Self-reported use of retrieval practice varies across age and domain

Jonathan G. Tullis & Geoffrey B. Maddox

ONLINE FIRST

Metacognition and Learning

ISSN 1556-1623

Metacognition Learning
DOI 10.1007/s11409-020-09223-x

Springer

Metacognition and Learning
https://doi.org/10.1007/s11409-020-09223-x

Self-reported use of retrieval practice varies across age and domain

Jonathan G. Tullis[1] · Geoffrey B. Maddox[2]

Received: 7 August 2019 / Accepted: 23 March 2020/Published online: 07 May 2020

Abstract
Study strategies that learners utilize impact how much they learn. Practicing retrieval from long-term memory (e.g., practice tests or flashcards) is a particularly effective study strategy that can provide large learning benefits; yet, students rarely recognize the benefits of retrieval practice. Here, we examine whether a sample of middle and high school students report using retrieval practice when studying on their own, why they use it, and whether its use varies by age and learning domain. The results show that most middle and high school students in our sample report using retrieval practice, but students utilize re-reading strategies more. The high school students in our sample report using retrieval practice more than the surveyed middle school students, and this may be driven by differences in their reasoning for using it. Finally, students' ages and learning domains interact to affect how widely retrieval practice is utilized. Students' use of retrieval practice grows with age and changes by domain. While more students report using retrieval practice than in prior literature, many students still fail to fully harness the learning benefits that retrieval practice can provide.

Keywords Retrieval practice · Study strategies · Metacognition

Students increasingly control their own learning as instruction shifts from being teacher-centered to student-centered (Cromley and Azevedo 2007). Being a successful learner, therefore, requires self-regulation and the ability to choose study strategies effectively (Winne and Hadwin 1998; Zimmerman 1990). Broadly, self-regulation involves proactively initiated thoughts and behaviors that are planned and cyclically adapted to feedback in order to achieve personal goals (Zimmerman 1989, 2000). Three sequential phases, forethought (e.g., goal setting and outcome expectations), performance (e.g., strategy selection and

✉ Jonathan G. Tullis
jonathantullis@gmail.com

[1] Department of Educational Psychology, University of Arizona, 1430 E. Second St., Tucson, AZ 85721, USA

[2] Department of Psychology, Rhodes College, Memphis, TN, USA

metacognitive monitoring), and self- reflection (self-evaluation and causal attribution), comprise self-regulation (Zimmerman and Moylan 2009). Students' use of effective study strategies during the performance phase is a vital component of appropriate self-regulation, such that learners' self-selected study strategies affect academic achievement (Crede and Phillips 2011; King 1992; Trigwell and Prosser 1991; Tullis and Benjamin 2012; Tullis and Benjamin 2011; VanderStoep et al. 1996).

A particularly effective and empirically supported study tactic is retrieval practice (Roediger III and Karpicke 2006). Retrieval practice, broadly, requires learners to retrieve information from long-term memory rather than re-read or re-expose themselves to the information (e.g. McDaniel et al. 2011; Roediger III et al. 2011). The learning benefits of retrieving information are not intuitive (Clark and Svinicki 2015; Miyatsu et al. 2018), students express little awareness of the benefits of retrieval (Roediger III and Karpicke 2006b), and the misconceptions cannot be resolved through practice alone (Tullis et al. 2013). Yet, much prior research has ignored students' use of retrieval practice and focused on students' use of intuitive study strategies like elaboration and organization. Existing surveys of study strategies (e.g., the Motivated Strategies for Learning Questionnaire [MSLQ: Pintrich et al. 1993], and the Learning and Study Strategies Inventory [LASSI: Weinstein et al. 1988]) do not specifically examine the use of retrieval practice during learning. In this project, we purposefully measure whether students report using retrieval practice when studying, how its usage compares to less effective study strategies (e.g. re-reading), and how the use of retrieval practices changes with grade level and learning domain. Before describing the current study, we explain two aspects of retrieval practice that make it different from many other study strategies: its effectiveness at boosting student learning and students' misconceptions about its benefits.

The effectiveness of retrieval for boosting learning

Retrieving information from long-term memory is one of the most effective study strategies for understanding and remembering information that has yet been identified (Pashler et al. 2007). Retrieval practice can take many forms (e.g., flashcards, practice problems, summarizing from memory) but must involve retrieving information from long-term memory. The consequences of retrieval practice have usually been compared to re-reading; the effect size in memory performance for retrieval practice over re-study is typically large (Cohen's ds from 0.31 to 1.26; Karpicke 2009; Tullis et al. 2013). While re-reading can bolster immediate learning, retrieval practice slows the rate of forgetting and leads to large and persistent benefits after 10 min (Roediger III and Karpicke 2006). Retrieval practice benefits learning across ages (Cull 2000; Rea and Modigliani 1985; Spitzer 1939), learning domains (Carpenter et al. 2016; McDermott et al. 2014; Rohrer et al. 2014), many kinds of to-be-learned information (Carpenter and DeLosh 2005; Roediger III and Karpicke 2006), and different memory tests (Agarwal et al. 2008; Butler and Roediger 2007; Glover 1989; Putnam and Roediger 2013).

Retrieval practice is helpful compared to various control conditions. For example, retrieval practice benefits students' performance on factual and conceptual learning compared to creating a concept map (Karpicke and Blunt 2011) or generating one's own examples (Rawson and Dunlosky 2016). Benefits of testing over re-study have been found in classroom settings (Leeming 2002; McDaniel et al. 2011; Rowland 2014). In addition to boosting simple retention of information, retrieval practice can improve the application and transfer of knowledge to new contexts and questions (Roediger III et al. 2011).

Misconceptions about its use

Students show two consistent and widespread failures of their metacognitive monitoring about retrieval practice that are not rectified through practice alone. First, learners fail to appreciate the large memory boost that testing provides compared to re-studying, especially when they judge how well items are learned on an item-by-item basis. Learners consistently rate restudied items as more memorable than tested items (Agarwal et al. 2008; Tullis et al. 2013), even when provided corrective feedback after each practice test (Karpicke 2009). Students may rate retrieval practice as ineffective because it can feel disfluent and effortful during study (Tullis et al. 2013). Students may interpret the disfluency and effort involved with retrieval practice as indicating its ineffectiveness (Clark and Svinicki 2015; Kirk-Johnson et al. 2019). Further, students may struggle to recognize the advantages of practice tests over re-reading because the benefits of retrieval over other study strategies are not apparent until after a delay. To be able to tie their memory outcomes at a delay to earlier strategy use, learners need comprehensive summary feedback about their test performance that explicitly compares memory for previously re-studied and previously tested material in order to correctly judge testing to be more beneficial than re-studying (Tullis et al. 2013). In other words, students do not become metacognitively aware of retrieval practice benefits through practice alone.

The second major misconception that learners hold is that retrieval merely assesses learning, rather than improves learning. In other words, most students believe that retrieval does not affect memory at all. Learners report using practice tests to monitor their learning, rather than to bolster their learning. For example, two-thirds of college students report that they test themselves only to figure out what they do and do not know (Kornell and Bjork 2007; Kornell and Son 2009). Less than a quarter of students report that they use self-testing during study because it causes them to learn more than re-studying. In fact, across all prior surveys, about twice as many students report using self-testing as a metacognitive strategy (i.e. to show what they know and do not know) rather than using it to bolster their learning (Hartwig and Dunlosky 2012; Karpicke 2009; McAndrew et al. 2016). Learners fail to recognize the benefits of testing as a strategy for remembering information even when they choose to self-test. Unlike the benefits of many other study tactics (e.g. re-reading [Koriat 1997] and deep processing [Shaw and Craik 1989]), the mnemonic benefits provided by retrieval practice are not readily understood (or learned) by the average student.

Do students use retrieval practice?

Most surveys of student learning strategies do not measure students' use of self-testing. For example, the MSLQ has been used widely to measure student self-regulation and study strategy use (Duncan and McKeachie 2005; Pintrich et al. 1993), but it does not include any questions to address retrieval from long-term memory. Questions about study strategies on the MSLQ measure rehearsal, elaboration, organization, and critical thinking. Similarly, the LASSI tests a small subset of possible study strategies that students use and is vague about the distinction between self-testing and re-reading (Weinstein et al. 1988). For example, the self- testing subscale includes an item "I go over homework assignments when reviewing class materials" and "I stop periodically while reading and mentally go over or review what was said". These questions may not actually involve self-testing or retrieval from long-term memory; further, recent research highlights the importance of being specific about language involving restudying (Kuhbandner and Emmerdinger 2018). Other research focuses on assessing deep versus shallow study strategies, but does not measure how frequently students use retrieval practice (Hadwin et al. 2001; Weinstein and Mayer 1986; Wolters and Pintrich 1998; Zimmerman and Martinez-Pons 1990). Retrieval practice, we argue, does not fit neatly into the "deep vs. shallow" dichotomy. The use of retrieval practice during self-regulated study may differ from strategies measured by most existing surveys because students express consistent misconceptions about its effectiveness, as described above. While students typically understand the real worth of many learning strategies (e.g., Rabinowitz et al. 1982), students consistently underestimate the benefits of retrieval practice.

