Learning is Quick: Evidence for the Impact of Learning Beliefs on Self-Regulated Learning

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Abstract

Exam preparation in introductory science courses is self-regulated. Practice testing has been shown to produce better learning then other strategies. However, many students do not use practice tests effectively when studying. This mixed-methods study examines two experiments aimed at improving examining student predictions about learning and studying. We found that scores on a mock exam impact students' intentions for studying but not study habits. We also found that many underperforming students initially increase the use of ineffective study strategies rather than adopt a strategy change. Students who distribute studying throughout the semester and engage with course concepts more deeply demonstrate improvement and increased satisfaction. These results suggest that exam preparation interventions may need to include study strategy and metacognitive instruction.

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Introduction

Exams are a widely used method of assessment in introductory science courses because of their reliability, validity, and efficiency for large-scale courses (Scott, et.al., 2006). While course grades include “effort grades” such as online homework and lab projects, exams make up a large proportion of students’ grades in most introductory science courses. This means that some students receive low grades due to exam scores, despite having good “effort grades.” This discrepancy between “effort grades” and exams is important, as grades in introductory courses are very strong predictors of persistence in STEM (Cromley et al., 2020).

Preparing for exams relies heavily on effective self-regulated learning (SRL) strategies (Winne & Hadwin, 2008). While instructors provide instructional materials to help guide studying (e.g., review sessions or practice exams), students control their own studying processes and how instructional resources are utilized. Because exam preparation is primarily a SRL activity, the effectiveness of studying relies on accurate metacognition (Zimmerman, 2008). Additionally, students have different preconceptions about effective study strategies. A dynamic and iterative relationship exists between metacognitive monitoring, beliefs, and control (Greene & Azevedo, 2007; Nelson & Narens, 1994). To prepare for exams, students assess their knowledge, monitoring the discrepancy between their self-assessed current state and an internal model representing the desired state. Students then decide to continue studying, change their study strategy, or stop studying. Student study choices are also impacted by beliefs about effective learning (Dunlosky & Rawson, 2012; Metcalfe & Finn, 2008).

Individuals’ metacognitive judgments correlate with performance in many settings (Fakcharoenphol, et.al, 2015; Ohtani & Hisasaka, 2018); however, students often overestimate their performance on exams, with low-performing students being overconfident by up to two to three letter grades (Morphew, 2021). The asymmetry in monitoring accuracy likely occurs because the expertise needed to make accurate judgments is the same expertise needed to produce good performance (Schlosser, 2013). Metacognitive monitoring accuracy is also related to enacting effective study strategies (Rakovic & Bernaki, 2021). However, to effectively study, students must know when each strategy is effective and how to enact effective strategies. Students who accurately monitor their learning can still struggle with knowing how to adapt their studying for different cognitive tasks. In other words, students may know they are unprepared for an upcoming exam but still be unsure how to study effectively.

Instructors can provide studying tools specifically designed to support student SRL. In the case of exam preparation, practice exams are helpful tools because testing is an effective active study strategy that promotes learning and retention (Roediger et al., 2011). Practice exams also provide students a formative assessment (Black & William, 1998), offering students proficiency feedback that can facilitate metacognitive monitoring and control. Compared to other study strategies, testing has been shown to result in better long-term retention and problem-solving ability than passive studying (Nip et.al, 2018; Morphew, et.al, 2020; Roediger & Karpike, 2006) and is an effective tool to improve exam performance (Kulik et al., 1984), especially when testing is spaced (Carpenter et al., 2012; Rawson et al., 2013). Engaging in testing benefits recall of declarative knowledge, recall of knowledge similar but not identical to tested knowledge (McDaniel et al., 2007), analogical problem solving (Peterson & Wissman, 2018), and inferential and application questions (Thomas et al., 2018). Additionally, testing with personalized feedback and restudy opportunities enhances learning for both correctly and incorrectly answered items (Karpicke & Roedigger, 2007; Richland et al., 2009).

