A Study Planning Exercise Associated with Decreased Distraction Levels among Introductory Biology Students

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ABSTRACT

Students struggle to regulate their learning during independent study sessions. In this study, we ask whether an online behavioral intervention helped introductory students decrease distraction while studying. The intervention consisted of exam 1 reflection, exam 2 planning, and exam 2 reflection exercises. During planning, students formed a goal, mentally contrasted (MC) a positive outcome of their goal to their present reality, identified an obstacle, and formed an implementation intention (II) to overcome that obstacle. During reflection, students self-reported their distraction while studying. Distraction was the most frequently reported study obstacle, and decreasing distraction was the second most frequently reported study goal. While students who aimed to decrease distraction as a goal did not follow through, students who planned for distraction obstacles did follow through on decreasing distraction levels. Only about half of students generated an II that aligned with their study goal, which may provide one reason for the opposing follow-through of distraction framed as a goal versus as an obstacle. Lastly, we examined the specificity of students' II's and found no relationship with follow-through. Overall, MC with II holds promise as a self-regulatory technique to help introductory biology students change their behaviors while studying.

INTRODUCTION

In the transition from high school to college, students shift to spending less time with the instructor in the classroom and more time in independent study sessions. Successful learners can manage their studies well in these independent sessions (Zimmerman and Martinez-Pons, 1990; Kornell and Metcalfe, 2006; Hattie, 2009; Ningrum *et al.*, 2018). This management includes initially constructing a plan and continuously striving to follow-through on that plan. Meanwhile, students must also monitor the difference between their progress and their plan so that they can adjust, as needed. While students are typically open to changing the study habits that they incorporate into their plan (Stanton *et al.*, 2015; Rowell *et al.*, 2020), students need structure and guidance in managing their studies to accomplish these habit changes. In this article, we ask whether reflection and planning exercises help students change their habits during their independent study time. We focus specifically on the habit of distraction while studying for exams in a large introductory biology course.

Distraction while studying has become an important self-regulatory challenge for students due to its prevalence, its negative relationship with performance, and its difficulty to change. Distraction occurs when students split their attention among multiple tasks (e.g., summarizing their notes while also texting with a friend), which can decrease working memory for the study tasks at hand (May and Elder, 2018). In

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addition, sources of digital distraction, such as social media, are addictive in nature (Sunday *et al.*, 2021). This means that even if students do recognize their distraction as an impediment to their learning, it can be difficult to change. In a prior study about study habits in this introductory biology course, we found that the majority (61%) of students are distracted more than 10% of the time during independent exam study sessions (Walck-Shannon *et al.*, 2021). Further, when controlling for preparation, class absences, and total study time, distraction during independent exam study sessions was negatively correlated with exam grades in this course (Walck-Shannon *et al.*, 2021). In the current study, we used the self-regulated learning (SRL) framework to guide development of exam study-planning and reflection exercises. Then, we qualitatively asked how students mentioned distraction in their plans and quantitatively asked whether students who mentioned distraction in study-planning exercise followed through on decreasing their distraction, as compared with students who mentioned other habits.

Theoretical Framework

Self-regulation refers to the ability to alter one's thoughts, emotions, and actions to achieve a goal (Bauer and Baumeister, 2011). When applied to learning outcomes, this is called SRL (Zimmerman, 1990). SRL requires: 1) **motivation** to achieve the goal, 2) real-time **monitoring** of habits while progressing towards the goal, and 3) prospective and retrospective awareness of one's own learning, or **metacognition**. In the following paragraphs, we describe a technique that has been used predominantly for self-regulation of health-related goals and apply the principles to learning goals by theoretically integrating it into the framework of SRL.

Goal pursuit involves both goal setting and goal striving. Though much focus of self-regulation has centered on goal-striving behaviors after goal setting, both phases of goal pursuit require self-regulatory skills (Gawrilow *et al.*, 2013). One self-regulatory intervention that incorporates both goal setting and goal striving is called **mental contrasting with implementation intentions** (MC-II; Oettingen and Gollwitzer, 2010). Mental contrasting (MC) is a goal setting strategy that helps individuals form realistic goal expectations, and forming implementation intentions (II) is a goal striving strategy that helps students plan for those goals. MC works by having individuals imagine a future desired state, then contrast that with obstacles in their current reality that stand in the way of the desired state. As an educational example, a student might imagine being calm and confident going into their exam and see getting distracted while studying as the current reality that limits them from effectively preparing. MC incorporates both motivation and monitoring components of self-regulation. Motivation is a key dimension of self-regulation during learning and is informed by the **subjective value** that a student places on the goal and the **expectancy** that the student has the skills and knowledge to attain that goal (Zimmerman and Schunk, 2008; Ambrose *et al.*, 2010). Elaborating on the positive outcome of goal attainment reactivates the subjective value of the goal. And, the contrast of the future desired outcome followed by the obstacles in present reality helps learners monitor which goals are realistic and worth pursuing, and which goals are unrealistic (Oettingen, 2012). As the realistic goal is set, MC helps increase the expectancy because it places the goal in the present reality.

An II is an "IF, THEN" statement that helps individuals metacognitively plan for obstacles during goal striving. Metacognition is a key dimension of self-regulation and refers to prospective planning towards a goal, which can be informed by retrospective reflection of what has been effective and ineffective. Metacognitive planning requires the selection of appropriate goal-oriented strategies and the allocation of cognitive energy towards those strategies. In the context of learning, IIs can be prospective metacognitive planning tools that focus on the obstacles to using the selected learning strategy. When making an II, individuals first determine an obstacle then select a response that will bring them closer to their goal. For example, "IF I am tempted to check my texts while studying, THEN I will turn off my phone." This association of the obstacle cue and the response brings automaticity of the response when the cue is encountered (Gollwitzer, 1999), thus freeing cognitive energy for study strategy use.

In theory, targeting both goal setting and goal striving by combining MC and II would be synergistic. This is also shown in psychology laboratory settings where completing MC before IIs had a stronger effect than each strategy alone (Adriaanse *et al.*, 2010; Kirk *et al.*, 2013). In summary, MC helps individuals set realistic goals and IIs help turn those goals into action; together, MC-II has been shown to be an effective behavioral change technique in health-behavior settings (exercise study: Sailer *et al.*, 2015; drinking study: Wittleder *et al.*, 2019; meta-analyses: Wang *et al.*, 2021; Okoro, 2023).

To What Extent has MC-II Been Used in Educational Settings?

Most MC-II studies have focused on health behaviors, but recent work has applied MC-II to various educational settings, including K–12 (Duckworth *et al.*, 2011, 2013), vocational schools (Oettingen *et al.*, 2015), massive open-enrollment courses (Kizilcec and Cohen, 2017), and medical schools (Saddawi-Konefka *et al.*, 2017). However, there have been limited uses of MC-II in undergraduate educational settings (Webb *et al.*, 2007; Clark *et al.*, 2021). In these studies, the goal was determined by the researcher, either to help increase class attendance among psychology students (Webb *et al.*, 2007) or increase overall study time among recruited student participants in a laboratory study (Clark *et al.*, 2021). However, to our knowledge, there are no studies using MC-II to help undergraduate students follow through on study goals that they set for themselves. In this study, we did not define a specific target behavior for the students but asked them to define their own study goals, then examined those goals for instances of distraction.

How Can MC-IIs Be Used Within a Course?

