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The Impacts of an Academic Intervention Based in Metacognition on Academic Performance

ABSTRACT

Providing reflective opportunities for students to independently develop their metacognition and expand their abilities to make judgments about themselves as learners, including which learning strategies are personally most effective for any given task, have been shown to improve academic performance. We designed a metacognition-based intervention that was structured to provide four weeks of reflective opportunities for students following a metacognitive learning strategies workshop. Qualitative analysis of student responses from the first week's survey found evidence of metacognitive skill development and self-reported improvements in learning, including an improvement in confidence and preparedness for classes and exams, and better understanding and retention of course content. Our results suggest that students who described an increase in their confidence during the first week were two times more likely to complete the intervention. This completion was correlated with a higher semester GPA, regardless of student identity, prior academic performance, and strategy choice or outcome description during the first week.

KEYWORDS

metacognition, reflective writing, intervention, self-regulated learning

INTRODUCTION

The number of students entering higher education who are ill-prepared for the rigorous and independent nature of the learning required is increasing. The ACT (2015a) reported that only 38% of all test-takers reached the college readiness benchmark for science, this number drops to 12% for Black and 23% for Hispanic students. A second report found that only 22% of students with an interest in STEM and parental education levels of high school or less met these benchmarks (ACT 2015b). Students of color and first-generation students often attend high schools in ethnically segregated, urban neighborhoods with higher-poverty rates and under resourced schools, resulting in inequitable access to opportunities for impactful learning and college preparation (Roderick, Nagaoka, and Coca 2009; Salehi, Cotner, and Ballen 2020). When planning their efforts to remediate ill-prepared students, institutions sometimes use this information to target specific student identities, including students of color and first-generation students. However, research has shown that programs with this specific targeting can reinforce negative stereotypes by unintentionally spotlighting them (McLoughlin 2005). Spotlighting, or directing attention to a specific problematic situation, may reinforce deficit model mentality by practitioners and administrators towards that group of students, because it bolsters an image that those students need extra help to be successful (Henwood 1999; Tonso 1996; Yates 1991). Due to the possible negative impacts of this phenomenon, colleges and universities need to adopt

pedagogical approaches designed to promote student learning and success. One potential way to avoid this is to focus on developing all students' abilities to regulate their own learning early on in their academic careers thus allowing all of them the opportunity to recognize their weaknesses and make appropriate adjustments to their learning.

Metacognition, or the ability to accurately assess one's level of understanding, is an important self-regulatory skill developed during one's educational career. Students are more successful when metacognition is practiced and refined earlier. Although currently contested, historically it was believed that students generally overestimated their abilities (Kruger and Dunning 1999). This seems to be particularly true for lower performing students (Gezer-Templeton et al. 2017; Miller and Geraci 2011). For students of color who perform poorly early in a course, the development and use of metacognition decreases over the semester.[1] When minimal feedback is provided to aid students as they develop this skill, little improvement in metacognition and academic performance are observed (Miller and Geraci 2011). In large enrollment courses, it may not be feasible for instructors to provide concrete feedback to all students. However, providing reflective opportunities for students allows them to work independently on developing their abilities and to make judgments more accurately about themselves as learners, the task and its level of difficulty, the amount of investment required to successfully complete it, and which strategies will provide the best outcome. Creating these reflective opportunities can also improve academic performance (Casselman and Atwood 2017; Cromley et al. 2020; Hoskins et al. 2017; Mutambuki et al. 2020; Muteti et al. 2021), as well as retention rates and graduation rates (Bail, Zhang, and Tachiyama 2008; Cambridge-Williams et al. 2013).

Simply stated, metacognition is thinking about one's thinking. McGuire explains metacognition is like having "a big brain outside of your brain looking at what your brain is doing" (McGuire and McGuire 2015, 16). Historically, it was thought to have two main sub-components: metacognitive knowledge and metacognitive experiences (Flavell 1979). Metacognitive knowledge is being aware of the factors that affect one's understanding, which Flavell (1979) refers to as person, task, and strategy. These factors include knowledge of oneself as a learner, additional information provided during the learning activity, and knowledge about which strategies may be more effective. Pintrich (2002) reframed the three factors of Flavell's metacognitive knowledge as self-knowledge, knowledge about cognitive tasks, and strategic knowledge. Self-knowledge involves the accurate perception of one's strengths and weaknesses as a learner, including what strategies they use most frequently and their level of motivation for various task types. Knowledge about cognitive tasks involves learners understanding that tasks can have varying levels of difficulty and may require the use of different cognitive strategies. Learners need to know when and why they want to use specific strategies. Strategic knowledge refers to the knowledge of effective cognitive strategies that are applicable across disciplines.