Misconceptions about retrieval practice's effectiveness may also impede students' appropriate use of it. The few studies that explicitly measure students' use of retrieval practice show that most college students do not use it (e.g., Karpicke et al. 2009; Hartwig and Dunlosky 2012). For example, when college psychology students were asked to list the study strategies that they used, a minority (~40%) reported using retrieval practice strategies, including solving practice problems, studying flashcards, and practicing recall (Karpicke et al. 2009). Further, in circumstances when restudy after a test is not allowed, only 18% of learners reported utilizing self-testing. In contrast, 84% indicated they relied upon re-reading to study. Subsequent surveys have also focused on undergraduate and graduate student study strategies (Blasiman et al. 2017; Hartwig and Dunlosky 2012; McAndrew et al. 2016; Wissman et al. 2012) and have revealed that students use retrieval practice about as frequently as they use re-reading, even though re-reading is less effective for long-term retention. In the current study, we expand upon the existing surveys that assess students' usage of retrieval practice by measuring reported use across a broader population and in many different learning domains.

Do development and learning domains affect the use of retrieval practice?

The few surveys that have directly assessed students' use of retrieval practice have ignored the impact of *development* and *learning domain* on the use of strategies. Indeed, student use of many learning strategies changes with age. For example, high schoolers report less text review (but more note reviewing) than middle schoolers (Zimmerman and Martinez-Pons 1990). Similarly, when preparing for tests, high school students re-read to a greater extent than do college students (Thomas and Rowher 1987). Strategy use may change with age because (a) metacognitive capabilities may develop with age (Kuhn 2000; Schneider 1998, 2008), (b) students typically develop a broader array of study strategies as they age (Wade et al. 1990), and (c) demands placed upon learners may change with development. Yet, estimates of students' use of retrieval practice come exclusively from undergraduate and graduate students (e.g., Blasiman et al. 2017; Karpicke et al. 2009; Hartwig and Dunlosky 2012; McAndrew et al. 2016; Wissman et al. 2012). We examined the use of retrieval practice in two new age groups: middle school and high school students. If college students rarely report using retrieval practice, we expect that even fewer younger students will utilize it during study.

Further, prior surveys have measured use of retrieval practice largely without respect to the learning domain. Theories of self-regulated learning suggest that context plays a vital role in self-regulation (Pintrich 2000; Winne and Hadwin 1998; Zimmerman 2000), so strategy use may depend upon context and the affordances of specific domains (Crede and Phillips 2011; Rotgans and Schmidt 2009). Research on a variety of different cognitive learning strategies suggests that students adapt their tactics to particular learning domains (Broekkamp and Van Hout-Wolters 2007; Brown et al. 1983; Schneider and Pressley 1989; Wolters and Pintrich 1998). More specifically, students' self-reported use of learning strategies varies across academic disciplines (Lonka and Lindblom-Ylänne 1996; VanderStoep et al. 1996), academic departments (Ramsden and Entwistle 1981), courses (Bråten and Samuelsten 2004; Thomas et al. 1993; Thomas and Rowher 1987; Vermeeten et al. 1997) and tasks (Hadwin et al. 2001; Zimmerman and Martinez-Pons 1986).

Despite some variability and adaptability in how students study in different domains, some consistency across tasks reflecting individuals' preference and use of strategies remains (Bong 2001, 2004; Gottfried 1985; Vermeeten et al. 1997; Warr and Downing 2000). Individual differences in students' knowledge about the effectiveness and use of cognitive strategies may underlie the stability in students' strategy use across domains (Siegler 1988; Sternberg 1988). For example, if a student has identified retrieval practice as an effective learning strategy, they may use it broadly across learning domains. Alternatively, some learning domains may have special affordances or proclivities for the use of retrieval practice. For example, the linear nature of math and its problem-centric structure may prompt students to engage in more self-testing than other domains. Thus, we examine self-reported use of strategies across four different disciplines: English, social studies, math, and science.

Current study

In the current research, we examined how middle and high school students report using retrieval practice learning strategies. We specifically measured how the use of retrieval practice (an effective learning strategy) compares to the use of re-reading (a less-effective learning strategy), as in prior surveys of college students. We expect that students will use re-reading strategies more frequently because students hold misconceptions about its effectiveness. Finally, we analyzed whether the use of retrieval practice varies by development and by learning domain.

Method

Sample Three public school teachers were recruited from a school district in central southern California. Two of the teachers taught high school (grades 10 and 11) and one taught middle school (grades 7 and 8). The middle school surveyed feeds into the high school surveyed. The surveyed high school has an average enrollment just below 2000 students, includes 99% Latinx students, and has 93% of students qualify for free or reduced lunch. The surveyed middle school includes grades 7 and 8, enrolls approximately 700 students, comprises 98% Latinx students, and has 91% of students qualify for free or reduced lunch. The curriculum for the middle school was a state-adopted standards-based commercial package from Houghton Mifflin; the curriculum for the high school was a state-adopted standards-based, college preparatory, commercial package from McDougal Littell. According to state assessments, only 4% of students at the middle school reach math proficiency (compared to 37% state-wide), and only 10% reach proficiency in reading/language arts (compared to 49% state-wide). According to state assessments, only 12% of students at the high school reach proficiency on Math test scores (compared to 38% state-wide), and 41% of students reach proficiency on reading/language arts (compared to 48% state-wide). Teachers passed out an informed consent form (for students' parents to sign) and a study strategies survey for students to complete on their own time. Students whose parents completed the informed consent form and who returned the survey were included in our data set; 228 high school students and 84 middle school students met these requirements. The teachers involved provided no guidance or structure related to the use of self-testing to their classes at this point in the semester.

Materials The study strategies survey was developed by combining questions used in prior surveys (Karpicke et al. 2009; Kornell and Bjork 2007), and is shown in the Appendix. As in those prior surveys, we queried students about their use of thirteen different study strategies, as shown in Table 1. We considered "testing oneself" and "flashcards" to be retrieval practice strategies, and "re-reading" and "recopying notes" as re-reading strategies. Additionally, questions were added to specifically address four domains, including science, math, social studies, and English.

Results

This manuscript focuses on the comparison between retrieval-based strategies and re- reading and how these strategies vary with age and context. The results will center on these comparisons. For the full data set, see https://osf.io/gsqm2/?view_only=644b3506779746038c9ba37498fa0a8b.

Rates of retrieval practice vs re-reading We first examined how frequently students self-reported the use of study strategies that involved retrieval or re-reading by examining responses to Question 1, which was an open-ended question that asked students to list any study strategy that they use. Each reported study strategy was coded for including the thirteen

Table 1 Proportion of middle and high school students freely reporting study strategies used at all (left columns) and used most frequently (middle columns) from Question 1. Proportion of freely reported strategies that involve each study strategy (right columns)

	Use at al		Most Frequent		Proportion of strategies	
	Middle School	High School	Middle School	High School	Middle School	High School
N	84	228	80	218	84	228
Test yourself	0.15	0.32[a]	0.05	0.06	0.06	0.11[a]
Flashcards	0.12	0.40[a]	0.00	0.13[a]	0.04	0.14[a]
TOTAL Retrieval Practice	0.24	0.59[a]	0.05	0.20[a]	0.09	0.25[a]
Rereading	0.49	0.69[a]	0.38	0.39	0.25	0.28
Recopy notes	0.08	0.10	0.02	0.04	0.03	0.03
TOTAL Re-reading Strategies	0.52	0.71[a]	0.43	0.46	0.28	0.31
Make Outlines	0.05	0.02	0.00	0.00	0.02	0.00
Underline	0.10	0.08	0.02	0.04	0.03	0.03
Make Diagrams	0.00	0.00	0.00	0.00	0.00	0.00
Create Questions	0.01	0.07	0.00	0.01	0.00	0.02
Think of own Examples	0.00	0.01	0.00	0.00	0.00	0.00
Study with Friends	0.20	0.25	0.05	0.04	0.07	0.08
Create mnemonics	0.02	0.02	0.01	0.00	0.01	0.01
Relate to other info	0.01	0.05	0.01	0.01	0.10	0.07
Research Online	0.27	0.21	0.07	0.05	0.03	0.05

[a] indicates significantly greater endorsement by high school students than middle school students at $p < 0.05$ according to two proportion z-tests

previously identified, common self-reported study strategies (e.g. re-reading, flashcards, making outlines). Responses were only coded as "re-reading" if students reported reading the chapter multiple times or reading their notes (i.e., a response about reading was not counted as re-reading unless the response indicated that students read the same material multiple times). We included flashcards and testing oneself as retrieval practice strategies, while we included re-reading and recopying notes as re-reading strategies. The Cohen's kappa coefficient across all 11 categories of free reports ranged from 0.76 to 0.996. When coding disagreements occurred between raters, the most common coding was chosen.

Given our research question, we focus our analyses on comparing the use of retrieval practice to re-reading strategies. When students freely reported their study strategies in Question 1, 50% of all students reported at least one retrieval practice strategy and 66% reported at least one re-reading strategy. McNemar's test showed that significantly more students reported a re-reading strategy than a retrieval practice strategy, $\chi^2(1) = 19.88$, $p = .009$. Students indicated the strategy that they use most frequently by circling one of their reported strategies. More students indicated that their most-used strategy involved re-reading (43%) than students who said their most-used strategy involved retrieval practice (16%), $\chi^2(1) = 41.76$, $p < .001$. Across all freely reported strategies, 21% involved retrieval practice and 30% involved re-reading; a paired t-test on proportion of strategies that students reported showed that more reported strategies involved rereading than retrieval practice, $t(311) = 4.07$, $p < .001$, $d = 0.23$.

