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REVIEW ARTICLE

# Encouraging Students to Use Retrieval Practice: a Review of Emerging Research from Five Types of Interventions

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## Abstract

Over 100 years of research shows that retrieval practice is highly effective for enhancing student learning. When managing their own study behaviors, however, students tend to avoid using retrieval practice as a way of learning. Understanding and improving students' study decisions is important given the increasingly autonomous nature of educational experiences that require students to initiate and regulate their own learning. This review summarizes the emerging research on interventions designed to increase students' decisions to use retrieval practice. Informing students about the benefits of retrieval, and even providing opportunities to directly experience retrieval, are not sufficient for getting students to engage with retrieval when they have the choice. However, reducing the effort and errors involved in retrieval, and providing students direct performance feedback on their own learning benefits associated with retrieval, can increase students' decisions to use it. The small but growing literature on multifaceted interventions also shows some promise for increasing students' decisions to use retrieval practice in their courses as a result of learning about its benefits, planning how to use it, practicing it over time, and reflecting on the outcomes. Suggestions are offered for how this research informs straightforward ways that teachers might encourage students to use retrieval practice in their own learning.

**Keywords** Retrieval practice · Self-regulated learning · Metacognition · Study strategies

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Education in the twenty-first century is undergoing continual transformation. As we move through the modern age of increasing technological and scientific developments, access to and flexibility of educational opportunities have increased dramatically. For students, these changes have involved increased time spent on learning activities outside of class, and even entire degrees that can be completed outside the walls of traditional classroom environments.

With these new developments have come increased challenges for students to manage their own learning. Many aspects of the educational experience—such as schedules, learning activities, and time spent learning—have shifted from structured elements primarily organized by an instructor to decisions that now must be made by students. Though instructors can still provide structure in courses that they teach, the increasing variety of options for accessing and delivering educational experiences has rendered modern learning opportunities more diverse, less dependent upon a particular type of structure, and more influenced by the decisions that students make about how and when to learn. Though students' decisions about how to approach learning have always been a central contributor to their learning, the importance of these decisions is ever increasing as many learning opportunities are becoming heavily, if not entirely, dependent on those decisions.

A timely and important research endeavor, therefore, is to understand students' self-regulated learning—that is, how they initiate decisions and actions to accomplish learning goals. One question in particular concerns the alignment between students' self-regulated decisions and effective methods for learning that are backed by empirical evidence. When faced with a decision about how to approach a learning situation—for example, what strategies or techniques to use for learning—do students choose the strategies that are most effective?

The short answer is *no*. Decades of research on metacognition have revealed a number of biases in students' perceptions and decisions regarding their own learning that are often at odds with empirically-validated ways for enhancing learning (Bjork et al., 2013; Carpenter et al., 2020a, 2020b). These biases can have a powerful influence on students' decisions, in part because they are so highly intuitive. When students do not have direct knowledge of effective ways to learn, and those ways are not particularly intuitive, students tend to rely on their own intuitions and experiences, even if those are flawed. Important goals for research on self-regulated learning, therefore, include not only mending these "metacognitive illusions" but also exploring ways to get students to choose effective learning strategies in their own studying.

This review focuses on a specific learning strategy—retrieval practice—that is highly effective but tends to be underutilized by students. A brief overview of retrieval practice is provided, followed by the reports of survey studies showing the rate at which students use (or do not use) retrieval practice in their own learning. This is followed by a review of the emerging research on interventions designed to increase the rate at which students use retrieval in their own learning. Reasons for the success (or lack thereof) of these interventions are discussed, and how the findings can inform the design of effective future interventions. Finally, practical suggestions are offered for teachers about ways that this research informs instructional methods that can encourage students to use retrieval practice.

## Retrieval Practice

Retrieving information from memory is one of the most powerful ways to enhance learning. Following an opportunity to learn new information, such as in a class lecture or reading assignment, trying to recall that information significantly benefits students' long-term memory compared to simply reading it again or reviewing it without trying to recall it. This benefit has commonly been referred to as *retrieval practice* or the *testing effect* and has been demonstrated in hundreds of studies spanning more than a century of research (for a review, see Carpenteret al., 2022).