In this study, we integrated MC-II into a commonly used metacognitive strategy called an exam wrapper, which is implemented in the context of a specific course (Ambrose *et al.*, 2010). The term "wrapper" is used because the exam is "wrapped" in a metacognitive prospective planning exercise before an exam and then followed by a retrospective reflection exercise after the exam. Existing randomized studies of these types of exercises offer mixed results (Craig *et al.*, 2016; Chen *et al.*, 2017; Soicher and Gurung, 2017; Stephenson *et al.*, 2017; Chambers, 2020; Rowell *et al.*, 2023). One approach to the planning exercise part of the wrapper is to use prompts that

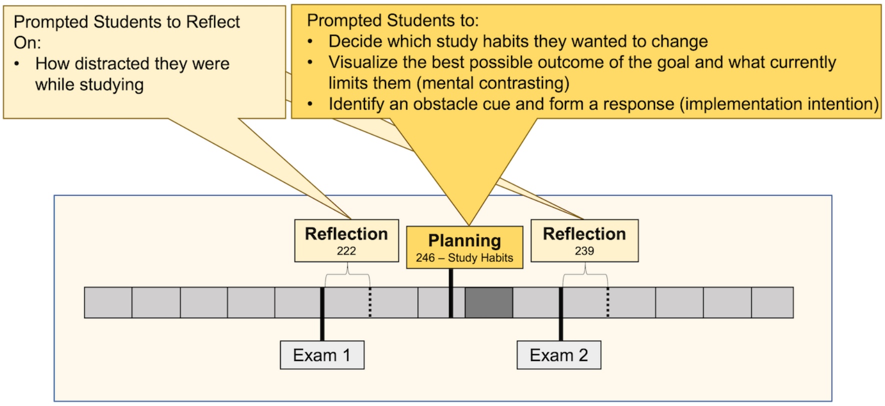

FIGURE 1. Overview timeline of assignments for this study. Each light gray box indicates 1 wk in the semester. The dark gray box indicates a break. Relevant exams are shown. Assignments analyzed in this study are shown in yellow. Light yellow shading indicates the exam 1 and exam 2 reflections and dark yellow indicates the planning exercise. Small text shows the number of students included in these analyses that completed each assignment. Only assignments, exams, and prompts relevant to this article are shown.

encourage effective strategy selection and time management. Our previous work suggested that students in this course generally selected cognitively effective, active strategies (Walck-Shannon *et al.*, 2021). Thus, in this work, we examined how students regulated the use of those strategies. We used MC-II to prompt students within their exam study planning exercise to set realistic goals and plan for obstacles that they may encounter when following through on their goals.

What are the Common Obstacles of Behavioral Change?

At its core, MC-II is an approach to help individuals follow through on their goals by overcoming obstacles. Gollwitzer and Sheeran, 2006 define four groups of common obstacles: 1) failing to get started, 2) becoming distracted (or derailed) during goal striving, 3) failing to adjust a plan during goal striving, and 4) being overextended. Through a meta-analysis of health-habit studies, Gollwitzer and Sheeran, 2006 found that IIs are effective for overcoming each of these common obstacle groups, including distraction. Students likely encounter one or more of these obstacles as they are studying.

Which Features of a MC-II Plan Make It Effective?

The effectiveness of MC-II depends on the specificity of the plan, the viability of the solution, and the alignment between the obstacle and the goal. In theory, effective IIs should be **specific** to increase automaticity of the response from the cue. For example, specific plans should include details like when and where they expect the obstacle to be encountered and details about how they will follow through on their solution, and they need to be commonly encountered. That is, if an obstacle cue is too specific (e.g., If I get distracted at 4:00 PM on Tuesday in the café at the student union), a student may never encounter that cue and thus the response will not be triggered. In addition, the response portion of the II should also be **viable**, meaning that it can realistically be carried out immediately after the obstacle cue is encountered. For example, a viable solution to checking a phone would be, "turning it off," and inviable plan would be, "breaking it to pieces." Last, the II should be instrumental to, or **aligned** with, the goal. For example, if the obstacle portion of the II does not get in the way of the goal that they set, then overcoming that obstacle may not get the individual closer to their goal. In a recent MC-II meta-analysis from broad behavior domains including health and education, one of the hypothesized reasons for varying effect sizes was varying levels of MC-II response quality (Wang *et al.*, 2021). However, the number of studies that have qualitatively looked at plan specificity, viability, or alignment in any context is quite low (Jackson *et al.*, 2005; Ziegelmann *et al.*, 2006; van Osch *et al.*, 2010; De Vet *et al.*, 2011) and to our knowledge, there are no studies that have specifically examined MC-II specificity, viability, or alignment in the context of undergraduate study habits. In this study, we hope to add to this literature base by qualitatively coding the specificity, viability, and alignment of our students' MC-II plans as part of their exam study-planning exercise.

Research Questions

In this study, we asked whether an online intervention could help students decrease their distraction levels when studying for exams. Our intervention consisted of a series of exam-wrapper assignments that aimed to incorporate all three SRL components. In these three assignments, students: 1) reflected on their study habits after exam 1, 2) created a study plan 2 wk before exam 2, and 3) reflected on their study habits after exam 2 (Figure 1). The exam reflections implemented the metacognitive element of SRL through retrospective reflection. Additionally, the two exam reflections allowed us to measure follow-through of behavior change more directly by surveying students about their study behaviors before (1, above) and after (3, above) the planning intervention.

The study-planning exercise contained both metacognitive and motivational elements of SRL. The study-planning exercise consisted of goal setting, MC, and planning for an obstacle with an II. From this study-planning exercise, we examined the prevalence of decreasing distraction as a study goal and the prevalence of distraction as a study obstacle. We then examined the extent of follow-through by relating students' goals or obstacles to their self-reported distraction from the exam 1 and 2 reflection exercises. Further, we examined whether distraction obstacles were aligned to students' goals and whether the specificity of students' IIs related to the extent to which they decreased distraction. Specifically, we asked these four questions:

1. How frequently did introductory biology students list decreasing distraction as a study goal? Did they, on average, follow through on that goal?
2. How frequently did introductory biology students list distraction as a study obstacle? Did they, on average, follow through on overcoming that obstacle?

3. To what extent did students' distraction obstacles align with their study goals?
4. Did students with more specific IIs overcome distraction obstacles to a greater extent than students with less specific IIs?

We used a mixed-methods approach. Qualitative analysis of students' responses in the study-planning exercise allowed us to determine whether and how students incorporated distraction into their study plans and the corresponding reflection exercises allowed us to examine the extent to which students followed through on decreasing their distraction during their exam study time. We used multiple regression analyses in which we examined distraction levels after the planning exercise (leading up to exam 2) as our outcome variable while controlling for distraction levels before the planning exercise (leading up to exam 1).

METHODS

Context and Participants

This study was completed in Principles of Biology I, a large-enrollment (n = 623) introductory course split into two similarly sized sections at a selective, private institution in the spring of 2019. This course covers cell biology, biochemistry, and molecular genetics and is typically taken by students who intend to major in Biology or apply to a health-related postgraduate program. It is the first course of a two-semester sequence. The format of this course–including the exams–was in-person. The study was approved by our Institutional Review Board (analysis: 201810007; data repository: 201408004). The results described herein were part of a larger set of analyses that examined a multitude of study habits. In this article, we focused on the analyses that are relevant to our research questions about distraction.

The overall intervention had randomly assigned study habits (n = 297) and health habits (n = 298) planning groups. In this article, we are only reporting on the study habits group because students in the health habits group did not mention distraction during study sessions. Within the study habits planning group, there were no exclusion criteria for the reported analyses. Any student within the study habits group who gave consent (n = 248) and completed the questions relevant for each analysis was included. Because different analyses rely on different data sources, the sample size changes analysis to analysis, as stated within the text.

Intervention Materials and Implementation

The intervention consisted of three assignments: a postexam 1 reflection, an exam 2 planning exercise, and a postexam 2 reflection (Figure 1). All three were completed online and outside of class time.