Given the effectiveness of practice testing, it is surprising that students prefer using passive methods when studying for exams, such as rereading and reviewing notes (Blasiman, 2017), which can create false perceptions of mastery (Butler, 2010). However, the effectiveness of practice exams also depends on implementation, similarity to the exams, and format of feedback (Fakcharoenphol, et.al,, 2011). In some cases, the format of practice exams can lead to an "illusion of understanding" (Morphew et.al,, 2020). Additionally, many students—and particularly students who are struggling—do not engage with practice exams effectively (Zhang, et.al., 2019). When students do engage in testing, they tend view testing as a way to measure preparation and tend to focus the majority of the studying one to two days before an exam (Hartwig & Dunlosky, 2012; Zhang, et.al., 2019). Although cramming can sometimes facilitate short-term performance (Brown et al., 2014), it has a detrimental effect on long-term learning and can lead to overly high confidence (Rohrer & Taylor, 2006).

For these reasons, providing tools that help students prepare for exams more effectively is an important task for instructors and course designers. While the vast majority of introductory physics students feel that practice exams are "essential" or "very important," most students either do not use them or begin one day before exams. In this paper, we present findings from a mixed-methods study in introductory science courses examining beliefs about learning and studying.

Research Questions

1) How does practice test use relate to students' predicted learning?

2) How do students adapt their study strategies across a semester when they underperform relative to their expectations?

Study Context

This study is situated in a large introductory physics course at a large Midwestern University with three exams and a cumulative final that comprise half the course grade. Four practice exams were available online before each exam and provided correctness feedback and video solutions. Experiment 1 was conducted during spring 2021, which was online due to Covid-19. Experiment 2 was conducted during spring 2022 and was in person. This study was reviewed and approved by the Institutional Review Board at Midwestern University.

Experiment 1

One week before the first exam, an optional "mock exam" was offered online. Students were encouraged and incentivized to take the mock exam. Correctness feedback and summative scores were given to students the following day. After receiving correctness feedback, students were asked to predict their exam grade and the number of practice exams they planned to complete. Eight hundred forty-seven students completed the mock exam. Of those, 801 completed the prediction survey. Fifteen students were dropped from the analysis due to improper predictions, leaving 784 in the analysis.

To estimate predicted and actual learning we used the students' mock exam scores as a proxy for student proficiency one week before the exam. Predicted learning was calculated by subtracting the mock exam score from students' predictions. Actual learning was calculated by subtracting the mock exam score from students' actual exam score. All assumptions for statistical tests were tested and the results indicated that these reported tests were appropriate.

Results

Five main results are reported in this paper. First, most students began using practice exams less than two days before the actual exam (Fig. 1). Second, the number of predicted practice exams was weakly correlated with predicted learning, r=.13, p<.001. This seems to indicate that students only loosely associated practice testing with learning (see Fig. 2a). Third, a one-way ANOVA showed that those who predict greater practice test use actually attempt more practice test problems, $F(4,784)=44.84$, $p<.0001$, $\eta^2=.19$. However, students attempted fewer practice exam questions than predicted (Fig. 2b).

Fourth, predicted learning was correlated with actual learning, r=.63, p<.0001. Given the extensive literature that lower performing students are less accurate in predicting performance, we divided the students into quartiles based on their exam scores. Finally, a 4x2 (quartile x learning type) mixed ANOVA was conducted with predicted and actual learning as repeated variables and quartile as the between-subjects variable. The interaction was significant, $F(3,780)=146.22$, $p<.0001$, indicating different patterns of results by quartile. Follow-up one-way ANOVAs found differences in predicted learning, $F(3,780)=32.38$, $p<.0001$, $\eta^2=.11$, and actual learning by quartile, $F(3,826)=13.98$, $p<.0001$, $\eta^2=.05$. Post-hoc Tukey tests indicate lower-performing students predicted the greater learning but demonstrated the least actual learning. Paired t-tests indicate that students in the lower quartiles overestimated their learning, $t(154)=14.56$, $p<.0001$, and $t(138)=5.28$, $p<.0001$, respectively. The higher quartiles did not exhibit such overconfidence (Fig. 3). In other words, while all ability groups demonstrated similar learning in the week before the exam, the lowest-performing students expected much greater learning to occur.

