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Original article

Exploring first-year engineering students' learning strategies and academic performance

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Abstract:
This study investigated the learning strategies of 450 U.S. engineering freshmen and their academic performance. Paired-samples t-tests indicated significant improvements in learning strategies, with higher mean scores on the post-survey compared to the pre-survey, except for the attitude subscale. Variation in two subscales, selecting main ideas and test strategies, was observed among demographic groups. Pell (Federal Pell Grant Program), first-generation, racially minoritized, and female students initially reported lower levels of learning strategies, but these differences diminished in the post-survey. Hierarchical linear regression analyses revealed learning strategies related to (coping with) anxiety and motivation significantly predicted academic performance, with effective anxiety management and higher motivation scores associated with better academic performance. This study provides insights into the learning strategies employed by first-year engineering students and their relationship with academic performance. It highlights the potential for improvements in these strategies over time and how they vary among different demographic groups.

1. Introduction

Internationally, retention and degree attainment issues in Science, Technology, Engineering, and Math (STEM) education have long been a concern, with a significant number of bachelor's STEM degree-seeking students leaving their programs without earning a degree. In the U.S., approximately 48% of college students who entered STEM fields between 2003 and 2009 did not complete their degrees by the spring of 2009 (Chen, 2013). The trend holds within engineering majors, with a noticeable equity gap in retention and graduation among different groups (American Society for Engineering Education, 2016). While various factors contribute to student retention and degree success (Geisinger & Rajraman, 2013), the utilization of effective learning strategies is crucial for academic performance (Tseng et al., 2019; Weinstein et al., 2011), especially for first-year college students.

Research suggests emphasizing learning strategies in purposefully designed first-year experience (FYE) courses can facilitate social and academic transitions into college and enhance college student success (Li et al., 2023; Padgett & Keup, 2011; Permzadian & Credé, 2016; Ryan & Glenn, 2014). However, examining the academic outcomes of learning strategies in FYE courses as an intervention yielded mixed results for specific student groups (Brake & Curry, 2016; Fan et al., 2012; Fong et al., 2021). Therefore, it is imperative to further investigate the specific outcomes and effectiveness of including learning strategies as an instructional component in FYE courses. By exploring the impact of such inclusion in FYE courses, researchers can gain insights into its potential benefits for students' academic success. This examination can contribute to evidence-based practices that

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support engineering student success initiatives and address the challenges associated with retention and degree attainment.

Additionally, existing studies on learning strategies and FYE courses have primarily focused on general student populations (Fong et al., 2021; Li et al., 2021). With the student population in higher education institutions increasingly becoming diverse in the United States (McFarland et al., 2019), it is vital to examine the effectiveness of learning strategies in FYE courses for diverse student groups, including racially minoritized students, first-generation students, and students from low-income backgrounds. Understanding how different student populations engage with and benefit from learning strategies can inform the development of inclusive and targeted interventions.

Researchers from different countries or regions measure learning strategies using different instruments. Among them, the Learning and Study Strategies Inventory (LASSI) is an established assessment tool widely used internationally (Fong et al., 2023; Yip, 2013). The findings of a recent meta-analysis suggested a positive correlation between higher LASSI scores and enhanced academic performance. Further, students with more knowledge of learning strategies generally achieved higher grade point averages (GPAs), had greater rates of course completion, and experienced increased rates of retention (Fong et al., 2021). The meta-analysis results advocated for the LASSI as a valuable tool for evaluating students' learning strategies. Through understanding the association between learning strategies and academic performance, instructors and administrators can effectively support students in developing effective learning strategies and thus improve students' academic performance.

Utilizing the LASSI, this study addressed the following three research questions:

1) How do engineering students' self-reported learning strategy scores change after completing the FYE course?
2) Do engineering students' learning strategy scores differ based on factors such as Pell status, first-generation (FG) status, race/ethnicity, and sex?
3) Controlling for student demographics (i.e., age, sex, FG status, Pell status, and race/ethnicity), unweighted high school grade point average (HSGPA), and ACT scores (ACT, American College Testing, is a standardized test used for college admissions in the United States), which specific learning strategies predict students' academic performance?

2. Literature review

2.1 Learning strategies and academic performance

Learning strategies encompass a range of techniques and approaches students can employ to enhance their understanding, retention, and application of knowledge. Scholars have defined learning strategies as patterns of information-processing activities used to prepare for an anticipated test of memory (Schmeck, 1983) or as skills students use to learn content or accomplish tasks more efficiently (Schumaker & Deshler, 1992). Following Weinstein and colleagues' (2000) definition, learning strategies refer to "any thoughts, behaviors, beliefs, or emotions that facilitate the acquisition, understanding, or later transfer of new knowledge and skills" (Weinstein et al., 2000, p. 727).

Learning strategies play a vital role in college success by enhancing academic performance (Hsieh et al., 2012) and boosting confidence and motivation (García-Ros et al., 2018). Studies have consistently found positive impacts of learning strategies on academic performance (Chen, 2002; Ergen & Kanadli, 2017). Sebesta & Speth (2017) found higher-achieving students in college introductory science courses reported using specific cognitive and metacognitive strategies significantly more frequently than their lower-achieving peers. Broadbent & Poon (2015) reviewed 12 studies and found strategies such as time management, metacognition, effort regulation, and critical thinking were positively correlated with academic outcomes. These findings highlight the relevance of investigating first-year students' academic performance in relation to learning strategies.

While learning strategies have been linked to student academic outcomes and college success, there is ample room for further investigation of learning strategies, especially within a given discipline. Recognizing learning strategies may be subject-specific, exploring these dynamics could deepen our understanding and provide valuable insights into optimizing educational approaches tailored to the unique demands of different academic fields. This understanding could contribute to enhancing overall student learning experiences and fostering success in their respective fields of study.

2.2 Engineering students' learning strategies and academic performance

The learning strategies employed by engineering students play a crucial role in shaping their academic outcomes. Previous research has delved into the dynamics of this relationship within the context of engineering courses, highlighting the impact of motivational, cognitive, and social interaction learning strategies on students' learning outcomes (Anais et al., 2012; García-Ros et al., 2018; Liebendörfer et al., 2022). For instance, Seabi (2011) utilized the LASSI survey to explore the connections between learning strategies, self-esteem, intellectual functioning, and academic achievement among first-year engineering students in South Africa. The study revealed modest yet significant correlations between self-esteem, learning strategies, and academic achievement. Notably, the limitation of these studies lies in their reliance on surveys to assess learning strategies with the cross-sectional data.

Recent investigations have shifted focus towards leveraging first-year engineering seminar courses (Stephen & Rockinson-Szapkiw, 2021) or modules (Pandey et al., 2022) to actively promote students' learning strategies, thereby enhancing their academic learning. However, there remains a gap in the literature concerning how first-year engineering students develop their learning strategies through meaningful and relevant learning experiences, ultimately enhancing their academic

outcomes.

2.3 Students' demographic variables and learning strategies

As enrollment in U.S. colleges and universities continues to become more racially and ethnically diverse, this trend is also evident in the Institution and the College where this study was conducted. The diverse student populations may exhibit variation in learning strategies. Studies revealed males score higher on the abstract conceptualization side of the continuum, but females tend to score higher in the concrete learning mode (Heffler, 2001; Tindall & Hamil, 2004). Another study (Ong et al., 2020) showed female students may face additional challenges such as anxiety or emotional stress during the learning process. As more female students are being recruited into the STEM fields, it is critical to explore learning strategies between male and female students and understand differences in their learning strategies and the support needed for both males and females.

FG students may face numerous challenges as they navigate the unfamiliar academic and social landscape of college. In their study, Capik & Shupp (2021) examined factors influencing FG students' persistence toward graduation, highlighting the importance of social capital, a sense of belonging, available support resources, and effective communication and interactions with peers, faculty, and staff. Given the unique needs of FG students, additional support is necessary to help them establish social capital and effectively adapt to the new college culture and environment.

