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Comparing the Relationship of Learning Techniques and Exam Score

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We assessed the extent to which students use 10 major learning techniques (e.g., practice retrieval, spaced practice; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013), and tested how each correlated with each other and exam scores. Students (N = 312) from Introduction to Psychology and Introduction to Human Development classes participated in an online survey that included items about the 10 learning techniques. Items measured how much a student used the specific technique and other factors such as high school GPA and American College Testing (ACT) scores. Instructors provided exam scores to assess learning. Students reported high use of learning techniques such as practice retrieval, and the use of many techniques were correlated. Only elaborative interrogation predicted exam scores in a multiple regression analysis controlling for other factors. Our findings provide teachers and students with a clear picture of study technique use and pedagogical researchers with a clear research program to assess the utility of study skills in the classroom.

Keywords: metacognition, study skills, introductory psychology

What is the best way to study? Most faculty are asked this question, and many recent reviews provide evidence-based tips on how to study (Bjork, Dunlosky, & Kornell, 2013; Dunlosky & Rawson, 2015; Gurung & McCann, 2012) possibly aided by recent trade publications discussing how learning takes place (Brown, Roediger, & McDaniel, 2014; Carey, 2014). A large body of academic literature identifies what learning techniques work well (e.g., Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). Study techniques are important because they predict academic performance over and above standardized tests and previous grades (Credé & Kuncel, 2008) and allow faculty a direct route to help students learn material better. If faculty know which study techniques are most effective, they can better advise students. Whereas many different factors have been linked to learning (Robbins et al., 2004), few studies examine many of them simultaneously in a single study. In particular, few studies explicitly compare different ways of studying (e.g., keyword use or practice testing), psychological variables (e.g., self-efficacy and effort), and contextual variables (e.g., class or professor ratings) at once. Students probably use more than one study technique and use of one technique may relate to the use of others, but we could not find any research to examine this issue. In this study, we measure how much students use different learning techniques and how use of techniques are related to each other, and we examine which techniques best predict exam scores.

Numerous factors such as achievement motivation, goals, social involvement, and perceived social support are associated with students' academic performance (Hattie, 2015; Robbins et al., 2004). In particular, factors such as effort, ability, habits, and self-efficacy are strongly related to academic performance (Credé & Kuncel, 2008; Komarraju & Nadler,

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2013). Not surprisingly, current college GPA and other cognitive indicators such as ACT scores and high school GPA also predict learning in a university setting (Komarraju, Ramsey, & Rinella, 2013). Beyond these commonly studied features, the study techniques that students utilize also have an influence on exam scores.

In one of the most comprehensive reviews of study techniques, Dunlosky et al. (2013) explored the efficacy of 10 learning techniques most commonly used by students to successfully influence learning. The authors described each technique, specified why it should improve learning, considered if use of the technique would generalize across contexts, highlighted real-world research with the technique (i.e., in educational settings), and addressed issues with implementation of the technique. The authors rated the techniques' "utility," or general effectiveness or usefulness, based on the techniques' generalizability to different learners, forms of testing, and educational contexts. For example, high utility techniques are "robust and generalize widely" (Dunlosky et al., 2013, p. 7). Low or moderate utility techniques only work when learning certain kinds of material, or lack empirical evidence. All 10 techniques (described below) improve learning, though they vary in utility with some being low (e.g., highlighting) and others being high utility (e.g., spaced practice).

Five techniques, summarization, highlighting, keyword mnemonics, rereading, and using imagery for text learning, have low utility although they relate to learning. For example, students who use imagery, creating a mental image for the text, learn better (Leutner, Leopold, & Sumfleth, 2009). Highlighting has also been used to assist a student in understanding the required text. Readers who were able to identify the most relevant material as evidenced by highlighting, achieved higher overall exam scores in the course (Bell & Limber, 2009). Three other techniques have moderate utility: Elaborative interrogation (generating an explanation for why a concept is true), self-explanation (relating new information to old information), and interleaved practice (studying by mixing different kinds of material within a single study session). For example, elaborative interrogation improved a student's learning of factual information (Woloshyn, Paivio, & Pressley, 1994). In addition, self-explanation enhanced a student's learning of the series of steps that needed to be taken for a specific task, especially when researchers gave specific instructions to the student (Rittle-Johnson, 2006). Only two techniques got top billing.