Of particular interest for education are studies showing benefits of retrieval in authentic class environments. Incorporating retrieval practice into course activities—in the form of online practice quizzes, "clicker" questions, or paper-and-pencil retrieval exercises—produces significant learning benefits across all levels of education. These include elementary school children learning basic concepts and skills like science (Jaeger et al., 2015) and spelling (Jones et al., 2016), middle and high school students learning mathematics (Dirkx et al., 2014), history (Carpenter et al., 2009), and science (McDaniel et al., 2011), and university and postgraduate students learning advanced topics in courses like biology (Pan et al., 2019), neuroscience (McDaniel et al., 2007), and medicine (Kromann et al., 2009). The quickly growing literature on classroom-based studies of retrieval practice has been captured in several recent reviews (e.g., Agarwal et al., 2021; Schwieren et al., 2017; Sotola & Credé, 2020).

This extensive literature showcases retrieval practice as a highly effective and flexible tool that can be applied to a wide variety of course material. Recent evidence suggests that retrieval is generally beneficial across all levels of education (Carpenter et al., 2022) and for students with neurodiverse conditions such as attention-deficit hyperactivity disorder (ADHD, Knouse et al., 2020). Importantly, almost everything we know about retrieval practice comes from studies where students are assigned, and typically required, to engage with retrieval practice. We know far less about whether students *choose* to use retrieval when it is not required. Exploring these choices is critically important given the increasing role that students' self-initiated actions play in their learning experiences. Whereas retrieval is clearly beneficial for learning, it will most certainly fail to benefit learning if students do not use it.

Indeed, the literature on students' study decisions indicates that retrieval practice is underutilized as a learning strategy. Though survey studies inquiring about students' study strategies do show that students list retrieval as one of the strategies that they use—for example, in the form of a practice test, quiz, or flashcards—the most common reason for doing so is to check their knowledge (Geller et al., 2018; Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007; Morehead et al., 2016; Tullis & Maddox, 2020; Yan et al., 2014). When asked about using retrieval as a learning method, only 6% of students in one recent survey reported doing so (Tricio et al., 2023). In real educational situations, therefore, students tend to see retrieval as a way of verifying what they know instead of *improving* what they know. This can lead to using retrieval practice in ways that are not optimal, such as a one-time check of knowledge at the end of studying.

The strong tendency to view retrieval primarily as a measure—instead of a *method*—of learning could stem in part from the longstanding use of tests for assessment purposes in education. Though teachers and students alike are familiar with taking tests to determine course grades, survey studies show that both teachers and students tend to be unfamiliar with the use of retrieval practice as a way to boost learning (Morehead et al., 2016), and observational studies of classroom teachers show that direct instruction on learning strategies seldom occurs (Granström et al., 2023). Getting students to use retrieval practice in their learning, therefore, could be as simple as just informing them about its benefits. The evidence supporting this fairly simple intervention is discussed next.

## Intervention #1: Increase Awareness of the Benefits of Retrieval Practice

Some studies have explored whether increasing students' awareness of retrieval practice leads to more frequent decisions to use it. Although a logical and straightforward approach, this intervention has met with limited success. In one recent study (Simone et al., 2023), students were given the opportunity to learn Swahili-English word pairs through either retrieval or restudy. Prior to learning the word pairs, students were informed about the benefits of retrieval practice and were encouraged to use it (the Instruction Group), or they were simply told to learn the word pairs using whichever method they chose (the Control Group). Half the students completed the task in a supervised laboratory environment, and the other half completed the task in an unsupervised online environment.

Results of a final test confirmed the overall benefit of retrieval practice in that word pairs learned through retrieval were remembered better than those learned through restudy. Whereas the Instruction Group made more frequent use of retrieval during learning than the Control Group, this was only true when students completed the study in a supervised laboratory environment. Students in the unsupervised online environment did not show an increased tendency to use retrieval after being instructed to do so. Thus, while Simone et al. (2023) showed that students tend to comply with instructions to use retrieval in a supervised environment (for similar results see Ariel & Karpicke, 2018), they do not appear to do so while in an unstructured environment that is more typical of real learning situations.

