# FURTHERING STEM MAJOR COMMITMENT: THE EFFECT OF SELF-REGULATED LEARNING AND NOTE TAKING STRATEGIES ON ACADEMIC SELF-EFFICACY

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**ABSTRACT**

There is increased demand for candidates in science, technology, engineering, and mathematics (STEM) careers, yet STEM undergraduate retention rates are not meeting this demand, as reported by the National Science Foundation in 2022. Prior research found students with greater proactive personality traits positively correlated with STEM commitment and score higher in academic self-efficacy (Major et al., 2012). Self-regulated learning (SRL), when utilizing strategies like engaged notetaking (Kauffman et al., 2011), has been shown to improve academic self-efficacy (Lavasani et al., 2011). Although SRL has been applied to K-12 and undergraduates, the research to date has not focused on undergraduate SRL improvement by engaged notetaking in STEM-specific settings. The current study sought to increase self-efficacy, SRL, and STEM attachment among STEM undergraduates with an online, note-taking strategies workshop as SRL training. STEM major students from a large Hispanic-serving university were recruited ($n$ = 99). Using pretest-posttest design, students' self-efficacy, SRL habits, and major attachment were recorded, while controlling for proactive personality. Results indicate significant improvement in self-efficacy, SRL, and STEM attachment scores following the intervention. Proactive personality's predictive ability on the degree of change experienced from the workshop is also discussed. The findings have implications for instructors on what easy-to-implement pedagogical methods may increase student STEM self-efficacy and potentially increase pathway persistence. Future studies may expand to student sub-groups shown to struggle persisting in STEM (e.g., first generation students, multi-lingual learners, etc.).

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# INTRODUCTION

The job market has seen a higher demand for candidates in science, technology, engineering, and mathematics (STEM) with STEM employment estimated to increase by 8% by 2029, surpassing the overall national employment growth of 3.7% for all other non-STEM fields (U.S. Bureau of Labor Statistics, 2021). Unfortunately, many STEM major retention rates are lower than expected as less than 40% of students entering college pursuing STEM as a major eventually graduated with a STEM degree in 2012 (President's Council of Advisors on Science and Technology, 2012). This is not a standalone case as there has been a continuous lack of undergraduate students declaring and finishing STEM degrees in recent years (Carnevale, Smith, & Melton, 2011; Doerschuk et al., 2016; Sithole et al., 2017). Despite efforts to address STEM pathway melt, the National Science Foundation indicated this trend of students falling out of the STEM pipeline within the first two years (NSF/NAES, 2022) is even more pervasive among undergraduate women and those from underrepresented minority backgrounds (e.g., Latinx, Black, first in college) entering STEM subject fields in higher education (Griffith, 2010; Seymour et al., 2019). As a result, there has been increased interest in research on what interventions can foster higher retention rates among undergraduate students majoring in the STEM field, including methods relating to proactive personality behaviors, self-efficacy, and self-regulated learning strategies.

Previous literature has identified proactive personality behaviors as being positively correlated with STEM major commitment among undergraduate students (Major et al., 2012). A proactive personality is best defined as a willingness to self-initiate steps to alter a presently unfavorable situation into a favorable one (Bateman & Crant 1993; Kirby, Kirby, & Lewis, 2002). Findings from other studies suggest that proactive personality plays such a role due to its relationship with self-efficacy—a person's belief in their capacity to do well in a specific task or environment (Bandura 1986; Bartimote-Aufflick et al., 2016). Specifically, research implicates that greater academic self-efficacy is both a byproduct of proactive behavior (Chen et al., 2021) as well as a construct that increases academic success and persistence (Multon et al., 1991). Therefore, an intervention that could increase STEM students' self-efficacy may also theoretically improve their sense of STEM major commitment just as more proactively inclined students experience.

In terms of how self-efficacy can be improved, self-regulated learning (SRL) student practices have been shown to significantly increase academic self-efficacy (Lavasani et al., 2011); this is reinforced further by positive correlations with GPA and achievement in undergraduate students (Wernersbach et al., 2014). In an educational setting, self-regulated learning, as opposed to regular learning, specifically calls for students to self-reflect and undertake planned, routine actions that modify their behavior to achieve intrinsic goals of achievement (Zimmerman, 2000).

The current study strives to synthesize proactive personality, academic self-efficacy, and SRL as influential constructs for designing an intervention that may increase STEM major attachment among undergraduate students. Namely, the research expands on the findings of a study that increased undergraduates' STEM achievement through a brief, online self-regulated learning strategies (SRLS) module (Bernacki et al., 2020). To do so, a 1-hour online workshop on notetaking strategies as a form of SRL training was administered to undergraduate STEM students. Participants' proactive personality, self-efficacy, SRL, and STEM major attachment (likelihood to persist in the STEM major) levels were measured before and after the workshop. Due to the implications gathered from the literature review, students' SRL, self-efficacy, and

STEM attachment scores are expected to increase following the workshop. In line with prior research, participants' level of proactive personality is also expected to predict the amount of change (if any) towards students' SRL, self-efficacy, and STEM attachment scores after the intervention. Thus, the main hypotheses of the current study are (1) there will be a significant improvement to students' SRL, academic self-efficacy, and STEM attachment scores after the intervention workshop and (2) students with a lower level of proactive personality will experience greater changes to their SRL, self-efficacy, and STEM attachment scores after the intervention compared to students with a higher level of proactive personality.