Dunlosky et al. (2013) rated a final category of techniques as having high utility—practice testing (or practice retrieval) and distributed practicing (or spaced practice). In one study, practice testing benefited a student the most when a student was able to correctly recall the initial concepts three times, and in addition, relearnt the concepts over a long period of time (Rawson & Dunlosky, 2011). Learning is more likely to occur not only when the student is able to recall the item, but also when a student had successfully retrieved the items twice (Karpicke, 2009). Some students spread out their studying, a technique referred to as distributed practice (Dunlosky et al., 2013). An example of the way a student may engage in both high utility techniques is by using flashcards. Students using flashcards are practice testing, and they tend to also space out their practice over time (Wissman, Rawson, & Pyc, 2012). Overall, students would most likely perform better on tests if they space out their studying over the course, despite differences in the way distributed practice is carried out (Bain, 2012). Even though the two techniques, distributed practice and practice testing, have high utility, is one more predictive of learning than the other when compared simultaneously? We did not find a study that answers this question.

Although many studies support the benefits of the learning techniques reviewed (Bjork et al., 2013), a close read of Dunlosky et al. (2013) show that the utility of the 10 learning techniques are partially based on the amount of previous research that has been done on that particular technique. The labels low and moderate for utility may be artifacts of the fact that little research has been conducted on these techniques. Furthermore, no study assesses all the techniques simultaneously testing for links to learning. It is unlikely that students only use one technique, and it would be prudent to examine the extent to which different techniques are used simultaneously.

The current study addresses this gap by including all 10 techniques within one study. In addition, based on previous research, we in-

cluded important academic and nonacademic factors such as student ratings of classroom lectures, the professor, procrastination, effort regulation, and self-efficacy to see how each relates to learning (Credé & Kuncel, 2008; Gurung, Daniel, & Landrum, 2012; Komarraju & Nadler, 2013. We had three major research questions: (a) which study techniques do students utilize the most?; (b) how does the use of one study technique correlate with the use of others?; and (c) how do these techniques, along with other factors, influence learning as measured by exam performance?

Method

Participants

Students from two introductory classes volunteered for this study ($N = 312$ out of a total enrollment of 382). A total of 137 students (111 women and 26 men) enrolled in an Introduction to Human Development (IHD) course at a midsized Midwestern university participated in an online survey. Participants ranged from 18–42 ($M = 19.7$, $SD = 2.6$) years of age, with 94 participants who identified as first-year students (68.2%), followed by 22 second-year students (16.1%), 14 third-year students (10.2%), 5 fourth-year students (3.6%), and 2 others (1.4%).

An additional 181 (124 female and 57 male) students enrolled in an Introduction to Psychology (IP) course at the same university participated in the identical survey. Participants ranged from 18–30 ($M = 19.5$, $SD = 1.8$) years of age. A total of 116 participants reported as first-year students (64.1%), followed by 35 second-year students (19.3%), 16 third-year students (8.8%), 10 fourth-year students (5.5%), and 4 who reported other (2.3%).

Prior to collecting data, the study was reviewed by the Institutional Review Board (IRB). Following approval, the instructors of the two courses made the survey link accessible to all students enrolled in both courses during the last 2 weeks of the semester. Instructors compensated students who participated in the survey with five bonus points on their final exam. We collected student consent for the use of their class exam scores. We told participants the instructors would not see their survey results until after grades had been handed in and would only receive their names to award credit.

