better than the baseline, all constrained model (Model 0). Therefore, we estimated a final model with both means and regression coefficients freely estimating (Table 3, Model 3; Figure 2) which we report below.

Estimated means and standard errors of the two self-efficacy measures were retrieved from the technical output in Mplus. First, as evidenced by overlapping confidence intervals, means of Year 3 science GPA for men ( $M = 3.44, SE = .04, 95\% \text{ CI } [3.37, 3.51]$ ) and women ( $M = 3.46, SE = .02, 95\% \text{ CI } [3.42, 3.51]$ ) did not significantly differ, supporting our hypothesis that men and women would not differ on achievement. Means of science research self-efficacy for men ( $M = 3.96, SE = .05, 95\% \text{ CI } [3.86, 4.04]$ ) and women ( $M = 3.88, SE = .04, 95\% \text{ CI } [3.80, 3.95]$ ) also did not significantly differ. For academic self-efficacy, men's mean levels ( $M = 4.15, SE = .05, 95\% \text{ CI } [4.06, 4.25]$ ) were significantly higher than women's ( $M = 3.84, SE = .04, 95\% \text{ CI } [3.77, 3.92]$ ), as evidenced by non-overlapping confidence intervals. Means of life satisfaction for men ( $M = 3.42, SE = .06, 95\% \text{ CI } [3.30, 3.54]$ ) and women ( $M = 3.41, SE = .05, 95\% \text{ CI } [3.32, 3.51]$ ) did not significantly differ. Career intentions for men ( $M = 5.18, SE = .18, 95\% \text{ CI } [4.84, 5.53]$ ) appeared to be slightly

higher than those for women ( $M = 5.01$ ,  $SE = .15$ , 95% CI [4.72, 5.29]), but the difference was not statistically significant. Overall, only academic self-efficacy significantly differed for men and women, with men reporting more confidence in their ability to do well in science courses during the last year of college.

Some key paths also differed across gender groups, while others showed similar patterns for men and women (see Figure 2). With respect to the relation between prior achievement and academic self-efficacy, the patterns were similar across men and women. Science GPA significantly predicted academic self-efficacy for both men ( $\beta = .27$ ,  $SE = .07$ ,  $p < .001$ , 95% CI [.13, .40]) and women ( $\beta = .31$ ,  $SE = .06$ ,  $p < .001$ , 95% CI [.20, .41]), and these effects did not significantly differ as evidenced by overlapping confidence intervals. Science GPA significantly predicted research self-efficacy for women ( $\beta = .13$ ,  $SE = .06$ ,  $p = .03$ , 95% CI [.01, .25]), but not men ( $\beta = .10$ ,  $SE = .08$ ,  $p = .20$ , 95% CI [−.05, .25]).

Additional gender differences in structural relations emerged with regard to the post-graduation outcomes. First, both women's science research self-efficacy ( $\beta = .18$ ,  $SE = .07$ ,  $p = .01$ , 95% CI [.04, .31]) and academic self-efficacy ( $\beta = .19$ ,  $SE = .07$ ,  $p = .01$ , 95% CI [.05, .33]) predicted life satisfaction. Similarly, for women, both self-efficacy beliefs significantly predicted career intentions ( $\beta_{\text{research}} = .19$ ,  $SE = .07$ ,  $p = .004$ , 95% CI [.06, .32];  $\beta_{\text{academic}} = .21$ ,  $SE = .07$ ,  $p = .002$ , 95% CI [.08, .35]). Comparing these coefficients to those for males reveal some differences with respect to the relations of research self-efficacy to life satisfaction ( $\beta = .06$ ,  $SE = .13$ ,  $p = .67$ , 95% CI [−.20, .31]) and career intentions ( $\beta = .03$ ,  $SE = .12$ ,  $p = .79$ , 95% CI [−.19, .26]), neither of which were significant. While overlapping confidence intervals for men and women indicate that these coefficients were not significantly different across gender groups, we note here the differences in terms of significant vs. non-significant relations. For males, only academic self-efficacy significantly predicted post-graduation life satisfaction ( $\beta = .42$ ,  $SE = .11$ ,  $p < .001$ , 95% CI [.20, .63]) and career intentions ( $\beta = .22$ ,  $SE = .11$ ,  $p = .047$ , 95% CI [.003, .45]).