Encouraging FG students to actively engage in academic socialization can contribute to their success by fostering social capital, which encompasses the network of relationships formed within the college community and provides valuable information and emotional support for navigating an otherwise unfamiliar setting (Attinasi, 1989). Moreover, research has shown implementing high-impact practices (HIPs), including FYE, has been beneficial for FG and underrepresented students (Finley & McNair, 2013; Shi et al., 2023). Participation in HIPs has been found to have positive effects on retention (Pascarella & Terenzini, 2005; Shi et al., 2023) and academic performance (Zhao & Kuh, 2004).

Another critical factor in students' success is the instructional support for racially minoritized students and FG students. Culturally responsive pedagogy (CRP) is central to addressing cultural issues faced by racially minoritized students and has been widely applied to teaching and learning in education and peer support. For instance, Wang and Castañeda-Sound (2008) suggested FG students are strongly encouraged to utilize the resources, support, and various socialization forms available at the university such as their interactions with faculty and peers. Thus, the described practices for engineering student academic success from literature are essential for effective course design improvements.

In summary, the existing literature demonstrates the viability of evaluating learning strategies to determine how engineering learning practices enhance academic performance. Moreover, it underscores the importance of adopting culturally responsive approaches to comprehend how learning strategies influence diverse student populations, particularly in relation to sex and FG status. By exploring the connection between learning strategies and academic performance while considering student characteristics, we aimed to gather evidence that can inform the development of effective strategies and interventions, ultimately supporting student success in an FYE course. In this context, the LASSI can serve as an informative tool for assessing the quality of FYE courses in terms of students' utilization of learning strategies.

3. Methods

3.1 The context of the study and course redesign

This Institutional Review Board (IRB) approved study was conducted at a large public R1 institution in the southwest of the United States, designated as a Minority-Serving Institution (MSI), a Hispanic-Serving Institution (HSI), and an Asian American and Native American, Pacific Islander-Serving Institution (AANAPISI) (hereafter "the Institution"), with 28,530 undergraduates in the fall of 2019. Within the College of Engineering (hereafter "the College") at the Institution, the average first-year attrition rate for undergraduate first-time full-time (FTFT) degree-seeking cohorts over the past ten years was as high as 31.0%, with an annual attrition rate of approximately 11.0% after the first year. Previous studies have shown that students from disadvantaged populations, such as Pell grant recipients, FG students, racially minoritized students, or female students, are often at risk academically (Loeb & Hurd, 2019). Therefore, proactive actions must take students' demographic factors into consideration and tailor the instructional strategies accordingly (Ishitani, 2006). Notably, female and racially minoritized students might need additional support (Ong et al., 2020), but it remains unclear what learning strategies students employ, particularly those from underrepresented groups. Thus, we examined the mean differences in pre-survey and post-survey results based on the aforementioned demographic factors.

Starting in the fall of 2018, the College began to enhance the FYE course through redesigning the curriculum, which emphasized enriching the learning experience and improving learning strategies. The redesigned FYE course recognized that creating a positive learning environment could impact learning strategies such as self-regulation or motivation during an introductory course (Alzubaidi et al., 2016; Micari & Pazos, 2020). By incorporating CRP as a mechanism to support students, this study further examined the relationship between learning strategies and students' academic performance.

The curriculum incorporated hypothesis-driven, hands-on experimentation, peer support, faculty-student interactions, and academic support (Kuh, 2008; Li et al., 2023), emphasizing added social value and relevance of content, which are crucial for students' persistence (Bonous-Hammarth, 2000). The redesigned FYE course provided a series of modules to help develop students' learning strategies. For example, Semester Master Schedule asked students to create a calendar map of all due dates for major assignments, quizzes, exams, and projects for all of their classes and submit it for review.

This was used to help illustrate the need for time management and proactive planning of course assignments. Weekly Study Plan required students to create a weekly study plan specific to their semester schedule that encompasses topics discussed in class and reviewed online including appropriate time lengths of study blocks for each class, in-class time, work needs, and personal life balance. Study Skills were introduced to students through video lecture material and case studies and students were asked to post to an online discussion based on the lecture material and the case study readings. Test Preparation & Campus Resources module asked students to view video lectures, read online material, and respond to an online survey about campus resources as a follow-up to the scavenger hunt assignment. Campus Resources Scavenger Hunt was a group project, students visited various student services across campus and identified the basic function of each office, a staff member, and its location. All these modules aimed at facilitating students in understanding and employing effective learning strategies and strengthening their comprehension of the essential traits necessary for academic performance and excellence as students within the College.

3.2 Participants of the study

Participants of this study consisted of 450 first-time (A student attending this institution for the first time at the undergraduate level) engineering students who enrolled in an FYE course in fall 2018 (n = 183) and fall 2019 (n = 267). Given there were no significant proportional differences in demographics between the two cohorts, the data from both cohorts were combined into a single dataset for analysis.

Demographic variables included age, sex, Pell status, FG status, and race/ethnicity. Age was the student's age when taking the FYE course. Sex was self-reported. The Pell status referred to whether a student received a Pell Grant at the time when they took an FYE section, which is awarded to low-income students based on the student's or parent's income for the previous year (Wei & Horn, 2002). FG students were those with parents who did not have a four-year degree. According to the Integrated Postsecondary Education Data System (IPEDS) definition, the race and ethnicity categories included American Indian or Alaska Native, Asian, Black or African American, Hispanic of any race, two more races, IPEDS International, Native Hawaiian or Pacific Islander, unknown race/ethnicity, and White. Specifically, in this study, there were 16% (n = 74) females, 35% (n = 157), Pell recipients, and 45% (n = 201) FG college students. Regarding race and ethnicity, 21% (n = 93) were Asian, 4.2% (n = 19) were Black or African American, 30% (n = 134) were Hispanic of any race, 14% (n = 65) were two more races, 0.7% (n = 3) were IPEDS International, 0.2% (n = 1) were Native Hawaiian or Pacific Islander, and 30% (n = 135) were White. Due to the small sample sizes of IPEDS international and Native Hawaiian or Pacific Islander, this study focused on five race and ethnicity categories: Asian, Black, Hispanic, two or more races, and White. The race/ethnicity variable was dummy coded, with White as the reference group. The outcome variable was students' cumulative first-year GPA, extracted from the Institution's final census data in spring of 2019 and 2020.

3.3 Measurement: LASSI

The LASSI (3rd version), a 60-item self-report inventory, was used to measure engineering students' learning strategies. The LASSI includes ten subscales, with each subscale consisting of six items, and is organized into three domains of learning strategies: will, skill, and self-regulation (Weinstein et al., 2011; Weinstein et al., 2016). The LASSI measures college students' covert and overt thoughts, behaviors, attitudes, motivations, and beliefs related to successful learning. For each item, students are asked to select one of the five response options that indicates how well the statement describes them, ranging from 1 = "not at all typical of me" to 5 = "very much typical of me". Each subscale has a maximum score of 30.

The LASSI is a self-administered survey and the computer-generated scoring reports mean and percentile scores, which are available immediately after completion. If a student scores low on a scale, such as (coping with) anxiety, compared to either national norms or cut-off scores developed by an institution or a program, they may need to learn "how to cope with anxiety-arousing stimuli and take more responsibility for the direction of her or his thinking processes" (Weinstein et al., 2016, p. 11). Upon completion, students can view their scores compared to a norm group. A score below the 50th percentile suggests areas for improvement.

3.4 Data collection and analysis

In this study, the FYE instructor administered the LASSI survey at the beginning and end of the fall semester in both 2018 and 2019, respectively (twice each semester). The survey collected student IDs which were then linked to enrollment data, demographics, and academic performance housed in the Institution's data warehouse. To answer the first research question, ten paired-samples t-tests were conducted simultaneously to compare the mean differences between the pre- and post-survey scores on the ten LASSI subscales with Bonferroni correction to the alpha level to 0.005 as statistical significance (0.05/10). To address the second research question, eight multivariate analyses of variance (MANOVAs) were conducted to examine mean differences in learning strategies based on demographic variables consisting of Pell status, FG status, race/ethnicity, and sex. The main effects of each variable were the primary focus of analysis, although the interactions between these variables were also explored.