The other sub-component of metacognition is what Flavell (1979) termed metacognitive experiences. These events involve the cognitive or affective reactions one has during a learning activity, which result in monitoring and regulating learning, and applying those changes to future cognitive tasks. Most metacognitive skill development research focuses on the provision and various methods of scaffolding these experiences for students. Examples include exam wrappers, study skill courses, and workshops. Whether it is integrated into the course directly or offered through supplemental instruction, metacognitive instruction is more impactful on student motivation and learning when it is embedded into the subject matter, describing the usefulness and possible benefits of metacognitive practice, and allowing for repeated exposure (Belzer, Miller, and Shoemake 2003; Cromley et al. 2020; Donker et al. 2014; Mutambuki et al. 2020; Tolman 2011; Veenman 2011; Veenman, van Hout-Wolters, and Afflerbach 2006; Zimmerman et al. 2011).

Exam wrappers, which are short surveys administered to students before and after an exam, are one example of reflective activities integrated into courses to facilitate meaningful gains in student's academic success (Chew et al. 2016; Gezer-Templeton et al. 2017; Lovett, 2013). These metacognitive exercises help students elucidate the limitations of their study strategies and provide students with individualized information regarding their study strategies and their outcomes. Exam wrappers can directly impact subsequent exam scores. Sebesta and Bray Speth (2017) found that students in introductory biology courses had limited knowledge of self-regulated learning strategies, including metacognition, which may in turn negatively impact exam grades. Even when students are aware of strategies and their studying difficulties, they do not necessarily change the strategy they use (Cao and Nietfield 2007; Dangremond Stanton et al. 2015). This could mean that exam wrappers may not have the positive impact on student learning and, specifically, course performance that instructors intend or hope (Chew et al. 2016; Soicher and Gurung 2017). However, there is some evidence to support the use of exam wrappers in order to facilitate additional reflections in students due to the effects perceived by students, including being helpful for future exam preparation and improving exam scores (Gezer-Templeton et al. 2017).

Moreover, it may not always be possible to scaffold study skill instruction directly into courses. Feasible alternatives are study skill courses or first-year orientation courses. These courses improve self-efficacy and metacognition (Cambridge-Williams et al. 2013), exam scores (Hoskins et al. 2017), and retention and graduation rates (Cambridge-Williams et al. 2013). Bail, Zhang, and Tachiyama (2008) found improvements in grade point averages for the four semesters following a study skills course where students picked strategies to use in a specific content course and reflect on their effectiveness. Sixty percent of their participants were from underrepresented ethnic minorities at their institution and 86% were first-generation students (Bail, Zhang, and Tachiyama 2008). Additionally, workshops during the academic semester are another intervention used in attempts to reach many students with positive results (Azevedo and Cromley 2004; Cook, Kennedy, and McGuire 2013; Dignath and Büttner 2008; Hattie 2009; Mutambuki et al. 2020; Zhao et al. 2014). McGuire has developed one such workshop ("Metacognition: The Key to Acing Courses") that entails carefully constructed messages designed to help students embrace evidence-based cognitive and metacognitive strategies (McGuire and McGuire 2015). Her workshop model has shown positive impacts on future exam performance at the course-level (Cook, Kennedy, and McGuire 2013; Zhao et al. 2014).

However, these workshops often lack follow-up activities that provide additional practice for students as they develop the metacognitive skills that result from the metacognitive knowledge gained from these workshops (Zohar and Barzilai 2013). This lack of additional opportunities can result in poor skill development due to utilization deficiency, or the inability to effectively use a strategy due to the cognitive energy spent on the proper performance of the strategy and not on learning the content through the strategy (Justice and Dornan 2001). Positive correlations to academic achievement have been seen when metacognitive instruction is provided to students and additional metacognitive activities were integrated throughout the remainder of the course (Cromley et al. 2020; Tolman 2011; Zimmerman et al. 2011). We designed an intervention based on metacognition principles to provide additional reflective opportunities following a study skills workshop. Prior analysis of this intervention (Kaldor and Swanson 2018) determined that completion of the intervention correlated with 4.46 points higher in final course grade for gateway science courses while finishing part of the intervention was not significant.

Based on the previously reported positive academic impact correlated to the completion of the intervention, this study attempted to determine what early experiences in the intervention

influence students' continuation and completion. We explored students' self-reported experiences from the first week of the intervention and used this data to determine if there were any indicators from students' earliest experiences of the intervention that differentiated those students who ultimately completed the intervention from those who did not. We also determined if completing the intervention continued to show a positive impact on academic outcomes. However, instead of looking at only gateway science courses, we used a more holistic academic measure—semester grade point average (GPA)—to determine if early experiences impacted students from different identities, including students of color and first-generation students, in unique ways.

METHODOLOGY AND ANALYSIS

Location

The intervention was conducted at a large, predominantly white, public research university in the northeastern United States. Dr. Saundra McGuire presented a metacognitive learning strategies workshop to a large campus audience (1029 students, just under 10% of the undergraduate student body). Instructors and students were informed of her workshop through email solicitations and an announcement on both the university and the center for teaching and learning websites. The workshop was intentionally planned to occur approximately after first exams and covered the following five strategies: (1) completing homework like a test, (2) teaching the material to someone else, (3) reading strategy, (4) Bloom's taxonomy, and (5) the study cycle, adapted from Frank Christ's PLRS system, 2015, Louisiana State University, Center for Academic Success (McGuire and McGuire 2015).