Some other notable differences concerned the relations of prior achievement to post-graduation outcomes. For females only, year 3 science GPA significantly predicted post-graduation life satisfaction ( $\beta = .16$ ,  $SE = .06$ ,  $p = .004$ , 95% CI [.04, .27]), controlling for the other effects in the model. For men only, year 3 science GPA significantly predicted science research career intentions ( $\beta = .16$ ,  $SE = .07$ ,  $p = .03$ , 95% CI [.02, .29]). Taken together, results indicated that science GPA in the 3<sup>rd</sup> year informed academic self-efficacy for men and women in addition to research self-efficacy for women, and that both competence beliefs predicted outcomes for women, but for men only academic self-efficacy predicted the two post-graduation outcomes.

## Discussion

Students finishing their university studies in science face important decisions about their next steps, and these decisions rely on judgments about the likelihood of success in various career pursuits. This is a particularly salient issue for instructors, programs, and policymakers aiming to support equitable representation of women in the research workforce (National Science Board, 2016). Students' confidence on academic and scientific tasks

are key predictors of science career goals (Bandura, 1977; Eccles et al., 1983; Elliot & Dweck, 2005; Pekrun, 2006; Robinson et al., 2018). It is important to understand the potentially similar or different roles of these two beliefs in order to more effectively design interventions to support student well-being and success in research careers.

A large body of research has established the importance of academic self-efficacy beliefs for STEM pursuit (da Silva Cardoso et al., 2013; Deemer et al., 2014; Lent et al., 2005; Soldner et al., 2012), largely among high school and early college students. Notably, this research suggests that self-efficacy beliefs may play differential roles in career pathways for men and women (Eccles, 2005; Eccles & Vida, 2003; Wang et al., 2013; Wegemer & Eccles, 2019). Our longitudinal study adds unique insights by examining the roles of science research self-efficacy and science academic self-efficacy during a key transition point at the end of university studies. Building on prior work largely examining gender differences in levels of academic competence beliefs, we examine both mean and structural differences of two distinct science self-efficacy beliefs.

For the overall sample, science achievement in the third year of college significantly predicted both academic self-efficacy and research self-efficacy in the final year of college. However, as we predicted, it appeared that prior achievement was more strongly related to academic self-efficacy than research self-efficacy. This aligns with theory and research showing stronger relations between variables of similar domains and levels of measurement (Valentine et al., 2004). In this case, prior science GPA was likely one of the most salient criteria students used to inform their levels of confidence in future academic success in science. For research self-efficacy, students may have relied on academic successes to some extent in forming judgements about their confidence in executing scientific tasks; however, they also likely relied on other experiences such as extracurricular research opportunities. Indeed, our intervention study comparing this sample to the intervention group demonstrated that early-college research experiences embedded with motivational support can enhance science research self-efficacy (Linnenbrink-Garcia et al., 2018). Considering the importance of both self-efficacy beliefs for different outcomes, future research should investigate what types of experiences might be particularly supportive of each. It may also be that our self-efficacy measures are more general in nature than students typically conceptualize their major courses, failing to reflect successes and failures in tasks related to specific fields (e.g. chemistry, biology, etc.), as opposed to scientific successes and failures more broadly.

In addition, for the overall sample, both forms of self-efficacy were significant predictors of science career intentions after college, controlling for prior achievement. This is a particularly interesting finding as it suggests that, on average, individuals appear to weight their confidence on both academic and scientific tasks equally in forming their career goals in science. Similarly, both academic and research self-efficacy significantly predicted post-graduation life satisfaction. It is unclear why this may be the case; however, the findings about academic self-efficacy may at least in part reflect our measure that includes aspects of overcoming challenges through trying hard and not giving up. This aspect may reflect a higher-order orientation to meeting challenges that also promotes higher life satisfaction. Students' efficacy beliefs on specific science-related tasks may be connected to overall life satisfaction in this environment that promotes scientific values, thus promoting satisfaction

via confidence on valued tasks. Further research should attempt to replicate this finding and consider why this may be the case.

### Mean and Structural Relations by Gender

The findings of the overall model contribute important understandings about the roles of two distinct self-efficacy beliefs for college science students in a key period, just before entering the early stages of their career. However, these findings were qualified by key gender differences in mean levels and roles of self-efficacy beliefs for men and women. First, in alignment with our hypotheses and with prior research on STEM self-concept (e.g., Simpkins et al., 2006), significant mean differences were revealed for science academic self-efficacy. This finding suggests that undergraduate science programs may be more facilitative of men's academic self-efficacy beliefs than women's despite men and women being equally capable, as evidenced by their similar levels of prior grades in science. These findings also suggest that women may need additional support to feel efficacious in science classes.