Next, we examined how frequently students endorsed retrieval and re-reading when selecting the study strategies that they use from a provided checklist of 13 study strategy options in Question 4. Across all students, 80% reported at least one retrieval practice strategy and 88% reported at least one re-reading strategy; more students checked at least one re-reading strategy than one retrieval practice strategy, $\chi^2(1) = 8.24$, $p = .005$. Students indicated the strategy that they use most frequently by ranking the used strategies in terms of their use. Thirty-three percent of students reported using retrieval practice most frequently, while 29% reported using re-reading strategies most frequently. The amount of students choosing retrieval practice for their most-used strategy on the checklist did not significantly differ from those choosing re- reading, $\chi^2(1) = 0.88$, $p = .39$.

Use of retrieval practice by grade level We examined students' use of study strategies as a function of grade level. First, we split the students into two grade level groups: middle school (7^{th} and 8^{th} graders) and high school (10^{th} and 11^{th} graders) and examined whether free report of retrieval practice (Question 1) differed by grade level. Free report of strategies is displayed in Table 1. As shown in Table 1 and indicated by a two-proportion Z test, high school students free reported greater use of retrieval practice strategies, $Z = 5.55$, $p < .001$, and re- reading strategies, $Z = 3.17$, $p < .001$, than middle school students. Students indicated their most frequent study strategy by circling a free reported answer. High school students' most frequent strategies involved re-reading as often as middle school students', $Z = 0.39$, $p = 0.35$; but, high school students' most frequent strategies involved retrieval practice more than middle school students' most frequent strategies, $Z = 3.17$, $p < .001$.

Differences found in free report between grade levels may reflect differences in the ability to recall and report study strategies, rather than differential use of those strategies. To minimize the impact of ability to recall strategies, students completed a checklist of the strategies they used after free reporting their strategies. We examined how frequently students endorsed retrieval practice and re-reading when selecting the study strategies that they use from a provided checklist in Question 4. Results are displayed in Table 2. Results replicate the patterns found in Table 1. A two-proportion z-test showed that high school students were more likely to endorse using a retrieval practice strategy than middle school students (left columns: $Z = 4.91$, $p < 0.001$); however, middle school students endorsed re-reading strategies more often than high school students, $Z = 1.96$, $p = .03$. High school students' most frequent strategies involved retrieval practice more than middle school students', $Z = 3.47$, $p < .001$, but no differences were found between the most-frequent use of retrieval strategies, $Z = 0.46$, $p = .32$. Consistently across our measures of study strategy usage, the self-reported use of retrieval practice increased from middle school to high school. In contrast, the self-reported use of re-reading strategies remained consistent (or dropped slightly) across grade level.

Reasons for using retrieval practice by grade level We also examined the reasons why students engage in retrieval practice by coding responses to an open-ended question about why students self-test (Question 6). Categories were created by initially reading through students' responses and adding a new category whenever a response did not fit into an existing category. This created 12 different categories of reasoning, including "testing being easier", "testing being fun", and "testing building confidence." Then, students' answers were coded by the two authors. Cohen's kappa coefficients for the codings ranged from 0.77 to 0.97; differences in coding were resolved through discussion. A student's answer could belong to multiple categories. The proportion of students supplying the five most popular reasons is displayed in Table 3 (the remaining 7 categories had fewer than 15 student endorsements). In contrast with previous surveys of college students, students reported using self-tests to bolster their learning more or as frequently as assessing what they know or do not know. A two- proportion Z-test on the proportion of students supplying justifications from the five most popular categories revealed that high school students reported "to know what I know" more than

Table 2 Proportion of students endorsing strategies on the checklist (Question 4) at all (middle columns) and as their most frequent strategy (right columns)

	Use at all		Most Frequent	
	Middle School	High School	Middle School	High School
N	84	228	67	216
Test yourself	0.60	0.75[a]	0.11	0.23
Flashcards	0.23	0.55[a]	0.05	0.17[a]
TOTAL Retrieval Practice	0.62	0.87[a]	0.16	0.40[a]
Rereading	0.88	0.82	0.25	0.24
Recopy notes	0.33	0.27	0.05	0.05
TOTAL Re-reading Strategies	0.94[b]	0.86	0.30	0.29
Make Outlines	0.25[b]	0.14	0.01	0.00
Underline	0.65	0.61	0.12	0.09
Make Diagrams	0.18	0.12	0.04	0.00
Create Questions	0.23	0.16	0.01	0.02
Think of own Examples	0.37	0.36	0.01	0.03
Study with Friends	0.48	0.51	0.07	0.06
Create mnemonics	0.15	0.23[a]	0.01	0.04
Relate to other info	0.31	0.35	0.04	0.03
Research Online	0.65[b]	0.45	0.18[b]	0.04

[a] indicates significantly greater endorsement by high school students than middle school students at $p < 0.05$ according to two-proportion z tests

[b] indicates significantly greater endorsement by middle school students than high school students at $p < 0.05$ according to two-proportion z tests

middle school students, $Z = 3.12$, $p < .001$, and that middle school students reported using self-testing "to get a good grade" more often than high school students, $Z = 2.08$, $p = .02$. All other comparisons failed to reach significance, *p*s > 0.25.

Not only does the self-reported use of testing increase with grade level, the reasons why testing is used changes. The difference in ages may be driven by high schoolers using self-testing to assess what they know more frequently than middle schoolers. Consistent with research indicating age-related differences in ability to self-regulate (Zimmerman and Martinez-Pons 1990), the current results suggest that older students engage in retrieval practice for both metacognitive and memory-based purposes, whereas younger students disproportionately rely on testing as a mechanism for memorizing.

Study strategies by domain We examined if students employed different study strategies across different domains. The proportion of students who endorsed the four most popular study strategies for each domain (Questions 8, 10, 11, & 12) is displayed in Table 4. Provided the binary dependent variable (i.e., use of each strategy was coded as yes or no), data were submitted to separate 2 (Grade Level) x 4 (Domain) repeated measures logistic regression analyses for each strategy. For the primary analyses, *high school* and *English* served as the reference groups for grade level and domain, respectively. To test further pairwise differences between domains, the reference group for the domain was systematically varied as described below.

Test yourself Results of the 2 x 4 repeated measures logistic regression revealed main effects of grade level. As is displayed in Table 5, the odds of students using self-testing in science are 1.40 times greater than in English and the odds of students using self-testing in math are 3.60 times greater than in English. Additionally, there was a joint influence of grade level and domain such that the discrepancy in self-testing between middle school and high school students was larger in math courses than in English courses (*M*diff = .22 and *M*diff = .08, respectively). When the reference group of the domain was systematically changed across follow-up analyses, contrasts revealed that testing was used significantly more often in math than in science. In turn, testing was used significantly more often than in social studies and English courses. In addition, the analyses consistently revealed a significant interaction term such that the discrepancy in self-testing between middle and high school students was larger in math than in all other content domains.

Flashcards As is displayed in Table 5, the odds of high school students using flashcards were 2.94 times greater than middle school students. The odds of using flashcards were 1.41 times greater in English than in science and 3.85 times greater in English compared to math. Additionally, there was a joint influence of grade level and domain such that middle school

Table 3 Proportion of students providing the five most common reasons for using retrieval practice during self-directed study

	To help memorize	To know what I know	To be prepared	To help understand	To get a good grade
Middle School	0.39	0.22	0.14	0.17	0.16
High School	0.43	0.44**	0.19	0.13	0.07*

*$p < .05$

**$p < .001$

Table 4 The proportion of students who report using retrieval practice and re-reading study strategies for each domain (Questions 8, 10, 11, & 12), for middle school and high school students

	Test Yourself		Use Flashcards		Re-read		Re-copy notes	
	Middle	High	Middle	High	Middle	High	Middle	High
Science	.45	.49	.23	.39	.75	.78	.37	.23
Math	.49	.71	.26	.19	.62	.71	.39	.29
Social Studies	.33	.38	.35	.50	.86	.85	.48	.29
English	.33	.41	.24	.48	.69	.79	.40	.25

students were more likely than high school students to use this strategy in math courses (*M* = .26 vs .19, respectively), whereas high school students were more likely than middle school students to use this strategy in English courses (*M* = .48 and *M* = .24, respectively). When the reference group of domain was systematically changed across follow-up analyses, contrasts revealed that flashcards were used significantly less often in math than in science. In turn, flashcards were used significantly less often than in social studies and English courses. In addition, analysis consistently revealed a significant interaction term such that the discrepancy

Table 5 Repeated measures logistic regression parameter estimates of grade level, learning domain, and interactive terms predicting strategy use. Note: English and High School served as reference groups