## METHODS

The University of California, Riverside Institutional Review Board approved this research under the IRB number HS 22-097 (Study Title: Furthering STEM Major Commitment: The Effect of Self-Regulated Learning and Note-Taking Strategies on Academic Self-Efficacy).

### Participants

103 undergraduate college students completed the study, 4 of which were removed due to being identified as from non-STEM major. This sample was determined sufficient following an a priori power analysis using G*Power version 3.1.9.6 (Faul et al., 2007). Results using a 0.05 alpha estimated a sample size of 79 necessary to report with 80% power a 0.32 small-to-moderate effect size for a *t*-test for the difference between two dependent means (matched pairs).

Of the remaining sample ($n$ = 99), 50 identified as female, 48 as male, and one as non-binary. The ethnic breakdown of the sample self-identified as 68% Asian, 10% Hispanic, 9% Non-Hispanic White, 9% Other (e.g., Middle Eastern, Asian and White), 2% African American, and 2% preferred not to say. The ages of the participants ranged from 18 to 33 years old (*M* = 19.25, *SD* = 2.0). In terms of college level, 55% of the sample were sophomores, 26% were freshmen, and 19% were juniors. None of the participants were seniors in college, which is preferable considering seniors majoring in STEM are less at risk of leaving the STEM pathway (Weston et al., 2019). 23% of participants identified as first-generation students.

Students were recruited by email announcement and class Canvas (an LMS) announcement posted by the cooperating instructors from an introductory computer science course and an introductory organic chemistry course at a designated four-year post-secondary Hispanic Serving Institution (University of California, Riverside). These courses were selected as they are typically large enrollment gateway courses for many STEM majors. The duration of recruitment and data collection occurred during the 2022 Fall school quarter. Most students, around 86%, completed the study by the end of week five of the quarter. Participants received extra credit comparable to 5% (as determined by their instructor) towards their course grade as compensation for completing the study. Other equivalent extra credit options were available to those who chose not to participate.

## Measures

Upon being recruited, students were directed to the informed consent link where they completed the informed consent process prior to starting any part of the study. The measures that were utilized are detailed below, in order of administration.

### *The Motivated Strategies for Learning Questionnaire (MSLQ)*

To measure participants' level of academic self-efficacy and self-regulated learning, three scales from the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich and De Groot (1990) were applied. The MSLQ has been widely translated and utilized due to its high validity, as well as reliability in measuring the motivation, cognitive strategies, and self-regulated learning among a broad range of students (Duncan & McKeachie, 2005; Lee et al., 2010; Zimmerman & Kitsantas, 2014). It was designed with a social-cognitive focus and the scales can be used collectively or individually to test for specific aspects of learning (Wernersbach et al., 2014). The full questionnaire included 56 items, however only 28 items consisting of the Self-Efficacy, Cognitive Strategy Use, and Self-Regulated Learning subscales were deemed appropriate for this study's constructs of interest. Items are rated on a 7-point Likert scale based on how well each best describes the participant, ranging from 1 = "not at all true" to 7 = "very true".

The Self-Efficacy subscale consists of nine items that seek to measure participants' perceived capability in accomplishing academic tasks (Pintrich & De Groot, 1990). Examples of items include, "I'm confident I can do an excellent job on the assignments and tests in this course," and "I'm confident I can understand the basic concepts taught in this course." Following the direction taken by Bong and Hocevar (2002), three items from the Self-Efficacy scale were removed due to their comparative, normative nature (e.g., "Compared with others in this class, I think I'm a good student.") which has been suggested to represent self-efficacy less than items on the basis of mastery alone (Bong & Clark, 1999; Zimmerman, 1995). Thus, the final adapted scale used to measure students' level of academic self-efficacy had a total of six items. Cronbach's alpha was reported by Yu et al. (2023) ($\alpha$ = .87) and was calculated with SPSS ($\alpha$ = .95) at both time points in this study.

The Cognitive Strategy Use and Self-Regulated Learning subscales were incorporated to measure the level of SRLS use and general SRL in the participants. The Cognitive Strategy Use scale is made up of 13 items (one reverse scored) that revolve around rehearsal, elaboration, and organizational cognitive strategies (e.g., “When studying, I copy my notes over to help me remember material,” “When I study, I put important ideas into my own words,” “I outline the chapters in my book to help me study”). Cronbach’s alpha was reported at $\alpha$ = .83 (Pintrich & De Groot, 1990). The Self-Regulated Learning scale consists of nine items (three reverse scored), that target metacognition and effort management, which are integral concepts to the self-regulated learning process. An example of one of the items includes, “Before I begin studying, I think about the things I will need to do to learn”. In terms of reliability, Cronbach’s alpha for the scale was $\alpha$ = .74 (Pintrich & De Groot, 1990).

### *Proactive Personality Scale*

To measure levels of proactive personality in the sample, the shortened version of Bateman and Crant’s (1993) Proactive Personality Scale developed by Seibert et al. (1999) was administered. The original scale contained 17 items while the shortened version has 10 items with a Cronbach’s alpha of $\alpha$ = .86 (Seibert et al., 1999). Scores are recorded on a 7-point Likert scale where participants select how much each item best describes them ranging from 1 (strongly disagree) to 7 (strongly agree). Higher scores represent a greater proactive personality. Though the items have no inherent academic connotations (e.g., “I am constantly on the lookout for new ways to improve my life.”), this scale has been successfully used to indicate predictive effects of proactive personality on academic self-efficacy in educational settings as well (Lin et al., 2014).