In a recent study conducted in a marketing communication course (Broeren et al., 2021), half of the students were given an instructional video describing the benefits of retrieval practice and how to use it, and half were not, prior to engaging with an online self-study session where they could choose to learn course concepts through retrieval (trying to recall the definition of a concept) or study (seeing the concept and definition together). Students were given three self-study sessions with these options. In two out of the three sessions (in weeks 3 and 5 of the course), students who had received the instructions about retrieval practice were not more likely to use the retrieval option than students who received no instructions about retrieval practice. In the final self-study session (during week 6), however, students who had received the retrieval practice instructions did choose the retrieval option more

often. Though the reasons for this pattern of results are not completely clear (for example, perhaps students are more likely to choose retrieval after some experience and practice with it; see next section), the data show that simply informing students about the benefits of retrieval practice does not lead to reliable and consistent use of retrieval practice.

Consistent with these findings, other research shows that students can have some awareness of effective study techniques, and even strong intentions to use those techniques, but still end up not using them (Rea et al., 2022). As one salient example, Blasiman et al. (2017) administered a survey to students in a variety of undergraduate courses to ask about study strategies students intended to use, their beliefs about the effectiveness of those strategies, and how often they actually used those strategies at various follow-up time points. Whereas retrieval-based strategies—namely, flashcards and practice tests—were two of the most common strategies that students *intended* to use, these strategies were actually used least often by students, even though students indicated some awareness of the effectiveness of flashcards. Thus, students' intentions to use effective study techniques do not automatically get carried out. Furthermore, students commonly report that the study techniques they choose are not the result of those techniques having been taught to them (Geller et al., 2018; Hartwig & Dunlosky, 2012; Kornell & Bjork, 2007; McAndrew et al., 2016; Yan et al., 2014), indicating that even if teachers were to provide direct instruction about effective study techniques, those techniques may still be avoided by students.

Thus, simply telling students about the benefits of retrieval is not sufficient. Even when they are aware of these benefits, students do not automatically choose to use retrieval practice on their own. Though exact reasons for this avoidance could vary, one logical possibility is that learners lack sufficient experience using retrieval, and thus may not directly see and feel its benefits. Directly experiencing retrieval could provide learners with personalized first-hand knowledge that retrieval works for them, which may in turn increase their tendency to use it.

## Intervention #2: Provide Opportunities to Directly Experience Retrieval Practice

If awareness alone is not enough, perhaps direct experience is. Some studies have explored this possibility by providing learners with the opportunity to learn material through retrieval practice, as compared to a different method like restudying, and then giving learners a choice of whether or not to use retrieval practice to learn subsequent material. If experience influences self-regulation decisions, then learners may be more likely to use retrieval practice following a direct experience with it.

In one recent study (Kirk-Johnson et al., 2019, Study 2), participants learned a text passage using retrieval practice (by reading it and then answering questions about it), and a different text passage using restudy (by reading it and then reading statements from the passage). Afterward, participants were given the opportunity to learn a third text passage and were permitted to choose whether they wanted to learn it using retrieval or restudy. Only 31% of participants chose retrieval, while 69% chose restudy. These choices run counter to the typical learning benefits of retrieval

practice, however participants were not given a final test over the material so the objective effects of retrieval practice could not be verified.[1]

In similar work by Hui and colleagues (Hui et al., 2021, 2022), participants learned Latin names for anatomical images. One set of images was learned using retrieval practice, and another set using restudy. After experiencing both strategies, participants were given an immediate test over images from both sets, requiring them to provide the name when given the image. Immediately afterward, participants were permitted to choose which strategy to use for learning a new set of anatomical images. Even when the results of this test revealed that retrieval was significantly more effective than restudy for learning the earlier images, participants did not reliably choose retrieval more often than restudy—instead opting for retrieval only about 50% of the time—when learning the new images.