To address the third research question, hierarchical linear regression analysis was performed to estimate the predictive power of LASSI scores on first-year student GPA, while controlling for demographics, HSGPA, and ACT composite score. For the categorical variables, the reference groups were female, non-Pell recipients, non-FG, and White. The regression analysis was conducted in a hierarchical order, with the first block of variables consisting of demographics (i.e., age, sex, Pell status, FG status, and race/ethnicity), HSGPA, and ACT scores, and the second block of variables consisting of ten LASSI subscales' scores from the post-survey. These two blocks of variables were entered into the predictive equation in

Table 1. Paired-Samples t-test Results, Mean (out of 30) and Percentile Scores (N = 450).

	Pre-Survey			Post-Survey			Change (Mean)	Change (Percentile)	*t*	*p*
	M	*SD*	Percentile	*M*	*SD*	Percentile				
Anxiety	19.22	5.77	54.26	21.28	5.92	63.98	2.06	9.72	8.23	0.001**
Attitude	22.75	3.80	39.82	22.91	4.39	42.55	0.16	2.73	0.86	0.390
Motivation	23.85	3.62	49.27	24.22	3.90	52.85	0.37	3.58	2.14	0.033
Information processing	21.55	4.24	47.91	23.10	4.24	57.88	1.56	9.97	8.31	0.001**
Selecting main ideas	20.59	4.63	46.72	22.64	4.39	59.21	2.05	12.49	10.03	0.001**
Test strategies	21.53	3.65	52.48	22.75	3.87	60.92	1.22	8.44	6.53	0.001**
Concentration	19.14	4.29	46.79	20.55	4.45	55.16	1.41	8.37	7.65	0.001**
Self testing	17.11	4.51	42.69	19.49	5.17	56.39	2.38	13.70	11.40	0.001**
Time management	16.72	4.54	39.54	18.55	4.81	50.56	1.83	11.02	8.67	0.001**
Using academic resources	18.99	4.46	40.36	19.55	4.79	43.91	0.56	3.55	2.65	0.008

* $p < 0.005$*, $p < 0.001$**.

Table 2. Descriptive Statistics of the Pre- and Post-Survey Results by Pell Status.

	Pre-Survey						Post-Survey					
	Non-Pell		Pell		*F*	*p*	Non-Pell		Pell		*F*	*p*
	M	*SD*	*M*	*SD*			*M*	*SD*	*M*	*SD*		
Anxiety	19.26	6.00	19.14	5.33	0.04	0.84	21.12	6.21	21.57	5.35	0.58	0.45
Attitude	22.71	3.79	22.83	3.83	0.09	0.76	22.84	4.46	23.04	4.25	0.23	0.63
Motivation	23.83	3.75	23.88	3.37	0.02	0.90	24.19	4.07	24.25	3.56	0.02	0.88
Information processing	21.75	21.75	21.75	4.19	1.88	0.17	23.13	4.34	23.05	4.05	0.04	0.85
Selecting main ideas	20.99	4.66	19.85	4.49	6.26	0.01**	22.76	4.50	22.41	4.17	0.68	0.41
Test strategies	21.71	3.72	21.21	3.52	1.89	0.17	22.84	3.91	22.59	3.80	0.42	0.52
Concentration	19.09	4.29	19.24	4.32	0.12	0.73	20.34	4.51	20.93	4.31	1.77	0.18
Self testing	17.19	4.41	16.96	4.70	0.28	0.60	19.50	5.23	19.47	5.08	0.00	0.95
Time management	16.65	4.52	16.86	4.59	0.23	0.63	18.37	4.80	18.90	4.81	1.29	0.26
Using academic resources	19.08	4.54	18.83	4.33	0.31	0.58	19.57	4.90	19.53	4.60	0.01	0.94

**$p < 0.01$.

a hierarchical order to examine which variables significantly predict the outcome variable of GPA with an additional block of variables introduced. The R^2 change (adjusted R^2 change), a measure of the increase in predictive power (R^2) resulting from the inclusion of a new predictor (or a block of predictors), and the significance of F value change (a measure of whether to decide the significance of the model and whether the inclusion of the second block of variables improves the prediction of first-year GPA) were used to evaluate the regression models. For all statistical tests, the alpha level was set at 0.05.

4. Results

The first research question compared the mean differences in students' scores on learning strategies before and after completing the FYE course. The results indicated students scored higher on the post-survey for all ten subscales (see Table 1). The mean score boost ranged from 0.37 to 2.38 from pre- to post-survey. Significant increases in mean scores were observed on seven out of ten subscales, with p values less than 0.001, except for three subscales of attitude, motivation, and using academic resources, where the difference was not statistically significant, p values > 0.005. The subscales with the highest mean score increase from pre- to post-surveys were self-testing, (coping with) anxiety, selecting main ideas, and time management (see Table 1).

The second research question examined whether students' learning strategy scores differed by demographic variables in both pre- and post-surveys. Tables 2 through 5 present the MANOVA results for demographic variables. The main effect of Pell status on pre-survey subscales was not significant,

Table 3. Descriptive Statistics of the Pre- and Post-Survey Results by First-Generation Status.

	Pre-Survey						Post-Survey					
	Non-FG		FG		*F*	*p*	Non-FG		FG		*F*	*p*
	M	*SD*	*M*	*SD*			*M*	*SD*	*M*	*SD*		
Anxiety	19.30	6.13	19.06	5.50	0.18	0.67	21.43	6.20	21.12	5.78	0.29	0.59
Attitude	22.47	3.82	23.04	3.71	2.47	0.12	22.55	4.63	23.21	4.14	2.42	0.12
Motivation	23.77	3.68	23.93	3.63	0.21	0.64	24.17	4.23	24.21	3.67	0.01	0.92
Information processing	21.73	4.29	21.45	4.14	0.48	0.49	23.30	4.33	22.94	4.11	0.78	0.38
Selecting main ideas	21.38	4.62	19.86	4.60	11.76	0.01**	23.15	4.53	22.15	4.28	5.50	0.02*
Test strategies	21.96	3.72	21.14	3.66	5.30	0.02*	23.18	4.05	22.34	3.71	5.07	0.03*
Concentration	19.00	4.38	19.26	4.26	0.40	0.53	20.21	4.62	20.80	4.29	1.88	0.17
Self testing	17.04	4.62	17.15	4.44	0.07	0.80	19.41	5.35	19.50	5.01	0.03	0.86
Time management	16.72	4.61	16.81	4.56	0.04	0.84	18.72	5.17	18.42	4.47	0.41	0.52
Using academic resources	19.22	4.67	18.80	4.33	0.91	0.34	19.80	4.97	19.38	4.67	0.80	0.37

*$p < 0.05$, $p < 0.01$.

with Wilks' Lambda = 0.974, $F(10, 439) = 1.181$, $p > 0.05$, partial $\eta^2 = 0.026$, indicating a small effect size (see Table 2). Post-hoc tests revealed a significant mean difference in selecting main ideas between Pell and non-Pell students on the pre-survey. Non-Pell students scored significantly higher than Pell students ($M = 20.99$, $SD = 4.66$ vs. $M = 19.85$, $SD = 4.49$), $F(1, 448) = 6.264$, $p < 0.05$, $R^2 = 0.14$ (adjusted $R^2 = 0.12$). Similarly, the main effect of Pell status on post-survey subscales was not significant, with Wilks' Lambda = 0.982, $F(10, 439) = 0.796$, $p > 0.05$, partial $\eta^2 = 0.018$, indicating a small effect size. Post-hoc tests indicated no significant differences in all ten subscale scores between Pell and non-Pell students, $p > 0.05$ (see Table 2).