### *STEM Major Embeddedness Scale*

To capture participants’ willingness to commit to majoring in STEM, without the use of any longitudinal data, the STEM Major Embeddedness Scale was applied. The measurement consists of 14 items divided into three subscales: Fit, Links, and Sacrifice. The subscales are further divided into different sub-dimensions such as “camaraderie” and “STEM-related professors and advisors" under the Links subscale. An example item reads, "I thrive on the challenge my major offers."

Students are asked to rate the extent they agree or disagree with the statements using a 5-point Likert scale. Possible responses include 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). The scale was devised and thoroughly validated by Major et al. (2020) who reported Cronbach's alpha to be $\alpha = .89$ and $\alpha = .90$ for two separate samples. Although recently developed, the measure has showcased significant convergent and discriminant validity, as well as being used to examine professional identity development in STEM settings (Burleson et al., 2021).

## PROCEDURE

For ease of accessibility and safety amidst the continuing COVID-19 pandemic, all surveys and study requirements were conducted online using *Qualtrics* software. Additionally, the workshop intervention on self-regulated learning and note-taking strategies was in an online meeting format using *Zoom* software.

### Consent And Pretest

All students completed the informed consent process before participating by reviewing important study/consent information and then opted to provide or deny consent in a *Qualtrics* survey. Those who consented went on to answer demographic questions and all the measures disclosed in the above section as part of the pretest survey. Upon completing the pretest component, participants were directed to attend one of two available workshop dates and were provided the Zoom link to access the online meeting.

**Intervention Workshop**

The intervention was delivered as a 1-hour, online synchronous workshop on Zoom led by the lead researcher. The content of the workshop focused on self-regulated learning (SRL) and instructed participants on note-taking strategies that could be used to begin engaging in SRL. Notetaking strategies were organized by which cognitive learning strategy (elaboration, rehearsal, and organization) they applied to, which were also identified and defined for the students. Students were additionally introduced to topics like metacognition and common challenges to SRL, including procrastination or multitasking. All information provided in the workshop was derived from educational psychology findings and citations were included on corresponding workshop slides.

Three different activities adapted from Seli and Dembo (2019) were included in the workshop that participants engaged with. This was done to spur active reflection and discussion. Two such activities were discussion based where students answered a prompt regarding their study behavior and answers were then anonymously presented in a word cloud format. These activities were facilitated using Mentimeter.com which is an online, Audience Response System (ARS) that many lecturers have employed to encourage student engagement, typically by submitting responses to a presented question (Mohin et al., 2022). The other activity had participants share whether they agreed, disagreed, or were uncertain about the validity of specific statements regarding student learning. Although involvement in the activities was greatly encouraged, students were consistently reminded that they could choose not to answer if they were uncomfortable doing so. At the end of the workshop, attendance was taken through a brief survey that also served to provide gateway access to the following post-test assessment.

## Posttest

Participants again answered all the same measures from the pretest as part of the posttest Qualtrics survey after which their study involvement was marked as completed. Students finished this last step on their own time but were instructed to do so after their first-course assessment (e.g. quiz, exam). Majority of students completed the posttest within two weeks, although a small number of participants did not finish the study until the end of the school quarter six to seven weeks after the workshop.

# RESULTS

All of the following statistical analyses were conducted using IBM SPSS version 28.0 (IBM Corp, 2021).

## Correlational Data

To investigate how the different variables are related, Pearson's correlations between all measures, gender, age, ethnicity, first-generation student status, major, and year in college were performed. A correlation matrix is provided in Table 1. Consistent with previous studies, proactive personality was most positively correlated with STEM major attachment compared to the other measures in both the pretest, $r(97) = .30$, $p < .01$, and posttest, $r(97) = .55$, $p < .01$ scores. Self-efficacy was also positively related to STEM attachment with pretest scores, $r(97) = .20$, $p < .05$, and to a stronger degree with posttest scores, $r(97) = .49$, $p < .01$. Similarly, SRL, had a positive relationship with STEM major attachment before, $r(97) = .27$, $p < .0$, and after the workshop, $r(97) = .46$, $p < .01$. Moderate correlations were observed between SRL and self-efficacy using pretest scores, $r(97) = .44$, $p < .01$, and posttest scores, $r(97) = .41$, $p < .01$. There was a slightly stronger positive relation than expected between proactive personality and SRL pre, $r(97) = .61$, $p < .01$, and post, $r(97) = .68$, $p < .01$, intervention. These relationships are all consistent with the literature review findings, specifically how SRL, self-efficacy, and proactive personality can interact to influence STEM major attachment.