Why do students not prefer retrieval even after directly experiencing it? There are at least two possibilities. First, the experience of using retrieval may not be sufficient to convince learners that it is effective. Some research shows that even after directly experiencing effective learning methods, learners still hold onto the belief that those methods are not effective (Kornell & Bjork, 2008). Indeed, in the studies described above, learners were not given feedback of their own performance while learning from retrieval vs. restudy, so without awareness of the benefits of retrieval they may have chosen restudy for the same reasons that they tend to prefer study techniques that feel smooth and easy, even if those techniques are less effective for learning (Tricio et al., 2023). Importantly therefore, the direct experience of a learning benefit may not guarantee that learners become aware of that benefit.

Second, learners may avoid choosing retrieval because of its undesirable side effects. In particular, retrieval involves errors when learners fail to retrieve information perfectly. Although errors are bound to happen and can easily be corrected through feedback, they are generally considered an undesirable experience and can work against the motivation to use retrieval (Carpenter et al., 2020a, 2020b). Even if students understand that errors are part of the learning process, they still prefer to avoid them (Pan et al., 2020).

Retrieval also requires effort, and effort appears to play an important role in learners' decisions to avoid using retrieval. Tullis et al. (2018) found that when learners were given a choice between retrieval and restudy to learn word pairs, even when they received feedback during retrieval attempts that allowed them to correct errors, they preferred to use restudy instead of retrieval for the more difficult items. Hui et al. (2022) collected ratings of subjective mental effort and found that participants rated retrieval more effortful than restudy, and higher ratings of mental effort were associated with reduced tendency to choose retrieval to learn the new images. Similarly, Kirk-Johnson et al. (2019) found that participants rated retrieval as more

[1] A follow-up study using different text passages involved a final fill-in-the-blank test 48 h after learning and found that performance was not significantly different for passages that had been learned via retrieval vs. restudy (Kirk-Johnson et al., 2019, Study 3). It was noted, however, that benefits of retrieval may have been reduced due to the difficulty of the text passages (with initial retrieval performance at 55%) and the absence of corrective feedback during initial retrieval.

difficult than restudy, and avoidance of retrieval was predicted by how difficult learners perceived the task to be. Furthermore, the relationship between subjective experience of difficulty and avoidance of retrieval was mediated by learners' impressions of their own learning. That is, greater difficulty was associated with impressions of less effective learning, which in turn led to reduced tendency to use retrieval.

Thus, although using retrieval can result in learning benefits, it can also result in an experience of its undesirable side effects. To the extent that learners try to avoid these side effects, they may choose to forego the benefits of retrieval as well. Just like exercise is good but comes with physical effort and fatigue, the mental effort and errors involved in retrieval might work against the motivation to use it. A successful intervention for increasing the use of retrieval in self-regulated learning, therefore, must address the motivational challenges that come with its undesirable side effects.

## Intervention #3: Emphasize the Desirable Aspects of Retrieval Practice

Although retrieval practice by nature is more effortful and error-prone than other strategies such as restudying, there may be positive aspects of retrieval that can be leveraged to increase students' desires to use it. For example, there is a long-standing positive relationship between curiosity and learning outcomes, such that greater curiosity leads to better learning (Berlyne, 1954, 1966; Mullaney et al., 2014). A retrieval opportunity has the potential to stimulate curiosity, and indeed some research has found that retrieval tasks that arouse curiosity are more likely to encourage students to choose retrieval.

In one recent study, Vaughn and Kornell (2019) found that providing hints during retrieval substantially increased participants' tendencies to choose retrieval over restudying. Participants learned word pairs (e.g., idea: seeker) and were given the options to choose restudying where they saw both words together, retrieval where they recalled the second word from the first word, or retrieval with hints where they had to recall the second word but with some of the letters already filled in for them (e.g., idea: se__er). Participants showed a strong tendency to choose restudy over retrieval—opting for restudy on 29% of the items and retrieval on only 2% of the items. When hints were provided during retrieval, however, participants chose retrieval 69% of the time. Making retrieval a little easier, therefore, greatly boosted participants' desires to use it. The positive effect of hints on participants' choices also came with no apparent cost to learning, as final test performance revealed a benefit of retrieval (with or without hints) relative to restudy.