Materials and Procedure

First, participants read over the informed consent form and reported demographic characteristics. Students identified which class they were enrolled in and which course they would prefer the bonus points (for students enrolled in both classes). Then, students rated 53 items on a 6-point scale (1 = *strongly disagree* to 6 = *strongly agree*) about how much they practice different study habits for the specific course and in relation to the final exam (e.g., "I frequently highlight or underline the information within one page").

We created the survey items specifically for this study, unless otherwise noted. Items incorporated the definition of the technique and assessed average usage. The 10 learning techniques (with number of items for each) were: highlighting/underlining (five items drawn from Bell & Limber, 2009), elaborative interrogation (three items), self-explanation (eight items), summarization (four items), highlighting/underlining (six items), keyword mnemonic (three items), imagery for text (three items), rereading (five items), practice testing (seven items), distributed practice (five items), and interleaved practice (four items; Dunlosky et al., 2013).

Guided by previous research, we also measured self-efficacy, effort regulation, procrastination, and classroom and instructor quality to assess the importance of additional factors relating to academic performance. We included two subscales from the Motivated Strategies for Learning Questionnaire (MSLQ) to measure participants' self-efficacy and effort regulation (Pintrich, Smith, Garcia, & McKeachie, 1991). For both subscales, responses were rated on a 7-point scale (1 = *not at all true of me* to 7 = *very true of me*). Eight items measured self-efficacy (e.g., "I believe I will receive an excellent grade in this class"). An additional four items measured a participant's effort regulation in relation to academic performance (e.g., "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do"). All measures showed high reliability using Cronbach's alpha: self-efficacy ($\alpha = .96$), effort regulation ($\alpha = .87$).

We measured procrastination (Ferner, 1980) with 10 items (e.g., "I invent reasons and look for excuses for not acting on a problem") rated on a 4-point scale (1 = *strongly disagree* to 4 = *strongly agree*). We measured quality of the class by assessing participants' levels of agreement to nine questions relating to their class lecture (clear, well organized, enjoyable and engaging, helped me learn the material, made textbook material clearer, helped me understand difficulty concepts, made knowledge meaningful, made me interested in the material, and challenged me to think about the material) using a 9-point scale (1 = *not at all* to 9 = *very much so*). We selected eight items from the Teacher Behavior Checklist (Keeley, Smith, & Buskist, 2006) for a short measure of strong teaching (knowledgeable, passionate/enthusiastic, approachable, cared about my learning, was an effective teacher, had effective teaching assistants, respectful, and interesting). For consistency with our measure of the lecture, participants rated the professor using a 9-point scale (1 = *not at all* to 9 = *very much so*). All measures showed high reliability using Cronbach's alpha: procrastination ($\alpha = .88$), class lecture ($\alpha = .97$), and professor ($\alpha = .96$).

We measured ability with participants' self-reported ACT scores, high school GPA, and cumulative college GPA. A small portion of the sample did not report their ACT scores (13 students) or GPA (8 students). We assessed learning by obtaining records of every student's exam scores from their course instructor. Students took four multiple-choice exams in each class.

Results

The means and standard deviations of the learning techniques, academic measures, and exam score of each course appear in Table 1.

Which Study Techniques Do Students Utilize the Most?

For the most part, students used each of the 10 techniques to the same extent in both classes. Students who were enrolled in IP reported using self-explanation the most ($M = 4.60$, $SD = .69$). Students enrolled in IHD reported used practice testing the most ($M = 4.67$, $SD = .74$). Distributed practice, a high utility technique, was not a highly used technique in our sample. Counter to anecdotal student comments, the use of highlighting appeared low on the list. Students rated two learning techniques, self-explanation and keyword mnemonic, within the top three learning techniques in both courses, suggesting that there are common learning techniques students engage in, even though the course content may vary. Furthermore, students enrolled in both courses reported using summarization the least.

To go beyond a mere ordinal view of the data, we tested for significant differences between study techniques using paired-sample *t* tests. To minimize the number of analyses (increasing the criterion for statistical significance), we pooled the data from both sections. The only difference in ordinal ranking is that practice testing dropped to sixth most used, whereas all other orderings stayed the same.