**Table 1.** *Pearson Correlations Among All Variables*

| | Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Pre Self-Efficacy | | | | | | | | | | | | | |
| 2. | Pre Self-Regulated Learning | **.44** | | | | | | | | | | | | |
| 3. | Pre Proactive Personality | **.34** | **.61** | | | | | | | | | | | |
| 4. | Pre STEM Major Attachment | **.20*** | **.27** | **.30** | | | | | | | | | | |
| 5. | Post Self-Efficacy | **.76** | **.27** | .16 | **.20** | | | | | | | | | |
| 6. | Post Self-Regulated Learning | **.38** | **.71** | **.44** | **.30** | **.41** | | | | | | | | |
| 7. | Post Proactive Personality | **.34** | **.53** | **.70** | **.29** | **.32** | **.68** | | | | | | | |
| 8. | Post STEM Major Attachment | **.30** | **.22** | **.29** | **.62** | **.49** | **.46** | **.55** | | | | | | |
| 9. | Gender | **.37** | -.03 | .02 | -.1 | **.39** | .08 | .13 | .09 | | | | | |
| 10. | Age | -.11 | .07 | .04 | .09 | -.06 | .03 | .07 | .09 | .06 | | | | |
| 11. | Ethnicity | -.03 | .13 | .01 | .12 | -.01 | .19 | .11 | .07 | .07 | **.22** | | | |
| 12. | First Generation Student | -.13 | -.01 | .12 | -.1 | -.01 | .01 | .09 | -.05 | -.07 | .14 | .04 | | |
| 13. | Major | **.24** | -.19 | -.07 | -.03 | **.33** | -.12 | -.07 | .07 | **.26** | -.13 | -.09 | -.01 | |
| 14. | Year in College | **-.21** | .11 | .13 | .06 | **-.23** | -.01 | .1 | -.01 | **-.25** | **.58** | .00 | **.20** | **-.54** |

*Note.* Bold items are significant at $p < .05$.

Interestingly, gender was positively correlated with self-efficacy scores before, $r(97) = .37$, $p < .01$, and after the workshop, $r(97) = .39$, $p < .01$. Moreover, students' major was positively correlated with self-efficacy pre, $r(97) = .24$, $p < .05$, and post, $r(97) = .33$, $p < .01$, while being negatively correlated with their year in college, $r(97) = -.54$, $p < .01$.

## Score Differences After Intervention

Paired samples *t*-test comparison of pretest and post-test means was performed to identify any differences in student scores for each measure following the intervention (findings can be seen in Table 2). Cohen's *d* was used to report effect sizes. A paired samples t-test indicated a significant difference between posttest self-efficacy scores ($M = 30.26$, $SD = 7.16$) and pretest self-efficacy scores ($M = 28.91$, $SD = 7.18$), $t(98) = 2.73$, $p < .01$, $d = 0.28$. Likewise, posttest SRL scores ($M = 109.65$, $SD = 15.58$) were significantly different from pretest SRL scores ($M = 105.86$, $SD = 15.45$), $t(98) = 3.19$, $p < .005$, $d = 0.32$. The difference between posttest proactive personalities scores ($M = 51.56$, $SD = 9.72$) and pretest proactive personality scores ($M = 50.06$, $SD = 9.75$) were not statistically significant, $t(98) = 1.99$, $p = .05$, $d = 0.20$. Scores were significantly higher for posttest STEM major embeddedness ($M = 53.68$, $SD = 8.22$) compared to pretest STEM major embeddedness ($M = 51.90$, $SD = 8.36$), $t(98) = 2.44$, $p = .016$, $d = 0.25$.

**Table 2.**

*Results of Paired Samples t-Tests Comparing Pretest and Posttest Score Differences*

| Paired Measures (post - pre) | Pretest | | Posttest | | | Significance | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t*(98) | *p* | Cohen's *d* |
| Self-Efficacy | 28.909 | 7.1800 | 30.263 | 7.1565 | 2.734 | .007** | 0.275 |
| Self-Regulated Learning | 105.859 | 15.4471 | 109.646 | 15.5788 | 3.186 | .002** | 0.320 |
| Proactive Personality | 50.061 | 9.7487 | 51.556 | 9.7177 | 1.988 | .050 | 0.200 |
| STEM Major Attachment | 51.899 | 8.3562 | 53.677 | 8.2249 | 2.442 | .016* | 0.245 |

*Note*. * $p < .05$. ** $p < .01$.

**Predictive Ability of Proactive Personality**

A simple linear regression model was applied to examine the influence proactive personality may have had on the observed score changes after the workshop. Regressions found to be significant are included in the tables below. Pretest proactive personality scores significantly predicted degree of self-efficacy change in students after the workshop ($F(1, 97) = 7.074$, $p < .01$), with an $R^2$ of .068. Specifically, students' change in academic self-efficacy scores decreased for each increase in proactive personality score total (B = -.132, $p < .01$). Pretest proactive personality scores also predicted degree of SRL change among participants following the intervention ($R^2 = .05$, $F(1, 97) = 5.082$, $p < .05$). The results of the simple linear regression equation indicate that as pretest proactive personality scores increased, a decrease in SRL score change could be significantly predicted (B = -.271, $p < .05$).

Though a simple linear regression was not significant between pretest proactive personality levels and change in STEM major attachment, posttest proactive scored did have a significant regression effect on STEM major attachment change ($R^2 = .085$, $F(1, 97) = 8.999$, $p < .01$). Increases in posttest proactive personality levels significantly predicted an increase in the amount of STEM attachment change to students' scores (B = .217, $p < .01$).