Exam Reflections. Exam reflections were administered on the course learning management system and could be completed any time from immediately following the exam through 1 wk after the exam. Students received 0.2% of the overall course points for completing each reflection. The reflections surveyed students on their study habits, including the percentage of time that they were distracted while studying and the percentage of the time that they used certain study strategies. The study habits that we assessed were based on common responses to preliminary, free-response questions about study habits for this class given in previous semesters. The full reflection exercises are in Supplemental Material 1.

Study-planning exercise. To allow for branch logic built into the study-planning exercise, we administered it through Qualtrics. Branch logic allowed students to see certain prompts based on their responses to questions earlier in the exercise. It was assigned 2.5 wk before the second exam and was due 1 wk before the exam. Students received 1% course credit for completing the planning exercise. The median time for completion was 12 min. Within the planning exercise, students were given a short table of research-supported do's and don'ts for studying. Then, they were prompted to set study goals to maintain and change, visualize the best positive outcome of following through on their plan (i.e., MC), predict obstacles, and make a concrete plan in the form of an if, then statement to follow if an obstacle occurred (i.e., II). The full planning exercise is in Supplemental Material 1.

Qualitative Coding

We qualitatively coded three aspects of students' study plans. We coded students' **goals** by categorizing the habits that they sought to change (Question 2). We coded students' study **obstacles** by categorizing the "IF" portion of their II (Questions 7 "IF" and 8A). Last, we coded the **specificity, viability, and alignment** of students' IIs (Questions 7 and 8).

Study Goals. Content analysis was conducted using a hybrid method of deductive and inductive coding (Fereday and Muir-Cochrane, 2006). The template codebook (i.e., preset codes) was developed to align with the study habits that we asked students about in their postexam reflections, but the codebook was flexible so that common responses that we did not predict were added during the process.

Two researchers (A.M.B. and G.Y.) coded the responses to which study habits students wanted to maintain (Question 1) and change (Question 2) from the planning exercise under the direction of E.W.S. The coders first read through the preset codes, clarified any questions, and then independently practiced applying the codes to a set of 15 student responses. Then, the goal-coding subgroup (A.M.B, G.Y., and E.W.S.) met to compare the researchers' application of codes among researchers and discussed until agreement was reached. The goal-coding subgroup revised any definitions in the codebook and added new codes, as necessary. Then, the goal-coding subgroup repeated this process with 15 different student responses. After these training sessions, the two coders proceeded to the inter-rater set (50% of total). This inter-rater set was coded independently by each coder, and after the inter-rater reliability was calculated, the goal-coding subgroup met to discuss any disagreements until consensus had been reached. The interrater reliability from this set ranged from a Cohen's kappa of 0.74 to 1, as shown in Table 1. The remaining responses were independently coded by either A.M.B. or G.Y. The final codebook is in Supplemental Material 2.

Although we asked students both which habits they planned to maintain and which habits they planned to change, only their planned changes mentioned distraction. Thus, only the planned changes are reported within this article.

TABLE 1. Categories of study goals that students reported in the exam study-planning exercise leading up to exam 2

Codes for Study Goals	Excerpt[a)]	Total Count (%)[b)]	Kappa[c)]
General Study Implementation			
Starting earlier (Study spacing)	"Space out studying over time – I studied just a day or two before but next time I should start exam studying earlier. … This is important because it's easier to learn over time than cramming."	93 (36.80%)	0.98
Less distracted	"Get distracted by technology less, it can take away from the studying process…"	62 (25.20%)	1
Study in groups	"I should … work with others. I didn't work with others much for the last exam, but the little bit that I did work with others was the most beneficial studying I did for the previous exam and I should make an effort to do more of it. "	16 (6.50%)	1
More of active strategies			
More organizing notes	"Making an outline will definitely help and is something I did not do last time. By writing an outline of my notes, it will help me understand the material because I am writing the information out in detail."	29 (11.79%)	0.78
More practicing problems	"Doing practice problems would be good. I didn't previously do that. It helps with learning how to apply things, and learning what mistakes are likely to be made"	26 (10.57%)	0.87
More explaining	"… I also think I should explain concepts to other people instead of just studying myself. If I can explain the concepts to other people, I know that I understand them."	18 (7.32%)	0.95
More quizzing	"I want to … actually quiz myself on topics to make sure I understand the material instead of just reading it over."	12 (4.88%)	0.79
Less of passive strategies			
Less rereading	"I reread the slides too many times–while they are a good resource as an overview or looking for answers to specific questions, they do not challenge thinking."	46 (18.70%)	0.91
Less rewriting	"Not copying my notes word for word is important to change because it is not beneficial to my memory and is only wasting time."	11 (4.47%)	0.89
Less misc. passive strategies	"I highlighted too much of my notes, and sometimes it was hard to distinguish which concepts were the most important so I should highlight less."	10 (4.07%)	1
Other strategies			
Use active strategies more effectively	"I definitely need to try the problem sets before looking at the answer keys. When I began to run out of time, I thought I would just look at the key and reason out the answer from there. However, I didn't truly know the information without the key in front of me, so I should be studying without the answers because the test won't have the answers on it."	39 (15.85%)	0.74

[a)]Prompt, "Think about the above list of suggested study habits. Which study habits will be most important for you to change for Exam 2? Write down 1–2 habits and explain why they are important to change."
[b)]Two out of 248 students left this question blank; thus, the percentages are out of 246. No students said that there was nothing they wanted to change.
[c)]*n* for interrater reliability was 124.

Study Obstacles. Content analysis was conducted using deductive coding. The codebook was based on the categories of obstacles proposed by Gollwitzer and Sheeran (2006) that prevent individuals from acting on their goals: failure to get started, getting derailed, failure to revise a plan when it is ineffective, and overextending oneself. Two researchers (A.E.B. and E.W.S.) coded the responses to the IF portion of students' IIs (Question 7) and the corresponding visualization (Question 8A) using the same process described for study goals above: both independently coded two sets of 15 training responses, both independently coded half of the remaining responses for reliability, and each coded part of the remaining half independently. The getting started and revising categories initially had a kappa below 0.7. Additional discussion was conducted to clarify the codebook, and then the codes for the entire inter-rater set were independently reapplied. After clarification, the inter-rater reliability ranged from a Cohen's kappa of 0.78 to 0.98 and is shown in Table 3. The final codebook is in Supplemental Material 2.

Plan Analysis. Content analysis was conducted using deductive coding for alignment between the goal and obstacle, the specificity of the plan, and the viability of the plan (van Osch *et al.*, 2010; De Vet *et al.*, 2011; Gollwitzer and Sheeran, 2020). Coding was carried out similarly to the above process, but three sets of training were performed. The full codebook is in Supplemental Material 2.

Alignment. For qualitative coding of alignment, we asked whether a student's stated obstacle would impede attainment of their stated goal. In other words, would overcoming the stated obstacle be instrumental in helping them attain their goal outcome? For this analysis, we examined the specific obstacle scenario that students listed in their II and associated visualization (Question 7 "IF" or Question 8A) and the single

TABLE 2. Statistics from a multiple linear regression model that predicted distraction while studying for exam 2 based on distraction while studying for exam 1, whether a student set a goal to decrease distraction [yes = 1, no = 0], and the interaction between these variables. The reference value for the categorical variable is shown in brackets and the *n* of that reference value is shown in parentheses

MODEL STATISTICS	
R^2	0.194361
N	216

Term	B	B Std Error	Std β	*P* value
Intercept	11.460217	1.852879	0	<0.0001*
% Distraction During Exam 1 Studying	0.4426369	0.070364	0.431599	<0.0001*
Set Goal to Reduce Distraction? [0] *(n = 162)*	0.9006791	1.132769	0.049115	0.4274
(% Distraction During Exam 1 Studying-20.1111)*Set Goal to Reduce Distraction? [0]	0.0194924	0.070364	0.018992	0.7820

goal that students focused on in their plan (Question 4). The Cohen's kappa for the inter-rater set ($n = 38$) was 0.821.