Experiment 2

Experiment 2 qualitatively examined how students modified their study strategies after underperforming on exams relative to their expectations. Immediately following the first exam, all students (N=1164) were invited to participate in a longitudinal survey study regarding study habits using a free-response survey. After each exam, we asked students to rate their satisfaction with their exam score and to describe in detail how they studied and any changes that they had made compared to previous exams. Of the 302 students who volunteered, 100 were selected to participate and received monetary compensation. Of the participants, 74 students completed all three surveys. Because participants volunteered, the results may not be representative of all dissatisfied students. However, this study provides insight into how study habits change for students who felt that they underperformed on the first exam and persisted in the course.

Results

Figure 4 shows that most students were dissatisfied with their exam 1 and 2 performance but satisfied with their exam 3 performance. For students dissatisfied with their first exam score, we reviewed the biggest changes in preparation between exams as identified by the students. We also analyzed student narratives of their exam preparation and coded for differences in the strategies reported.

Although the sample size is small, we identified some revealing patterns in the data. First, while all students reported using practice exams to study, increasing the number of practice exam problems does not necessarily result in increased satisfaction in exam score. Most students

(87.5%) who were dissatisfied on all three exams reported practicing more for later exams. In contrast, 38.9% of students who increased their satisfaction reported practicing more. This may be due to the timing of using practice exams. As noted above, most students do not engage with practice exams until shortly before the exams, when learning benefits are limited. This result suggests that simply doing more of the same studying behaviors does not necessarily lead to success.

Rather than increasing the amount of previous study behaviors, students who engaged more meaningfully with course activities, an approach that we labeled "higher engagement," were more likely to demonstrate increased success. These students tended to focus on understanding course concepts more deeply and distributed this effort across the semester. Almost half of the students who eventually became satisfied (44.4%) changed their strategies to engage more deeply with the course material, whereas 12.5% who never became satisfied tried this approach. For example, one student whose exam satisfaction increased reported that they "focused on understanding the material as we went along with the unit rather than just trying to learn most of it at the end." Another student who was dissatisfied with exam 2 after increasing the amount of time doing the same study activities demonstrated increased satisfaction on exam 3 after they changed their study strategy to instead "work on knowing how to explain what I was doing."

Discussion

The findings from both experiments suggest that all students—and low-performing students in particular—could benefit from interventions targeting metacognitive monitoring and beliefs about study strategy use. The study rationale examined how theoretical model of SRL manifest within an introductory science course. The findings show that there are many factors that impact student studying. Further, low-performing students need metacognitive support and may benefit from instruction on effective study strategies. However, it should be acknowledged that students may need to experience dissatisfaction with ineffective study strategies to motivate strategy change, particularly as the students in this study were successful in previous courses using these strategies.