**Table 3.**
*Simple Linear Regression Results for Pretest Proactive Personality Predicting Self-Efficacy Changes*

| | | | | | 95.0% Confidence Interval | |
|---|---|---|---|---|---|---|
| Variable | B | Std. Error | Beta | *p* | *LL* | *UL* |
| (Constant) | 7.949 | 2.526 | | .002 | 2.94 | 12.96 |
| Pretest Proactive Personality | -0.132 | 0.050 | -0.261 | .009 | -0.23 | -0.03 |

*Note. LL* = lower limit; *UL* = upper limit

**Table 4.**

*Simple Linear Regression Results for Pretest Proactive Personality Predicting SRL Changes*

| | | | | | 95.0% Confidence Interval | |
|---|---|---|---|---|---|---|
| Variable | B | Std. Error | Beta | *p* | *LL* | *UL* |
| (Constant) | 17.342 | 6.124 | | .006 | 5.19 | 29.50 |
| Pretest Proactive Personality | -0.271 | 0.120 | -0.223 | .026 | -0.51 | -0.03 |

*Note. LL* = lower limit; *UL* = upper limit

**Table 5.**

*Simple Linear Regression Results for Posttest Proactive Personality Predicting STEM Major Attachment Changes*

| | | | | | 95.0% Confidence Interval | |
|---|---|---|---|---|---|---|
| Variable | B | Std. Error | Beta | *p* | *LL* | *UL* |
| (Constant) | -9.421 | 3.798 | | .015 | -16.96 | -1.88 |
| Posttest Proactive Personality | 0.217 | 0.072 | 0.291 | .003 | 0.07 | 0.36 |

*Note. LL* = lower limit; *UL* = upper limit

## DISCUSSION

The present study confirmed that not only could are the levels of SRL and academic self-efficacy of undergraduate STEM students malleable, but also indicated they can be increased.Student attachment to their major was also significantly improved by the intervention. This is evidenced by the results of the paired samples *t*-test which showed significant improvement in mean scores across SRL, self-efficacy, and STEM major attachment measures. Although effect sizes for these increases hovered around small to moderate ranging from 0.25 to 0.32, considering the workshop was only one hour, online, and a one-time occurrence, the findings are informative. This brief, yet effective nature of the SRL and notetaking strategies workshop reinforces findings from Bernacki et al., (2020).

Since the online workshop content primarily centered on SRL and notetaking strategies, the subsequent impact on self-efficacy and STEM attachment scores supports the role SRL has on such variables. In short, it is reasonable to suggest that SRL can improve academic self-efficacy in STEM undergraduate students, which in turn increases the amount of attachment they feel towards their major. This directly supports previous empirical evidence from the educational psychology literature (Kauffman et al., 2011; Theobald, 2021). The correlational results that display significant positive relationships between all the measured variables also furthers this sentiment. Future studies may examine the specific mediating relationship and direction of these variables. From the findings of the current research alone, SRL and self-efficacy should be taken into consideration when designing curriculum or resource interventions in STEM undergraduate education. The only measure that did not see a significant increase in score means before and after the workshop was proactive personality. This is consistent with expectations as well as previous studies discussing proactive personality as a more stable disposition (Crant, 2000; Lin et al., 2014). Overall, there is ample support in favor of our first hypothesis regarding significant improvements to SRL, academic self-efficacy, and STEM major attachment following the intervention.

Our second hypothesis was partially supported by the results. As expected, students' proactive personality scores prior to the workshop did significantly predict how great of an effect the intervention had on their SRL and academic self-efficacy levels. The simple linear regressions applied indicated a higher proactive personality score predicted less SRL and self-efficacy change. This is reasonable as a more proactive student that may already engage in SRL behaviors or have higher pre-existing amounts of academic self-efficacy, would stand to feel less impacted by the intervention. However, pretest proactive personality scores could not significantly predict the degree of STEM attachment change experiences by the participants.

In contrast, posttest proactive personality scores did significantly predict the amount of STEM attachment change. Interestingly, the regression revealed that higher proactive personality levels after the workshop predicted greater improvement to STEM attachment scores. This disagreement between pre and post proactive personality scores may be partially attributed to a confirmation effect. In other words, a student with greater proactive personality may experience more improvement to their STEM major attachment after having their proactive behaviors confirmed during the workshop. If a student that readily engages in proactive behaviors due to their personal disposition, having that disposition confirmed to be successful during the learning intervention logically could boost academic self-efficacy and STEM attachment. Unsurprisingly, research has indicated that both instructor and student-to-student confirmation can lead to stronger perceptions of competency in college students (Shin & Johnson, 2021). Likewise, Johnson and LaBelle (2022) found that teacher and student-to-student confirmation was significantly related to intention to persist in an educational setting, directly and indirectly through academic self-efficacy. Seeing as the workshop was peer-led, it is likely that students high in proactive personality might have felt more inclined to persist in STEM after experiencing student-to-student confirmation, thus leading to the predicted increase to STEM attachment change.

The current study is not without certain limitations. One such limitation is that participants may have been influenced by their experiences after the intervention. To elaborate, the posttest survey differed from the pretest survey by being completed up to 8 weeks later. Although participants were directed to complete the posttest step after their first course assessment, students had a wider range of time to do so unlike the pretest survey which had to be completed withing a week before the synchronous workshop was set to occur. Due to the greater timespan participants had when finishing the posttest measures, students were more able to implement SRL changes to their behavior and possibly receive further confirmation of their academic potential/self-concept as a result. This confirmation effect could have arisen in a variety of educational contexts such as a peer communicating appreciation for their SRL study habits or receiving personal feedback from instructors after attending office hours more as part of their SRL cycle. This serves as another possible explanation as to why posttest proactive personality scores predicted the degree of STEM attachment effects where pretest scores could not. Beyond confirmation effects, students' posttest scores were subject to more confounding variables that may have impacted participants in the greater time they had to complete the final survey.