	Predictor	β	*SE* β	95% CI of β	Wald χ^2	*p*	*Odds Ratio*	*95% CI of Odds*
Test Yourself	Middle School	−.31	.27	[−.84, .22]	1.34	.25	.73	[.42, 1.25]
	Science	.34	.17	[.01, .67]	4.00	.05*	1.40	[1.01, 1.95]
	Math	1.28	.19	[.91, 1.64]	46.27	< .001**	3.60	[2.48, 5.16]
	Social Studies	−.13	.15	[−.42, .16]	.76	.39	.88	[.66, 1.17]
	Grade x Science	.16	.28	[−.38, .71]	.34	.56	1.17	[.68, 2.03]
	Grade x Math	−.63	.31	[−1.23, −.03]	4.23	.04*	.53	[.29, .97]
	Grade x Social Studies	.13	.25	[−.36, .62]	.27	.60	1.13	[.70, 1.86]
Flashcards	Middle School	−1.07	.29	[−1.63, −.50]	13.65	< .001**	.34	[.20, .61]
	Science	−.34	.17	[−.67, −.02]	4.29	.04*	.71	[.51, .98]
	Math	−1.36	.20	[−1.75, −.97]	46.34	< .001**	.26	[.17, .38]
	Social Studies	.11	.15	[−.19, .40]	.50	.48	1.11	[.83, 1.49]
	Grade x Science	.28	.35	[−.41, .96]	.63	.43	1.32	[.66, 2.61]
	Grade x Math	1.48	.32	[.85, 2.12]	21.13	< .001**	4.39	[2.34, 8.33]
	Grade x Social Studies	.42	.30	[−.18, 1.01]	1.90	.17	1.52	[.84, 2.75]
Reread	Middle School	−.51	.29	[−1.08, .05]	3.22	.07	.60	[.34, 1.05]
	Science	−.08	.20	[−.47, .32]	.15	.70	.92	[.63, 1.38]
	Math	−.40	.18	[−.75, −.05]	5.12	.02*	.67	[.47, .95]
	Social Studies	.42	.21	[.01, .84]	3.93	.05*	1.52	[1.01, 2.32]
	Grade x Science	.37	.37	[−.35, 1.09]	1.03	.30	1.45	[.70, 2.97]
	Grade x Math	.09	.39	[−.67, .84]	.05	.83	1.09	[.51, 2.32]
	Grade x Social Studies	.57	.40	[−.22, 1.36]	2.00	.16	1.77	[.80, 3.90]
Recopy Notes	Middle School	.75	.27	[.22, 1.29]	7.76	.01*	2.11	[1.25, 3.63]
	Science	−.10	.19	[−.47, .28]	.27	.61	.90	[.63, 1.32]
	Math	.27	.15	[−.03, .57]	3.16	.08	1.31	[.97, 1.77]
	Social Studies	.25	.17	[−.08, .58]	2.21	.14	1.28	[.92, 1.79]
	Grade x Science	−.05	.33	[−.70, .60]	.03	.88	.95	[.50, 1.82]
	Grade x Math	−.32	.32	[−.94, .30]	1.03	.31	.73	[.39, 1.35]
	Grade x Social Studies	.04	.28	[−.51, .59]	.02	.88	1.04	[.60, 1.80]

in use of flashcards between middle and high school students reversed in direction when comparing math (i.e., middle school students were more likely to use flashcards) against all other content areas (i.e., high school students were more likely to use flashcards).

Re-read As is displayed in Table 5, the odds of students re-reading in English were 1.49 times greater in English than math; the odds of students re-reading in social studies were 1.52 times bigger than in English (M = .86 vs .76, respectively). Further contrasts between the domains revealed that re-reading was used significantly more often in social studies than in all other learning domains. Use of re-reading in math was significantly lower than in social studies and English and was marginally lower than in Science.

Recopy notes As is displayed in Table 5, the odds of middle school students recopying notes were 2.13 times greater than high school students. Math and English were marginally different, $p = .076$. When the reference group was systematically changed across follow-up analyses, contrasts revealed that re-copying notes was used significantly less in science than in math and social studies.

Retrieval-based strategies and grades We analyzed whether self-reported grades were associated with endorsement of retrieval practice strategies. Students reported grades they typically achieve in each of the four surveyed domains (Questions 14-17). To examine the relationship between grades and retrieval-based strategies, we first converted grades into a single GPA that ranged from 0 (Fs) to 4 (As). We analyzed whether GPAs differed based upon the freely-reported use of self-testing or re-reading strategies from Question 1. In a 2 (self-tester or not) x 2 (middle or high school) ANOVA, main effects of both grade level, $F(1, 306) = 9.00$, $p = 0.003$, $\eta p^2 = 0.03$, and self-testing, $F(1, 306) = 3.97$, $p = 0.047$, $\eta p^2 = 0.013$, reached significance. The interaction between self-testing and grade did not reach significance, $F(1, 306) = 1.44$, $p = 0.23$, $\eta p^2 = 0.005$. GPAs were higher for middle school students and for students who reported using self-testing strategies, but these two factors did not interact.

To specifically analyze whether retrieval-based strategies in a particular domain related to a student's grade in that domain, we conducted a multi-level model. We examined whether retrieval-based strategies endorsed on a checklist for a domain (e.g., whether a student checked off "flashcards in science") related to self-reported grade in that domain. As described above, we converted grade in each domain to a 0 (F) to 4 (A) scale. Using a logistic regression, we predicted the reported use of retrieval-based strategies in a specific domain from each student's reported grade in that domain, participant number, grade level (middle vs. high school), and domain (e.g., science). Self-reported use of retrieval-based strategies in a specific domain did not relate to self-reported grade in that domain ($\beta = 0.018$, SE of $\beta = .10$, 95% CI of $\beta = [-.18, .21]$, $p = .85$).

Retrieval-based strategies and enjoyment Finally, we examined whether retrieval- based strategies checked on a checklist for each surveyed domain (e.g., whether a student checked off "flashcards in science") related to self-reported enjoyment in that domain (Questions 18-21). To do so, we conducted a multi-level logistic regression in which we predicted the reported use of retrieval-based strategies in a specific domain from their reported enjoyment in that domain, participant number, grade level, and domain. Results revealed that self-reported enjoyment in a specific domain predicted the use of retrieval practice in that domain ($\beta = 0.14$, SE of $\beta = .05$, 95% CI of $\beta = [.04, .24]$, $p < .001$). The odds of using retrieval-practice strategies increases by 1.15 times for each additional point on the self-reported enjoyment scale. With increased enjoyment in a domain, students are more likely to utilize retrieval-based strategies.

Discussion

Here, we examined whether a sample of middle and high school students reported using retrieval practice and re-reading study strategies across four different school domains. The results show a large proportion of sampled students, in both middle and high school, report using retrieval practice to support their learning. In fact, half of all students freely reported at least one retrieval practice strategy and 80% of students endorsed using retrieval practice when selecting study strategies from a provided list. Although our sample was recruited from one middle school and one high school and was relatively homogenous in its demographic composition (i.e., >98% Latinx, >90% free lunch), it is important to note that estimated use of retrieval practice in our sample is much higher than estimates from prior samples (e.g., Karpicke et al. 2009). The discrepancy between estimates is especially interesting because prior studies have focused on populations of college students. Of course, it is possible that the results obtained in the current study are limited to the specific population included in our sample or the teachers in the sampled schools. However, there is reason to believe these results are generalizable beyond the current sample. For example, students who reported that they learned study strategies from a teacher did not report using self-testing strategies more frequently than students who did not learn their strategies from a teacher.[1] In other words, teachers' instruction in study strategies did not affect the amount of self-testing in the current sample. The ways in which current results are consistent with and extend on extant literature are described below. Further, recent research warns against the use of broad terms, like "re-studying", when asking students about their study strategies (Kuhbandner and Emmerdinger 2018); our survey questions students about their use of "re- reading" and "re-copying notes", rather than about their use of "re-study". Using this specific language should provide a clean measure of specific study habits.

Consistent with prior research, students in our sample reported and endorsed using re- reading strategies more than retrieval practice strategies. The preference for re-reading over testing has typically been interpreted to reveal inefficient and ineffective self-regulation because retrieval practice provides significant cognitive advantages over re-reading (Roediger III and Karpicke 2006; Carpenter and DeLosh 2005). Retrieval practice produces longer lasting memories, better metacognitive monitoring, and even improved transfer of understanding to new problems (Carpenter 2012). However, recent research questions whether learners choose retrieval practice ineffectively. When learners choose to test themselves, they selectively test well-learned items (Tullis et al. 2018). Learners choose to stop studying the best-learned information, restudy the worst learned information, and selectively test the information in between (Karpicke 2009). Son (2005) showed that even first-graders selectively choose to restudy the difficult items and test themselves on the easiest items. Selectively choosing to practice retrieval when students can successfully retrieve the information may be an effective strategy. Using retrieval practice selectively for well-learned information, rather than for all information, may be the most effective use of retrieval practice because benefits of testing occur only when students successfully retrieve information. According to the bifurcation model of retrieval practice, information successfully retrieved from long-term memory receives a large mnemonic boost (Kornell et al. 2011). Attempted, but unsuccessful, retrieval does not benefit memory. Re-reading benefits memory, but to a much smaller degree than successful retrieval. The most efficient strategy for studying, according to the bifurcation model, is to

[1] Students who learned study strategies from their teachers did not freely report more self-testing study strategies than students who did not learn study strategies from their teacher, in both middle school (teacher taught: .24 vs. not teacher taught: .23), $Z = 0.11$, $p = 0.91$, and high school (teacher taught: .62 vs. not teacher taught: .56), $Z = 0.92$, $p = 0.36$.

use retrieval practice for well-learned information and re-reading for poorly learned information. The data reported here reveal mixed results about the relationship between retrieval-based strategies and grades. Broadly, students who freely report using retrieval practice have higher grades than those that do not, but reported use of a strategy in a specific domain does not relate to a grade in that domain. Prior surveys reveal similar mixed results relating GPAs to retrieval- based study strategies in college samples (Hartwig and Dunlosky 2012; McAndrew et al. 2016).