Table 1
Mean and Standard Deviations of Study Technique Use, Class and Instructor Ratings, Psychological Variables, and Exam Scores

	Introduction to Human Development		Introduction to Psychology	
Learning variables	*M*	*SD*	*M*	*SD*
Practice testing	4.67	.74	4.23	.93
Self-explanation	4.64	.72	4.60	.69
Keyword mnemonic	4.62	1.02	4.57	1.03
Rereading	4.55	.83	4.48	.81
Imagery for text	4.47	1.09	4.52	1.01
Distributed practice	4.13	.90	4.09	.95
Interleaved practice	4.09	.90	3.98	1.05
Highlighting/underlining	3.49	1.13	3.71	1.13
Elaborative interrogation	3.21	.45	3.23	.43
Summarization	2.60	1.18	2.47	1.02
Professor	8.12	1.25	7.91	1.46
Lecture	7.00	1.66	7.15	1.67
Procrastination	2.25	.63	2.28	.62
Self-efficacy	5.32	1.17	5.27	1.14
Effort regulation	4.03	.68	3.96	.85
ACT score	22.88	3.36	22.66	3.52
High school GPA	3.45	.43	3.40	.42
Cumulative GPA	3.08	.51	2.91	.70
Exam 1	33.27	6.75	22.63	2.14
Exam 2	36.02	6.68	19.81	3.20
Exam 3	33.87	8.71	17.88	3.01
Exam 4	38.10	10.33	23.30	1.97

Note. Introduction to Human Development exam scores are out of 45 points. Introduction to Psychology exam scores are out of 25 points.

Whereas there were few significant differences among the most commonly used techniques (self-explanation, keyword mnemonics, imagery, rereading, and practice tests), use of practice tests, $M = 4.60$ ($SD = .82$), was significantly higher than use of distributed practice, $M = 4.06$ ($SD = .99$), $t(317) = 6.23$, $p = .032$. Analyses also showed statistically significant differences between techniques used less frequently. Use of interleaved practice, $M = 4.06$ ($SD = 1.06$), was significantly higher than use of highlighting, $M = 3.79$ ($SD = 1.28$), $t(317) = 5.74$, $p = .014$, use of highlighting was significantly higher than use of elaborative interrogation, $M = 3.01$ ($SD = .98$), $t(317) = 5.67$, $p = .037$, and use of elaborative interrogation was significantly higher than use of summarization, $M = 2.52$ ($SD = 1.15$), $t(316) = 10.03$, $p = .009$.

How Much Does Using One Technique Relate to Using Another?

Not surprisingly, many techniques correlated with one another (shown in Table 2). The magnitude of most correlations suggest students tend toward using more than one technique and use constellations of techniques without necessarily favoring one over the other—no one technique was correlated much higher than another. For example, students enrolled in IHD who highlighted/underlined also used interleaved practice, $r(137) = .29$, and distributed practice, $r(137) = .32$, all p values $< .001$. Corresponding with these results, students enrolled in IP who utilized highlighting/underlining also engaged in rereading, $r(180) = .36$, and practice testing, $r(180) = .34$, all p values $< .001$.

Furthermore, within both courses, students who reported having engaged in self-explanation, practice testing, and distributed practice had higher ratings of their lecture and professor, suggesting the bidirectional relationship between classroom and professor satisfaction and learning techniques.

How Are Study Techniques Associated With Exam Score?