While the workshop provided several data-driven study strategies, the key message threaded throughout the presentation was designed to motivate students to change their studying behaviors and reflect on those changes in order to find strategies that worked for them. The strategies presented suggestions to begin the process but are not the only strategies students may find beneficial. The message students were presented with is how small changes in behavior can have large impacts on learning and that these changes can help all types of students. In an effort to motivate students to nurture a growth mindset, it was also important that students heard how their prior academic performance was not a measure of their innate ability but instead a reflection of their previous behaviors. The workshop and the intervention was presented to students in a way that was non-punitive or seen as a remedial intervention.

After the workshop, the intervention was run for four weeks to provide students with scaffolded, reflective opportunities to extend the impact of the workshop. The survey items were written to aid in students' metacognitive skill development, particularly self-observation and self-judgment. They included questions asking students to describe what strategies they were using that day, the day before, and the following day. After this self-observation, students were asked to describe any improvement in their learning. They were also asked about receiving feedback from instructors around changes in learning and academic performance. Refer to Kaldor and Swanson (2019) for a more detailed description of the full intervention and Swanson, Kaldor, and Caulkins (2018) for the survey items. Students were informed at the end of the presentation that if they completed all four online surveys, they would be entered into a raffle for one of ten, $100 gift cards for the campus bookstore. Of those students who attended the presentation, 360 began the intervention and 203 completed all four surveys. Informed consent was collected following the completion of the surveys through email solicitations to all participating students, as approved by the university's Institutional Review Board (IRB) protocol (IRBNet 1105935, HU1718-019). With a consent rate of 44% (N = 157) for

students who did not complete all the surveys and 94% (N = 191) for those who did, the total sample size for the study was 348.

Qualitative coding

Thematic content analysis was conducted through qualitative coding of all open-response items across the four survey weeks. Thematic coding involved a norming process between two coders where multiple rounds of open coding by both coders were conducted on groups of 25 participants. For each round, codes were compared, and an inter-rater reliability (IRR) score was calculated via the percentage agreement method (Kirk and Miller 1986). Any differences in codes were discussed and agreed upon. These rounds continued until saturation was reached and no new descriptive codes were created. The final step in the norming process included an additional round of coding 25 participants' responses and calculating an IRR score via percent agreement. With satisfactory reliability reached, the remaining participants' responses were split and coded by a single person. After all open coding was completed, a random sample of 25 responses coded by the single readers were selected, and a final IRR score was calculated to ensure continued reliability. Quotes from students for each code were then compiled and analyzed to ensure reliability within the code descriptors. Finally, thematic constructs of the descriptive codes were determined according to Braun and Clarke (2006).

This study used social cognitive theory (SCT) (Bandura 1986) and the reciprocal relationships between personal factors, environmental factors, and behaviors as a framework for thematizing the initial descriptive codes for student outcomes. Personal factors include constructs like self-efficacy, task value, and motivation. Behaviors include the strategies students use, the amount of effort they expend, and task performance. Environmental factors include the climate and community found within a class and across a campus, teaching pedagogies and expectations, feedback, and any biases, discrimination, or stereotypes present. A subset of the data, including the codes based on students' descriptions of their strategy choice and the impacts they observed during the first week of the intervention, are discussed in this article.

Quantitative analyses

Student descriptive variables were collected from the Institutional Research (IR) office, including high school grade point average (GPA), semester GPA, sex, ethnicity, familial college status, class standing, credits completed, and specific college enrollment. Institutional data previously suggested that high school GPA is the strongest predictor of student academic success in most STEM courses. For this reason, it was included as a variable instead of SAT scores. All statistical analyses were conducted with the use of SAS9.4. Frequencies were calculated for categorical variables and chi-squared analyses were used to determine differences in the experiences of students who did and did not complete all four reflections. Based on significant correlations to the completion of the intervention, logistic regression was run to determine if any factors that influenced students' completion could be established from the first week of reflections. Multiple regression modeling was conducted to analyze the influence of student-level variables and participation in the intervention on the fall semester GPA. Student demographic variables included in model one and model two contained any variables that were determined to be significantly different between students who completed the intervention and those who did not as determined by the aforementioned chi-square analyses. Model three was used to determine the most parsimonious model using significant variables in the prior models and to determine coefficients for regression equations.

RESULTS

Qualitative coding

Due to the manner of informed consent, member checking, or the validating of codes with participants, was not possible; therefore, qualitative analysis is limited to the descriptive coding of student comments and the categorization of those codes. When deciding how the descriptive codes were interconnected into categories, the coders acknowledged how their individual views, personal backgrounds, and training in educational research positioned them within the context of the data. It was apparent that the strategies described by the students were either based on strategies presented in the workshop (e.g. study cycle, homework like a test, teaching the material, asking higher order questions) or not (e.g. flashcards, spending time every day, creating a distraction free environment, seeking external help) (Table 1).