Our research cannot address when or why students use particular strategies for specific information or how their use of strategies changes with learning. Yet, our data reflect the prior literature, which suggests that context plays a vital role in self-regulated learning (e.g., Pintrich 2000; Winne and Hadwin 1998) and that strategy use changes based upon specific content domains (e.g., Crede and Phillips 2011; Rotgans and Schmidt 2009). For example, college students' learning strategies may depend upon specific tasks (Hadwin et al. 2001), courses (Bråten and Samuelsten 2004), academic department (Ramsden and Entwistle 1981), and academic discipline (Lonka and Lindblom-Ylänne 1996; VanderStoep et al. 1996). Beyond context, tasks, and domain, study strategy selection and use is enacted over time and through a series of contingent events, with important relationships among prior and subsequent sequences (Hadwin 2000; Winne and Perry 2000). These sequences are not captured by our, or others', surveys. Consequently, static measures of study strategy endorsements may offer an incomplete representation of the dynamics of self-regulation during study. Recent experiments aiming to capture students' study choices across time suggest that students select retrieval practice more frequently later in learning, when they are more likely to be able to successfully recall the target information (e.g., Janes et al. 2018).

Our data indicate that study strategies change with age, which is consistent with prior research (Zimmerman and Martinez-Pons 1990). More specifically, our sample of high school students report greater use of retrieval strategies than our sample of middle school students. The change in use of retrieval practice across grade level may result from a shift in the reasons students use retrieval practice. Our sample of high school students reported using retrieval practice as a metacognitive tool (i.e. to assess what they know and do not know) more frequently than our sample of middle school students. High school students may need to use retrieval practice as a metacognitive monitoring tool more than middle school students because they spend more time controlling their own study. Effectively controlling their own study requires that they understand what they have mastered and what needs more study. These results hint at an interesting and important developmental question about how and why study strategies change with grade level and this question deserves greater attention. Prior research with young children suggests that study strategies can develop spontaneously but is primarily dependent upon students' exposure to effective models of the use of specific strategies and opportunities to practice in appropriate environments (Bjorklund and Zeman 1983; Wade et al. 1990). Yet, even when students have exposure to appropriate models, not all students learn from the information in their environment (Bielaczyc et al. 1995).

Some consistencies in study strategy usage emerged in our data, such that some strategies did not differ between domains (e.g. recopying notes). Prior research suggests that students can have preferred study strategies (Bong 2001, 2004; Gottfried 1985; Vermeeten et al. 1997; Warr and Downing 2000). For example, students may consistently choose study strategies according to a deep approach to learning (i.e. focusing on the meaning and understanding of material) or according to a surface approach (i.e. focusing on recall and reproduction: Biggs 1979; Marton and Säljö 1976). Similarly, Thomas and Bain (1982) reported consistencies between surface and deep study strategies between mathematics and psychology in college students. Some of our data reveal these consistencies in strategy use across domains.

Yet, other results show that the use of study strategies often depends upon a combination of domain and age. For example, our sample of students self-test more frequently in science and math classes than in English classes and our sample of students re-read more frequently in English than in math. Further, our sample of high school students use retrieval practice strategies more broadly than our sample of middle school students. While retrieval practice strategies were used primarily for math classes in middle school, our sample of high school students greatly increase their usage in English classes. Interestingly, the use of "testing oneself" and "flashcards" was not equivalent: in math and science domains, our sample of students used testing frequently, but in English classes, our sample of students used flashcards frequently. This suggests that retrieval practice is not a unitary construct for students; rather, students adapt retrieval practice differently across domains and tasks. Students do not uncover the benefits of retrieval practice as a general effective strategy and implement it across classes. Instead, implementations of retrieval practice grow and develop differently across domains.

Study strategy use may differ by context and age for several reasons. Students' characteristics, the nature of the to-be-learned information, previous tests, peer influences, and teacher expectations may all shift study tactics. Several individual characteristics, like interest and task value, influence what strategies students use. In fact, our data suggest that use of retrieval practice increases with increased enjoyment of a content domain. Prior research suggests that students who value a task and have interest in the subject area report using higher levels of cognitive strategies than others (Cleary and Chen 2009; Pintrich and DeGroot 1990; Schiefele 1991). Similarly, students with higher self-efficacy (Schunk 1991) and with learning or mastery goal orientations (Ames 1992) show more effective strategy use. Further, students' past experiences in a particular subject can shape the strategies they use in that domain; when students are first introduced to an area, they rely heavily upon general strategic knowledge, rather than domain-specific strategies (Brown and Palincsar 1989; Reynolds 1992).

Beyond individual differences, domains and contexts may afford differential strategy usage. The structure or nature of an academic field may be more or less suitable to specific study strategies. Prior research suggests that disciplinary differences can provide more or less opportunity for self-regulated learning in terms of strategy use (Grossman and Stodolsky 1994, Grossman and Stodolsky 1995; Stodolsky 1998). More specifically, math classes are typically rigid, linear, and highly structured, while social studies classes typically are not. Social studies classrooms offer more diverse tasks than math classrooms, which allows for greater self-regulation and use of varied cognitive strategies. Like prior research, our results show influences of domains on students' strategy use. Across our sample, English classes prompted greater use of re-reading strategies than math, but math classes prompted greater use of self-testing than English. Further, English classes prompted greater flashcard use than math classes.

Finally, because students are typically thoughtful about their use of effort and strategies, students' perceptions about task demands may shift the strategies that they use. Specifically, students' beliefs about assessment can change the strategies that they employ during learning. The kind of assessment shapes how much, how (their study strategy), and what (the content) students learn (for a review, see Scouller and Prosser 1994). For example, students expecting a multiple-choice exam engage in more surface learning approaches than those expecting an essay exam (Scouller 1998). Similarly, if students expect a free recall test, they engage different encoding processes than if they expect a cued-recall test (Finley and Benjamin 2018). Providing students guidance about the criterion task either through explicit instruction or through providing example assessment questions during learning (Wong et al. 1982) can change the study strategies that students use.

Broadly, self-regulatory processes are teachable and can increase students' achievement (Schunk and Zimmerman 1998). Using cognitive learning strategies, more specifically, is a mutable component that supports students' academic achievement (Pintrich et al. 1994; Weinstein 1978). In fact, a meta-analysis examining the impact of self- regulatory training on academic performance revealed that self-regulated learning training and strategy use training both produce medium-sized benefits for students (Dignath et al. 2008). Training on strategy use, however, has not yet included training on appropriately and effectively harnessing the benefits of retrieving information from long term memory. Only one intervention has tried to boost the use of retrieval practice and it showed that a 10-minute lecture about the benefits of retrieval practice (with subsequent reminders) can mildly sway students' self-reported behavior in a college biology class (Rodriguez et al. 2018). Training students on this particularly effective strategy could produce significant benefits on academic performance. Alternatively, teachers may be able to bridge students' existing preferred routines with more effective strategies by helping students optimize their use of their preferred strategies (Miyatsu et al. 2018). For example, students often indicate strong preferences to underline or highlight text; teachers can help students optimize this practice by prompting students to only highlight the text after they have read the entire section of text.

Practical Recommendations

While our results suggest that a new sample of learners utilizes retrieval-based strategies more frequently than prior samples, much room for improvement exists. A large proportion of students in our sample do not report using retrieval practice at all, and many students in our sample who report using retrieval practice do so only to monitor their learning (rather than improve it). Our data show that only 54% of the students in our sample report that they have learned study strategies from teachers. Given that many effective study strategies are un-intuitive, teachers may need to provide the guidance and support in order for students to utilize strategies that value long-term outcomes over quick, short-term gains. Alternatively, teachers may be able to prompt or encourage students to optimally implement the preferred strategies that students already have (Miyatsu et al. 2018). Further, our results show that the use of retrieval- based strategies in our sample varies widely by content domain, even though experimental research suggests that retrieval-based strategies boost learning across domains (e.g., Rohrer et al. 2014; McDermott et al. 2014). Interventions to improve students' learning strategies may need to be targeted to specific domains and age ranges. Teachers may be able to guide students to incorporate retrieval-based strategies into specific contexts.

Limitations and future directions

All data in our study reflect students' self-reporting of their study strategy use. Self- reported strategy use may reasonably reflect actual strategy use (cf. Ericsson and Simon 1980; Van Hout-Wolters 2000; Veenman 2005; Winne et al. 2001), but may not always correspond to student behavior (Jamieson-Noel and Winne 2003). Our self-reported data reveal some slight inconsistencies across question format. For example, differences emerge in the reported use and most frequently used strategies from open- to closed-questions. These differences underscore the importance of utilizing both types of questions in future research and including a more comprehensive list of strategies that reflect the various ways these broad categories can be realized in practice. Future research can harness technology to query students more frequently and while students are studying to produce a concurrent report of study strategy use. Indeed, the current instrument and results could serve as the basis for developing a retrieval-practice strategy use scale to be used for such a purpose.