The main effect of FG status on pre-course subscales was significant, with Wilks' Lambda = 0.937, $F(10, 419) = 2.836$, $p < 0.01$, partial $\eta^2 = 0.063$, indicating a medium effect size. Significant differences were observed between FG and non-FG students on the pre-survey for two subscales of selecting main ideas and test strategies (see Table 3). Regarding the pre-survey scores for selecting main ideas, non-FG students reported higher strategy usage, with $M = 21.38$, $SD = 4.62$, compared to FG students, who reported lower strategy usage, with $M = 19.86$, $SD = 4.60$; $F(1, 428) = 11.763$, $p < 0.01$, $R^2 = 0.27$ (adjusted $R^2 = 0.24$). For the pre-survey on test strategies, non-FG students reported higher strategy usage, with $M = 21.96$, $SD = 3.72$, compared to FG, who reported slightly lower strategy usage, with $M = 21.14$, $SD = 3.71$; $F(1, 428) = 5.30$, $p < 0.05$, $R^2 = 0.12$ (adjusted $R^2 = 0.10$).

The main effect of FG status on post-survey subscales was found to be significant, with Wilks' Lambda = 0.936, $F(10, 419) = 2.848$, $p < 0.01$, partial $\eta^2 = 0.064$, indicating a medium effect size. Significant differences were observed between FG and non-FG students on two subscales of selecting main ideas and test strategies on the post-survey (see Table 3). In terms of selecting main ideas non-FG students reported higher strategy usage with $M = 23.15$, $SD = 4.53$ compared to FG students who reported lower usage with $M = 22.15$, $SD = 4.28$; $F(1, 428) = 5.497$, $p < 0.05$, $R^2 = 0.13$ (adjusted $R^2 = 0.10$). Similarly, for the post-survey of test strategies non-FG students reported higher strategy usage with $M = 23.18$, $SD = 4.05$ relative to FG students who reported lower strategy usage with $M = 22.34$, $SD = 3.71$; $F(1, 428) = 5.068$, $p < 0.05$, $R^2 = 0.12$ (adjusted $R^2 = 0.09$). Consistently, FG students reported significantly lower scores on selecting main ideas and test strategies compared to their non-FG peers in both pre-survey and post-survey.

The main effect of race/ethnicity on pre-survey subscales was significant, with Wilks' Lambda = 0.873, $F(40, 1640) = 1.493$, $p < 0.05$, partial $\eta^2 = 0.033$, indicating a medium effect size. The post hoc test indicated there was a significant difference in attitude between Asian and Hispanic students in the pre-survey, $p < 0.05$. As shown in Table 4, Hispanic students scored significantly higher ($M = 23.59$, $SD = 3.45$) than Asian students ($M = 21.86$, $SD = 3.90$). Additionally, the main effect of race-ethnicity on post-course subscales was not significant, with Wilks' Lambda = 0.984, $F(40, 1640) = 1.277$, $p > 0.05$, partial $\eta^2 = 0.029$, indicating a small effect size. The post hoc test revealed there was not a significant difference on LASSI subscales in the post-survey among the five racial and ethnic groups (see Table 4).

The main effect of sex on pre-survey subscales was found to be significant, with Wilks' Lambda = 0.909, $F(10, 439) = 4.371$, $p < 0.01$, partial $\eta^2 = 0.091$, indicating a medium effect size (see Table 5). Significant differences were observed between male and female students on the (coping with) anxiety (management), attitude, and motivation subscales for the pre-survey. Female students reported significantly lower scores on (coping with) anxiety than their male peers ($M = 17.09$, $SD = 5.77$ vs. $M = 19.64$, $SD = 5.68$), $F(1, 448) = 12.30$, $p < 0.01$, $R^2 = 0.27$ (adjusted $R^2 = 0.25$). However, female students

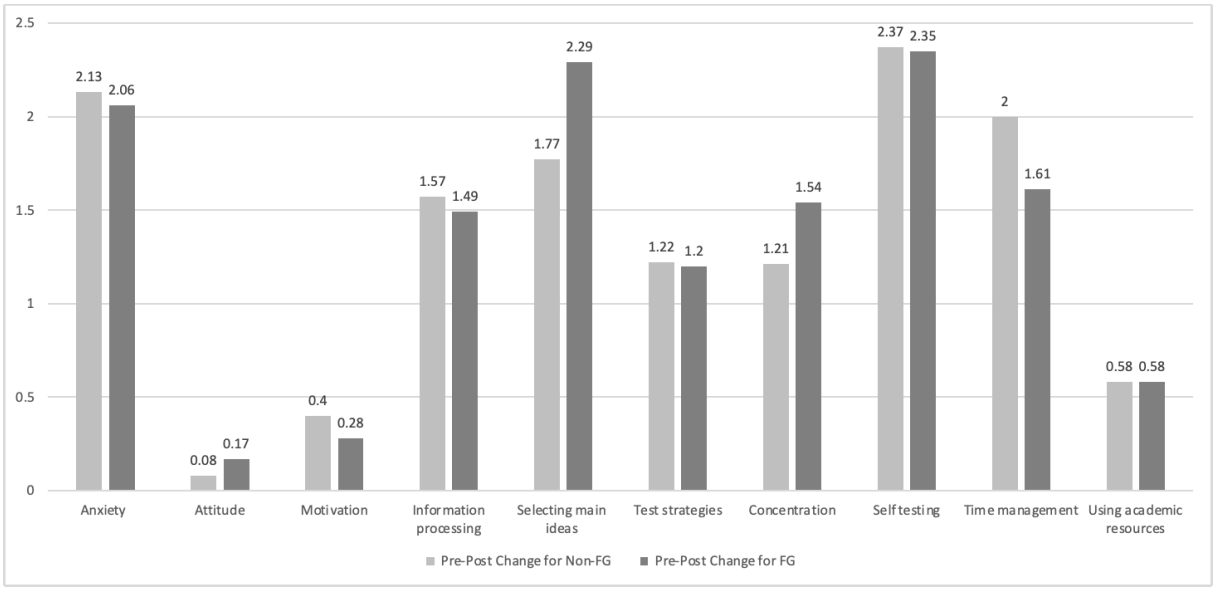

Fig. 1. Mean Score Change from Pre- to Post-Survey by First-Generation Status.