Another limitation of this research is that participants' STEM major attachment was solely measured rather than looking at more objective indicators of STEM major commitment.

Therefore, it would be improper to assume that the intervention thoroughly improved undergraduates' commitment to the STEM pathway when only their attachment to their STEM major was increased. Future studies may seek to remedy this limitation by integrating longitudinal data to record STEM major attachment throughout a student's undergraduate years and to verify if they did persist in the STEM pathway until degree attainment. In the same vein, the long-term quality of the significant effects seen in this study was not fully investigated. Subsequent research should consider follow up studies or longitudinal data to verify how enduring of an effect the intervention had on students' SRL, self-efficacy, and STEM attachment.

Despite the limitations, the current research findings contribute exciting implications for future studies. Namely, the intervention may be implemented more repeatedly such as after every course exam or consistently throughout an academic school year. Since significant score improvements were observed using the present one-time workshop, the effects produced when being administered repeatedly would be especially eye opening. Not only could the frequency of the intervention be modified, but researchers might look at specific aspects that could play a role in moderating the improvement of SRL, self-efficacy, and STEM major attachments. Aspects include whether a peer or instructor led intervention would influence results or how an in-person format of the workshop would compare with the online model used here. Additionally, other researchers may seek to more closely examine how each type of content major relates to STEM persistence.

Although unrelated to the main research questions of this study, a notable significant correlation between gender and self-efficacy was observed that can be further explored. Albeit unexpected, the correlation was not entirely unsurprising as it is in line with literature regarding how women are often underrepresented in STEM and display lower science self-efficacy (Miles & Naumann, 2021). Hardin and Longhurst (2016) described how women experienced decreased self-efficacy after perceiving significant barriers during the duration of an introductory chemistry course, while men had increased support perception. Not only does lowered self-efficacy occur for women in the dominantly gender-segregated STEM fields (i.e., physics, engineering, mathematics, and computer science) (Li & Singh, 2021; Zeldin & Pajares, 2000), but more gender-balanced subjects like the biological sciences observe the same concerning self-efficacy decrease among women (Ainscough et al., 2016).

Many studies attribute this self-efficacy effect to stereotype threat, rather than simply the disproportionate distribution of women to men in undergraduate STEM contexts. Stereotype threat is a psychological response to negative stereotypes that often entails lowered performance quality, as well as feelings of anxiety and avoidance over perceived stereotype-confirming situations (Piatek-Jimenez et al., 2018). This reasoning is supported by Schuster and Martiny (2017), who found that undergraduate women expect to experience more negative affect under STEM conditions that activate certain stereotypes. Such findings are relevant since higher self-efficacy scores among female-identifying students has been shown to correlate with persistence in science, both academically and occupationally (Fisher et al., 2020). Should future studies adapt the current study to target women in STEM, it would be prudent to include considerations towards stereotype threat when designing the intervention to hopefully improve self-efficacy.

## CONCLUSION

A major takeaway from the study is that a brief online SRL intervention on notetaking strategies can significantly improve SRL, academic self-efficacy, and STEM major attachment levels among undergraduate STEM students. This is especially relevant for underrepresented minority populations and women who have been shown to be at risk of falling out of the STEM pathway (Griffith, 2010; Seymour et al., 2019). Proactive personality scores were able to somewhat predict the amount of change experienced, with more highly proactive participants experiencing smaller changes to SRL and self-efficacy than those with low proactive personality. In contrast to expectations, proactive personality scores after the intervention significantly predicted the amount of STEM major attachment change in the positive direction. This may have been due to possible confirmation effects after partaking in the workshop. The current findings add onto the previous literature on how SRL can increase self-efficacy, and in turn influence STEM major commitment like that seen among high proactive personality students. Results of the study also fill in the gap on SRL improvement by notetaking strategies in undergraduate STEM-specific contexts. The present research has far-reaching implications for STEM instructors interested in applying a feasible pedagogical method to improve STEM major commitment among undergraduate students.

## REFERENCES


Ainscough, L., Foulis, E., Colthorpe, K., Zimbardi, K., Robertson-Dean, M., Chunduri, P., & Lluka, L. J. (2016). Changes in Biology Self-Efficacy during a First-Year University Course. *CBE- Life Sciences Education*, *15*(2), ar19. https://doi.org/10.1187/cbe.15-04-0092

Bandura, A. (1986). The Explanatory and Predictive Scope of Self-Efficacy Theory. *Journal of Social and Clinical Psychology*, *4*(3), 359–373. https://doi.org/10.1521/jscp.1986.4.3.359

Bartimote-Aufflick, K., Bridgeman, A. J., Walker, R., Sharma, M. D., & Smith, L. (2016). The study, evaluation, and improvement of university student self-efficacy. *Studies in Higher Education*, *41*(11), 1918–1942. https://doi.org/10.1080/03075079.2014.999319