Although our study examined student use of a more distinct set of strategies than past research, we did not assess the extent to which students use specific sequences or combinations of strategies. For example, students may re-read before engaging in self-testing so that they can succeed on the self-tests. Indeed, the degree to which material is initially learned appears to modulate the subsequent benefit of retrieval practice in adult populations (e.g., Bui et al. 2013; Maddox and Balota 2015), and evidence suggests that college students are sensitive to these differences in initial learning when subsequently implementing their own strategies for enhancing learning and memory (Maddox and Balota 2012). Similarly, although the benefits of retrieval practice are robust, they are not always observed (e.g., Mulligan and Peterson 2015) and in some instances have negative consequences for other to-be-remembered materials (e.g., Anderson et al. 1994). Taken together, we did not collect data regarding individual differences (e.g. self-efficacy across domains) or metacognitive knowledge that would allow us to better predict why and when students harness specific study strategies as a function of personal abilities or situational factors. Thus, it will be important for future research to examine the extent to which younger learners are sensitive to these differences. Finally, it is important to revisit the possibility that our results may not generalize more broadly. Critically, compared to prior research, we surveyed a new population of students (i.e. >98% Latinx, >90% free lunch); however, we only had the opportunity to survey students of three teachers. It remains an open question whether students of these teachers are unique or if the self-reported behaviors in the current study will be observed more broadly. Of course, our analyses indicate that most students did not learn retrieval strategies from their teachers, and instead they discovered these strategies on their own; further, learning study strategies from teachers did not increase the rate of self- testing. Even if the current sample represented a unique population that reliably incorporated retrieval practice as a study strategy due to external factors, the current results suggest that middle and high school students can implement various forms of retrieval practice given explicit instructions or an educational environment that promotes these strategies (c.f., Rodriguez et al. 2018). The social and environmental conditions under which diverse populations of middle and high school students utilize self-testing need to be examined more thoroughly.

Conclusions

Our sample of middle and high school students report using retrieval practice strategies widely. In fact, retrieval practice strategies comprise the second-most utilized study strategy for most of the sampled students. Still, the most frequently used strategy among our sample is re-reading. Reasons for using retrieval practice included improving memory and understanding, and supporting metacognitive monitoring. The reasons for using retrieval practice change, such that our sample of high schoolers reported using retrieval practice for metacognitive purposes more than our sample of middle school students. Finally, while some consistencies in strategy use exist across classes, context strongly drives study strategy use. For example, our sample of students use self-testing more in math than in social studies. Understanding the development and use of retrieval practice across ages and learning domains is important to supporting student success; helping students recognize and harness the benefits of retrieval practice may enable their success across many domains.

Compliance with ethical standards

The authors have no potential conflicts of interest to disclose. Human participants were treated in accord with APA ethical standards. Students and their guardians signed informed consent before participating in this research.

APPENDIX: Study Strategies Survey

Study Strategy Questionnaire

Please answer each question in the order they are presented. Please do NOT return to earlier questions after you have moved to later ones.

1. What strategies do you use when you are studying? In other words, outside of classroom time, what do you do to learn your class material? Please write down all of the strategies that you use.

2. Circle the strategy from Question 1 that you use most frequently.

3. Why do you study the way that you do? Put an X next to ALL the answers that apply.

_________ A teacher taught me

_________My parents taught me

_________I just figured it out on my own

Other: please write in your answer: _______________________________

4. Put an X next to each strategy that you use when you are studying on your own.

___________ Test yourself with questions or practice problems

___________ Use flashcards

___________ Recopy your notes

___________ Reread chapters or notes

___________ Create and answer my own practice questions

___________ Make outlines

___________ Underline or highlight while reading

___________ Make diagrams, charts, or pictures

___________ Think of my own examples of concepts from class

___________ Study with friends

___________ Create rhymes, songs, stories, or images to connect important ideas

___________ Relate new material to information I already know

___________ Research more about topics online

5. Go back to question 4 on the previous page and rank the strategies you selected in terms of how effective they are at helping you learn. Please rank your most effective strategy "1", your second most effective strategy "2", your third most effective strategy "3", etc, until you have ranked **ALL** of the strategies that you use.

6. <u>If you quiz yourself while studying, **why do you do it**</u>? Quizzing can include using flashcards, solving practice problems from the textbook or teacher, answering review questions from your teacher, or trying to remember any information from your memory without looking it up)

IN THE NEXT SECTION, WE WILL ASK ABOUT HOW YOU STUDY FOR SPECIFIC CLASSES.

7. Which **SCIENCE** class (or classes) are you currently taking?

8. Which of the following study strategies do you use regularly TO STUDY FOR YOUR **SCIENCE CLASS**?
   Circle all of the strategies you use.
   a. Test yourself with questions or practice problems
   b. Use flashcards
   c. Recopy your notes
   d. Reread chapters or notes
   e. Create and answer my own practice questions
   f. Make outlines
   g. Underline or highlight while reading
   h. Make diagrams, charts, or pictures
   i. Think my own examples of concepts from class
   j. Study with friends
   k. Create rhymes, songs, stories, or images to connect important ideas
   l. Relate new material to information I already know
   m. Research more about topics online
   n. Other: write in other strategies you use when studying for science:

9. Which **MATH** class (or classes) are you currently taking?

10. Which of the following study strategies do you use regularly TO STUDY FOR **MATH**? Circle all of the strategies you use.
    a. Test yourself with questions or practice problems
    b. Use flashcards
    c. Recopy your notes
    d. Reread chapters or notes
    e. Create and answer my own practice questions
    f. Make outlines
    g. Underline or highlight while reading
    h. Make diagrams, charts, or pictures
    i. Think of my own examples of concepts from class
    j. Study with friends
    k. Create rhymes, songs, stories, or images to connect important ideas
    l. Relate new material to information I already know
    m. Research more about topics online
    n. Other: write in other strategies you use when studying for math:

11. Which of the following study strategies do you use regularly **TO STUDY FOR SOCIAL STUDIES** (e.g., history, economics, government)? Circle all of the strategies you use.
    a. Test yourself with questions or practice problems
    b. Use flashcards
    c. Recopy your notes
    d. Reread chapters or notes
    e. Create and answer my own practice questions
    f. Make outlines
    g. Underline or highlight while reading
    h. Make diagrams, charts, or pictures
    i. Think of my own examples of concepts from class
    j. Study with friends
    k. Create rhymes, songs, stories, or images to connect important ideas

l. Relate new material to information I already know

m. Research more about topics online

n. Other: write in other strategies you use when studying for social studies:

12. Which of the following study strategies do you use regularly TO STUDY FOR **ENGLISH**?
Circle all of the strategies you use.

a. Test yourself with questions or practice problems

b. Use flashcards

c. Recopy your notes

d. Reread chapters or notes

e. Create and answer my own practice questions

f. Make outlines

g. Underline or highlight while reading

h. Make diagrams, charts, or pictures

i. Think of my own examples of concepts from class

j. Study with friends

k. Create rhymes, songs, stories, or images to connect important ideas

l. Relate new material to information I already know

m. Research more about topics online

n. Other: write in other strategies you use when studying for English:

13. How effective do you think each of these strategies are for helping **YOUR CLASSMATES** learn? Rank them from most effective (1) to least effective (13).

________ Test yourself with questions or practice problems

________ Use flashcards

________ Recopy your notes

________ Reread chapters or notes

________ Create and answer my own practice questions

________ Make outlines

________ Underline or highlight while reading

________ Make diagrams, charts, or pictures

________ Think of my own examples of concepts from class

________ Study with friends

________ Create rhymes, songs, stories, or images to connect important ideas

________ Relate new material to information I already know

________ Research more about topics online

NEXT, WE WILL ASK YOU ABOUT THE TYPES OF GRADES THAT YOU TYPICALLY RECEIVE IN SPECIFIC COURSES.

14. What type of grades do you typically get in **SCIENCE**? (circle your normal grade) A B C D
15. What type of grades do you typically get in **MATH**? (circle your normal grade) A B C D
16. What type of grades do you typically get in **SOCIAL STUDIES**? (circle your normal grade)

    A B C D
17. What type of grades do you typically get in **ENGLISH**? (circle your normal grade) A B C D

FINALLY, WE WILL ASK YOU HOW MUCH YOU TYPICALLY ENJOY SPECIFIC COURSES.

18. How much do you enjoy **SCIENCE**? (Rate from 1 [very little] to 6 [very much])

    1 2 3 4 5 6

    Very little Very much
19. How much do you enjoy **MATH**? (Rate from 1 [very little] to 6 [very much])

    1 2 3 4 5 6

    Very little Very much
20. How much do you enjoy **SOCIAL STUDIES**? (Rate from 1 [very little] to 6 [very much])

    1 2 3 4 5 6

    Very little Very much
21. How much do you enjoy **ENGLISH**? (Rate from 1 [very little] to 6 [very much])

    1 2 3 4 5 6

    Very little Very much

References

Agarwal, P. K., Karpicke, J. D., Kang, S. H. K., Roediger, H. L., & McDermott, K. B. (2008). Examining the tested effect with open- and closed-book tests. *Applied Cognitive Psychology, 22*, 861–876.

Ames, C. (1992). Achievement goals and the classroom motivational climate. In D. Schunk & J. Meece (Eds.), *Student perceptions in the classroom* (pp. 327–349). Hillsdale, NJ: Erlbaum.

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 20*, 1063–1087. https://doi.org/10.1037/0278-7393.20.5.1063.

Bielaczyc, K., Pirolli, P. L., & Brown, A. L. (1995). Training in self explanation and self- regulation strategies: Investigating the effects of knowledge acquisition activities on problem solving. *Cognition and Instruction, 13*, 221–252.

Biggs, J. B. (1979). Individual differences in study processes and the quality of learning outcomes. *Higher Education, 8*, 381–394.