Thus, a greater likelihood of success may provide a positive experience that makes retrieval more desirable. Consistent with this notion, research by Finn and colleagues on "remembered success" shows that learners' decisions to engage and persist on challenging tasks (e.g., solving a series of difficult math problems) can be enhanced by including experiences of success (e.g., by incorporating easier problems), even if this means additional tasks to complete (Finn & Miele, 2016; Finn et al., 2023).

Although increasing retrieval success is a promising way to make retrieval more desirable, there may be limits to how effectively the effort involved in retrieval can be realistically reduced. This may be especially true in real educational situations that involve challenging learning material. There is the potential concern that making retrieval too easy could backfire, as the effort involved in retrieval—i.e., the "desirable difficulty"—is likely to be a key contributor to its effectiveness (e.g., see Bjork & Bjork, 2023; Carpenter et al., 2020a, 2020b).

Optimistically, even challenging material can be learned effectively through repeatedly engaging in retrieval practice, which has the dual benefit of enhancing learning and reducing the anxieties associated with retrieval (Agarwal et al., 2014). However, if retrieval is undesirable in the first place, learners may have a hard time using it at all, much less using it repeatedly. Thus, further motivational strategies will likely be needed to help offset the undesirable experiences of effort and errors.

## Intervention #4: Provide Feedback on the Positive Outcomes of Retrieval Practice

A straightforward strategy for boosting students' motivation to use retrieval is to show them that it is working. Some research has shown that students more often choose retrieval practice when they see how the benefits apply directly to them. For example, if students can see how their own use of retrieval practice relates to their desired learning outcomes—such as higher exam scores—they are more likely to use it.

This was demonstrated in a recent study that provided students with optional practice quizzes in an introductory biology course (Carpenter et al., 2017). Students were given online practice quizzes after each class meeting and were encouraged (but not required) to use them as a study tool. Less than 50% of students completed at least one practice quiz prior to the first two exams, and students who completed the practice quizzes scored significantly higher on those exams compared to students who did not complete any practice quizzes. About 1 week before the third exam, all students were reminded about the practice quizzes and were shown a graph of the anonymized average exam scores for students who completed practice quizzes and those who did not. After this, the percentage of students completing the practice quizzes increased to 80% before the third exam. Thus, seeing desirable outcomes associated with a retrieval-based study tool substantially and significantly increased students' decisions to use that tool.

Other studies show that providing learners with their own performance-based feedback on the benefits of retrieval can increase their tendencies to choose retrieval. In the study by Hui et al. (2021), during an initial learning phase participants did not favor retrieval over restudy for learning anatomical images (choosing retrieval less than 50% of the time), even when they had learned an earlier set of images better through retrieval practice than through restudy. In this initial phase, participants were not provided with feedback on their performance, however. When participants were shown their own performance on a 7-day delayed test—which showed an advantage of retrieval over restudy—they were

significantly more likely to choose retrieval (about 70% of the time) when given a subsequent opportunity to learn new images.

A follow-up study by Hui et al. (2022), using similar materials and a 4-day delayed test, observed the same increase in the tendency to choose retrieval as a result of feedback. Even though retrieval was initially rated more effortful than restudy (and effort ratings were associated with avoidance of retrieval), after feedback showing the benefits of retrieval, participants were significantly more likely to choose retrieval over restudy.

These findings are consistent with research exploring students' self-reported use of retrieval as a study strategy. Following an in-class activity where students practiced retrieving vs. restudying prose material, Einstein et al. (2012) found that retrieval led to significant advantages over restudy on a later final test over the information. Students scored their own final tests and discussed the results as a class and also were presented with information about the research findings showing benefits of retrieval. At the end of the academic term, students reported that they were significantly more likely to use retrieval practice in their studying compared to at the beginning of the term. Along similar lines, in a recent study by McCabe et al. (2021), students in an introductory psychology course completed an in-class demonstration where they read a prose passage and then either practiced retrieving or restudying it, and then scored their own final tests to see the learning benefits of retrieval. Several weeks later, students' self-reported use of retrieval practice in their own learning was significantly higher for those students who had completed the class demonstration compared to a control group of students who had not.