Bateman, T. S., & Crant, J. M. (1993). The proactive component of organizational behavior: A measure and correlates. *Journal of Organizational Behavior*, *14*(2), 103–118. https://doi.org/10.1002/job.4030140202

Bernacki, M. L., Vosicka, L., & Utz, J. C. (2020). Can a brief, digital skill training intervention help undergraduates "learn to learn" and improve their STEM achievement? *Journal of Educational Psychology*, *112*(4), 765–781. https://doi.org/10.1037/edu0000405

Bong, M., & Clark, R. E. (1999). Comparison between self-concept and self-efficacy in academic motivation research. *Educational Psychologist*, *34*(3), 139–153. https://doi.org/10.1207/s15326985ep3403_1

Bong, M., & Hocevar, D. (2002). Measuring Self-Efficacy: Multitrait-Multimethod Comparison of Scaling Procedures. *Applied Measurement in Education*, *15*(2), 143–171. https://doi.org/10.1207/s15324818ame1502_02

Burleson, S. D., Major, D. A., Hu, X., & Shryock, K. J. (2021). Linking undergraduate professional identity development in engineering to major embeddedness and persistence. *Journal of Vocational Behavior*, *128*, 103590. https://doi.org/10.1016/j.jvb.2021.103590

Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Science, technology, engineering, mathematics. Washington, DC: Georgetown University.

Chen, P., Bao, C., & Gao, Q. (2021). Proactive Personality and Academic Engagement: The Mediating Effects of Teacher-Student Relationships and Academic Self-Efficacy. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.652994

Crant, J. M. (2000). Proactive Behavior in Organizations. *Journal of Management*, *26*(3), 435–462. https://doi.org/10.1177/014920630002600304

Doerschuk, P., Bahrim, C., Daniel, J., Kruger, J., Mann, J., & Martin, C. (2016). Closing the Gaps and Filling the STEM Pipeline: A Multidisciplinary Approach. *Journal of Science Education and Technology*, *25*(4), 682–695. https://doi.org/10.1007/s10956-016-9622-8

Duncan, T., & McKeachie, W. J. (2005). The Making of the Motivated Strategies for Learning Questionnaire. *Educational Psychologist*, *40*(2), 117–128. https://doi.org/10.1207/s15326985ep4002_6

Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

Fisher, C. R., Thompson, C. C., & Brookes, R. H. (2020). ‘95% of the time things have been okay’: the experience of undergraduate students in science disciplines with higher female representation. *International Journal of Science Education*, *42*(9), 1430–1446. https://doi.org/10.1080/09500693.2020.1765045

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review*, *29*(6), 911–922. https://doi.org/10.1016/j.econedurev.2010.06.010

Hardin, E. E., & Longhurst, M. O. (2016). Understanding the gender gap: Social cognitive changes during an introductory stem course. *Journal of Counseling Psychology*, *63*(2), 233–239. https://doi.org/10.1037/cou0000119

Johnson, Z. D., & LaBelle, S. (2022). College Students' Intent to Persist with Their Education: The Direct and Indirect Effects of Classroom Confirmation and Academic Self-Efficacy. *Western Journal of Communication*, 1–20. https://doi.org/10.1080/10570314.2022.2131464

Kauffman, D. R., Zhao, R., & Yang, Y. (2011). Effects of online note taking formats and self-monitoring prompts on learning from online text: Using technology to enhance self-regulated learning. *Contemporary Educational Psychology*, *36*(4), 313–322. https://doi.org/10.1016/j.cedpsych.2011.04.001

Kirby, E., Kirby, S. L., & Lewis, M. (2002). A Study of the Effectiveness of Training Proactive Thinking1. *Journal of Applied Social Psychology*, *32*(7), 1538–1549. https://doi.org/10.1111/j.1559-1816.2002.tb01451.x

Lavasani, M. G., Mirhosseini, F. S., Hejazi, E., & Davoodi, M. (2011). The Effect of Self-regulation Learning Strategies Training on the Academic Motivation and Self-efficacy. *Procedia - Social and Behavioral Sciences*, *29*, 627–632. https://doi.org/10.1016/j.sbspro.2011.11.285

Lee, J. D., Zhang, Z., & Yin, H. (2010). Using multidimensional Rasch analysis to validate the Chinese version of the Motivated Strategies for Learning Questionnaire (MSLQ-CV).

*European Journal of Psychology of Education*, *25*(1), 141–155. https://doi.org/10.1007/s10212-009-0009-6

Li, Y., & Singh, C. (2021). Effect of gender, self-efficacy, and interest on perception of the learning environment and outcomes in calculus-based introductory physics courses. *Physical Review*, *17*(1). https://doi.org/10.1103/physrevphyseducres.17.010143

Lin, S., Lu, W., Chen, M., & Chen, L. C. (2014). Association Between Proactive Personality and Academic Self–Efficacy. *Current Psychology*, *33*(4), 600–609. https://doi.org/10.1007/s12144-014-9231-8

Major, D. A., Cigularov, K. P., Litano, M. L., Streets, V. N., Henson, J. M., & Reynoldson, K. R. (2020). The Development and Validation of STEM Major Embeddedness and University Embeddedness Scales. *Human Performance*, *33*(5), 378–405. https://doi.org/10.1080/08959285.2020.1802727