Bjorklund, D. F., & Zeman, B. R. (1983). The development of organizational strategies in children's recall of familiar information: Using social organization to recall the names of classmates. *International Journal of Behavioral Development, 6*, 341–353.

Blasiman, R., Dunlosky, J., & Rawson, K. A. (2017). The what, how much, and when of study strategies: Comparing intended versus actual study behaviour. *Memory, 25*(6), 784–792. https://doi.org/10.1080/09658211.2016.1221974.

Bong, M. (2001). Between- and within-domain relations of academic motivation among middle and high-school students: Self-efficacy, task value, and achievement goals. *Journal of Educational Psychology, 93*, 23–34.

Bong, M. (2004). Academic motivation in self-efficacy, task value, achievement goal orientations, and attributional beliefs. *Journal of Educational Research, 97*, 287–297.

Bråten, I., & Samuelstuen, M. S. (2004). Does the influence of reading purpose on reports of strategic text processing depend on students' topic knowledge? *Journal of Educational Psychology, 96*, 324–336.

Broekkamp, H., & Van Hout-Wolters, B. (2007). The gap between educational research and practice: A literature review, symposium, and questionnaire. *Educational Research and Evaluation, 13*, 203–220.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 393–451). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc..

Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). Learning, remembering, and understanding. In J. H. Flavell & E. M. Markman (Eds.), *handbook of child psychology (4th ed.): Cognitive development* (Vol. 3, pp. 77–166). New York: Wiley.

Bui, D. C., Maddox, G. B., & Balota, D. A. (2013). The roles of working memory and intervening task difficulty in determining the benefits of repetition. *Psychonomic Bulletin & Review, 20*, 341–347. https://doi.org/10.3758/s13423-012-0352-5.

Butler, A. C., & Roediger, H. L. (2007). Testing improves long-term retention in a simulated classroom setting. *European Journal of Cognitive Psychology, 19*, 514–527.

Carpenter, S. K. (2012). Testing enhances the transfer of learning. *Current Directions in Psychological Science, 21*, 279–283. https://doi.org/10.1177/0963721412452728.

Carpenter, S. K., & DeLosh, E. L. (2005). Application of the testing and spacing effects to name learning. *Applied Cognitive Psychology, 19*, 619–636.

Carpenter, S. K., Lund, T. J., Coffman, C. R., Armstrong, P. I., Lamm, M. H., & Reason, R. D. (2016). A classroom study on the relationship between student achievement and retrieval- enhanced learning. *Educational Psychology Review*, 1–23.

Clark, D. A., & Svinicki, M. (2015). The effect of retrieval on post-task enjoyment of studying. *Educational Psychology Review, 27*, 51–67.

Cleary, T. J., & Chen, P. P. (2009). Self-regulation, motivation, and math achievement in middle school: Variations across grade level and math context. *Journal of School Psychology, 47*, 291–314.

Crede, M., & Phillips, L. A. (2011). A meta-analytic review of the motivated strategies for learning questionnaire. *Learning and Individual Differences, 21*, 337–346.

Cromley, J. G., & Azevedo, R. (2007). Testing and refining the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology, 99*, 311–325.

Cull, W. L. (2000). Untangling the benefits of multiple study opportunities and repeated testing for cued recall. *Applied Cognitive Psychology, 14*, 215–235.

Dignath, G., Buettner, G., & Langfeldt, H. P. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review, 3*, 101–129.

Duncan, T. G., & McKeachie, W. C. (2005). The making of the motivated strategies for learning questionnaire. *Educational Psychologist, 40*, 117–128.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87*, 215–251.

Finley, J. R., & Benjamin, A. S. (2018). *Metacognitive control of transfer-appropriate processing*. Manuscript in preparation.

Glover, J. A. (1989). The "testing" phenomenon: Not gone but nearly forgotten. *Journal of Educational Psychology, 81*, 392–399.

Gottfried, A. E. (1985). Academic intrinsic motivation in elementary and junior high school students. *Journal of Educational Psychology, 77*, 631–645.

Grossman, P., & Stodolsky, S. (1994). Considerations of content and the circumstances of secondary school teaching. In L. Darling-Hammond, ed. *Review of Research in Education* (Vol. 20, pp. 179–221). Washington, DC: American Educational Research Association.

Grossman, P. L., & Stodolsky, S. S. (1995). Content as context: The role of school subjects in secondary school teaching. *Educational Researcher, 24*(8), 5–11 23.

Hadwin, A. F. (2000). Building a case for self-regulating as a socially constructed phenomenon. Unpublished doctoral dissertation, Simon Fraser University, Burnaby, British Columbia, Canada.

Hadwin, A. F., Winne, P. H., Stockley, D. B., Nesbit, J. C., & Woszczyna, C. (2001). Context moderates students' self-reports about how they study. *Journal of Educational Psychology, 93*, 477–487.

Hartwig, M. K., & Dunlosky, J. (2012). Study strategies of college students: Are self-testing and scheduling related to achievement? *Psychonomic Bulletin & Review, 19*(1), 126–134.

Jamieson-Noel, D., & Winne, P. H. (2003). Comparing self-reports to traces of studying behavior as representations of students' studying and achievement. *German Journal of Educational Psychology, 17*, 159–171.

Janes, J. L., Dunlosky, J., & Rawson, K. A. (2018). How do students use self-testings across multiple study sessions when preparing for a high-stakes exam? *Journal of Applied Research in Memory and Cognition, 7*(2), 230–240.

Karpicke, J. D. (2009). Metacognitive control and strategy selection: Deciding to practice retrieval during learning. *Journal of Experimental Psychology: General, 138*, 469–486.

Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*, 772–775.

Karpicke, J. D., Butler, A. C., & Roediger III, H. L. (2009). Metacognitive strategies in student learning: Do students practice retrieval when they study on their own? *Memory, 17*(4), 471–479.

King, A. (1992). Comparison of self-questioning, summarizing, and notetaking-review as strategies for learning from lectures. *American Educational Research Journal, 29*, 303–323.

Kirk-Johnson, A., Gallo, B. M., & Fraundorf, S. H. (2019). Perceiving effort as poor learning: the misinterpreted-effort hypothesis of how experienced effort and perceived learning relate to study strategy choice. *Cognitive Psychology*, 115.

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology: General, 126*, 349–370.

Kornell, N., & Bjork, R. A. (2007). The promise and perils of self-regulated study. *Psychonomic Bulletin & Review, 14*(2), 219–224.

Kornell, N., & Son, L. K. (2009). Learners' choices and beliefs about self-testing. *Memory, 17*, 493–501.

Kornell, N., Bjork, R. A., & Garcia, M. A. (2011). Why tests appear to prevent forgetting: A distribution-based bifurcation model. *Journal of Memory and Language, 65*, 85–97.

Kuhbandner, C., & Emmerdinger, K. J. (2018). Do students really prefer repeated rereading over testing when studying textbooks? A reexamination. *Memory, 27*(7), 952–961. https://doi.org/10.1080/09658211.2019.1610177.

Kuhn, D. (2000). Theory of mind, metacognition, and reasoning: A life-span perspective. In P. Mitchell & K. J. Riggs (Eds.), *Children's reasoning and the mind* (pp. 301–326). Hove, England: Psychology Press.

Leeming, F. C. (2002). The exam-a-day procedure improves performance in psychology classes. *Teaching of Psychology, 29*, 210–212.

Lonka, K., & Lindblom-Ylänne, S. (1996). Epistemologies, conceptions of learning, and study practices in medicine and psychology. *Higher Education, 31*, 5–24.

Maddox, G. B., & Balota, D. A. (2012). Self control of when and how much to test face-name pairs in a novel spaced retrieval paradigm: An examination of age-related differences. *Aging, Neuropsychology, and Cognition, 19*, 620–643. https://doi.org/10.1080/13825585.2011.640658.

Maddox, G. B., & Balota, D. A. (2015). Retrieval practice and spacing effects in young and older adults: An examination of the benefits of desirable difficulty. *Memory and Cognition, 43*, 770–774. https://doi.org/10.3758/s13421/s13421-014-0499-6.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning II: Outcome as a function of the learner's conception of the task. *British Journal of Educational Psychology, 46*, 115–127.

McAndrew, M., Morrow, C. S., Atiyeh, L., & Pierre, G. C. (2016). Dental student study strategies: Are self-testing and scheduling related to academic performance? *Journal of Dental Education, 80*(5), 542–552.

McDaniel, M. A., Agarwal, P. K., Huelser, B. J., McDermott, K. B., & Roediger III, H. L. (2011). Test-enhanced learning in a middle school science classroom: The effects of quiz frequency and placement. *Journal of Educational Psychology, 103*(2), 399.

McDermott, K. B., Agarwal, P. K., D'Antonio, L., Roediger, H. L., & McDaniel, M. A. (2014). Both multiple-choice and short-answer quizzes enhance later exam performance in middle and high school classes. *Journal of Experimental Psychology: Applied, 20*, 3–21.

Miyatsu, T., Nguyen, K., & McDaniel, M. A. (2018). Five popular study strategies: Their optimal implementation and pitfalls. *Perspectives on Psychological Science, 13*(3), 390–407.

Mulligan, N. W., & Peterson, D. J. (2015). Negative and positive testing effects in terms of item- specific and relational information. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41*(3), 859–871. https://doi.org/10.1037/xlm0000056.