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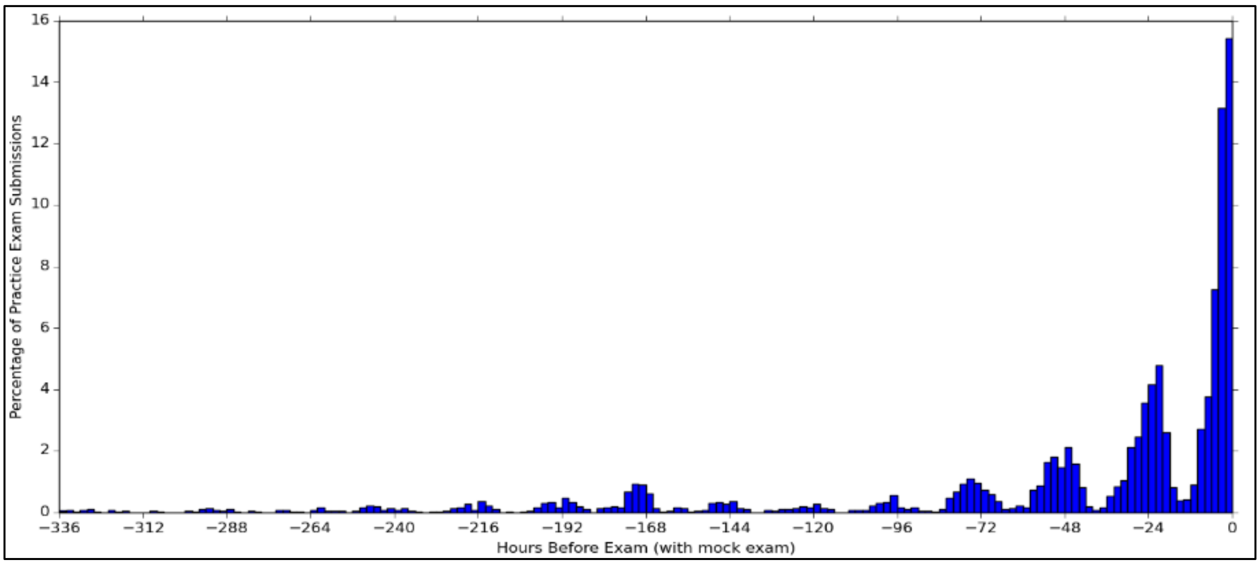
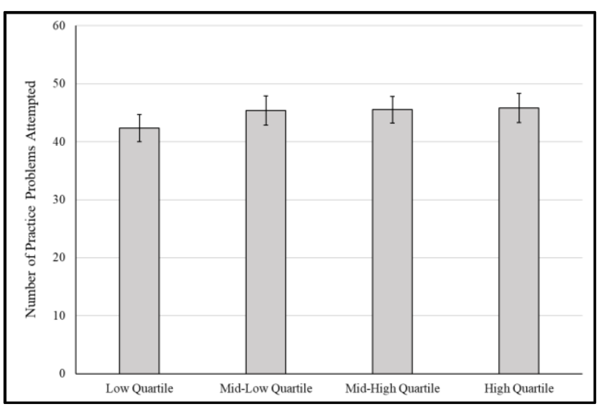


FIG. 1. Timing of online practice exam use. The height of each bar represents the percentage of online submissions that falls in the time bin on the x-axis. In Spring 2021, we made the practice exams available to students 2 weeks (336 hours) ahead of the exam so that they could practice for the mock exam.



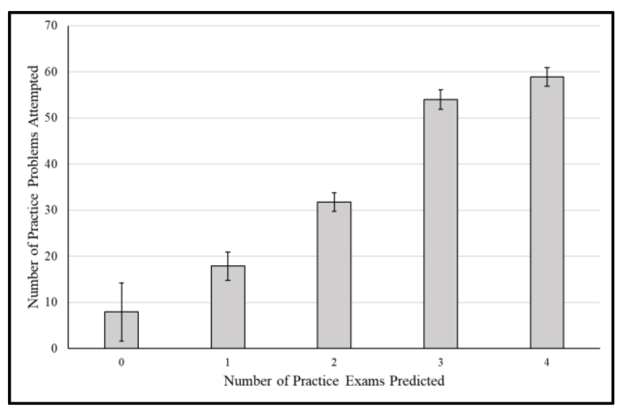


FIG. 2. (a) Number of practice exams predicted by predicted improvement quartile. (b) Number of practice exam problems attempted by number of practice exams predicted. Each practice exam contains about 25 questions.