We first answered this question using zero-order correlations and then with a hierarchical multiple regression analysis. Numerous learning techniques correlated with exam scores. For example, for IHD students, higher use of imagery for text, $r(134) = .19$, $p = .03$; self-explanation, $r(135) = .20$, $p = .02$; practice testing, $r(135) = .29$, $p < .001$; and distributed practice, $r(135) = .19$, $p = .03$, correlated with higher scores on Exam 2. Corresponding to this finding, IP students who reported higher use of imagery for text, $r(175) = .19$, $p = .01$; self-explanation, $r(177) = .25$, $p < .001$; practice testing, $r(176) = .38$, $p < .001$; distributed practice, $r(177) = .32$, $p < .001$; rereading, $r(176) = .20$, $p = .01$; keyword mnemonic, $r(175) = .24$, $p < .001$; and interleaved practice, $r(177) = .21$, $p = .01$, scored higher on Exam 2. Furthermore, practice testing had a positive relation with all exam scores for both courses, suggesting that quizzes or provided study material related to the exam are positive resources for students within the university setting.

Other nonacademic factors also had a significant correlation to exam scores. For example, students who procrastinated scored lower on Exam 1, $r(135) = -.26$, $p < .001$; Exam 2, $r(135) = -.24$, $p < .001$; Exam 3, $r(135) = -.26$, $p = .01$; and Exam 4, $r(135) = -.25$, $p < .001$, in IHD. Also, in IP, students who reported higher procrastination scored lower on Exam 1, $r(178) = -.18$, $p = .01$; Exam 2, $r(177) = -.25$, $p < .001$; and Exam 3, $r(178) = -.20$, $p = .01$. The lack of significant correlation between procrastination and Exam 4 scores in IP may be because the students took the final exam more seriously in what was a larger class.

Similar to past findings (Komarraju & Nadler, 2013), self-efficacy had a positive impact on all exam scores for both courses, signifying that a student's belief to accomplish tasks and goals is of importance to succeed in a university setting. Counter to previous research (Komarraju & Nadler, 2013), effort regulation did not have any association to exam scores for both classes. However, both lecture and professor ratings had a positive influence on exam scores. Not surprisingly, students who liked the class and the professor did better on the exams.

We used a multiple linear regression analysis to predict final exam scores from the study techniques and other key factors. We first entered class section (Step 1), then ACT and high school GPA (Step 2) to account for ability. Next, we entered ratings of the classroom and professor and the three psychological variables

Table 2
Correlations Between Key Variables in Introduction to Human Development (Above Diagonal) and Introduction to Psychology (Below Diagonal) Courses

