From “Make It Stick: The Science of Successful Learning” by Brown, Roediger and McDaniel, The Belknap Press of Harvard University Press, 2014.

What was the result? On exams administered during the semester, the students were asked questions that assessed their understanding of the key concepts that they had worked on learning. They scored significantly (approximately half a letter grade) better on the ones they had written about in their own words than on those they had copied, showing that it was not simply exposure to the concepts that produced the learning benefit. In follow-up tests approximately two months later to measure retention, the benefits of writing to learn as a form of reflection had dropped but remained robust.[15]

Start here:

Failure and the Myth of Errorless Learning

In the 1950s and 1960s, the psychologist B. F. Skinner advocated the adoption of “errorless learning” methods in education in the belief that errors by learners are counterproductive and result from faulty instruction. The theory of errorless learning gave rise to instructional techniques in which learners were spoonfed new material in small bites and immediately quizzed on them while they still remained on the tongue, so to speak, fresh in short-term memory and easily spit out onto the test form. There was virtually no chance of making an error. Since those days we’ve come to understand that retrieval from short-term memory is an ineffective learning strategy and that errors are an integral part of striving to increase one’s mastery over new material. Yet in our Western culture, where achievement is seen as an indicator of ability, many learners view errors as failure and do what they can to avoid committing them. The aversion to failure may be reinforced by instructors who labor under the belief that when learners are allowed to make errors it’s the errors that they will learn.[16]

This is a misguided impulse. When learners commit errors and are given corrective feedback, the errors are not learned.

Even strategies that are highly likely to result in errors, like asking someone to try to solve a problem before being shown how to do it, produce stronger learning and retention of the correct information than more passive learning strategies, provided there is corrective feedback. Moreover, people who are taught that learning is a struggle that often involves making errors will go on to exhibit a greater propensity to tackle tough challenges and will tend to see mistakes not as failures but as lessons and turning points along the path to mastery. To see the truth of this, look no further than the kid down the hall who is deeply absorbed in working his avatar up through the levels of an action game on his Xbox video console.

A fear of failure can poison learning by creating aversions to the kinds of experimentation and risk taking that characterize striving, or by diminishing performance under pressure, as in a test setting. In the latter instance, students who have a high fear of making errors when taking tests may actually do worse on the test because of their anxiety. Why? It seems that a significant portion of their working memory capacity is expended to monitor their performance (How am I doing? Am I making mistakes?), leaving less working memory capacity available to solve the problems posed by the test. "Working memory" refers to the amount of information you can hold in mind while working through a problem, especially in the face of distraction. Everyone's working memory is severely limited, some more than others, and larger working memory capacities correlate with higher IQs.

To explore this theory about how fear of failure reduces test performance, sixth graders in France were given very difficult anagram problems that none of them could solve. After struggling unsuccessfully with the problems, half of the kids received a ten-minute lesson in which they were taught that difficulty is a crucial part of learning, errors are natural and to be expected, and practice helps, just as in learning to ride a

bicycle. The other kids were simply asked how they had gone about trying to solve the anagrams. Then both groups were given a difficult test whose results provided a measure of working memory. The kids who had been taught that errors are a natural part of learning showed significantly better use of working memory than did the others. These children did not expend their working memory capacity in agonizing over the difficulty of the task. The theory was further tested in variations of the original study. The results support the finding that difficulty can create feelings of incompetence that engender anxiety, which in turn disrupts learning, and that "students do better when given room to struggle with difficulty."[17]

End here:

These studies point out that not all difficulties in learning are desirable ones. Anxiety while taking a test seems to represent an undesirable difficulty. These studies also underscore the importance of learners understanding that difficulty in learning new things is not only to be expected but can be beneficial. To this point, the French study stands on the shoulders of many others, among the foremost being the works of Carol Dweck and of Anders Ericsson, both of whom we discuss in Chapter 7 in relation to the topic of increasing intellectual abilities. Dweck's work shows that people who believe that their intellectual ability is fixed from birth, wired in their genes, tend to avoid challenges at which they may not succeed, because failure would appear to be an indication of lesser native ability. By contrast, people who are helped to understand that effort and learning change the brain, and that their intellectual abilities lie to a large degree within their own control, are more likely to tackle difficult challenges and persist at them. They view failure as a sign of effort and as a *turn* in the road rather than as a measure of inability and the *end* of the road. Anders Ericsson's work investigating the nature of expert performance shows that to achieve expertise requires thou-