Table 1. Classification and frequency of students in week one for each strategy code and comparison between students who completed or did not complete the entire four-week intervention

Strategies		**Frequency (%)**	
	p-value	Non-completers (N = 157)	Completers (N = 191)
Workshop strategies			
Main workshop strategies			
Complete homework like a test	0.084	27.4	36.1
Teach the material	0.679	26.8	28.8
Study cycle (full cycle)	0.515	17.8	15.2
Preview and review	0.973	8.3	8.4
Preview only	0.803	10.2	9.4
Review only	0.913	23.6	24.1
Reading strategy or more thorough reading	0.359	7.6	5.2
Bloom's taxonomy (ask higher-level questions)	0.521	3.2	2.1
Additional strategies mentioned in workshop			
Plan to avoid procrastination	0.253	7.0	4.2
Spend more time or spend time every day	0.249	22.3	27.7
Do more problems	0.066	12.1	19.4
Seek additional help	0.325	3.2	1.6
Non-workshop strategies			
Flashcards	0.345	3.8	2.1
Create a distraction-free environment	0.800	3.2	3.7
Create and complete study guides	0.306	2.6	4.7
Application of content outside of courses (work environment, internship, etc.)	0.188	0	1.1

Note. Some students replied with multiple codes hence the total frequency is greater than 100%.

Strategies from the workshop were further separated into the main strategies discussed and those that were additionally mentioned. Main strategies had student usage and evidence of academic improvement anecdotally presented. This classification was used in the subsequent quantitative content analysis of comparisons between groups of students as the variable "strategy choice." Students were classified as "workshop" if they had any of the main strategy codes from the workshop,

regardless of if they also described non-workshop strategies. Students were classified as "non-workshop" if they only described strategies that were not presented in the workshop. This created non-overlapping groups. The top workshop strategies described included completing homework like a test, teaching the material, and reviewing material (Table 1).

One workshop strategy code, the "study cycle," was reported by nearly 60% of students, both for completers and non-completers, during the first week. When students identified the study cycle as their preferred strategy, they described implementation approaches that varied in alignment to how it was defined within the workshop. Approximately 15% of both completers and non-completers reported the study cycle in its entirety as presented in the workshop, for example:

> Today I implemented the study cycle with my sociology class. Last night, I read through the chapter and took notes on the chapter we would be studying in class, then listened to the class lecture. Then after class I went back to my room and quickly reread my notes. Later tonight I plan on studying the material again while I do my homework. Later on today I will use an intense study session for my Sociology class, by planning out what to study, then testing myself on the material, and after a quick break assessing my knowledge.

Eight percent of both groups of students described previewing material before attending class, followed by reviewing material; however, their descriptions lacked other elements of the cycle, including intense study sessions or evaluative checks for understanding. Some students described merely previewing material before attending class or simply reviewing material after class (10% and 24% respectively).

Many students chose to continue with their preferred strategies regardless of the strategies presented to them in the workshop (Cao and Nietfield 2007; Dangremond Stanton et al. 2015). Some of these students described metacognition within the use of the strategy. For example, one student wrote:

> I test myself before looking at the material to see what I'm not too sure on, write flash cards on that, and then once I'm done, do the test again . . . I feel [with the strategy] I have a more fundamental guide, before I just memorized it in time blocks and not really knowing much.

This student used a strategy they were comfortable with but explained how it was enhanced by the impact on their metacognitive skill development.

The outcomes students described were placed into three main themes based on the type of impact: positive, negative, or a lack of impact (Table 2).

Table 2. Classification and frequency of students in week one for each outcome code and comparison between students who completed or did not complete the four-week intervention

Codes		Frequency (%)	
	p-value	Non-completers (N = 157)	Completers (N = 191)
Positive			
Changes in skills (adjectives), "I am . . ."			
More focused	0.144	6.4	3.1

More prepared	0.324	8.3	11.5
More efficient	0.031	10.8	4.7
More motivated	0.739	3.2	2.6
More confident	0.008	8.9	18.8
More comfortable	0.571	1.3	2.1
Less anxious	0.054	3.2	0.5
Changes in tasks (Verbs), "I can . . ."			
Retain, remember, recall more content	0.186	15.9	21.5
Understand more content	0.270	32.5	38.2
Learn content more deeply (metacognitive growth)	0.254	9.6	6.3
Perform better on assessments	0.751	8.9	9.9
Apply knowledge more	0.953	2.5	2.6
Engage more in class	0.199	3.8	1.6
Negative (intimidated, anxious, less confident)	0.681	0.6	1.0
Lack of evidence, "I haven't seen any improvements yet."	0.133	13.4	8.4

Note. Some students replied with multiple codes hence the total frequency is greater than 100%.