Major, D. A., Holland, J., & Oborn, K. L. (2012). The Influence of Proactive Personality and Coping on Commitment to STEM Majors. *Career Development Quarterly*, *60*(1), 16–24. https://doi.org/10.1002/j.2161-0045.2012.00002.x

Miles, J. D., & Naumann, S. E. (2021). Science self-efficacy in the relationship between gender & science identity. *International Journal of Science Education*, *43*(17), 2769–2790. https://doi.org/10.1080/09500693.2021.1986647

Mohin, M., Kunzwa, L., & Patel, S. S. (2022). Using mentimeter to enhance learning and teaching in a large class. *International Journal of Educational Policy Research and Review*, *9*(2), 48–57. https://doi.org/10.15739/ijeprr.22.005

Multon, K. D., Brown, S. S., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology*, *38*(1), 30–38. https://doi.org/10.1037/0022-0167.38.1.30

National Center for Education Statistics. (2021). *Number and percentage distribution of science, technology, engineering, and mathematics (STEM) degrees/certificates conferred by postsecondary institutions, by race/ethnicity, level of degree/certificate, and sex of student: 2010-11 through 2019-20*. https://nces.ed.gov/programs/digest/d21/tables/dt21_318.45.asp

National Science Board, National Science Foundation. (2022, January). Science and Engineering Indicators 2022: The State of U.S. Science and Engineering. https://ncses.nsf.gov/pubs/nsb20221/data#figure-block

Piatek-Jimenez, K. L., Cribbs, J., & Gill, N. (2018). College students' perceptions of gender stereotypes: making connections to the underrepresentation of women in STEM fields. *International Journal of Science Education*, *40*(12), 1432–1454. https://doi.org/10.1080/09500693.2018.1482027

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33–40. https://doi.org/10.1037/0022-0663.82.1.33

President's Council of Advisors on Science and Technology (PCAST). (2012, February). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics (No. 19). https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Schuster, C., & Martiny, S. E. (2017). Not Feeling Good in STEM: Effects of Stereotype Activation and Anticipated Affect on Women's Career Aspirations. *Sex Roles*, *76*(1–2), 40–55. https://doi.org/10.1007/s11199-016-0665-3

Seibert, S. E., Crant, J. M., & Kraimer, M. L. (1999). Proactive personality and career success. *Journal of Applied Psychology*, *84*(3), 416–427. https://doi.org/10.1037/0021-9010.84.3.416

Seli, H., & Dembo, M. H. (2019). *Motivation and Learning Strategies for College Success: A Focus on Self-Regulated Learning* (6th ed.). http://ci.nii.ac.jp/ncid/BB1116574X

Seymour, E., Hunter, A., & Weston, T. B. (2019). Why We Are Still Talking About Leaving. In *Springer eBooks* (pp. 1–53). https://doi.org/10.1007/978-3-030-25304-2_1

Shin, M., & Johnson, Z. D. (2021). From student-to-student confirmation to students' self-determination: an integrated peer-centered model of self-determination theory in the classroom. *Communication Education*, *70*(4), 365–383. https://doi.org/10.1080/03634523.2021.1912372

Sithole, A., Chiyaka, E. T., McCarthy, P. J., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges. *Higher Education Studies*, *7*(1), 46. https://doi.org/10.5539/hes.v7n1p46

Theobald, M. (2021). Self-regulated learning training programs enhance university students' academic performance, self-regulated learning strategies, and motivation: A meta-analysis. *Contemporary Educational Psychology*, *66*, 101976. https://doi.org/10.1016/j.cedpsych.2021.101976

Wernersbach, B. M., Crowley, S. T., Bates, S. C., & Rosenthal, C. (2014). Study Skills Course Impact on Academic Self-Efficacy. *Journal of Developmental Education*, *37*(2), 14. http://files.eric.ed.gov/fulltext/EJ1070256.pdf

Weston, T. B., Seymour, E., Koch, A. M., & Drake, B. E. (2019a). Weed-Out Classes and Their Consequences. In *Springer eBooks* (pp. 197–243). https://doi.org/10.1007/978-3-030-25304-2_7

Weston, T. B., Seymour, E., Koch, A. M., & Drake, B. E. (2019b). Weed-Out Classes and Their Consequences. In *Springer eBooks* (pp. 197–243). https://doi.org/10.1007/978-3-030-25304-2_7

Yu, W., Zhou, S., & Zhou, Y. (2023). Measuring mathematics self-efficacy: Multitrait-multimethod comparison. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1108536

Zeldin, A. L., & Pajares, F. (2000). Against the Odds: Self-Efficacy Beliefs of Women in Mathematical, Scientific, and Technological Careers. *American Educational Research Journal*, *37*(1), 215–246. https://doi.org/10.3102/00028312037001215

Zimmerman, B. J. (1995). Self-efficacy and educational development. In *Cambridge University Press eBooks* (pp. 202–231). https://doi.org/10.1017/cbo9780511527692.009

Zimmerman, B. J. (2000). Attaining Self-Regulation. In *Elsevier eBooks* (pp. 13–39). https://doi.org/10.1016/b978-012109890-2/50031-7

Zimmerman, B. J., & Kitsantas, A. (2014). Comparing students' self-discipline and self-regulation measures and their prediction of academic achievement. *Contemporary Educational Psychology*, *39*(2), 145–155. https://doi.org/10.1016/j.cedpsych.2014.03.004