Specificity and Viability. For qualitative coding of specificity, we looked at whether their IF, THEN plan contained four attributes: 1) when the obstacle would occur, 2) where the obstacle would occur, 3) how they would overcome the obstacle, and 4) whether the obstacle was viable or realistic. Students' IF, THEN IIs plans (Question 7) and the visualization of their plans (Question 8) were examined during coding. Interrater reliabilities ranged from a Cohen's kappa of 0.721 to 0.804. The score for each dimension was summed to give a specificity score, which had a maximum total of four.

Statistical Analyses

JMP Pro (SAS Institute) was used for all statistical analyses. For follow-through analyses of distraction, multiple regression analyses were used. Multiple regression is a powerful and flexible statistical technique that allows researchers to control for variation in their data (Cohen *et al.*, 2003; Theobald and Freeman, 2014). It can be used to predict a continuous outcome variable based on numerous predictor variables of many types (e.g., categorical, ordinal, and/or continuous) and interactions between those predictor variables. For our analyses, the outcome variable was self-reported distraction during studying from the exam 2 reflection exercise (continuous). The predictor variables differed in each analysis, as described in the text. In every case, self-reported distraction during studying from the exam 1 reflection (continuous) was used as one predictor variable. In Research Questions 1 and 2, categorical predictor variables were used. These categorical variables were dummy-coded: plans that included distraction as a goal (Research Question 1) or obstacle (Research Question 2) were coded as a one, and plans that did not include distraction as a goal or an obstacle were coded as a 0. The reference level in all analyses was 0.

We performed the following steps to check that the assumptions of linear regression were met for each model. First, we made scatterplots and found that the relationship was roughly linear. Second, we checked for normality of residuals by evaluating residual normal quantile plots and did not see obvious patterns. Last, we checked for multicollinearity and found that no two predictor variables were correlated.

RESULTS

In the study-planning exercise, we first asked students to choose study goals and list a positive outcome on following-through on that goal. Then, we asked them to identify an obstacle and formulate a plan to overcome that obstacle using an II. In research question 1, we look at the prevalence of decreasing distraction as a study goal. In research question 2, we look at the prevalence of distraction as a study obstacle. We also relate students' goals and obstacles to their self-reported distraction from exam 1 and 2 reflection exercises.

Research Question 1: How frequently did introductory biology students list decreasing distraction as a study goal? Did they, on average, follow through on that goal?

We first aimed to determine which habits students intended to change in their exam 2 studying, relative to their exam 1 studying. In the planning process, students were given a list of effective and ineffective strategies, and then asked, "Think about your study habits leading up to Exam 1. Which habits will be most important for you to ***change*** leading up to Exam 2?" Of students who responded to this question ($n = 246$), we found that the three most common habits that students sought to change were: 1) starting to study earlier (36.8%), 2) being less distracted during study sessions (25.2%), and 3) rereading less (18.7%). The full results are listed in Table 1. In summary, decreasing distraction was the second most frequently listed study goal for introductory biology students.

We then related students' distraction goals to their self-reported distraction levels from exam 1 and exam 2 reflection assignments. While the percent of exam 1 study time distracted was a significant predictor of exam 2 study time distracted (B = 0.443, beta = 0.432, $p < 0.0001$), setting a goal to decrease distraction was not (B [0] = 0.901, beta = 0.049, $p = 0.4274$). There was not a significant interaction between these two variables (B = 0.019, beta = 0.019, $p = 0.7820$; Table 2). A box plot comparing the distribution of distraction among groups is shown in Supplemental Figure 1. The relationship is also shown as a scatterplot in Figure 2, where the best fit lines for students who did (red) and did not (blue) set a distraction goal were nearly overlapping. Thus, students who set the goal of being less distracted while studying for exam 2, did not report actually being less distracted than students who did not set this goal. In other words, students who

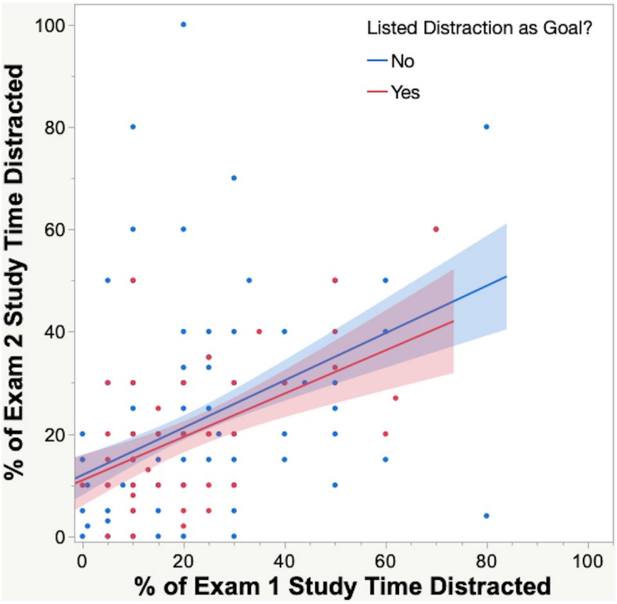

FIGURE 2. Self-reported distraction while studying from exam 1 and exam 2 reflection responses by whether students set the goal to decrease distraction in Question 2 of their Exam 2 planning exercise. Lines indicate best fit lines and shading indicates the 95% CI, $n = 216$. See Table 2 for corresponding linear regression model statistics.

listed the goal of decreasing distraction did not follow-through on that goal.

Research Question 2: How frequently did introductory biology students list decreasing distraction as a study obstacle? Did they, on average, follow through on overcoming that obstacle?

Distraction can be an obstacle in students' plans to follow through on a wide variety of goals. To capture this manifestation of distraction within study plans, we categorized students' obstacles to following through on their goals. We asked students to, "…think of one major obstacle that could prevent you from sticking with the plan that you just made. Then, commit to overcoming this obstacle by writing an If-Then statement…IF [obstacle], THEN I will [solution]." The students then completed a visualization exercise consisting of the obstacle and the following through on the solution. We coded the obstacles that students listed according to the four categories proposed by Gollwitzer and Sheeran (2006) that prevent individuals from acting on their goals. As shown in Table 3, we found that getting distracted or derailed was the most frequently listed obstacle (42.3%), followed by failing to get started (36.2%), and less commonly not revising a plan when it is unproductive (11.3%) or being overwhelmed by an internal state (10.1%). In summary, distraction while studying was the most common obstacle that introductory biology students listed for following through on their study goals.

TABLE 3. Categories of study obstacles that students reported in the exam study-planning exercise leading up to exam 2

Codes for Study Obstacles	Representative Excerpt (IF portion of II and visualization)[a]	Count (%)[b]	Kappa[c]
Getting Derailed	**IF:** *I am distracted by my phone,* **Visualization of Situation:** *I am in a study room studying when my phone goes off. I don't give it attention until it goes off again and again and again. I pick it up and spend 5 min on my phone before I realize how distracted I am.*	104 (42.3%)	0.98
Failing to Get Started	**IF:** *If I don't want to study during my designated block,* **Visualization of Situation:** *I will wake up tired on Saturday morning, tempted to hit snooze and unmotivated to study after a long week of classes. I won't want to venture to Olin from my dorm.*	89 (36.2%)	0.85
Not Revising Plan When Unproductive	**IF:** *I get frustrated* (sic) *with not understanding something* **Visualization of Situation:** *I would get frustrated* (sic) *if I am sitting in my room alone and a concept just doesn't* (sic) *click for me.*	28 (11.3%)	0.78
Internal State (Overextending Oneself)	**IF:** *I am feeling unmotivated* **Visualization of Situation:** *During the first exam, I felt overwhelmed while studying and was distracted by my sadness, so I gave myself time to recollect myself and it was much more efficient than ignoring my emotions/stress.*	25 (10.1%)	0.82

[a]Prompts: IF, Question 7, "First, think of one major obstacle that could prevent you from sticking with the plan you just made. Then commit to overcoming this obstacle by writing an If-Then statement…If [obstacle], then I will [solution]." Visualization, Question 8A, "To finish this planning exercise: A) Vividly imagine a scenario where you are likely to encounter the obstacle that you just stated. Now, write down details about this scenario, such as where you are, what is going on, how you are feeling, etc…"
[b]For total percentages, $n = 246$.
[c]n for interrater reliability was 87.