The positive theme was divided into two sub-themes: changes in skills and changes in tasks. Based on SCT's three factors, codes were classified as skills if they were examples of personal factors and as tasks if examples of behaviors. Students who described changes in skills described how the strategies improved them as individuals, with the three most common being: more confident, more efficient, and more prepared. Students also described observing changes in the tasks they were able to do, such as understanding more content, being able to remember more information, recalling information for longer, and performing better on coursework (i.e. exams, quizzes, homework). Three students described negative impacts, including an increase in anxiety and a decrease in confidence as outcomes. Thirty-seven students did not see any improvement, often describing a lack of tests or quizzes in the course.

The top two responses for both groups were "understanding more content" and "retaining more content." While many students reported improvements in understanding content, more responses included an increase in their retention, including remembering larger amounts of information, remembering it for longer, or more easily recalling it. Large amounts of time were spent during the workshop discussing the differences between memorizing information for an assessment and being able to understand the content at a level where students could make connections between topics, apply it to novel situations, and construct personal meaning. While some students simply mentioned "recalling things faster/easier," there were students who included retention in their responses but were also describing deeper learning. For example, one student explained: "[I am] retaining the information a lot better, whereas before I would simply try to memorize what I thought I needed to know in order to pass." This illustrates metacognitive skill development through their ability to differentiate between memorizing information for a test and having it in their long-term memory. This description of metacognitive growth in student responses resulted in their coding as "learn content more deeply" as opposed to "understand more content" or "recall more content."

However, there were differences in responses between the completers and non-completers. Non-completers reported being more efficient at a significantly higher frequency than the completers

(Table 2). Often, students described an improvement in the speed with which they were completing a specific strategy, such as, "I improved my pace with reading and understanding what I am reading. And improved my time management." Another student explained, "I have learned the problems more efficiently, without constantly having to give up and look at the answer before finally understanding the problem."

Another distinction between the two groups was confidence. Students who completed the entire intervention more frequently reported improvements in confidence during the first week, often referring to a sense of confidence around taking an assessment: "Since the seminar last week I worked on anatomy a little bit every day and tonight I had my lab practical and I felt extremely confident in my performance and am looking forward to getting my grade back." Relatedly, one student described overcoming testing anxiety through an increase in confidence:

> I feel more confident in what I know. Usually I am always second guessing myself and sometimes I don't even answer a question because I am afraid to try and I have found that I know more than I thought after using these strategies.

Quantitative impact

Differences in the students' experience during the first week of intervention were observed between the students who completed all four weeks and those who did not. Comparisons between the "completers" and "non-completers" were analyzed for students' demographic information as obtained from the university's IR, including ethnicity, familial college status (first generation or continuing generation), sex, and specific college enrollment. Comparisons of each strategy and outcome code were also conducted. Additional codes were created to account for when student described working with peers and if their overall response was perceived as positive or negative/neutral by the coders. There were no differences in students' ethnicity, familial college status, sex, strategy choice (workshop strategy), or collaboration with peers between those who completed all the reflections and those who did not (Table 3).

Table 3. Descriptive variables (continuous and categorical) and their means or frequency for students who completed the intervention and those who did not

		Mean or frequency (%)	
Variable	**p-value**	**Non-completers**	**Completers**
High school GPA	<.0001	3.60	3.82
Ethnicity (white, dichotomous, frequency of yes)	0.098	45.7	54.4
Familial college status (first generation, dichotomous, frequency of yes)	0.340	30.3	25.0
Sex (female, dichotomous, frequency of yes)	0.990	45.2	54.8
Strategy choice (workshop strategy, dichotomous, frequency of yes)	0.890	87.3	87.4
Collaboration with peers	0.643	17.8	19.8
Positive perception	0.036	87.9	94.2
Colleges			
Arts and sciences	0.848	5.7	5.3
Business	0.178	8.3	4.7
Engineering	0.649	9.6	11.1
Health sciences	0.720	15.9	17.4

Nursing	0.234	24.2	19.0
Pharmacy	0.236	9.6	13.7
Education	0.760	3.2	2.6
Environmental and life science	0.023	14.0	23.7
Undeclared majors	0.010	8.9	2.6

Note. ANOVA was used to compare high school GPA; a chi-squared was completed for the remaining analyses; strategy choice, yes (N = 304) and no (N = 44); first-generation students, non-completers (N = 36) and completers (N = 36); white students, non-completers (N = 118) and completers (N = 141); students of color, non-completers (N = 39) and completers (N = 50).

However, there were observed differences in the perceptions of students' experiences. From our observations, a slightly higher frequency of completers possessed positive perceptions. Frequency differences based on specific college enrollment existed as well. Among the completers, there was a higher frequency of students enrolled in life science programs, while there was a higher frequency of students who were undeclared majors among non-completers. Slightly higher frequencies of students reported "completing homework like a test" and "doing more problems" by completers (Table 1). Those students also reported more confidence at significantly higher frequencies, while non-completers reported being more efficient and less stressed at higher frequencies (Table 2).