## Intervention #5: Multifaceted Approaches

The interventions discussed so far involve relatively simple ways of increasing the use of retrieval practice usually over fairly short time intervals. Importantly, interventions also exist that are more thorough, multi-faceted, and long term. These approaches contain multiple components designed to produce changes in students' mindsets and behaviors with respect to using retrieval practice and other effective learning strategies.

The Study Smart Program consists of three facilitated training sessions, each about 90 min, separated by 1 or 2 weeks (see Biwer et al., 2020). Learners first participate in a session to promote *awareness* of effective learning strategies through sharing their own learning strategies, and sorting the effectiveness of various learning strategies (including retrieval, as well as ineffective strategies) provided by the facilitator. The facilitator then addresses the concept of desirable difficulties and presents the empirical evidence supporting these strategies, followed by students' reflections about a time when they had to invest effort and deliberate practice to improve upon something they were learning, a practice test over the strategies, and finally a homework assignment to log their study behaviors until the next session. In the second session, students *reflect* on their study behaviors that they logged, reflect on their learning goals and motivation, and make a specific plan for future use of these strategies in their studying. In the third session, students give a report

on their plan and their study behaviors since the previous session. They also directly *practice* using retrieval vs. a less effective strategy (i.e., highlighting) and have the opportunity to score their own performance on the learning material, and finally are reminded about the effectiveness of different learning strategies.

Studies have shown that the Study Smart Program improves knowledge and self-reported use of effective study strategies. In one study, a survey was administered over knowledge and use of effective learning strategies both before and after completing the Study Smart Program (Biwer et al., 2020). Relative to a wait list control group, students who completed the program showed increased awareness and more frequent use of retrieval practice and other effective study strategies. In a subsequent study (Biwer et al., 2023), implementing the Study Smart Program across a 4-week pharmacy course resulted in more accurate awareness of retrieval practice and other effective study strategies from before to immediately after completing the program, and also on a delayed survey administered 24 weeks after the program began. Students also reported using effective study strategies more often after the Study Smart Program, and self-reported use of retrieval practice correlated positively with performance on the first exam in a 14-week course that immediately followed the Study Smart Program.

Other frameworks have been proposed that can inform multi-faceted interventions for increasing the use of retrieval practice and other effective study strategies. The Start and Stick to Desirable Difficulties (S2D2) framework (de Bruin et al., 2023) highlights three components of an intervention that are important to achieving this goal: improving learners' awareness of effective learning strategies, reducing the perceived effort involved in learning at the task level, and providing effective strategies for motivation and self-regulation. The Knowledge, Belief, Commitment, and Planning (KBCP) framework (McDaniel & Einstein, 2020) emphasizes learners' accurate knowledge of effective learning strategies, the importance of believing that the strategies work, commitment to using them, and future planning of how the strategies will be implemented.

Recent evidence reveals promising outcomes from a classroom intervention based on the KBCP framework. McDaniel and Einstein (2023) describe a semester-long course for university undergraduates on the science of learning that incorporated its key elements. First, *knowledge* of effective learning strategies (including retrieval practice) was imparted to students through assigned readings and lectures that focused on the evidence supporting these strategies and how to use them. Next, *belief* in the strategies was instilled through in-class demonstrations requiring students to learn information via their usual learning strategies vs. the effective strategies that they were taught. These demonstrations included reviewing the results of the learning strategies and reflecting on the effectiveness of the new strategies vs. the usual strategies that students were accustomed to. Finally, *commitment* and *planning* were incorporated through a course assignment where students generated and carried out a plan for applying the effective learning strategies to one of their courses, and then discussed the results of how it went. Based on a survey administered on the first and last day of class, students' self-reported use of learning strategies revealed a significant increase in the use of retrieval practice and other effective strategies, and a significant decrease in re-reading course material and other ineffective strategies.

These multi-faceted approaches highlight many of the same components. For example, all of them emphasize direct instruction on effective learning strategies to increase awareness of these strategies. Direct experience and knowledge of the outcomes are also emphasized. As such, these approaches build on many of the individual interventions reviewed above, and seek to combine these elements in a way that can produce durable and lasting improvements in students' use of retrieval and other effective study strategies in real learning situations.