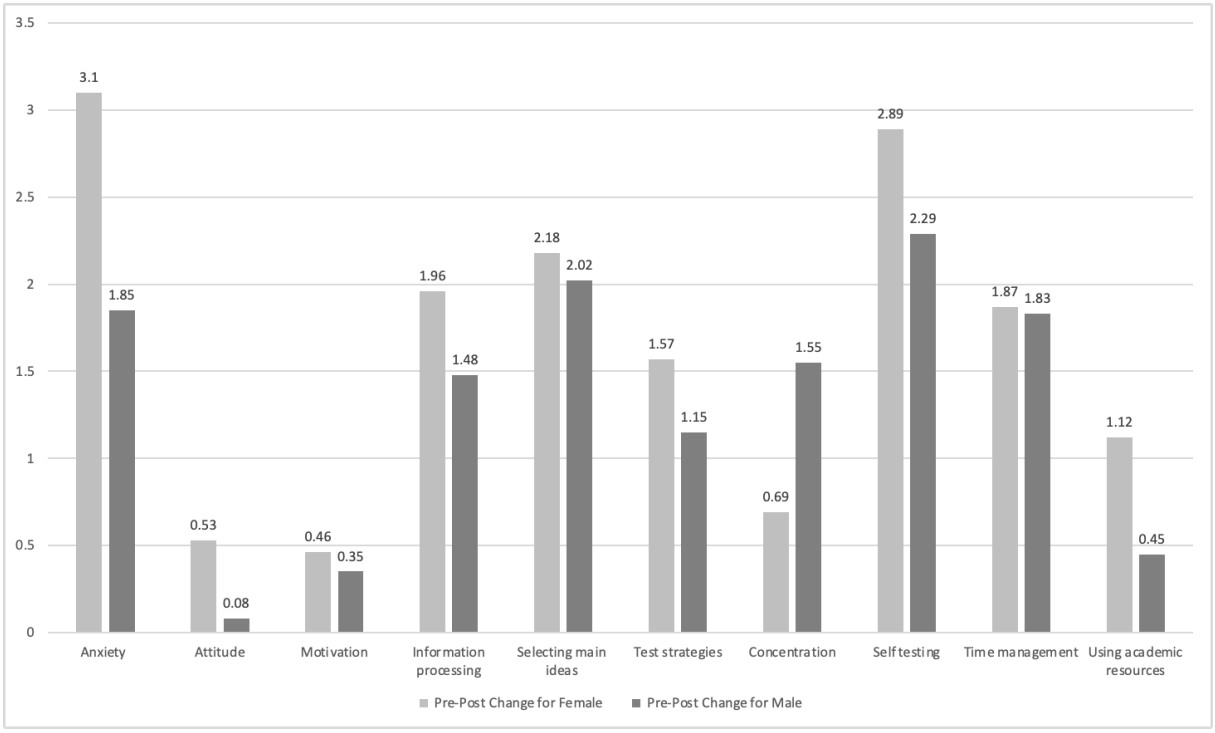

Fig. 2. Mean Score Change from Pre- to Post-Survey by Sex.

scored significantly higher on attitude than their male peers (M = 23.58, SD = 3.53 vs. M = 22.59, SD = 3.33), $F(1, 448)$ = 4.235, $p < 0.05$, R^2 = 0.09 (adjusted R^2 = 0.07). Furthermore, female students scored significantly higher on motivation than their male peers (M = 24.69, SD = 3.33 vs. M = 23.68, SD = 3.65), $F(1, 448)$ = 4.819, $p < 0.05$, R^2 = 0.11 (adjusted R^2 = 0.08).

For the post-survey, the main effect of sex on subscales was found to be significant, with Wilks' Lambda = 0.927, $F(10, 439)$ = 3.473, $p < 0.01$, partial η^2 =0.073, indicating a medium effect size (see Table 5). Significant differences were observed between male and female students on attitude, motivation, and test strategies subscales. Female students reported significantly higher scores on attitude (M = 24.11, SD = 3.53 vs. M = 22.67, SD = 4.50), $F(1, 448)$ = 6.707, $p < 0.01$, R^2 = 0.15 (adjusted R^2 = 0.13) compared to their male peers. Female students also scored significantly higher on motivation (M = 25.15, SD = 3.79 vs. M = 24.03, SD = 3.90), $F(1, 448)$ = 5.123, $p < 0.05$, R^2 = 0.11 (adjusted R^2 = 0.09), and test strategies than those of their male peers (M

= 23.73, SD = 3.79 vs. M = 22.56, SD = 3.86), $F(1, 448)$ = 5.690, $p < 0.05$, $R^2 = 0.13$ (adjusted $R^2 = 0.10$).

Table 6 provides a summary of learning strategy score changes from pre- to post-survey, disaggregating by Pell, FG, race/ethnicity, and sex. The analysis helped identify areas where the gaps have narrowed and areas for further improvements for specific groups. The results revealed pre- and post-survey changes on LASSI subscales by FG and Sex (see Table 3 and Table 5). To further illustrate these significant changes on LASSI subscales, we presented Figures 1 and 2 here as examples, indicating the LASSI mean score changes from pre- to post-survey by FG and sex.

Regardless of Pell, FG, race/ethnicity, and sex, students' learning strategies improved almost on all subscales, except for motivation for Black and White students and using academic resources for Black students. Students gained more in coping with anxiety, information processing, selecting main ideas, and self testing. Overall, it is not evident students' learning strategies improved much in attitude, motivation, and using academic resources. These results echoed the findings of no significant improvement in these three subscales, demonstrated in Table 1.

The third research question aimed to determine how students' scores on learning strategies predicted their academic performance while controlling for demographic variables, HS-GPA, and ACT composite scores. The results of the hierarchical linear regression analysis are presented in Table 7. The analysis revealed adding LASSI subscales to the predictive model significantly improved the model's fit, with $R^2 = 0.42$ (adjusted $R^2 = 0.39$). The inclusion of the LASSI subscales resulted in a significant change in R^2 of 0.11, F Change (10, 335) = 6.404, $p < 0.01$. Overall, the combined variables accounted for approximately 42.2% of the total variance in GPA.

Among the subscales, two were significant predictors of GPA. Coping with anxiety demonstrated a positive relationship with GPA, with $B = 0.02$, $\beta = 0.14$, $t = 2.63$, $p < 0.01$. Motivation was also a significant predictor of GPA, with $B = 0.08$, $\beta = 0.35$, $t = 5.69$, $p < 0.01$. In addition to the learning strategies, three demographic variables significantly predicted students' academic performance. Age demonstrated a positive relationship with GPA, with $B = 0.05$, $\beta = 0.09$, $t = 2.05$, $p < 0.05$. HSGPA also had a positive relationship with GPA, with $B = 0.74$, $\beta = 0.42$, $t = 8.75$, $p < 0.01$. Relative to White students, being a Black or Hispanic student tends to earn a lower first-year GPA, p values < 0.05; being a two or more races student tends to earn a higher first-year GPA, $p < 0.05$. Other factors, such as sex, FG status, and Pell status, were not evident to be significant (see Table 7).

5. Discussion

5.1 Improving students' learning strategies

This study aimed to examine U.S. students' learning strategies and their relationships with academic performance across the three research questions. The first research question of this study investigated changes in undergraduate engineering students' learning strategies from the pre-survey to the post-survey. The findings indicated the course, which placed an emphasis on learning strategies, can contribute to students' improved learning strategies (Permzadian & Credé, 2016; Roy, 2019; Uddin, 2020). By incorporating learning strategies through lectures, hands-on projects, peer support, and CRP in the FYE course, there is potential for enhancing students' learning strategies (Li et al., 2023). Consequently, students may become more aware of these strategies and make dedicated efforts to improve their academic performance.

However, there are areas for improvement, particularly in self-regulation strategies such as time management and using academic resources. For example, self-regulation strategies, which encompass constructs such as time management, metacognition, effort regulation, and critical thinking, are described as having positively impacted students' academic performance (Chen, 2002; Broadbent & Poon, 2015; Ergen & Kanadli, 2017; Sebesta & Speth, 2017). While there was an overall improvement in self-regulation strategy scores in the post-survey, subscales such as time management, self-testing, and utilization of academic resources still scored lower compared to other strategies. Furthermore, when comparing the students' LASSI scores with the national norms at the 75th percentile, all subscale scores appeared lower, suggesting ample room for improvement in students' learning strategies. Regarding the first research question, students reported a slight increase in their attitude scores in the post-survey, but the difference was not statistically significant compared to the pre-survey. This indicated attitude change may not occur rapidly through an FYE course within a single semester but may require more time or other high-impact practices to foster meaningful learning experiences for students, extending into their sophomore year and beyond.

5.2 Learning strategies related to student characteristics

The second research question examined the differences in learning strategies across various demographic groups and found students such as Pell recipients, FG students, and female students showed improvements in specific subscales of learning strategies. However, significant differences in selecting main ideas and test strategies persisted between these groups and their counterparts. These findings underscore the importance of continued support and targeted interventions to address the specific needs of these unique students with intersectionality. Previous literature has also indicated differences among demographic groups, including Pell status, FG status, race/ethnicity, and sex (Heffler, 2001; Capik & Shupp, 2021). Our study further revealed learning strategies for Pell students, FG students, and female students improved in different subscales. However, consistent differences in LASSI scores were observed in two subscales across all demographic groups including selecting main ideas and test strategies. In the pre-survey, Pell students, FG students, racially minoritized students, and female students reported lower mean scores compared to their counterparts, although the difference became smaller in the post-survey. These results implied students with Pell grants, FG students, and female students have made

Table 4. Descriptive Statistics of the Pre- and Post-Survey Results by Race/Ethnicity.