There were three additional differences detected between the two groups. Drop-off in response rates differed between the third and final survey for both students of color ($p = 0.069$) and first-generation students ($p = 0.005$). Drop-off rates between weeks one and two, weeks two and three, and weeks three and four were -37%, -12%, and -3% for white students; -30, -15, and -8% for students of color; -35%, -12%, and -2% for continuing generation students; and -34%, -17%, and -10% for first generation students. Differences were observed in high school GPA, where students who completed all four weekly surveys had a higher mean high school GPA ($M = 3.82$, $SD = 0.48$) compared to those who did not ($M= 3.60$, $SD= 0.47$) (Cohen's $d = 0.46$). Finally, while the majority of students described strategies from the workshop, there were differences in these frequencies based on ethnicity; higher rates of students of color described workshop strategies compared to their white peers (x^2 (1, $N = 347$) $= 3.863$, $p = 0.049$, Cramer's $V = 0.106$).

Odds ratios were evaluated for variables with significant correlations to continuing from the first to the second week and ultimately to the completion of the intervention. While "'doing more problems,'" a "'lack of evidence'" in outcome, and an overall negative perception were negatively correlated with continuing into the second week, the 95% confidence intervals for the odds ratios included "1" and were therefore not significant predictors. A positive perception, a higher sense of efficiency, a higher sense of confidence, and enrollment in life science programs or undeclared majors were positively correlated with the completion of all four weeks of the intervention. However, it was only the reporting of an increase in confidence during the first week that was significant, doubling students' odds for completing all reflections (OR = 2.11, 95%CI [1.07, 4.14]).

Multiple regression modeling found significant associations between semester GPA and student-level descriptors, high school GPA, ethnicity, and familial college status. However, inclusion of variables from the intervention explained more of the variance in the data (model two). But model 3 proved to provide the best explanation of the data; in addition to student-level descriptors, it was merely the completion of the intervention that was correlated with an increase in semester GPA (Table 4).

Table 4. Regression modeling analysis for fall semester GPA

Variables	Model 1 (n = 251)	Model 2 (n = 251)	Model 3 (n = 251)
Intercept	1.038*	1.127*	1.116*
	(0.305)	(0.302)	(0.301)
High school GPA (hsgpa)	0.552*	0.492*	0.496*
	(0.078)	(0.078)	(0.078)
Familial college status	-0.220*	-0.205*	-0.208*
	(0.085)	(0.084)	(0.084)
Ethnicity	0.277*	0.279*	0.285*
	(0.087)	(0.087)	(0.086)
Increase in confidence in week 1	---	0.054	---
		(0.076)	
Completion of intervention	---	0.225*	0.231*
		(0.076)	(0.075)
Model fit			
adjusted-R^2	0.230	0.253	0.256

Note. Fall semester = September through December; GPA = grade point average; standard errors are in parentheses; estimation method = ML; first-generation students, N = 72; white students, N = 258; students of color, N = 63. *$p < 0.01$.

Based on model three, for all student identities, the impact of high school GPA on the fall 2017 semester GPA was 0.496 (95%CI [0.342, 0.650]), meaning for every increase of 1.0 in high school GPA, there is an increase of 0.496 in their semester GPA. When accounting for high school GPA, the completion of the intervention was correlated to an increase of 0.231 (95%CI [0.083, 0.379]) in the semester GPA. First-generation status was also correlated with a decrease in GPA, and first-generation students (-0.208, 95%CI [-0.373, -0.043]) and ethnicity was positively correlated for white students (0.285, 95%CI [0.116, 0.454]). Regression equations for each of the intersectional student identities are found in Table 5.

Table 5. Regression equations for each of the interactional groups

Intersectional student identity	Intervention status	Equation
First-generation, students of color	Non-completers	y = 1.116 + (0.496*hsgpa)
First-generation, students of color	Completers	y = 1.116 + (0.496*hsgpa) + 0.231
Continuing-generation, students of color	Non-completers	y = 1.116 + (0.496*hsgpa) + 0.208
Continuing-generation, students of color	Completers	y = 1.116 + (0.496*hsgpa) + 0.439
First-generation, white students	Non-completers	y = 1.116 + (0.496*hsgpa) + 0.285
First-generation, white students	Completers	y = 1.116 + (0.496*hsgpa) + 0.516
Continuing-generation, white students	Non-completers	y = 1.116 + (0.496*hsgpa) + 0.493
Continuing-generation, white students	Completers	y = 1.116 + (0.496*hsgpa) + 0.724

Note. hsgpa = high school grade point average.

These equations illustrate the impact of completing the interventions across all student identity groups and the ability to minimize the academic gap for first-generation students and students of color. For example, if a student had a high school GPA of 3.5, completion of the intervention would increase the predicted semester GPA from 3.35 to 3.58 for a continuing-generation, white student and

from 3.14 to 3.37 for a first-generation, white student. For continuing-generation students of color with a high school GPA of 3.5, completion of the intervention would increase their semester GPA from 3.06 to 3.29 and from 2.85 to 3.08 for first-generation students of color.

DISCUSSION

In this article, we describe students' initial experiences during a reflective, study skills intervention to determine if it had differential impacts for students of color and first-generation students.