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Highlighting/underlining	—	.25**	.27**	.21**	.22**	.36**	−.13	.32**	.34**	.34**	.14	.11	−.14	−.01	−.14	.19*	.16*	.02	.14	.02	.03
2. Summarization	.34**	—	.24**	.15*	.12	.25**	−.21**	.15*	.23**	.33**	−.12	−.16	−.05	−.06	−.05	.32**	.03	.10	.09	.10	.10
3. Interleaved practice	.29**	.33**	—	.24**	.28**	.33**	−.16*	.25**	.34**	.35**	.10	.09	−.13	−.04	−.19*	.15*	.21**	.02	.21**	.10	.08
4. Keyword mnemonic	.28**	.17*	.16	—	.51**	.41**	−.24**	.44**	.33**	.34**	.17*	.20**	.21**	.18*	−.24**	.02	.32**	.14	.24**	.16*	.26**
5. Imagery for text	.15	.16	.27**	.53**	—	.36**	−.29**	.37**	.19*	.30**	.11	.12	.05	.07	−.19*	.04	.24**	.05	.19*	.15*	.21**
6. Rereading	.14	.08	.19*	.45**	.31**	—	−.27**	.56**	.39**	.55**	.19*	.23**	−.06	.10	−.19*	.10	.34**	.16*	.20**	.11	.09
7. Elaborative interrogation	.03	−.06	−.10	−.18*	−.34**	−.10	—	−.46**	−.19**	−.25**	−.00	.01	.02	.00	.02	−.34**	−.12	−.00	−.12	−.25**	−.24**
8. Self-explanation	.30**	.13	.35**	.50**	.51**	.47**	−.34**	—	.41**	.43**	.22**	.24**	.10	.15	−.23**	.05	.37**	.10	.25**	.18*	.10
9. Practice testing	.25**	.11	.31**	.40**	.38**	.41**	−.13	.46**	—	.55**	.28**	.24**	.07	.11	−.25**	.19*	.41**	.23**	.38**	.18*	.17*
10. Distributed practice	.32**	.27**	.39**	.20*	.16	.32**	−.07	.33**	.41**	—	.31**	.24**	.02	.10	−.37**	.09	.48**	.25**	.32**	.25**	.11
11. Lecture	.05	−.00	.14	.34**	.30**	.28**	−.24**	.42**	.42**	.26**	—	.83**	−.00	.16*	−.08	−.09	.62**	.28**	.35**	.22**	.10
12. Professor	.04	−.12	.08	.35**	.25**	.34**	−.15	.43**	.45**	.19*	.77**	—	−.00	.12	−.13	−.14	.61**	.23**	.28**	.26**	.15*
13. ACT score	−.03	−.02	.03	−.07	−.00	.03	.00	.16	.04	.05	.11	.16	—	.20**	−.05	−.13	.12	.20**	.20*	.16*	.08
14. High school GPA	.03	.00	−.03	.04	.04	−.14	−.09	−.14	−.10	−.08	−.05	−.08	.26**	—	−.15*	−.04	.12	.21**	.18*	.18*	.12
15. Procrastination	.04	.04	−.04	−.09	.01	−.17	−.02	−.08	−.25**	−.22*	−.27**	−.24**	−.06	.00	—	.24**	−.29**	−.18*	−.25**	−.20**	−.10
16. Effort regulation	.04	.12	−.03	.08	−.04	.13	.15	−.00	.09	.02	.06	.17	.04	.07	.10	—	.03	−.03	−.03	−.01	−.07
17. Self-efficacy	.10	−.08	.16	.29**	.24**	.35**	−.13	.39**	.44**	.31**	.70**	.61**	.25**	−.01	−.37**	.14	—	.40**	.62**	.54**	.23**
18. Exam 1	−.04	−.22*	−.01	.08	.11	.07	−.09	.23**	.22*	.06	.47**	.43**	.36**	.20*	−.26**	.12	.58**	—	.35**	.32**	.33**
19. Exam 2	.06	−.09	.12	.08	.19*	.12	−.08	.20*	.29**	.19*	.41**	.42**	.30**	.40**	−.24**	−.01	.52**	.57**	—	.42**	.34**
20. Exam 3	.02	−.17*	.11	.05	.11	.21*	−.07	.21*	.27**	.09	.46**	.43**	.34**	.32**	−.24**	.07	.59**	.54**	.69**	—	.33**
21. Exam 4	.04	−.18*	.00	.10	.14	.12	−.12	.20*	.25**	.10	.51**	.54**	.24**	.18*	−.25**	.00	.47**	.55**	.68**	.88**	—

Note. Numbers appearing above the diagonal represents the correlations for the Introduction to Human Development course. Numbers appearing below the diagonal represent the correlations for the Introduction to Psychology course.
* $p < .05$. ** $p < .01$.

(Step 3). In the final step, we entered the 10 study techniques and used stepwise extraction (Step 4). Our goal was to test if study techniques predicted a significant portion of the variance in exam score over and above other established factors. Stepwise entry allowed an exploratory simultaneous comparison of the different methods. Given we conducted the survey at the end of the semester, we only used the last exam as a dependent variable.

Each of the first three steps was significant. Table 3 shows the main results. Class section, ACT, and high school GPA, and variables in Step 3, were significant predictors of exam score variance. In Step 3, ratings of the professor and self-efficacy were significant coefficients. Students who rated their professor highly and who were high in self-efficacy also did better on their exam. In Step 4, only one technique, elaborative interrogative, explained an additional 1% of the variance in exam score. A close examination of the beta values shows an inverse relationship between this study technique and exam scores. Students who used this technique also received lower exam scores.