	Pre-Survey					Post-Survey				
	Asian	Black	Hispanic	Two more races	White	Asian	Black	Hispanic	Two more races	White
Anxiety	18.62	20.37	19.46	18.94	19.23	21.87	20.74	21.27	20.12	21.44
Attitude	21.86	22.11	23.59	22.28	22.74	22.22	22.16	23.62	22.65	22.81
Motivation	23.86	23.47	23.87	23.15	24.16	24.82	22.89	24.22	23.89	24.13
Information processing	21.89	19.95	21.53	20.91	21.89	23.45	21.58	22.99	23.18	23.16
Selecting main ideas	220.09	18.95	20.87	20.43	20.84	22.63	22.21	22.48	22.20	23.03
Test strategies	20.98	21.47	21.41	21.51	21.99	22.99	21.47	22.92	22.17	22.85
Concentration	19.00	18.05	19.28	18.38	19.48	21.00	18.63	20.60	20.17	20.55
Self testing	17.97	16.11	16.94	17.28	16.70	20.14	17.11	19.37	20.15	19.15
Time management	16.53	17.00	16.78	15.72	17.10	19.28	17.21	18.46	17.62	18.73
Using academic resources	19.97	19.84	18.85	18.22	18.70	20.72	18.74	19.59	18.86	19.19

Table 5. Descriptive Statistics of the Pre- and Post-Survey Results by Sex.

	Pre-Survey						Post-Survey					
	Female		Male		*F*	*p*	Female		Male		*F*	*p*
	M	*SD*	*M*	*SD*			*M*	*SD*	*M*	*SD*		
Anxiety	17.09	5.77	19.64	5.68	12.30	0.001**	20.19	6.76	21.49	5.73	2.99	0.08
Attitude	23.58	3.53	22.59	3.83	4.24	0.04*	24.11	3.53	22.67	4.50	6.71	0.01**
Motivation	24.69	3.33	23.68	3.65	4.82	0.03*	25.15	3.79	24.03	3.90	5.12	0.02*
Information processing	20.95	5.23	21.66	4.02	1.78	0.18	22.91	4.71	23.14	4.15	0.19	0.66
Selecting main ideas	21.16	4.97	20.48	4.56	1.36	0.24	23.34	4.49	22.50	4.36	2.25	0.14
Test strategies	22.16	3.83	21.41	3.61	2.63	0.11	23.73	3.79	22.56	3.86	5.69	0.02*
Concentration	19.58	4.87	19.05	4.17	0.94	0.33	20.27	4.86	20.60	4.37	0.35	0.56
Self testing	17.54	4.62	17.02	4.49	0.81	0.37	20.43	5.15	19.31	5.16	2.95	0.09
Time management	16.82	5.12	16.70	4.42	0.05	0.83	18.69	5.32	18.53	4.71	0.07	0.79
Using academic resources	18.95	4.71	19.00	4.42	0.01	0.93	20.07	4.60	19.45	4.82	1.02	0.31

*$p < 0.05$, **$p < 0.01$.

Table 6. Summary of Learning Strategy Score Changes from Pre- and Post-Survey by Pell, FG, Race/Ethnicity, and Sex.

	Non-Pell	Pell	Non-FG	FG	Asian	Black	Hispanic	Two or more races	White	Female	Male
Anxiety	1.86	2.43	2.13	2.06	3.25	0.37	1.81	1.18	2.21	3.10	1.85
Attitude	0.13	0.21	0.08	0.17	0.36	0.05	0.03	0.37	0.07	0.53	0.08
Motivation	0.36	0.37	0.40	0.28	0.96	-0.58	0.35	0.74	-0.03	0.46	0.35
Information processing	1.38	1.88	1.57	1.49	1.56	1.63	1.46	2.27	1.27	1.96	1.48
Selecting main ideas	1.77	2.56	1.77	2.29	2.54	3.26	1.61	1.77	2.19	2.18	2.02
Test strategies	1.13	1.38	1.22	1.20	2.01	0.00	1.51	0.66	0.86	1.57	1.15
Concentration	1.25	1.69	1.21	1.54	2.00	0.58	1.32	1.79	1.07	0.69	1.55
Self testing	2.31	2.51	2.37	2.35	2.17	1.00	2.43	2.87	2.45	2.89	2.29
Time management	1.72	2.04	2.00	1.61	2.75	0.21	1.68	1.90	1.63	1.87	1.83
Using academic resources	0.49	0.70	0.58	0.58	0.75	-1.10	0.74	0.64	0.49	1.12	0.45

Table 7. Results of Hierarchical Linear Regression of GPA.

	B	SD Error	β	t	p
(Constant)	-2.017		0.691	-2.919	0.004
Age	0.050	0.024	0.092	2.053	0.041*
Sex	-0.065	0.078	-0.039	-0.826	0.410
First-generation	0.114	0.075	0.067	1.522	0.129
Pell recipient status	-0.124	0.107	-0.052	-1.161	0.246
Asian	-0.116	0.113	-0.102	-1.026	0.306
Black	-0.524	0.214	-0.321	-2.452	0.015*
Hispanic	-0.248	0.114	-0.225	-2.179	0.030*
Two or more races	1.057	0.411	0.583	2.571	0.011*
Unweighted HS GPA	0.738	0.084	0.417	8.748	< 0.001**
ACT composite score	0.010	0.012	0.041	0.863	0.389
Anxiety	0.019	0.007	0.137	2.627	0.009**
Attitude	-0.004	0.011	-0.019	-0.331	0.741
Motivation	0.076	0.013	0.350	5.692	< 0.001**
Information processing	-0.017	0.010	-0.085	-1.673	0.095
Selecting main ideas	-0.010	0.012	-0.054	-0.852	0.395
Test strategies	-0.009	0.015	-0.043	-0.614	0.540
Concentration	0.000	0.012	0.002	0.027	0.978
Self testing	0.010	0.009	0.064	1.157	0.248
Time management	-0.004	0.012	-0.025	-0.373	0.709
Using academic resources	0.008	0.009	0.049	0.947	0.344

*$p < 0.05$, **$p < 0.01$.

significant progress in these domains by the end of the FYE course.

Given the tendency for racially minoritized students to have lower academic performance (Loeb & Hurd, 2019), we examined the differences in learning strategies between racial and ethnic groups in the pre-survey and post-survey. The results showed no significant differences. The reason may be attributed to the inclusiveness of the FYE course with CRP, where all students were provided with ample opportunities for social capital, a sense of belonging, available resources, communication, and interactions with peers, faculty, and staff. With the presence of academic and social support, racially minoritized students may have learned more from their peers, gaining valuable information and emotional support to navigate the engineering environment (Attinasi, 1989), thereby narrowing the gap between racially minoritized and non-minority students.

5.3 Sex-related learning strategies, needs, and support

Addressing the second research question, one significant finding concerning sex was the evidence of differences in learning strategies between male and female students across four subscales. These results align with existing research that has indicated sex-related differences in learning strategies (e.g., Schrader & Brown, 2008; Wang & Degol, 2017). Specifically, female students exhibited lower mean scores on the (coping with) anxiety subscale, indicating a higher level of anxiety (management) compared to male students. This suggested female students may require additional emotional support to effectively manage or reduce their stress and anxiety. Regarding test strategies, female students scored significantly higher than male students in the post-survey, although no significant difference was observed in the pre-survey. This result indicated female students improved their test strategies throughout the FYE course.