Previous studies show that study skills workshops help increase students' academic performance (Azevedo and Cromley 2004; Cook, Kennedy, and McGuire 2013; Dignath and Büttner 2008; Hattie 2009; Mutambuki et al. 2020; Zhao et al. 2014). Although students in the current study more frequently described strategies presented in the workshop during the first week of the intervention, there was no overall impact of strategy choice on semester GPA, as observed in the regression model. Most students also described positive outcomes during the first week and, again, there was no impact on semester GPA. A previous analysis of the intervention found a positive relationship between the completion of the intervention and final course grade in a sample of participants who were enrolled in eight large-enrollment, gateway science courses (Kaldor and Swanson 2018); however, the study did not look at the experiences of the students while in the intervention.

The current study provides evidence that supports the impacts on final course grades observed in Kaldor and Swanson (2018) could result from the multiple opportunities for students to reflect on their efforts and develop their metacognitive skills and not on their early experiences in the intervention. The impacts did not correlate to specific strategies students chose to use, or the types of improvements they observed in their learning during the first week of the intervention, except for an increased odds of completing the intervention for those students who reported an improvement in confidence during the first week. Additionally, this study found a correlation between completing the intervention and a higher semester GPA, regardless of student identity, prior academic performance, strategy choice, or outcome description. This further supports the positive impact the intervention has on academic success across all the student identities studied.

Since the differences in the students' experiences reported during the first week of the intervention were minimal, it is possible that completing all four weeks of the reflective surveys served as a proxy for student motivation. Students who were already highly motivated were more likely to complete the intervention regardless of their experience during the first week. Previous studies have shown that more motivated students differentially benefit more from supplemental pedagogical interventions, like study skills workshops (Biggs and Moore 1993). Students in this study who completed all the surveys had a higher mean high school GPA, suggesting that they could have been more highly motivated initially. These students also consented to the study at a significantly higher rate (94% versus 44%). Some have estimated that motivation can affect between 45% and 60% as a confounding variable in studies where motivation is not directly measured (Hoskins et al. 2017). In this study, a 1.0 increase in high school GPA correlated to a 0.496 increase in semester GPA; however, after controlling for high school GPA, there was still a 0.231 increase due to completion of the intervention.

This study supports the role student motivation has on academic achievement but also highlights the continued academic gaps observed for students of color and first-generation students. Historically, these students are disadvantaged due to a reduced exposure to opportunities for adequate post-secondary education preparation (Roderick, Nagaoka, and Coca 2009; Salehi, Cotner,

and Ballen 2020), including formative instruction in effective study strategies. A 0.23 GPA point increase could be transformative for those first-generation students of color. In practical terms, this could be the difference between successful course completion or remaining on an academic scholarship, allowing students to continue in their program of study.

Completion of the intervention by continuing-generation students of color would close the academic outcomes gap by 80% between them and their continuing-generation white peers who did not complete the intervention. However, there was no improvement in the academic gap (semester GPA) if comparisons are made between continuing-generation students of color who completed the intervention and white peers who also completed the intervention. This is because the completion of the multiple reflective opportunities can improve student academic success across all student identities, as was illustrated in the regression model. Further investigation with larger sample sizes for all the student identity groups would allow for a more thorough statistical analysis of identity as a random effect in the modelling.

However, efforts to increase first-generation and students of color as participants needs to avoid spotlighting, or directing attention to a specific problem, as it can lead to the reinforcement of stereotypes (McLoughlin 2005). Framing of the intervention should avoid a deficit model mentality which would perpetuate the notion that these groups of students need extra support to be successful (Henwood 1999; Tonso 1996; Yates 1991). While this study supports the use of this intervention to promote metacognition and academic success for all students, to truly promote equitable learning for marginalized groups, future efforts to implement this intervention would require strategic implementation and messaging to ensure participation by the student groups most likely to benefit from the intervention. One possibility could involve adding the intervention to programmatic efforts in student groups focused on academic success for specific student populations, like multicultural student organizations.

This study also attempted to identify characteristics of students and their experiences during the first week that could influence their completion of the intervention. There were some differences observed between the two groups of students—the completers and the non-completers. Life science majors completed the intervention more frequently than other majors, and undeclared students were the most frequently observed in the non-completer group. This, paired with the increased use of "solving problems like a test" and "answering more problems" during the first week by completers, points to the notion that some strategies may be more easily applied to certain subjects versus others. Study skills difficulties are often observed in STEM courses. Some of the strategies presented in the workshop, such as solving problems like a test or solving more problems, were based on the inherent calculation-based problems STEM students encounter, making them better suited to STEM courses.