Discussion

Our study simultaneously assessed the extent to which 10 major study techniques are used, were related to each other, and related to exam score. Consistent with previous research (Dunlosky et al., 2013; Gurung & McCann, 2012), some techniques such as rereading notes and memorizing key terms appear high on the list. Our results move beyond past research in illustrating a rich pattern of associations between different study techniques together with relationships with class and professor ratings, as well as exam score. Our correlational matrix also allows scholarly teachers and pedagogical researchers to examine how study techniques, psychological factors, and contextual factors are related. The results in general provide instructors with important insight into how students engage material and what factors may influence the use of certain techniques.

The use of certain techniques may be tied to how the techniques are recommended and required by instructors. Of the two high utility techniques, practice testing was used the most in IHD while distributed practice was used less often. The relative use across classes of these two techniques draws valuable attention to the role of the instructor in facilitating study techniques. The IHD instructor assigned 10% of the course grade for completion of textbook technology, which could explain why it is on top of the list. In contrast, practice tests were recommended in IP, but the instructor did not provide class credit for their use. In the IHD class, the higher use of practice testing is associated with more self-explanation and rereading, suggesting that requiring more practice testing may also drive up the use of other techniques needed for practice testing to be successful. This finding is consistent with recent work showing that students, who use online systems more, perform better on exams (Gurung, 2015). Textbook technology supplements complement most introductory textbooks and could be used to increase both practice testing and distributed practice as instructors can suggest or even mandate when and how often practice tests should be taken.

Only one of the study techniques was a significant predictor of exam score after controlling for other factors. Whereas at first this result is troubling, there are many factors that alleviate concern. First, class section, high school GPA, and ACT scores accounted for a significant portion of variance in the first two steps. Whereas there is still a significant portion of variance

Table 3
Hierarchical Multiple Regression Analysis Predicting Exam 4 Scores From Class Section, High School GPA, ACT Scores, Class and Instructor Ratings, Psychological Variables, and Study Technique Use

Predictor	*b*	*SE* B	β	ΔR^2
Step 1				
Class section	−.29	.03	−.53***	.28***
Step 2				
High school GPA	.14	.07	.11*	.03**
ACT	.02	.01	.11*	
Step 3				
Class rating	.00	.03	.01	.10***
Self-efficacy	.07	.03	.15*	
Effort	.02	.03	.03	
Procrastination	−.03	.05	−.03	
Step 4				
Elaboration	−.14	.06	−.12*	.01
Total R^2				

* $p < .05$. ** $p < .01$. *** $p < .001$.

remaining, it is clear that GPA and study skills go hand in hand (Gurung & McCann, 2012), hence Step 2 may have soaked up much of the variance of study techniques. The lack of additional study aids being significant may also suggest that in some cases, student perceptions of the instructor and their sense of self-efficacy may be stronger predictors of exam scores than how the student studied. Furthermore, it may also be an artifact of the high correlation between professor rating and exam score limiting variance available for Step 4. As seen by the numerous zero-order correlations between techniques and exam score, it is clear that study techniques relate to exam scores. In this sample (these classes and instructors), study techniques seem to be overshadowed. Perhaps this is good news for the power of a well-perceived teacher.

Counter to our expectations, the greater use of elaborative integration related to lower exam scores. A number of possible explanations exist. First, some students may not allocate their study time well and may use this technique to the exclusion of other techniques. This phenomenon has been previously seen in relation to usage of key terms, which could be dangerous detours (Cherney, 2011; Gurung, 2004) to learning, keeping students from effective studying. Given the correlational design of our study and the general level of measurement, this possibility is difficult to test but calls for more detailed longitudinal designs. Conversely, students in introductory classes may use easier techniques, such as highlighting and rereading, instead of the more active and challenging elaborative interrogation. This possibility is supported by negative correlations between elaborative interrogation and the use of all other study techniques. Students just do not have time to utilize this technique. It is also possible that students' use of elaborative interrogation was flawed (e.g., their explanations of the concepts or facts were inaccurate), which led to poor scores on the exam. Finally, students employing this strategy may be doing so in response to lower exam performance, rather than exam performance indexing ineffective use of this strategy.