As learning experiences become more autonomous, effective motivational strategies will become especially important in multi-faceted interventions. Whereas learners might utilize effective strategies when instructed to do so under supervised conditions, they are less likely to do so under unsupervised conditions (Simone et al., 2023). The temptation to "cheat" may be greater in unsupervised situations, and the negative side effects of effort and errors associated with retrieval practice might further increase the temptation to forego retrieval in favor of a more comfortable yet ineffective way to learn. Thus, specific strategies to increase motivation—such as re-framing the effort involved in a learning task as a positive thing (Zepeda et al., 2020)—are likely to be key components of successful multi-faceted interventions and a valuable area for future research on improving self-regulated learning.

## Practical Suggestions for Teachers

The research to date provides some valuable information that teachers can use to support students' decisions to use retrieval in their own learning. While teachers do not have the resources or time to carry out complex multi-faceted interventions, there are a number of straightforward "tweaks" that teachers can make to any course to encourage students to use retrieval.

First, teachers can provide direct and easy access to retrieval resources. Providing practice quizzes online via a course management system can give students immediate access to retrieval practice in a way that is low key and low stakes, and that students can use multiple times as a study tool. Teachers can also embed correct answer feedback directly into the quizzes (to be viewed after students try to answer the questions), providing students the timely opportunity to check their answers without teachers needing to grade the responses. For many students, the effort involved in retrieval is not inherently enjoyable (Carpenter et al., 2020a, 2020b), and additional effort would likely be involved in seeking out or generating their own practice questions. As such, providing quick and easy access to practice questions is one way that teachers can remove additional motivational obstacles to encourage retrieval practice.

Other forms of technology can be utilized to provide easy access to retrieval resources. In one recent study (Cleary et al., 2021), retrieval was effective for learning when practice questions were delivered to students via prompts on a smartwatch. Another study found that a mobile app could be effectively used to implement spaced retrieval practice for improving students' financial knowledge (Kang et al., 2023). Digital technology provides a number of possibilities for ways that

retrieval practice and other effective learning strategies can be accessed and utilized by students.

It is important to note, however, that easy access to retrieval does not guarantee that students will use it. A number of studies show that students do not automatically use retrieval resources simply because they are available (Corral et al., 2020; Walck-Shannon et al., 2019); however, students can be encouraged to use these resources when incentives are applied such as giving students course credit (Trumbo et al., 2016) or showing students the positive outcomes associated with using retrieval (Carpenter et al., 2017). In addition, although prompting retrieval with digital technology and other tools is different from students making their own decisions to use retrieval, such tools can expand students' opportunities to experience retrieval practice, which is a necessary ingredient in the development of students' self-regulated decisions to engage in retrieval. An interesting area for future research might be to explore how retrieval prompts can be used as scaffolding while students are initially learning to use retrieval practice, and to examine effective ways of removing this scaffolding over time to enable more self-initiated decisions to engage in retrieval. Although giving students easy access to retrieval can reduce the motivational costs, such easy access should be considered a first step that will most certainly need to be combined with other approaches to encourage students' use of retrieval in self-regulated learning situations.

Second, teachers can leverage the power of positive experiences. Providing sets of practice questions that include some easier questions may help motivate students to use retrieval by providing the experience of success. Making retrieval easier and more successful can greatly increase students' decisions to use it (Vaughn & Kornell, 2019), and can reduce the perceived costs of effort (Finn et al., 2023). Including some easier questions is thus a straightforward way to boost students' curiosity and motivation that may help them decide to engage and persist at using retrieval.

Third, teachers can show students the positive results associated with retrieval practice. Seeing that retrieval works can be highly effective for getting students to use it (Carpenter et al., 2017; Hui et al., 2021, 2022). This could be done through simple demonstrations (done in class or online) where students practice retrieving some of their course material, and then later take a memory test covering material that they practiced retrieving vs. material they did not practice retrieving (see Einstein et al., 2012; McCabe et al., 2021). Presenting students with the positive outcomes resulting from retrieval, either through individualized or group scores, can be a direct and concrete way to show them that it works.