A second reason for this difference could be a result of the stronger encouragement provided by STEM instructors for student attendance at the workshop. It was reported in Kaldor and Swanson (2018) that the gateway science instructors provided extra credit to students who attended the study strategy workshop. The workshop is designed to motivate students in attendance to try one of the strategies. Having more STEM students in attendance could have resulted in the larger frequency of STEM students completing the intervention. Another distinction included those students who described increases in confidence during the first week who were two times more likely to complete the intervention. Recognizing early successes, as described by these students as more confidence and not as higher assessment scores, was a positive intrinsic motivator for continuing the intervention. Future iterations could further expand on student's self-views on improvements in their confidence to encourage more students to complete all four weeks of the intervention. This could be achieved through adding a prompt to the surveys that ask students directly about their sense of confidence.

Further research could include focus groups or follow-up interviews with students who choose not to complete the intervention in order to determine what factors, in addition to confidence, could be important for continued participation.

One final distinction between student experiences was how students of color were more likely to describe the strategies presented in the workshop than their white peers. This could be due to several possible reasons. One possible conclusion could be that those students of color who attended the workshop and subsequently participated in the intervention were demonstrating yet another instance of assimilation into higher education at a predominantly white institution. Higher education is based on a Eurocentric curriculum, albeit efforts are being taken to design more multicultural and inclusive curriculums (Arday, Zoe Belluigi, and Thomas 2021). This Eurocentricity is specifically prevalent in STEM education, where a single epistemology often dictates pedagogy, and more explicitly intellectual assessment methods in the classroom (Gutierrez 2017; O'Hara 2022; Prescod-Weinstein 2020; Ralph et al. 2022). Often students from non-majority backgrounds, like students of color and first-generation students, are viewed from a deficit view in which they require interventions to provide them with the necessary skills they are presumably lacking (Yosso 2005). Students can internalize this view and respond using respectability politics (Okello 2021), that is they may feel more inclined to follow advice sanctioned by any agent representing the institution of power, such as the metacognitive learning strategies workshop in this study. Another possibility is that there was a differential impact of having a woman of color as the workshop leader. While studies have reported the positive benefits of mentors and faculty members of color on students' social capital (Luedke 2017), retention (Palmer and Gasman 2008), and self-efficacy (Santos and Reigadas 2002), there are mixed findings for academic achievement (Palmer and Gasman 2008; Strayhorn 2008). The literature on the role of faculty and/or mentor representation on student motivation suggests that even this one-time exposure to a study skills workshop led by a woman of color could have differentially inspired a stronger connection, as compared to that felt by their white peers; however, further research is needed to understand this possible connection. The increased reporting of workshop strategies from students of color, combined with the advantage or privilege detected in the regression model for white, continuing generation students, raises the ongoing issue of institutional barriers in higher education for students of color, demanding discussion and further research.

Additional limitations

The qualitative codes included in this study were from the first week of the intervention. They do not describe how strategy choice may have changed or developed for students over the four weeks. It is important to also note that there was no systematic support offered during the intervention. Students were queried for feedback from instructors and teaching assistants regarding their learning, but there was no coaching or mentoring provided through the intervention specifically for the purpose of metacognitive skill development. This has previously been shown to be important in the development of this skill (Casselman and Atwood 2017; Miller and Geraci 2011). In addition to the lack of continued support, there were time constraints placed on students fully understanding workshop strategies, specifically the study cycle. This time constraint could have led to the multiple versions of the study cycle that were reported and the subsequent coding of the study cycle strategy in the student responses as parts of the full cycle (i.e., preview and review, preview only, and review only). The different resulting codes illustrate the limitation of interventions which provide a single exposure to learning strategies without adequate time and guidance to process the information and practice skill development. It also illustrates the different levels of metacognitive knowledge and skill development students have and the importance of presenting the strategies as starting points while

focusing on motivating students to adopt a growth mindset. Future analysis of this dataset may provide insight to if and how strategy choice changes throughout the intervention, and if and how the use of strategies, such as the study cycle, become more developed over the four weeks. Additional research is also needed to determine the impact coaching or mentoring has on the development of metacognition.

CONCLUSION

Thematic analysis of undergraduate student descriptions of their first week experiences during a four-week reflective survey intervention following a workshop on metacognition and effective study strategies provides evidence of the importance of designing metacognitive interventions. In addition to presenting study strategies to students, this intervention provided students with opportunities to practice and develop those skills through repeated, reflective activities. Multiple regression findings suggest that the strategies the students choose initially or merely an opportunity to practice them did not improve learning, but rather, the completion of the intervention did. It was also found that fostering a sense of improved confidence early in the intervention increased completion rates. Students who reported an increase in confidence during the first week of the intervention were two times more likely to complete the intervention. Additionally, the study indirectly observed that motivation, measured by grade point average, may also play a role in student academic success and the completion of a four-week intervention. It is important to find ways to leverage and sustain motivation and confidence to improve completion rates and subsequently academic success. However, to design interventions aimed at sustaining student motivation, we must better understand students' various motivations and what constitutes student motivation in different contexts.

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NOTES

1. Swanson, Holly J., and Bryan Dewsbury. "Changes in Self-Regulated Learning of First-Year Students in an Introductory Biology Course." Manuscript in preparation.

ETHICS

Research was approved through the University of Rhode Island ethical review process.

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