Previous studies have highlighted the existence of different learning styles between male and female students (Heffler, 2001; Tindall & Hamil, 2004) and advocated for supporting students of all learning styles through diverse strategies (Kulturel-Konak et al., 2011). In this FYE course, the learning environment, course assignments, and activities were designed to address the unique needs of both male and female students. While past research suggests that males may value competitive environments and females tend to value collaboration, our findings confirm that collaborative

environments that are featured with the peer group projects which promoted communication and teamwork (Fear-Fenn & Kapostasy, 1992). As a result, both male and female students are beneficiaries (Barrett et al., 2006).

5.4 Learning strategies and academic performance

The third research question of this study examined the relationship between learning strategies and academic performance while controlling for demographics, high school GPA, and ACT scores. The findings revealed that strategies related to anxiety and motivation significantly predicted academic performance, with higher levels of (coping with) anxiety and higher motivation scores being associated with higher academic performance. Existing literature has consistently highlighted motivation as an essential component of academic performance and a predictor of academic success (Eccles & Wigfield, 2002; Prus et al., 1995; Wild & Neef, 2023). Specifically, higher motivation, particularly in terms of academic self-concept and curiosity, has been linked to the use of cognitive learning strategies in STEM education (Wild & Neef, 2023). This study corroborates previous research indicating the crucial role of motivation in academic performance among engineering students. It further emphasizes the need for additional research to identify effective strategies for enhancing student motivation in engineering fields.

While further examination is needed to understand the impact of other learning strategies on GPA scores, our findings contribute to the existing research on the LASSI by highlighting the importance of coping with anxiety and maintaining motivation. The preceding discussion on the learning environments created in the FYE course suggests that these environments may result in stronger motivation and reduced anxiety among first-year students, enabling them to concentrate on their learning (Alzubaidi et al., 2016). Additionally, it is plausible that racially minoritized students in the program derived enjoyment from their cultural values and meaningful experiences, resulting in interconnected non-cognitive attitudes, motivation, and academic success (Noel-Levitz, 2013).

5.5 Limitations of the study

It is important to acknowledge several limitations of this study. While the FYE course showed promising results in supporting students' learning strategies and academic success, it is essential to recognize that additional factors, both within and beyond the course, can influence students' academic performance. Factors such as student engagement, interactions with faculty, individual attributes, social support networks, and external influences should be taken into consideration in future research to develop a more comprehensive understanding of the factors that impact student success.

Despite these limitations, the findings of this study suggest the potential benefits of the FYE course in supporting students to improve their learning strategies. By developing effective learning strategies, students can experience reduced stress and anxiety (Owens et al., 2012), avoid common pitfalls and failures (Ashcraft, 2001), and decrease student attrition rates (Eisenberg et al., 2009), particularly among underrepresented student populations. By addressing these limitations in future research and considering a broader range of factors, educators and institutions can continue refining and enhancing interventions aimed at improving students' learning experiences and academic performance.

5.6 Conclusion and future research

This study investigated the development of learning strategies in engineering students through an FYE course by utilizing pre- and post-surveys of the LASSI, examining differences in learning strategies among demographic groups, and exploring their relationship with academic performance. The results revealed significant improvements in mean scores on the post-survey, except for the attitude subscale. Differences in the subscales, selecting main ideas and test strategies, were observed among demographic groups such as Pell status, FG status, racial status, and sex. Additionally, (coping with) anxiety and motivation were identified as significant predictors of academic performance, with lower anxiety scores and higher motivation scores associated with better academic performance.

This research contributes to our understanding of engineering students' learning strategy development within the context of an FYE course and its implications for academic performance. First, the findings underscore the importance of integrating learning strategy components into educational interventions and the potential benefits of creating supportive learning environments. The identification of specific areas where students demonstrated improvements and the observed differences among demographic groups offer insights for targeted interventions and support.

Second, the study highlights the enhancements in engineering students' learning strategies from the pre-survey to the post-survey, aligning with existing literature that links these strategies to desired academic performance. Future research could explore additional factors related to students' learning strategy development and academic performance in the engineering program and FYE course. Furthermore, there may be a need for students to further develop their strategies beyond the FYE course, particularly in areas related to social and emotional competence and culturally relevant learning.

Last, this study contributes to the existing knowledge on learning strategies in engineering education and provides actionable insights that can inspire instructors to explore more effective instructional strategies for supporting student success in engineering education. In conclusion, the findings of this research highlight the significance of learning strategy development in engineering students within an FYE course and emphasize the importance of targeted interventions, supportive environments, and ongoing development of learning strategies throughout students' educational journeys.

Conflict of interest

The authors declare no competing interest.

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References

Alzubaidi, E., Aldridge, J. M., & Khine, M. S. (2016). Learning English as a second language at the university level in Jordan: Motivation, self-regulation and learning environment perceptions. Learning Environments Research, 19(1), 133–152.

American society for engineering education. (2016). Engineering by the numbers: ASEE retention and time-to-graduation benchmarks for undergraduate engineering schools, departments and programs. Washington, D.C.

Anais, M. J., Hojas, A. M., Bustos, A., et al. (2012). Motivational and cognitive learning strategies used by first-year engineering undergraduate students at Universidad Católica in Chile. Creative Education, 3(6A), 811–817.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. Journal of Experimental Psychology: General, 130, 224–237.

Attinasi Jr, L. C. (1989). Getting in: Mexican Americans' perceptions of university attendance and the implications for freshman year persistence. The Journal of Higher Education, 60(3), 247–277.

Barrett, D. E., Katsiyannis, A., & Zhang, D. (2006). Predictors of offense severity, prosecution, incarceration and repeat violations for adolescent male and female offenders. Journal of Child and Family Studies, 15(6), 708–718.

Bonous-Hammarth, M. (2000). Pathways to success: Affirming opportunities for science, mathematics, and engineering majors. Journal of Negro Education, 69(1-2), 92–111.

Brake, N. A., & Curry, J. C. (2016). The impact of one-credit introductory engineering courses on engineering self-efficacy: Seminar v. project-based. ASEE's 123rd Annual Conference & Exposition. New Orleans, LA.

Broadbent, J., & Poon, W. L. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. The Internet and Higher Education, 27, 1–13.

Capik, D., & Shupp, M. (2021). Addressing the sophomore slump: First-generation college students' completion of year two of study in a rural bachelor's degree-granting college. Journal of College Student Retention: Research, Theory & Practice, 0(0), 1–25.

Chen, C. S. (2002). Self-regulated learning strategies and achievement in an introduction to information systems course. Information Technology, Learning, and Performance Journal, 20(1), 11–25.

Chen, X. (2013). STEM attrition: College students' paths into and out of STEM fields (NCES 2012-001). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. Annual Review of Psychology, 53, 109–132.

Eisenberg, D., Golberstein, E., & Hunt, J. B. (2009). Mental health and academic success in college. The B. E. Journal of Economic Analysis & Policy, 9.

Ergen, B.,& Kanadli, S. (2017). The effect of self-regulated learning strategies on academic achievement: A meta-analysis study. Eurasian Journal of Educational Research, 17(69), 55–74.

Fan, H. et al., (2012). An engineering introductory seminar course for first-year college students. Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Hong Kong, pp. H1B-18-H1B-21,

Fear-Fenn, M., & Kapostasy, K. K. (1992). Math + science + technology = vocational preparation for girls: A difficult equation to balance. Monograph, 7(1), n1.

Finley, A., & McNair, T. (2013). Assessing underserved students' engagement in high- impact practices..

Fong, C. J., Krou, M. R., Johnston-Ashton, K., Hoff, M. A., Lin, S., & Gonzales, C. (2021). LASSI's great adventure: A meta-analysis of the learning and study strategies inventory and academic outcomes. Educational Research Review, 34.

Fong, C. J., Lee, J., Krou, M. R., et al. (2023). Meta-analyzing the factor structure of the learning and study strategies inventory. The Journal of Experimental Education, 91(2), 380–400.