TABLE 4. Statistics from a multiple linear regression model that predicted distraction while studying for exam 2 based on distraction while studying for exam 1, whether a student formed an II about distraction (yes = 1, no = 0), and the interaction between these variables. The reference value for the categorical variable is shown in brackets and the *n* of that reference value is shown in parentheses

MODEL STATISTICS	
R^2	0.233364
N	214

PARAMETER STATISTICS				
Term	B	B Std Error	Std β	*P* value
Intercept	11.432543	1.593618	0	<0.0001*
% Distraction During Exam 1 Studying	0.4450137	0.062082	0.439646	<0.0001*
Formed II About Distraction? [0] *(n = 124)*	2.0428404	0.962568	0.128698	0.0350*
(% Distraction During Exam 1 Studying-20.0654)* Formed II About Distraction? [0]	0.1273717	0.062082	0.125429	0.0414*

We next asked whether students who listed distraction as an obstacle reported less distraction while studying than students who did not. We reasoned that if creating and visualizing a solution to the obstacle of distraction using an II was effective, students who planned for distraction obstacles would report lower distraction levels on exam 2 relative to exam 1 than those who did not plan for distraction. We found that when controlling for exam 1 distraction levels, students who formed an II about distraction reported significantly lower levels of distraction during exam 2 studying than students who formed an II about a different obstacle (B [0] = 2.04, beta = 0.129, p = 0.0350; Table 4). Additionally, there was a significant interaction between exam 1 distraction levels and whether a student formed an II about distraction (B = 0.127, beta = 0.125, p = 0.0414), where students with higher distraction levels on exam 1 and who also formed a distraction II tended to have lower levels of exam 2 distraction than students with higher distraction levels and who did not form a distraction II. A box plot comparing the distribution of distraction among groups is shown in Supplemental Figure 2. This can also be seen as a scatterplot in Figure 3. The best fit line for students who planned for a distraction obstacle (red) was overall lower than students who did not plan for a distraction obstacle (blue). In addition, the best fit line for students who planned for distraction as an obstacle to (red) had a relatively shallow slope, meaning that students who were distracted a lot while studying for exam 1 spent relatively less time distracted while studying for exam 2. In contrast, the slope of the best fit line for students who did not plan for distraction (blue) was relatively steep, meaning that those who were distracted a lot while studying for exam 1 also were distracted a lot while studying for exam 2. In summary, students who had high levels of distraction for exam 1 studying and formed an II reduced their distraction to a greater extent than students who had low levels of distraction and formed an II.

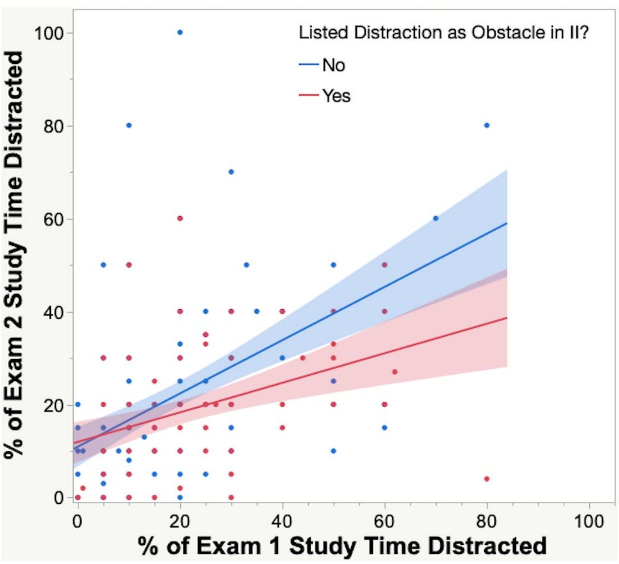

FIGURE 3. Self-reported distraction while studying from exam 1 and exam 2 reflection responses by whether students formed an II about distraction in Questions 7 and 8 of their Exam 2 planning exercise. Lines indicate best fit lines and shading indicates the 95% CI, *n* = 214. See Table 4 for corresponding linear regression model statistics.

This interaction can also be described more concretely with example values. On average, students who reported being distracted 5% of their exam 1 study time, and did not form an II about distraction, reported being distracted 16.3% of their exam 2 study time; meanwhile, students who did form an II about distraction reported being distracted 11.0% of their exam 2 study time. In other words, there was a small reduction in distraction if students had relatively low (5%) distraction levels and planned for distraction obstacles. In contrast, on average, students who reported being distracted 50% of their exam 1 study time and did not plan for a distraction obstacle reported distraction 42.1% of their exam 2 study time, while those who did form IIs about distraction reported being distracted 25.3% of their exam 2 study time. In other words, there was a large reduction in distraction if exam 1 distraction levels were relatively high (50%) and students planned for distraction obstacles. In summary, IIs about distraction had a more powerful effect for students who were very distracted when studying in comparison to students who were not very distracted.

Post-hoc Analysis: Which study habits did students who listed distractions as their obstacle intend to change?

Together, the above data suggested that students more commonly listed distraction as an obstacle than they listed reducing distraction a goal. However, we were curious how these two distraction dimensions were distributed. For each intended study habit change, we calculated the proportion of students who listed distraction as an obstacle (Supplemental

TABLE 5. Statistics from a multiple linear-regression model that predicted the percent of study time that students were distracted leading up to exam 2 based on the percent of study time that students were distracted leading up to exam 1, whether a student formed an II aligned to distraction (yes = 1, no = 0), and an interaction between these two variables. Only students who set reducing distraction as a goal were included in this analysis. The reference value for the categorical variable is shown in brackets and the *n* of that reference value is shown in parentheses.

MODEL STATISTICS	
R^2	0.355274
N	54

PARAMETER STATISTICS				
Term	**B**	**B Std Error**	**Std β**	***P* value**
Intercept	10.903329	2.417628	0	<0.0001*
% Distraction During Exam 1 Studying	0.4165504	0.089777	0.527832	<0.0001*
Aligned Goal and Obstacle About Distraction? [0] *(n = 25)*	–0.445527	1.476507	–0.0343	0.7641
(% Distraction During Exam 1 Studying-21.2963)* Aligned Goal and Obstacle About Distraction? [0]	0.2040816	0.089777	0.258323	0.0273*

Table 1). We found that more than half of the students who listed decreasing distraction as a goal also listed a distraction scenario as their obstacle (35/62, 56.5%). Additionally, students who listed wanting to explain concepts more and do practice problems more listed distraction as an obstacle to a similar extent (10/18, 55.6%; 14/26, 53.8%). However, 41.9% of students who wanted to start studying earlier listed distraction while studying as their obstacle (39/93). This result further motivated us to examine goal/obstacle alignment in the next Research Question. Overall, this analysis suggests that students listed distraction as an obstacle for a variety of study goals, including but not limited to, decreasing distraction.

Research Question 3: To what extent did students' distraction obstacles align with their study goals?

Given that IIs appeared to be effective in helping students decrease their distraction levels, we wondered whether this effectiveness was moderated by the alignment of the obstacle and goal within the plan. For an II to be effective, the situation that the student describes must be an obstacle, or impede achievement, of the specific goal that they state.