Our correlational matrix provides teachers with a lot of key information to share with students, suggests some key recommendations, and raises some important questions. Table 2 suggests three main study techniques most relate to exam scores: keyword mnemonics, using imagery, and practice testing. Whereas the last technique has been well advanced, the first two are not discussed as much. Given their direct correlations with exam scores, instructors may want to recommend the greater use of these methods. Advocating for study techniques may be easier that trying to address psychological variables, although some variables are clear targets for attention.

Surprisingly, psychological variables such as procrastination and effort regulation did not correlate significantly with most of the study techniques. Whereas instructors are quick to blame procrastination or poor effort regulation, contradictory to the past, our data suggests these two variables may not be the problem. In contrast, self-efficacy was significantly correlated with six study techniques, suggesting efforts to bolster student self-efficacy may be time well spent. The strong positive correlations between perceptions of the instructor and the class are good reminders of the value of paying attention to course design and delivery and instructor behavior in light of how these factors are associated with use of study techniques.

Our descriptive data and correlations among the 10 techniques suggest that students are not using all techniques equally. The means of technique use are significantly different, and correlations across measures show that the use of one technique does not mean the use of another (except in a few cases such as rereading and practice testing). Whereas differential utility suggests all techniques should not be used to the same extent, one could argue that the greater use of more techniques will increase depth of processing of material and correspondingly lead to better learning. Examining this possibility is a worthwhile challenge for the design of future classroom research.

Our results are tempered by two key limitations. One major limitation is that we relied on self-report to measure ability. Although this technique is par for the course in most assessments of study strategies (Bjork et al., 2013), we do not really know what students actually did to study for their tests. Whereas many researchers have examined how students allocate study time when given material (Son & Kornell, 2008), these studies are all done in the lab. A second limitation is that we based findings on foundational courses from two different majors.

Learning techniques may vary among different majors in a higher education setting. In addition, the majority of the populations within the two courses are female and first-year students. It is important to note that techniques that are utilized by students may differ between gender and class status. Our small sample of men precluded statistical tests of gender differences.

Implications for the Scholarship of Teaching and Learning

These limitations notwithstanding, our results provide students and teachers of psychology with valuable insights into what helps (and could hurt) learning. We also present some important future directions for research in the classroom. First, we hope that other teacher-scholars replicate this study in their classes and at different universities (full survey available on request). In most disciplines, *Scholarship of Teaching and Learning in Psychology* (*SoTLP*) is limited by studies conducted on one or so class. If readers of *SoTLP* replicated published studies and shared data, we would move toward theory building. Whereas our results show a few consistent patterns, it will take many more studies with different samples to establish reliable patterns (if one exists). Second, our results highlight a critical problem with translational research. Whereas one could eagerly digest recent trade books and scholarship on learning (Brown et al., 2014; Carey, 2014; Dunlosky et al., 2013) and recommend what the books and articles proclaim, a large part of the findings discussed are lab studies. More studies need to be done in the classroom (Daniel & Chew, 2013; Daniel & Poole, 2009), and our results show that when research is conducted in the classroom, findings are not as neat and tidy as the lab suggests. Even two social science classes do not show completely consistent patterns. We see the influence instructor ratings can have. We see the varying role of past performance. All these results highlight the complexity of learning and reveal the need for robust *SoTLP*.

We hope that educators can incorporate the learning techniques within the classroom setting to benefit learning outcomes for students. In particular, teachers can better inform how to use successful learning techniques and perhaps also caution students against overusing certain techniques. In addition, students may wish to integrate learning techniques, such as practice testing, and distributed practice, into their study habits to improve academic performance. The proof of the efforts to diversify study techniques is evident in the associations with exam scores. Looking to benefit student success in higher education, the next step is to design interventions to get more students to study differently.

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