Considering prior research that suggests women may rely more on social sources of self-efficacy (Linver & Davis-Kean, 2005; Usher & Pajares, 2005), one promising avenue for supporting women's self-efficacy may lie in increasing the number of female faculty and connecting them with mentorship programs designed to support academic self-efficacy. In contrast with our predictions and with prior research showing gendered differences in STEM career pursuits (Zarrett & Malanchuk, 2005), mean levels of research self-efficacy, career intentions, and well-being did not differ across gender groups in our sample. While the differences in academic self-efficacy might suggest a motivational mechanism for gender gaps in science participation, we did not see evidence of gender gaps in research-related science career intentions or life satisfaction in our sample.

Second, the overall model showed that both academic and research self-efficacy were significantly related to prior achievement in science, but findings also suggested that prior achievement may be most important for academic self-efficacy. Indeed, the multigroup model results indicated that science GPA in the third year significantly predicted academic self-efficacy for both men and women, but predicted research self-efficacy only for women, perhaps indicating that the significant relations between science GPA and research self-efficacy observed in the full-sample model reflected women only. It may be that for men, activities outside of the classroom such as research experiences and mentorship are most important for shaping research self-efficacy, whereas women at least partially rely on academic successes to inform their research self-efficacy.

Lastly, relations of self-efficacy beliefs to the outcomes differed by gender group. Whereas for women both self-efficacy beliefs appeared to be important for life satisfaction and research career intentions, only academic self-efficacy predicted these outcomes for men. This suggests that women may rely on a more diverse set of self-beliefs to make career and life decisions with implications for their well-being. Interventions to support women's research career persistence and well-being may involve a greater emphasis on supporting both of these self-efficacy beliefs rather than just one of the two.

## Limitations and Future Directions

One factor that may limit our study is that most of the variables consisted of self-report measures. This may have introduced common method bias, and thus inflated relations among variables. In line with theoretical traditions such as the theory of planned behavior (Ajzen, 1991), we relied on intentions as a presumed predictor of science career behavior. We acknowledge that in order to more fully explicate the roles of science self-efficacy beliefs, it may be most effective to consider intentions combined with measures of actual career behavior. An important future direction for research that may complement and extend our findings would be to use observed measures of science career involvement to examine whether relations differ based on self-report versus more objective measurement methods. Relatedly, we note our single-item measure of career intentions as a limitation due to its potential vulnerability to random measurement error. As a balance to this limitation, we rely on prior research that has yielded promising support for the use of single-item measures of related constructs (Gogol et al., 2014; Nagy, 2002). In this case, due to the clear, single-faceted nature of the construct, a single-item measure may be most appropriate (Gogol et al., 2014) and indeed, cross-sectional and longitudinal evidence supports its psychometric properties, most notably through significant correlations with scientific behaviors and beliefs in prior research using this item (Estrada et al., 2009; 2011).

Second, we found evidence for theorized links between science self-efficacy and a relatively novel outcome: post-graduation life satisfaction. However, in our study we did not explore mechanisms of these relations, such as involvement and success in valued science activities. In addition, these mechanisms may differ depending on students' majors, and we did not include students' major in our analyses. Thus, we do not have evidence for why self-efficacy predicted subsequent life satisfaction. In this study, we considered it a primary aim to establish evidence of relations between self-efficacy and life satisfaction, a construct not typically considered in achievement motivation studies from a social-cognitive perspective. As we now have evidence that self-efficacy indeed predicts life satisfaction, a natural next step for future research would be to test the theorized mechanisms of these relations as proposed by Lent et al. (2000) and across different fields of study.

In addition, it is possible that our sample size may not have been sufficient to detect some of the smaller effects, particularly gender differences in specific parameters, within the multigroup models. These differences, although small, may be practically meaningful and so future research may be needed to investigate gender differences in relations between self-efficacy and important post-graduation outcomes.

It is also important to acknowledge that our sample consisted of students at a highly selective university. Such students tend to be high-achieving during and after university studies, and so may in particular show different patterns of life satisfaction and relations of self-efficacy to life satisfaction compared to students at other institutions. It may be interesting in future studies to test this proposition by comparing these processes across different academic settings.

A final limitation of our study concerns the inferences that can be made about why means and relations among variables are different for men and women. These inferences are limited

because we do not know if women experienced threat or discrimination, for example, or if these differences were due to other processes. Future research should investigate the mechanisms that lead to differences in self-efficacy between men and women. In addition, because self-efficacy is only one of several important processes involved in career choices, life satisfaction, and gender differences in STEM (e.g., Eccles & Wang, 2016; Wang et al., 2013; Wegemer & Eccles, 2019), it is important to examine self-efficacy alongside other key constructs, such as career-related values, that are subject to gendered socialization processes. Such research will be important for developing interventions to support women in STEM.