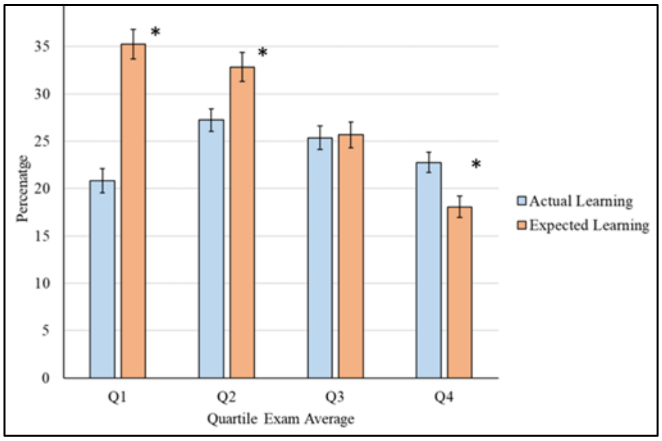


FIG. 3. Comparison between expected learning and actual learning for different proficiency quartiles.

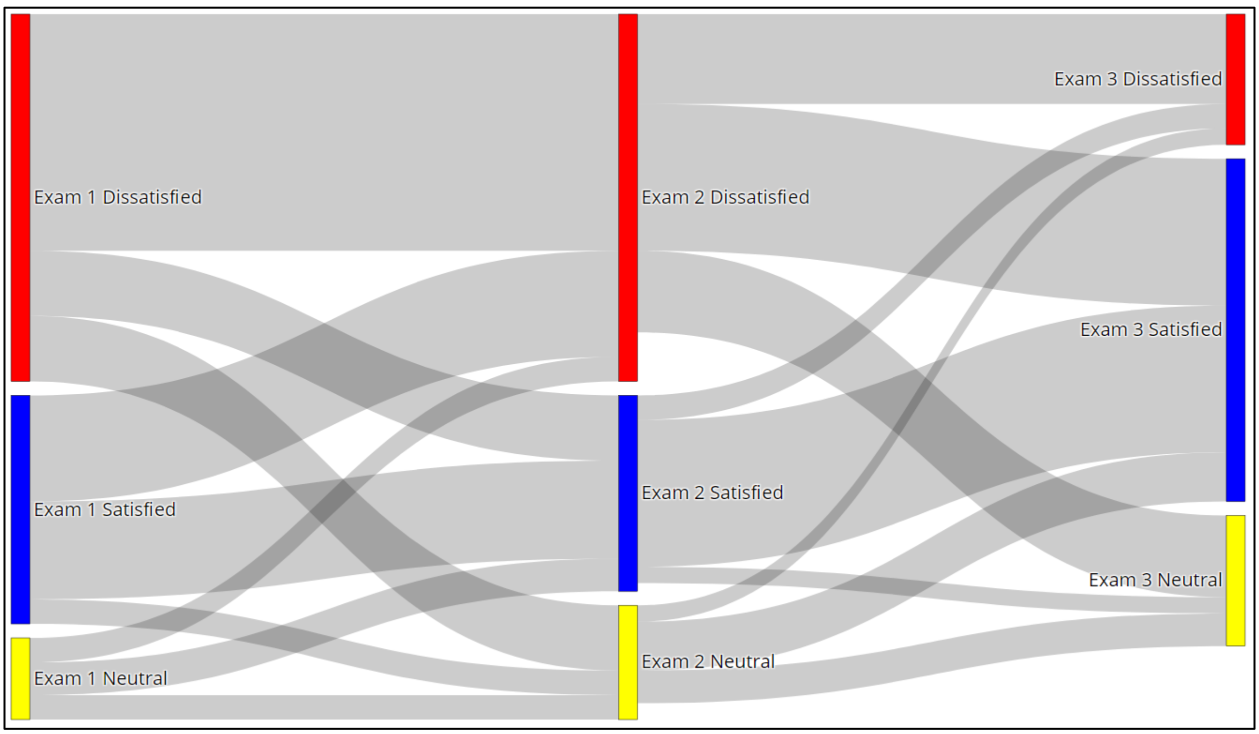


FIG. 4. Sankey diagram showing the change in satisfaction in exam performance for students across the semester. Note: $n_{exam1} = 87$, $n_{exam2} = 83$, $n_{exam3} = 74$.