Distraction can be a common obstacle for multiple goals; however, it is not relevant for every goal. Most directly, a specific situation of distraction would serve as an obstacle to the goal of decreasing distraction itself. As an example, one student's most important goal was to decrease, "getting distracted by technology." In the obstacle (IF) portion of their II, they listed a specific situation as, "I try to check my phone while studying." This situation is an aligned obstacle to the goal. Similarly, if a student wants to do more of a specific strategy during their study session, distraction away from studying would be an aligned obstacle. As an example, another student's goal was, "active studying through summarizing notes," and they described being, "distracted by other people while studying," as an obstacle in the IF portion of their II. Because distraction during studying would be an obstacle to performing the specific strategy of summarizing during the study session, this is also an aligned plan. In contrast, some students did not describe situations in the IF portion of their plan that would be an obstacle for the specific goal that they stated. If a student's goal is to start studying earlier, distraction after the study session has already begun is not an aligned obstacle. As an example, one student set the goal to, "start studying sooner," described the following obstacle in the IF portion of their plan, "I am a few hours into studying. I am tempted to check my phone." Because this situation would occur during a study session that has already begun and the goal is to start new study sessions earlier, this situation is not an obstacle to this specific goal. Thus, the plan is not aligned. Overall, when we examined the 91 plans of students who listed distraction as their study obstacle and completed the exam 1 and exam 2 reflections, we found that 49 (53.8%) students described situations that would be aligned obstacles to their goal while 42 (46.2%) students described situations that were not aligned to their goal. In summary, in our study-planning exercise, misalignment of goals and obstacles was fairly common for introductory biology students.

Post-hoc Analysis: Did students who listed decreasing distraction as a goal follow through to a greater extent if they formed an aligned plan than if they formed an unaligned plan?

Initially, we were perplexed by the contrasting results that students who listed decreasing distraction as a study goal did not tend to follow-through on decreasing distraction (Figure 2), but students who listed a situation of distraction as an obstacle did tend to follow-through on decreasing distraction (Figure 3). As we proceeded with the above planned qualitative evaluation of IIs, misalignment arose as one reason for this contrast.

Thus, we asked whether students who wrote IIs aligned to the goal of decreasing distraction followed through to a greater extent than those who chose obstacles not aligned to distraction multiple regression analysis. For this analysis, we examined students who listed decreasing distraction as a study goal and for which exam 1 and exam 2 distraction levels were available ($n = 54$). We found that when controlling for exam 1 distraction levels, forming an aligned II was not significant (B [0] = –0.446, beta = –0.0343, $p = 0.7641$). However, there was a significant interaction between forming an aligned II and exam 1 distraction (B = 0.204, beta = 0.258, $p = 0.0273$; Table 5). Students who formed an aligned II and had high levels of distraction

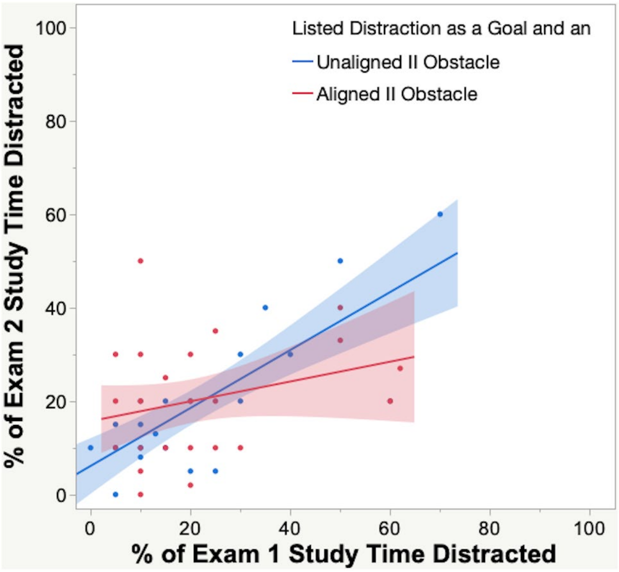

FIGURE 4. Self-reported distraction while studying from exam 1 and exam 2 reflection responses by whether students formed an aligned II about distraction. Only students who listed decreasing distraction as a study goal are included in this analysis, $n = 54$. Lines indicate best fit lines and shading indicates the 95% CI. See Table 5 for corresponding linear regression model statistics.

while studying for exam 1 reported significantly lower levels of distraction during exam 2 studying than students who did not form an aligned II and had high levels of distraction during exam 1 studying. This can be seen in Figure 4, where the best fit line for students who planned for aligned obstacles (red) had a shallower slope than the best fit line for students who planned for unaligned obstacles (blue). These results suggest that alignment between the study goal and the planned obstacle may be one important contributing factor to following through on the goal of decreasing distraction for students who struggle with high distraction.

Research Question 4: Did students with more specific IIs overcome distraction obstacles to a greater extent than students with less specific IIs?

Last, we analyzed the specificity of IIs for students who listed a distraction obstacle and completed the exam 1 and exam 2 reflections ($n = 91$). We qualitatively coded the specificity of students' plans by examining four dimensions, as summarized in Table 6.

Overall, students generated specific IIs. The median specificity score was three, the mean was 2.64, and the SD was 0.966 (Table 6). While the majority (76.9%) of students mentioned in their plan where their obstacle would occur, less than a quarter of students designated when their obstacle would occur (23.1%). Most students reported enough details about how they would follow through on their chosen solution that another could carry it out (26.4% with one detail, 68.1% with multiple details, see Table 7 for examples). Additionally, we interpreted the majority (82.4%) as viable, or that the student could realistically initiate the solution immediately after the obstacle was encountered. As an example, we interpreted plans like breaking their phone or, "hurl[ing] my phone aggressively at the sturdiest looking part of the wall," as unrealistic, and thus unviable (Table 7). Overall, when looking at the IIs, and the corresponding visualizations, it was clear that most students put sufficient thought into listing a specific obstacle and a realistic solution.

Last, we asked whether the variation in II specificity that we observed was a significant predictor of following through on decreasing distraction. We found that when controlling for exam 1 distraction levels, specificity score was not a significant predictor of exam 2 distraction levels (B = 0.778, beta = 0.055, $p = 0.5959$), nor was there a significant interaction between

TABLE 6. II Specificity Coding. Descriptive statistics of specificity dimensions

Dimension	Description[a]	Kappa[b]	Count (%)[c]
When Will Obstacle Occur?	Students received 1 if they stated a specific day, a specific time, or a relative time (i.e., after an hour of studying) that the obstacle would occur. Students received 0 if their plan did not mention time.	0.77	0:70 (76.9%) 1:21 (23.1%)
Where Will Obstacle Occur?	Students received 1 if they stated a specific location where the obstacle would occur. Students received 0 if their plan did not mention a location.	0.80	0: 21 (23.1%) 1:70/91 (76.9%)
How Will Solution Occur?	Students received 1 if they stated multiple, specific details about how they would follow-through on their solution. Students received 0.5 if they only stated minimal details. Students received 0 if there was not enough detail that another could follow-through on the plan after reading the solution.	0.74	0:5 (5.5%) 0.5:24 (26.4%) 1:62 (68.1%)
Is the solution viable?	Students received 1 if they could initiate the solution immediately after the obstacle was encountered. Students received 0 if initiating their solution required another, must have occurred before the obstacle was encountered, or could not be followed through on.	0.72	Frequency 0:16 (17.6%) 1:75 (82.4%)
Overall Measure	**Description**	**Median**	**Mean (Std Dev)**
Specificity Sum	The sum of the above dimensions. Range 0–4	3	2.64 (0.966)

[a]See Supplemental Material for entire codebook.
[b]*n* for interrater reliability was 38.
[c]For total percentages, $n = 91$.