## Conclusion

Our findings that two different self-efficacy beliefs were differentially related to prior achievement and post-graduation outcomes contributes to understandings of which specific constructs should be supported during college and the processes that shape them at a key developmental transition point. Evidence of differential relations among these variables across gender groups can be used to better understand gender disparities in science. For example, it appeared that women's research career aspirations and life satisfaction were tied to their self-efficacy for both academic and scientific tasks, whereas men relied solely on academic self-efficacy rather than both forms of self-efficacy to inform post-graduation career intentions and life satisfaction. Our findings extend theoretical understandings of two distinct but related self-efficacy beliefs and their roles in persistence intentions and well-being, which addresses the need to extend motivation theory in pursuit of a more nuanced understanding of motivational processes in science contexts.

## APPENDIX. Survey Items

### Science Academic Self-Efficacy (Midgley et al., 2000)

1. I'm certain I can master the skills taught in science classes.
2. I'm certain I can figure out how to do the most difficult class work in science.
3. I can do almost all the work in science classes if I don't give up.
4. Even if the work in science is hard, I can learn it.
5. I can do even the hardest work in science if I try.

### Science Research Self-Efficacy (Estrada et al., 2011)

I am confident that I can...

1. Use technical science skills (use of tools, instruments, and/or techniques).
2. Generate a research question to answer.
3. Figure out what data/observations to collect and how to collect them.
4. Create explanations for the results of the study.
5. Use scientific literature and/or reports to guide research.

### Science Career Intentions (Estrada et al., 2011)

To what extent do you intend to pursue a research-related career in science?

Satisfaction with Life Scale (Diener, 1985)

1. In most ways, my life is close to my ideal.
2. The conditions of my life are excellent.
3. I am satisfied with my life.
4. So far, I have gotten the important things I want in life.
5. If I could live my life over, I would change almost nothing.

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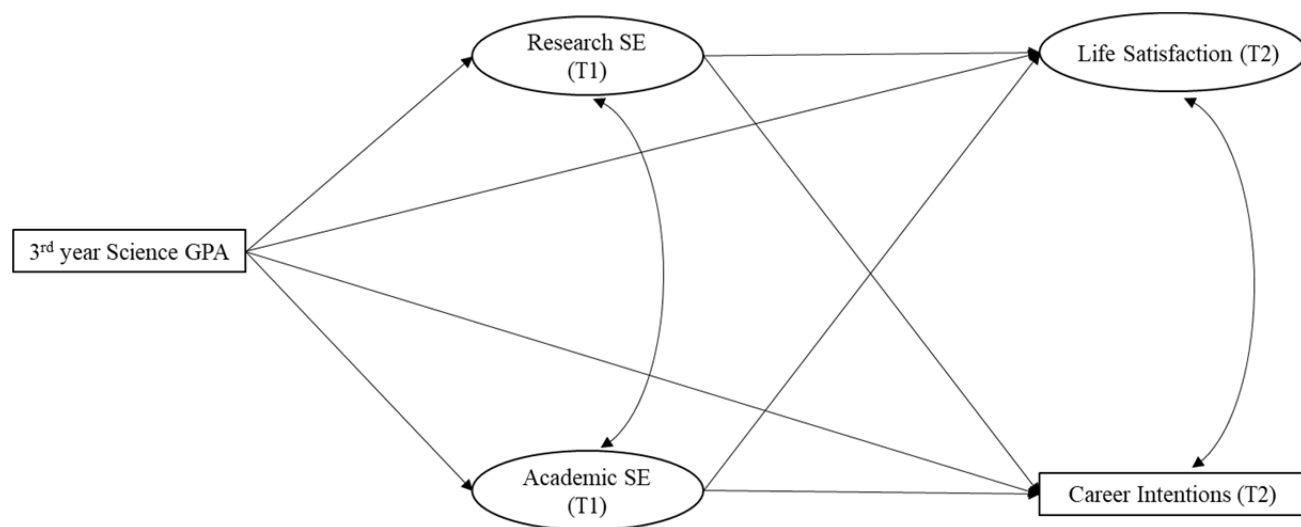
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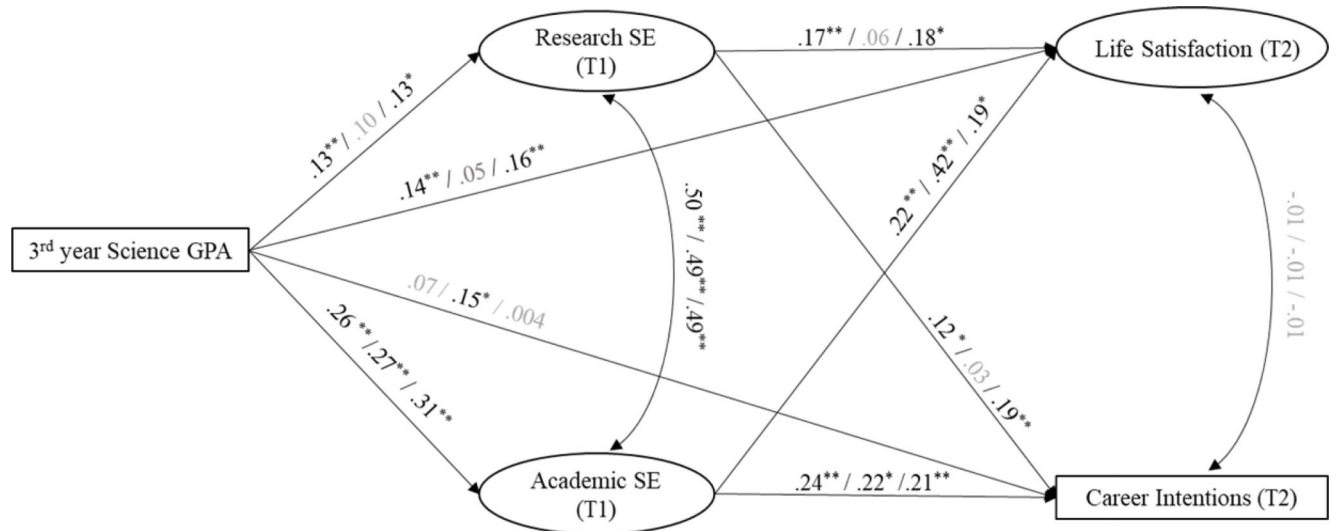
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**Figure 1.**  
Hypothesized relations among study variables.