García-Ros, R., Pérez-González, F., Cavas-Martínez, F., et al. (2018). Social interaction learning strategies, motivation, first-year students' experiences and permanence in university studies. Educational Psychology, 38(4), 451–469.

Geisinger, B., & Raman, R. (2013). Why they leave: Understanding student attrition from engineering majors. International Journal of Engineering Education, 29(4), 914–925.

Heffler, B. (2001). Individual learning style and the learning style inventory. Educational Studies, 27(3), 307–316.

Hsieh, P. H., Sullivan, J. R., Sass, D. A., et al. (2012). Undergraduate engineering students' beliefs, coping strategies, and academic performance: An evaluation of theoretical models. The Journal of Experimental Education, 80(2), 196–218.

Ishitani, T. T. (2006). Studying attrition and degree completion behavior among first-generation college students in the United States. The Journal of Higher Education, 77(5), 861–885.

Kuh, G. D. (2008). High-impact educational practices: What they are, who has access to them, and why they matter. Washington, DC: Association of American Colleges and Universities.

Kulturel-Konak, S., D'Allegro, M. L., & Dickinson, S. (2011). Review of gender differences in learning styles: Suggestions for STEM education. Contemporary Issues in Education Research (CIER), 4(3), 9–18.

Li, C., Garza, T., Zhang, S., & Jiang, Y. (2023). Constructivist learning environment and strategic learning in engineering education. Learning Environments Research, 26, 743-759.

Li, C., Zhang, S., Garza, T., & Jiang, Y. (2021). Data of the Constructivist Practices in the Learning Environment survey from engineering undergraduates: An exploratory factor analysis. Data in Brief, 39, 1-6.

Liebendörfer, M., Göller, R., Gildehaus, L., et al. (2022). The role of learning strategies for performance in mathematics courses for engineers. International Journal of Mathematical Education in Science and Technology, 53(5), 1133–1152.

Loeb, E., & Hurd, N. M. (2019). Subjective social status, perceived academic competence, and academic achievement among underrepresented students. Journal of College Student Retention: Research, Theory & Practice, 21(2), 150–165.

McFarland, J., Hussar, B., Zhang, J., et al. (2019). The condition of education 2019 (NCES 2019-144). U.S. Department of Education. National Center for Education Statistics.

Micari, M., & Pazos, P. (2021). Beyond grades: Improving college students' social-cognitive outcomes in STEM through a collaborative learning environment. Learning Environments Research, 24(1), 123–136.

Noel-Levitz Inc. (2013). Research, trend reports, and strategies for higher education.

Ong, M., Jaumot-Pascual, N., & Ko, L. T. (2020). Research literature on women of color in undergraduate engineering education: A systematic thematic synthesis. Journal of Engineering Education, 109(3), 581–615.

Owens, M., Stevenson, J., Hadwin, J. A., & Norgate, R. (2012). Anxiety and depression in academic performance: An exploration of the mediating factors of worry and working memory. School Psychology International, 33, 433–449.

Padgett, R. D., & Keup, J. R. (2011). 2009 national survey of first-year seminars: Ongoing efforts to support students in transition. National Resource Center for The First-Year Experience and Students in Transition.

Pascarella, E. T., & Terenzini, P. T. (2005). How college affects students: A third decade of research. Jossey-Bass Publishers.

Pandey, M., Paul, R., Johnston, K., et al. (2022). Learning from learners: Wellness seminars and self-reflections for first-year engineering students to enhance their journey in engineering education. Proceedings of the Canadian Engineering Education Association (CEEA).

Permzadian, V., & Crede, M. (2016). Do first-year seminars improve college grades and retention? A quantitative review of their overall effectiveness and an examination of moderators of effectiveness. Review of Educational Research, 86(1), 277–316.

Prus, J., Hatcher, L. Hope, M., & Grabiel, C. (1995). The Learning and Study Strategies Inventory (LASSI) as a predictor of first-year college academic success. Journal of The Freshman Year Experience, 7(2), 7–26.

Roy, J. (2019). Engineering by the numbers.

Ryan, M. P., & Glenn, P. A. (2014). What do first-year students need most: Learning strategies instruction or academic socialization? Journal of College Reading and Learning, 34(2), 4–28.

Seabi, J. (2011). Relating learning strategies, self-esteem, intellectual functioning with academic achievement among first-year engineering students. South African Journal of Psychology, 41(2), 239–249.

Sebesta, A. J., & Speth, B. E. (2017). How should I study for the exam? Self-regulated learning strategies and achievement in introductory biology. CBE—Life Sciences Education, 16(2), ar30, 1–12.

Schmeck, R. R. (1983). Learning styles of college students. In N. R. F. Dillon and R. R. Schmeck (Eds.), Individual differences in cognition, Volume 1 (pp. 233–279). Academic Press Inc.

Schrader, P. G., & Brown, S. W. (2008). Evaluating the first-year experience: Students' knowledge, attitudes, and behaviors. Journal of Advanced Academics, 19(2), 310–343.

Schumaker, J. B., & Deshler, D. D. (1992). Validation of learning strategy interventions for students with learning disabilities: Results of a programmatic research effort. In Wong, B. Y. L. (Eds). Contemporary intervention research in learning disabilities: An international perspective. (pp. 22–46). Springer.

Shi, Q., Cresiski, R. H., Thanki, S., & Navarrete, L. (2023). Unlocking undergraduate student success: A study of high-impact practices in a comprehensive and diverse college. Journal of Postsecondary Student Success, 2(4), 83-107.

Stephen, J. S., & Rockinson-Szapkiw, A. J. (2021). A high-impact practice for online students: the use of a first-semester seminar course to promote self-regulation, self-direction, online learning self-efficacy. Smart Learning Environments, 8(6).

Tindall, T., & Hamil, B. (2004). Gender disparity in science education: The causes, consequences, and solution. Education, 125(2), 282–295.

Tseng, H., Yi, X., & Yeh, H. (2019). Learning-related soft skills among online business students in higher education: Grade level and managerial role differences in self-regulation, motivation, and social skill. Computers in Human Behavior, 95, 179–186.

Uddin, M. M. (2020). Best practices in advising engineering technology students for retention and persistence to graduation. Journal of Technology, Management & Applied Engineering, 36(1), 1–13.

Wang, C. C. D., & Castañeda-Sound, C. (2008). The role of generational status, self-esteem, academic self-efficacy, and perceived social support in college students' psychological well-being. Journal of College Counseling, 11(2), 101–118.

Wang, M-T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. Educational Psychology Review, 29(1), 119–140.

Wei, C. C., & Horn, L. (2002). Persistence and attainment of beginning students with Pell Grants (NCES 2002-169). Postsecondary Education Descriptive Analysis Reports. U.S. Department of Education, National Center for Education Statistics.

Weinstein, C. E., Acee, T. W., & Jung, J. (2011). Self-regulation and learning strategies. New Directions for

Teaching and Learning, 126, 45–53.

Weinstein, C. E., Husman, J., & Dierking, D. R. (2000). Self-regulation interventions with a focus on learning strategies. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), Handbook of self-regulation (pp. 727–747). Academic Press.

Weinstein, C. E., Palmer, D. R., & Acee, T. W. (2016). Learning and Study Strategies Inventory (LASSI) user's manual (3rd ed.). H&H Publishing Company, Inc.

Wild, S., & Neef, C. (2023). Analyzing the associations between motivation and academic performance via the mediator variables of specific mathematic cognitive learning strategies in different subject domains of higher education. International Journal of STEM Education, 10(32), 1–14.

Yip, M. C. (2013). The reliability and validity of the Chinese version of the learning and study strategies inventory (LASSI-C). Journal of Psychoeducational Assessment, 31(4), 396–403.

Zhao, C. M., & Kuh, G. D. (2004). Adding value: Learning communities and student engagement. Research in Higher Education, 45(2), 115–138.