TABLE 7. II Specificity Coding Examples

IF…[a]	THEN…	Scenario Visualization[b]	Solution Visualization	When[c]	Where	How	Viable	Sum
I play on my phone	*I will break it*	*A booth [at the campus café]. Nuff said* [sic]	*Snag a booth*	0	1	0	0	1
I get distracted by my phone	*[I will] turn it off*	*My phone buzzes while I work, I check it because I have little self-control.*	*I resist the urge to continue to use it, and I hold my thumb on the power button while watching the screen power off. I feel empowered.*	0	0	1	1	2
my phone distracts me	*set it to do not disturb and put it out of sight*	*I am probably sitting at a booth in [a campus cafeteria] studying and my phone is face up and I will notice the screen turn on from the corner of my eye*	*I will flip it over so that I won't be able to see the notifications, but if I continue to get distracted I will silence it and place it in my backpack or somewhere else harder to reach*	0	1	1	1	3
I get tempted my Facebook Feed,	*I will remind myself that I can wait until I finish studying the necessary material before I check my feed.*	*I am studying by my desk at midnight in my dorm room, slowly losing my focus on the biology material that I am studying. Instead of walking around my room to take a mental break, I am tempted to check all the feeds and posts on all of my social media such as Facebook, Instagram, and Snapchat, which would take a long time.*	*Instead of succumbing to my temptations, I remind myself of this exercise that I am filling out right now to attempt to stray myself away from the social media distractions and would try to find a shorter alternative way to take a study break.*	1	1	1	1	4

[a]Prompt, "First, think of one major obstacle that could prevent you from sticking with the plan you just made… Your commitment statement: If [obstacle] _[column 1 of table]__, then I will [solution] _[column 2 of table]__."
[b]Prompt, "To finish this planning exercise: A) Vividly imagine a scenario where you are likely to encounter the obstacle that you just stated. Now, write down details about this scenario, such as where you are, what is going on, how you are feeling, etc. [column 3 of table]; B) Last, continue to imagine yourself in that scenario, but also imagine yourself doing the actions to follow through on your plan. Write down the details that you just imagined about following through on your plan. [column 4 of table]."
[c]See descriptions of codes in Table 3.

exam 1 distraction levels and specificity score ($B = 0.033$, $beta = 0.044$, $p = 0.6952$)[1]. Model statistics are in Table 8. Together, this suggests that our students wrote specific IIs; however, the degree of specificity was not predictive of more extensive follow-through in decreasing distraction.

DISCUSSION

In this study, we analyzed the extent to which introductory biology students mentioned distraction in their exam 2 study plans. We also related students' plans to their self-reported study distraction levels from their exam 1 and 2 reflections. This allowed us to ask whether differences in exam 2 distraction levels related to their plans when taking into account their exam 1 distraction levels. We found that students who planned for distraction obstacles using IIs reported less distraction on exam 2 than students who planned for other types of obstacles. We also found that many students did not align their obstacles with their study goals; however, this alignment was important for following through on the goal to limit distraction.

Research Questions 1 and 2: Decreasing Distraction as a Study Goal and Overcoming Distraction as a Study Obstacle

We examined both the frequency with which students mentioned distraction during goal setting and the frequency with which students mentioned distraction as an obstacle to their goal-striving. We found widespread incorporation of distraction into college students' study plans. In our sample, nearly a quarter (25.2%) of students set the study goal of reducing distraction itself. This was the second most frequently listed habit that students intended to change. Distraction was also mentioned in students' study plans as an obstacle to following through on a variety

[1]Additionally, we examined the when, where, and how dimensions of specificity in three separate multiple regression models and found a similar result. When controlling for distraction while studying for exam 1, none of the specificity dimensions were significant predictors of exam 2 study distraction.

TABLE 8. Statistics from a multiple linear regression model that predicted the percent of study time that students were distracted leading up to exam 2 based on the percent of study time that students were distracted leading up to exam 1, their II specificity score, and an interaction between these two variables. Only students who formed an II about distraction were included in this analysis

MODEL STATISTICS	
R^2	0.117093
N	91

PARAMETER STATISTICS				
Term	**B**	**B Std Error**	**Std β**	***P* value**
Intercept	10.479288	4.649002	0	0.0267*
% Distraction During Exam 1 Studying	0.3160073	0.097468	0.359082	0.0017*
II Specificity Score	0.7781987	1.462187	0.054975	0.5959
(% Distraction During Exam 1 Studying-21.4176) * (II Specificity Score-2.63736)	0.0327581	0.083323	0.044305	0.6952

of goals, including but not limited to, decreasing distraction. In fact, it was the most frequently listed study obstacle (42.3%) that students reported. This observation suggests that introductory biology students both noticed that they were distracted while studying (metacognitive monitoring) and noticed that distraction decreased the effectiveness of their exam study time and thus in need of change (metacognitive planning). While it had been previously reported that students know there is a negative relationship between distraction and performance (reviewed in May and Elder, 2018), the present findings show that students prioritize this impact of distraction by including it in their study plans.

Instances of distraction can arise as obstacles to a variety of study goals beyond decreasing distraction itself. Our study-planning exercise prompts were not focused solely on distraction; students could have chosen any study goal. In fact, students listed distraction as the main, relevant obstacle for a variety of goals. For example, students who listed incorporating an active, effective strategy, such as organizing their notes more, may still have struggled to overcome distraction. We found that students who listed distraction as an obstacle in their II (IF, THEN) plan followed through on decreasing distraction while studying between exam 1 and exam 2. This effect was especially pronounced for students who had high levels of distraction at exam 1. This provides evidence that planning for distraction obstacles using IIs can be effective in educational contexts, in addition to the more established health contexts (Gollwitzer and Sheeran, 2006). This also builds the literature base about the use of IIs in undergraduate educational contexts, adding to prior research on devoting larger amounts of time to studying (Clark *et al.*, 2021) and attending class more regularly (Webb *et al.*, 2007). Overall, this suggests that MC-II is a promising self-regulatory tool to help students overcome distraction obstacles.

In contrast, we found that students who listed decreasing distraction as a study goal did not follow through on decreasing distraction more than those who chose other goals. This contrasting result on follow-through is intriguing. Why did students, on average, follow through with decreasing distraction when distraction was listed as an obstacle but not when decreasing distraction was listed as a goal? One explanation for this contrast is misalignment between the goal and the obstacle. Among students who had the goal to decrease distraction, when we factored in alignment between the goal and obstacle as a predictor variable, we saw a significant interaction where students with high levels of distraction do benefit from aligned obstacles in decreasing their distraction more than students with high levels of distraction who have misaligned obstacles. However, there was no main effect of alignment. This suggests that misaligned obstacles are an important contributor, but likely not the sole reason that students did not follow through on their goal. Rather, it may be congruent with a broader explanation. It has been shown that MC-II during planning was more effective for medical students to follow through on reading primary literature than setting specific, actionable goals (Saddawi-Konefka *et al.*, 2017). Thus, planning for distraction obstacles during goal striving may be more impactful than focusing on distraction during goal setting in the attainment of study goals. Within the process of goal striving, IIs target metacognitive planning, which may be especially sensitive to training. In a meta-analysis of self-regulatory training programs, strategies that targeted planning had the highest effect size within the metacognitive domain (Dignath *et al.*, 2008). This suggests that planning for obstacles during goal striving may be an especially important area for intervention.