**Figure 2.**

Model-estimated relations among study variables including standardized path coefficients for each model labelled in the following order: overall / male / female. Control variables (underrepresented minority group membership, first-generation college student) predicting science GPA, research self-efficacy, academic self-efficacy, life satisfaction, and career intentions are not displayed.

**Table 1:**

## Descriptive Statistics and Correlations of Study Variables

	1	2	3	4	5
1. Year 3 GPA	–				
2. Year 4 Research Self- Efficacy (T1)	.11 *	–			
3. Year 4 Academic Self-Efficacy (T1)	.28 **	.49 **	–		
4. Post-Grad Life Satisfaction (T2)	.19 **	.21 *	.30 **	–	
5. Post-Grad Career Intentions (T2)	.11 *	.25 **	.28 **	.11 *	–
<i>M</i>	3.50	3.95	4.02	3.50	5.61
<i>SD</i>	0.51	0.52	0.67	0.91	2.98

*Note.* All observed and latent variable correlations, means, and standard deviations were calculated in Mplus.

\*  
 $p < .05$ .

\*\*  
 $p < .001$ .

**Table 2:**

## Gender Group Measurement Invariance for Latent Variables

Model	$\chi^2$	df	RMSEA	CFI	CFI	TLI	SRMR
RSE & ASE							
Configural	240.400	86	0.077	0.960		0.949	0.050
Weak	262.841	95	0.076	0.957	-0.003	0.950	0.074
Strong	309.411	104	0.081	0.947	-0.010	0.944	0.081
Strict	355.692	115	0.083	0.938	-0.009	0.941	0.096
Life Satisfaction							
Configural	38.818	10	0.081	0.986		0.972	0.021
Weak	42.476	14	0.068	0.986	0.000	0.980	0.034
Strong	52.827	18	0.067	0.983	-0.003	0.981	0.046
Strict	61.059	23	0.062	0.982	-0.001	0.984	0.052

*Note.* RSE = T1 Research Self-Efficacy, ASE = T1 Academic Self-Efficacy

**Table 3:**

## Fit Indices for Multigroup Model Comparisons

	Model	#	$\chi^2$	df	$\chi^2$	df	RMSEA	CFI	TLI
0	Means and regression coefficients equal across groups	74	739.505	376	-	-	0.047	0.938	0.938
1	Means freely estimating; regression coefficients equal across groups	79	704.286	371	-35.129	-5	0.045	0.943	0.942
2	Means equal across groups; regression coefficients freely estimating	82	699.757	368	-39.748	-8	0.045	0.943	0.942
3	By gender: means and regressions free	87	695.198	363	-44.307	-13	0.046	0.943	0.941

*Note:* # = number of free parameters. Change in  $\chi^2$  and degrees of freedom for  $\chi^2$  were calculated with Model 0 as the reference model, and all difference tests were significant at  $p < .001$ .