## Summary and Directions for Future Research

The increasing autonomy of education places growing challenges on learners to successfully regulate their own learning. Rapid changes in educational access and delivery that entail greater flexibility for the learner can be problematic, however, if learners lack the knowledge and skills to use that flexibility in a way that is best for their learning. Understanding and improving students' self-regulated learning is therefore a critical theme for current and future research.

Abundant research shows that retrieval is a highly effective but underutilized strategy for learning. While students can be made aware of the benefits of retrieval, this awareness does not translate directly into more frequent use of retrieval. Having students use retrieval practice can provide a direct experience with it, but even this direct experience may not lead to greater use of retrieval practice if students remain unaware of its benefits, or if retrieval comes with undesirable side effects. Increasing the success of retrieval does appear to increase students' tendencies to use it, as does showing students the positive outcomes associated with retrieval. The small but growing number of studies on multi-faceted interventions also shows some promising potential for them to increase students' use of retrieval in their courses.

The emerging research on the effectiveness of these interventions brings to light some important questions and directions for future research. It is clear that simply informing students about retrieval is not enough and that more direct experience using it and directly seeing how its benefits apply to them is needed for encouraging students to use retrieval in their own learning. Future research, therefore, would benefit by addressing the motivational challenges and pitfalls that arise as a result of experiencing retrieval, and how these might be mitigated.

A major motivational challenge to using retrieval is the effort involved. Students tend to avoid effortful learning experiences, in part due to an intuitive but false perception that effort is a sign of ineffective learning (Kirk-Johnson et al., 2019), and also likely due to the fact that effort itself tends to be an undesirable experience. Indeed, when asked about their reasons for not using retrieval and other effective learning strategies, the most common responses from students in one recent study were that the strategies take too much effort and time (Rea et al., 2022). Because effort is likely to be part of the retrieval experience—and indeed is inherent in the "desirable difficulties" of many effective learning strategies (Bjork & Bjork, 2011, 2023)—future interventions are worthwhile that can reduce the perceived costs, and increased the perceived value, of retrieval practice and other desirable difficulties as learning tools.

Future research is especially encouraged that can inform effective interventions in real world learning situations. Presently, data are lacking on the long-lasting effects of interventions designed to increase use of retrieval practice. What factors help learners not only start, but also stick to, retrieval practice and other effective learning strategies over time? (See de Bruin et al., 2023). If reminders or follow-up activities are needed, what kinds of activities are effective and what are the best ways to implement and schedule these activities?

Finally, given the complex nature of self-regulated learning, multiple methods of data collection will likely be helpful in understanding the decisions students make while learning. In addition to quantitative data on students' decisions and learning outcomes, qualitative data can be valuable as well. Focus groups and other sources of information on students' experiences could be good sources of information about why students use (or do not use) effective learning strategies and identify potential strategies for reducing obstacles to optimal study decisions (Biwer et al., 2020). Given that retrieval practice can be applied more easily to some types of learning materials (e.g., vocabulary, terms, and definitions) than others (e.g., prose passages), the convenience of using retrieval practice is an important factor that likely influences the readiness to use it, and this

should be considered from both the perspective of the student engaging in retrieval and the instructor designing retrieval activities.

Understanding and supporting effective self-regulated learning can be challenging given the learner-centered nature of the knowledge, beliefs, motivation, and other factors that underlie learners' decisions. Further adding to the challenge is the fact that the internal processes underlying such decisions can be hard to observe. Fortunately, the emerging research on self-regulated learning reveals some key elements of effective interventions that can promote students' decisions to use retrieval practice.

Future research endeavors aimed at optimizing self-regulated learning will benefit from diverse approaches, comprehensive methods, and longitudinal designs that can help develop a complete understanding of students' decisions and actions in real learning situations. Interventions aimed at optimizing students' self-regulated learning in real educational situations should consider in particular the trust and rapport that students have with an instructor who seeks to help them develop effective learning strategies, the degree of support provided by a learning environment that emphasizes successful learning, and whether such interventions can successfully improve students' learning behaviors at a programmatic or institutional level, beyond individual courses. Like learning itself, such endeavors will require time and persistence, but are worth the effort.

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