Pashler, H., Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., McDaniel, M., et al. (2007).Organizing instruction and study to improve student learning (NCER 2007–2004). Washington, DC: U. S. Department of Education, National Center forEducation Research, Institute of Education Sciences.

Pintrich, P. R. (2000). Multiple goals, multiple pathways: The role of goal orientation in learning and achievement. *Journal of Educational Psychology, 92*, 544–555.

Pintrich, P. R., & DeGroot, E. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*, 33–40.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). *Educational and Psychological Measurement, 53*, 801–813.

Pintrich, P. R., Brown, D. R., & Weinstein, C.-E. (1994). *Student motivation, cognition and learning*. Hillsdale: Lawrence-Erlbaurn.

Putnam, A. L., & Roediger, H. L. (2013). Does response mode affect amount recalled or the magnitude of the testing effect? *Memory & Cognition, 41*, 36–48.

Rabinowitz, J. C., Ackerman, B. P., Craik, F. I. M., & Hinchley, J. L. (1982). Aging and metamemory: The roles of relatedness and imagery. *Journal of Gerontology, 37*, 688–660.

Ramsden, P., & Entwistle, N. J. (1981). Effects of academic departments on students approaches to studying. *British Journal of Educational Psychology, 51*, 368–383.

Rawson, K. A., & Dunlosky, J. (2016). How effective is example generation for learning declarative concepts? *Educational Psychology Review, 28*, 649–672.

Rea, C. P., & Modigliani, V. (1985). The effect of expanded versus massed practice on the retention of multiplication facts and spelling lists. *Human Learning: Journal of Practical Research & Applications, 4*(1), 11–18.

Reynolds, R. E. (1992). Selective attention and prose learning: Theoretical and empirical research. *Educational Psychology Review, 4*, 345–391.

Rodriguez, F., Rivas, M. J., Matsumura, L. H., Warschauer, M., & Sato, B. K. (2018). How do students study in STEM courses? Findings from a light-touch intervention and its relevance for underrepresented students. *PLoS One, 13*(7), 1–20.

Roediger III, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science, 17*, 249–255.

Roediger III, H. L., Agarwal, P. K., McDaniel, M. A., & McDermott, K. B. (2011). Test enhanced learning in the classroom: Long-term improvements from quizzing. *Journal of Experimental Psychology: Applied, 17*(4), 382–395.

Rohrer, D., Dedrick, R. F., & Burgess, K. (2014). The benefit of interleaved mathematics practice is not limited to superficially similar kinds of problems. *Psychonomic Bulletin & Review, 21*, 1323–1330.

Rotgans, J., & Schmidt, H. (2009). Examination of the context-specific nature of self-regulated learning. *Educational Studies, 35*, 239–253.

Rowland, C. A. (2014). The effect of testing versus restudy on retention: A meta-analytic review of the testing effect. *Psychological Bulletin, 140*, 1432–1436.

Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist, 26*, 299–324.

Schneider, W. (1998). The development of procedural metamemory in childhood and adolescence. In G. Mazzoni & T. O. Nelson (Eds), *Monitoring and control processes in metacognition and cognitive neuropsychology* (pp. 1–21). Mahwah, NJ : Erlbaum.

Schneider, W. (2008). The development of metacognitive knowledge in children and adolescents: Major trends and implications for education. *Mind, Brain, and Education, 2*, 114–121.

Schneider, W., & Pressley, M. (1989). *Memory development between 2 and 20*. New York: Springer-Verlag.

Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist, 26*, 207–231.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (1998). *Selfregulated learning: From teaching to self- reflective practice*. New York: Guilford Press.

Scouller, K. (1998). The influence of assessment method on students' learning approaches: Multiple choice question examination versus assignment essay. *Higher Education, 35*, 453–472.
Scouller, K. M., & Prosser, M. (1994). Students' experiences in studying for multiple choice question examinations. *Studies in Higher Education, 19*, 267–279.
Shaw, R. J., & Craik, E. I. M. (1989). Age differences in predictions and performance on a cued recall task. *Psychology and Aging, 4*, 131–135.
Siegler, R. S. (1988). Strategy choice procedures and the development of multiplication skill. *Journal of Experimental Psychology: General, 3*, 258–275.
Son, L. K. (2005). Metacognitive control: Children's short-term versus long-term study strategies. *Journal of General Psychology, 132*, 347–363.
Spitzer, H. F. (1939). Studies in retention. *Journal of Educational Psychology, 30*(9), 641–656.
Sternberg, R. J. (1988). *The triarchic mind: A new theory of human intelligence*. New York: Viking.
Stodolsky, S. (1988). *The subject matters: classroom activity in math and social studies*. Chicago: The University of Chicago Press.
Thomas, P. R., & Bain, J. D. (1982). Consistency in learning strategies. *Higher Education, 11*, 249–259.
Thomas, J. W., & Rowher, W. D. (1987). Grade-level and course-specific differences in academic studying: Summary. *Contemporary Educational Psychology, 12*, 381–385.
Thomas, J. W., Bol, L., Warkentin, R. W., Wilson, M., Strage, A., & Rowher, W. D. (1993). Interrelationships among students study activities, self-concept of academic ability, and achievement as a function of characteristics of high-school biology courses. *Applied Cognitive Psychology, 7*, 499–532.
Trigwell, K., & Prosser, M. (1991). Improving the quality of student learning: The influence of learning context and student approaches to learning on learning outcomes. *Higher Education, 22*, 251–266.
Tullis, J. G., & Benjamin, A. S. (2011). On the effectiveness of self-paced learning. *Journal of Memory and Language, 64*, 109–118.
Tullis, J. G., & Benjamin, A. S. (2012). Consequences of restudy choices in younger and older learners. *Psychonomic Bulletin & Review, 19*, 743–749.
Tullis, J. G., Finley, J. R., & Benjamin, A. S. (2013). Metacognition of the testing effect: Guiding learners to predict the benefits of retrieval. *Memory & Cognition, 41*, 429–442.
Tullis, J. G., Fiechter, J. L., & Benjamin, A. S. (2018). The efficacy of learners' testing choices. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 44*, 540–552.
Van Hout-Wolters, B. (2000). Assessing active self-directed learning. In R. Simons, J. van der Linden, & T. Duffy (Eds.), *New learning* (pp. 83–101). Dordrecht: Kluwer.
VanderStoep, S. W., Pintrich, P. R., & Fagerlin, A. (1996). Disciplinary differences in self- regulated learning in college students. *Contemporary Educational Psychology, 21*, 345–362.
Veenman, M. V. J. (2005). The assessment of metacognitive skills: What can be learned from multi-method designs? In C. Artelt & B. Moschner (Eds.), *Lernstrategien und Metakognition: Implikationen für Forschung und Praxis* (pp. 77–99). Münster: Waxmann.
Vermeeten, J., Lodewijks, H., & Vermunt, J. (1997). Change and stability in learning strategies during the first two years at the university. Paper presented at the annual meeting of the American Educational Research Association, Chicago, march 24–28.
Wade, W., Trathen, W., & Schraw, G. (1990). An analysis of spontaneous study strategies. *Reading Research Quarterly, 25*, 147–166.
Warr, P., & Downing, J. (2000). Learning strategies, learning anxiety, and knowledge acquisition. *British Journal of Psychology, 91*, 311–333.
Weinstein, C. E. (1978). Teaching cognitive elaboration learning strategies. In H. F. O'Neal (Ed.), *Learning strategies*. New York: Academic Press.
Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 315–327). New York: MacMillan.
Weinstein, C. E., Zimmerman, S. A., & Palmer, D. R. (1988). Assessing learning strategies: The design and development of the LASSI. In C. E. Weinstein, E. T. Goetz, & P. A. Alexander (Eds.), *Learning and study strategies: Issues in assessment, instruction, and evaluation* (pp. 25–40). New York: Academic.
Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. Hacker, J. Dunlosky, & A. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 279–306). Hillsdale, NJ: Erlbaum.
Winne, P., & Perry, N. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531–566). San Diego, CA: Academic Press.
Winne, P., Jamieson-Noel, D., & Muis, K. (2001). Methodological issues and advances in researching tactics, strategies, and self-regulated learning. In P. R. Pintrich & M. L. Maehr (Eds.), *Advances in motivation and achievement*, *New directions in measures and methods* (Vol. 12, pp. 121–155). Amsterdam: JAI Press Elsevier Science.

Wissman, K. T., Rawson, K. A., & Pyc, M. A. (2012). How and when do students use flashcards? *Memory, 20*(6), 568–579. https://doi.org/10.1080/09658211.2012.687052.
Wolters, C., & Pintrich, P. R. (1998). Contextual differences in student motivation and self regulated learning in mathematics, English, and social studies classrooms. *Instructional Science, 26*, 27–47.
Wong, B. Y. L., Wong, R., & Lemare, L. (1982). The effects of knowledge of criterion task on comprehension and recall in normally achieving and learning disabled children. *The Journal of Educational Research, 76*(2), 119–126.
Zimmerman, B. J. (1989). A social–cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*, 329–339.
Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*, 3–17.
Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91.
Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal, 23*, 614–628.
Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology, 82*, 51–59.
Zimmerman, B. J., & Moylan, A. R. (2009). Self-regulation: where metacognition and motivation intersect. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of Metacognition in Education* (pp. 299–315). New York, NY: Routledge.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.