Research Question 3: Alignment between Study Goals and Obstacles

While it is clear that alignment between the goal and the obstacle is one important factor in follow-through, only about half (53.8%) of students formed obstacles that aligned to their goals in our study-planning exercise. Based on limited reports about IIs, this misalignment may seem surprising; however, based on more general research about metacognitive planning, the misalignment is expected. There are not many studies that have examined II alignment (i.e., instrumentality) with which to compare our results. In one study that focused on smoking cessation, van Osch and colleagues found that about three-quarters of participants formed an II that was aligned to the goal (van Osch *et al.*, 2010). While this is considerably higher than our observation, the intended goal is very different making comparison difficult. On the other hand, misalignments occur during the related process of strategy selection during metacognitive planning (Butler and Winne, 1995). During strategy selection, learners choose strategies appropriate and relevant to their target learning goals. As an example, in one introductory biology classroom, less than half of students selected an appropriate strategy based on their previous experience (Stanton *et al.*, 2015). Similarly, students who have the goal to effectively learn the material commonly use passive, ineffective strategies in their independent study time (Karpicke *et al.*, 2009). It may be that alignment during planning is a general metacognitive challenge, applying to both obstacle selection and strategy selection.

Alternatively, something about our online planning exercise format may have also contributed to the high prevalence of goal/obstacle misalignment. For example, our exercise was completed online and independently, as opposed to an in-person training (Saddawi-Konefka *et al.*, 2017). During an in-person training, alignment may be emphasized and discussed based on student examples. Second, in our study, MC-II was integrated into a longer study-planning exercise. Students set goals, imagined a positive outcome, and then were asked to select a specific strategy to help them with their goal before proceeding to the II. Though these specific strategies were intended to give students new ideas to incorporate into their plans, the additional questions may have inadvertently shifted focus away from the study goal that they formed, thus reducing alignment with their selected obstacle.

Research Question 4: II Specificity

In general, our students formed specific IIs (median = 3 on a 4-point scale). However, the degree of specificity was not related to the extent of reducing distraction. Due to the lack of studies that qualitatively examine II specificity in educational settings, we will compare our findings to the limited health-habit studies that examine specificity. Our specificity scores were higher than those reported in Van Osch *et al.* 2010, who examined the specificity of IIs focused on smoking cessation, and slightly lower than de Vet *et al.* 2011, who examined the specificity of IIs focused on increasing physical activity. There are multiple possible reasons for this difference, but one important contributor may be the inclusion of a visualization step following the II. Based on Oettingen *et al.*, 2015, we incorporated a step that asks students to visualize the obstacle and solution. While van Osch *et al.* 2010 did not include this step, De Vet *et al.*, 2011 asked five very pointed questions prompting participants to include specific attributes. Together, this suggests that the prompts themselves may contribute towards the level of specificity that respondents incorporate into their IIs. Unlike our results, in both of the studies above, specificity was a contributing factor for following through on the target health habit. However, in both of these studies, participants formed multiple IIs, which make it hard to compare to ours where students only formed one. It may be that some medium level of specificity is ideal. Obstacle scenarios that are too specific may not have been encountered and obstacle scenarios that are too vague may not allow for full association with the response.

Limitations

Our conclusions have several caveats. First, the outcome measure of percent of exam study time distracted relies on self-reporting, which can be biased and inaccurate. We tried to limit the inaccuracies by controlling for the same student's report on a previous exam. This means that if students' misestimations are consistent across the two reflections, conclusions about differences between groups should hold. Because metacognitive monitoring is a known challenge for students (Koriat and Bjork, 2005; Kornell and Bjork, 2007; Dignath *et al.*, 2008; Stanton *et al.*, 2015), it is possible that over the two iterations of exam reflections, students may have become more adept at accurately monitoring their behaviors, which would muddy the results. However, if there are any differences among groups, we would expect that students who mention distraction in their study plans would be more attentive in monitoring it. Because students often underestimate the extent of distraction (reviewed in May and Elder, 2018), this would mean that students who are attending to distraction more may increase their distraction estimates. Such increased distraction estimates would lessen the observed effect of our intervention, rather than strengthen it. We also tried to limit inaccuracies by asking students to reflect about their distraction shortly after the exam. However, reporting distraction immediately after each study session may be even more accurate. Examples of this approach include asking for distraction estimates daily in the form of a text message survey or assigning a study session reflection that is due immediately after the study session. Second, we do not have a way to assess whether the behavior change that we documented for exam 2 was sustained for future studying. Last, our intervention was performed independently, outside of class, and no feedback was given. While preparing this publication, a meta-analysis based on a broad variety of target behaviors, including education, was published, which showed that MC-II had higher effect sizes when participants were interacting with an experimenter rather than with documents (Wang *et al.*, 2021). Additionally, devoting class time to the exercise would help students prioritize and engage fully in the planning process. Thus, an intervention that was done in-person, and with interactions from the instructor, may have a stronger impact.

Implications for Instruction

These results suggest that our students self-identify distractions as obstacles to their studying and thus know that distractions have negative impacts. This means that it may be worthwhile to have open conversations with students about the difficulty of distraction and the frequency with which it occurs among students. However, our results suggest opening up the conversation is not enough–this conversation needs to be combined with introducing students to self-regulatory strategies to overcome distraction. We suggest it is especially important to ask students to predict which obstacles they will encounter and metacognitively plan for those obstacles. Here, we describe a method called MC with IIs (MC-II). In this method, the student first identifies the goal, imagines the best possible outcome of achieving that goal, identifies obstacles, and plans for those obstacles using II (IF [obstacle], THEN [solution]) plan. This series of steps can be executed in a variety of ways. Although we describe an online, independent exercise that was done outside of class and framed as an exam study-planning exercise, we believe it would also be suitable for an in-class activity, as part of a tutor group or discussion section, or in individual meetings with students. Our results also show that we should emphasize to students the importance of the obstacle being aligned to the goal. While MC-II is just beginning to be appreciated in educational contexts as a self-regulatory tool, MC-II has a long track record of being effective for changing a variety of health behaviors, some of which may also affect academic performance (e.g., sleep). Thus, asking students to develop this strategy early in their careers may have important outcomes for their overall health and success as a student.

Future Directions and Conclusion

In our intervention, which was framed to students as an exam wrapper, we sought to incorporate a self-regulatory tool to help students be motivated during goal setting (MC) and metacognitively plan for obstacles (II). We then looked specifically at those plans that incorporated distraction as a goal or obstacle. We provide evidence that careful planning of distractions using IIs may help students overcome distraction obstacles. Ideally, this means that students can focus more of their cognitive resources on the study and learning tasks at hand.

In the future, it would be interesting to manipulate attributes of the planning exercise itself, investigate whether certain individual differences moderate the effectiveness of the exercise, and assess a larger variety of outcome behaviors. As examples of manipulations to the exercise itself: does prompting students to generate multiple IIs lead to greater reduction in distraction levels than asking them to generate a single II? Does providing students with feedback make the exercise more effective? Second, there is fascinating but unresolved work about implementation-intention effectiveness being moderated by conscientiousness. It has been observed that less conscientious individuals benefit the most from planning IIs (Webb *et al.*, 2007; Gollwitzer and Oettingen, 2013). Because there is also a known relationship between conscientiousness and academic performance for science majors (Vedel *et al.*, 2015) and conscientiousness and test anxiety (Conrad and Patry, 2012), IIs have the potential to help students who are typically more prone to struggle with exams. Last, in this study, we focus on distraction as a behavioral outcome, but are IIs effective for other types of intended study changes? For example, studies from other contexts suggest that IIs may be valuable for time management (Oettingen *et al.*, 2015) and sleep (Schmidt *et al.*, 2023).

Overcoming distraction obstacles is difficult but important in improving student performance. Distraction is not only negatively associated with grades in this course (Walck-Shannon *et al.*, 2021), but digital distractors are also addictive in nature (Sunday *et al.*, 2021). Here, we provide evidence that the MC-II strategy can help introductory biology students overcome distraction obstacles in their independent exam study sessions. Although just beginning to be studied in the undergraduate educational context, this self-regulatory strategy holds promise to be applied to additional behaviors that students wish to change.

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